タンザニア連合共和国
キリマンジャロ農業開発計画
専門家総合報告書
（冨高元徳）

平成３年10月

国際協力事業団

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序　　　文

タンザニア・キリマンジャロ農業開発計画は、キリマンジャロ州総合開発計画の一環として、昭和53年9月13日より7年半にわたって実施された第1フェーズにひきつづき、昭和61年3月13日より5年間の計画で第2フェーズが実施され、現在平成3年3月13日より2年間のフォローアップ協力を実施中である。

本プロジェクトはローアモシ地区において稲作及び畑作栽培技術の開発普及、水管理と水利施設維持管理及び、農業機械の操作・維持管理等に対する助言・指導等を行うことによって農業技術の確立を図り、キリマンジャロ州の農業開発の推進に寄与することを目的としてる。

本報告書は、昭和61年6月5日より平成3年3月12日まで畑作物分野の専門家として現地で活動し、任期を満了して帰国された富高元徳専門家のプロジェクトにおける活動をとりまとめたものである。本報告書が、本プロジェクトの今後の発展とアフリカ地域をはじめとする他の類似の農業開発計画を推進してゆくうえで参考となれば幸いである。

最後に、本プロジェクトの実施にあたり、多大なご協力をいただいている外務省、農林水産省及びプロジェクト関係者に対し、感謝の意を表するとともに、2カ年間のフォローアップ協力期間中における一層の御支援をお願いするものである。

平成3年10月

国際協力事業団
農業開発協力部長
崎　野　信　義

PREFACE

Kilimanjaro Agricultural Development Project (KADP) is a cooperation project between Tanzanian and Japanese Governments. It started on 13 March, 1986 following Kilimanjaro Agricultural Development Center Project (which lasted from 13 September, 1978 to 12 March, 1986). The period of cooperation was initially 5 years. Later, it was agreed to extend the cooperation period for 2 years but with a reduced scale.

I was dispatched by Japan International Cooperation Agency (JICA) as an agronomist for upland crops, and stayed at KADP since June 1986 to March 1991. This report consists of (1) outline of KADP, (2) activities of Upland Crops Section in the last 5 years, and (3) other topics relating to KADP activities.

Upland Crops Section is a minor Section in KADP which has been known as "Rice Project". The Section, however, has paid efforts for the improvement of cultivation techniques of some upland crops (i.e. soybean, maize) through mutual cooperation among the staff. It conducted a training of extension workers in Kilimanjaro Region every year, and a soybean promotion seminar at several villages in the Region.

If KADP is recognized by Tanzanian Government and peoples, it should not be because of Japanese aid project, but should be because of the efforts and contributions of Tanzanian staff for the improvement of farmers' welfare through research, training and extension works.

I would like to express my sincere gratitude to Mr. G.R. Moshi (Project Director) for his cooperation, Mr. Z. K. Sarakikya (Head of Upland Crops Section), Mrs. G. Mshanga, Mr. B. Macha and Mr. M. G. Rugemalira (staff of Upland Crops Section) for their efforts in field and office. Many thanks are to the laborers who worked under severe conditions, and to the driver (Mr. C. Abbasi) who traveled with me many times.

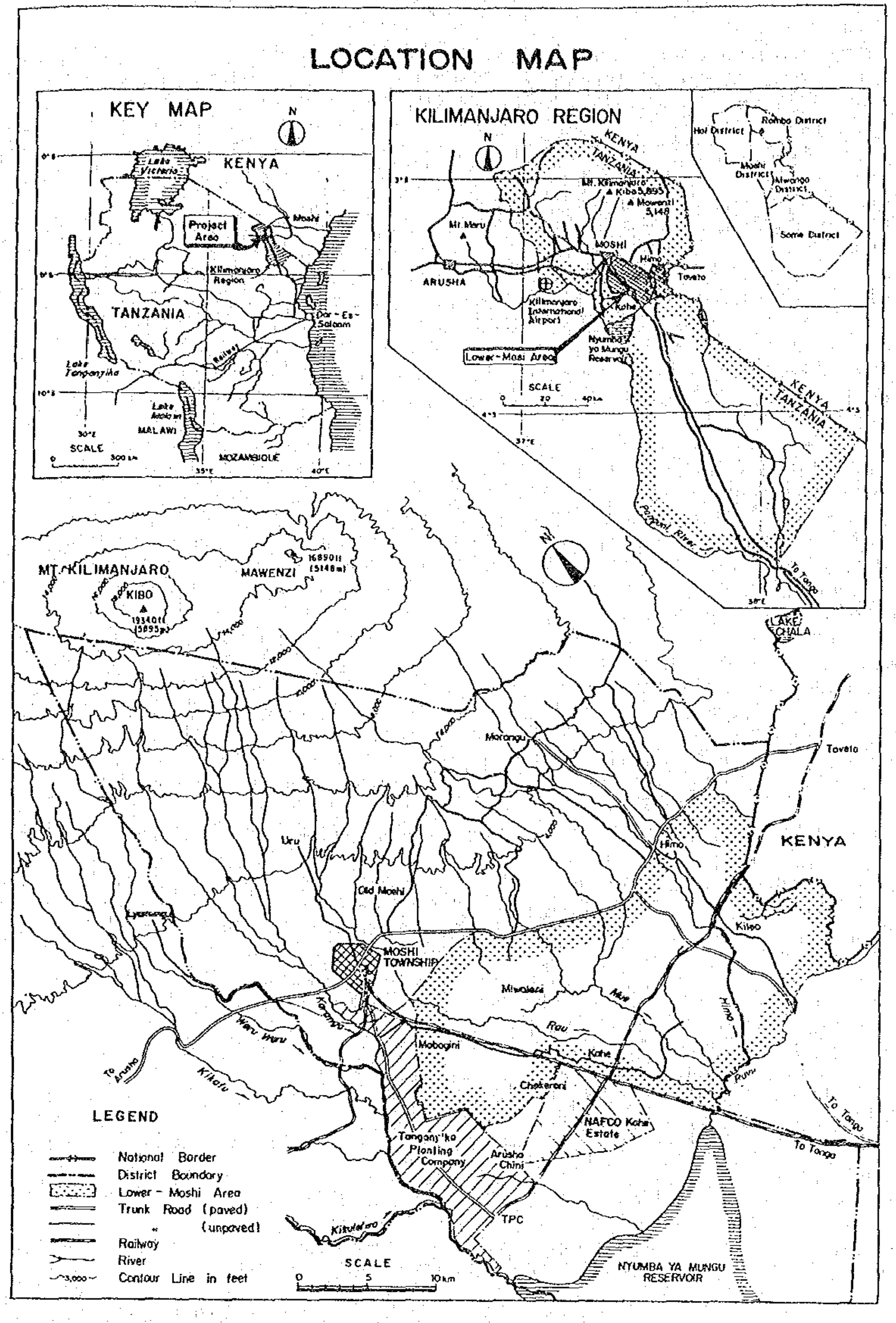
I am also thankful to many Tanzanian researchers. To mention few of them: Prof. M.P. Salema (then Sokoine University of Agriculture) for providing Rhizobium inoculant for soybean, researchers at Ilonga Agricultural Research and Training Institute (i.e. Dr. A.J. Moshi, Messrs. F.F.A. Mbowe, J.K. Mligo and J.A. Assenga) for providing seeds (maize, sunflower, soybean, and other kinds of beans) and information, Mrs. J. Kaaya (Department of Research and Training, Ministry of Agriculture and Livestock Development) for providing general information.

Material and moral supports from JICA headquarters, its Institute of International Cooperation, and other concerned agencies helped a lot for the activities of the Section.

I would also like to mention my deep appreciation to the staff of Kilimanjaro Christian Medical Center for their kind services to me and my family (and to other Japanese in general).

I have received suggestions and advice from both Tanzanian and Japanese staff during the preparation of this report. However, views and opinions expressed in the report may not always reflect those of JICA or KADP but of myself.

March, 1991
Motonori Tomitaka



Obtained from "Feasibility report on Lower-Moshi agricultural development project" Main report, October 1980, JICA

Kilimanjaro mountain:
The roof of African Continent

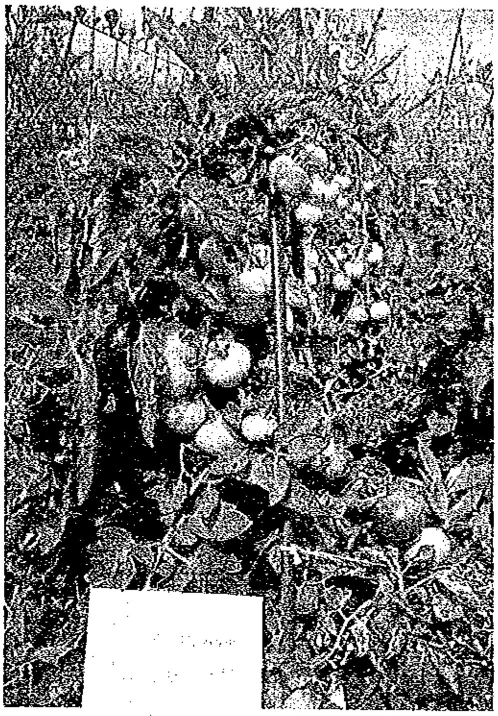
Traditional furrows along Kilimanjaro and Pare mountains are famous for their long histoty of irrigating crops

Coffee／banana (and other crops) mixed farming is practiced at high altitude areas in Kilimanjaro Region

Low altitude areas in Kilimanjaro Region are marginal lands for crop production under rainfed conditions

Experiments of
different crops
to improve
performance of
crops and staff

With counterparts
after harvesting



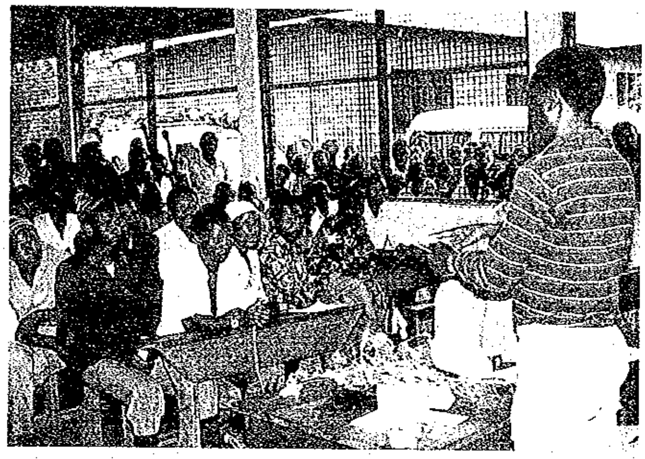
Soybean?
Maeze?
Sunflower?
Any of vegetable crops?
Which crops are
to be investigated
under what aspects?

Upland plot in the
Pilot Farm (left) : 1,250 kg/ha
Fallowed paddy plots in
Lower Moshi Irrigation Project
(below) : 1,884 kg/ha

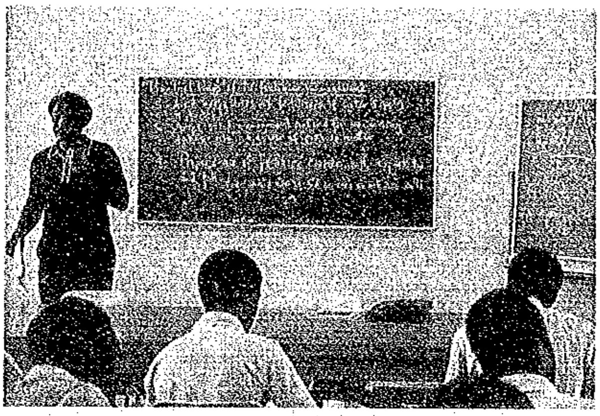
Soybean extension plots

At Rombo District
(with a extension worker)

At Mwanga District (right)



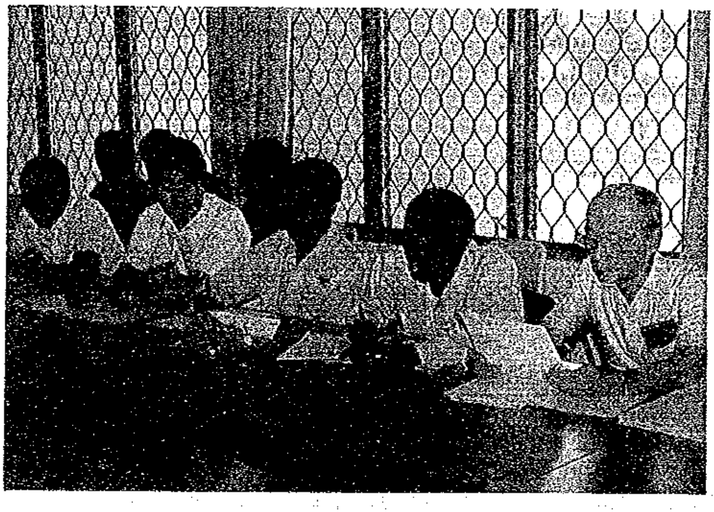
Introduction of soybean to the diet:
Soybean promotion party (above)
What is soybean? (above right)
Lets taste soybean (right)
Nursery children like the taste of uji (soft porridge) which is made from maize flour mixed with soybean flour (below right)

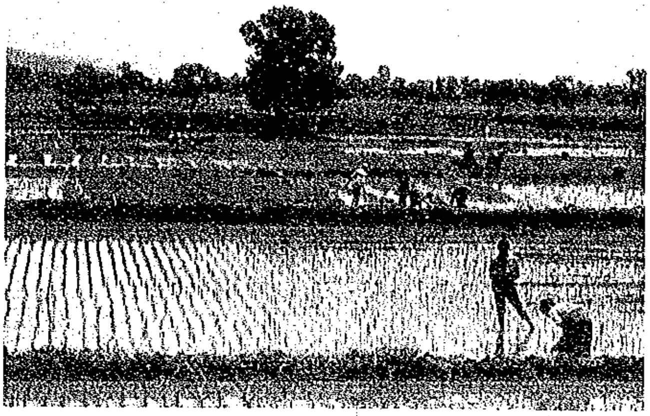


Training of agricultural extension workers in Kilimanjaro Region:
Lectures on agriculture and agricultural extension, field practices, visiting agricultural research organizations, and others

Meeting of Water Users' Association for Lower Moshi Irrigation Project is held among farmer leaders and concerned government staff

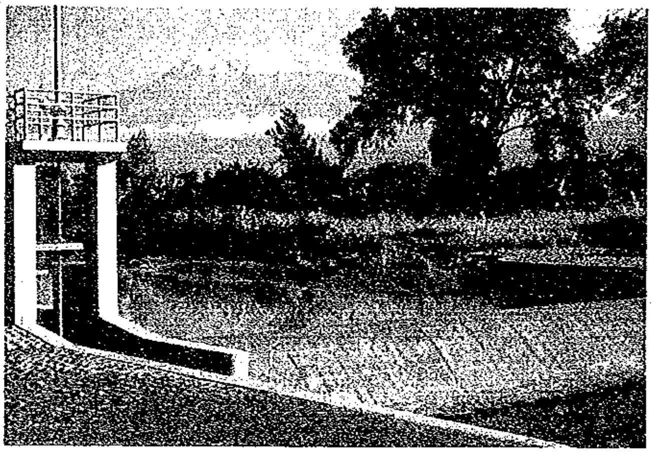
Exchange ideas among Tanzanian and Japanese staff for better management of Kilimanjaro Agricultural Development Project and Lower Moshi Irrigation Project



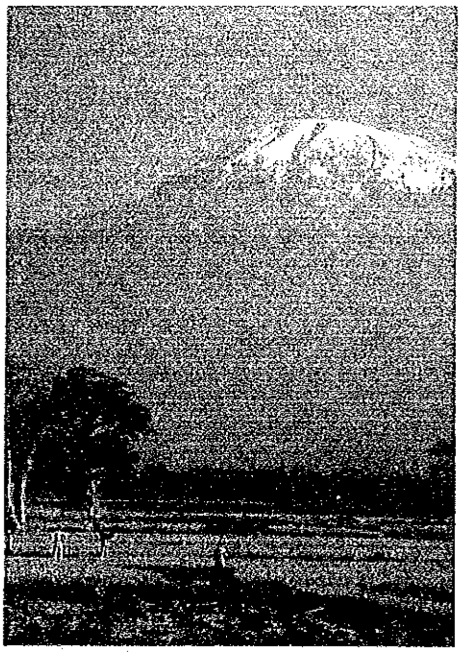


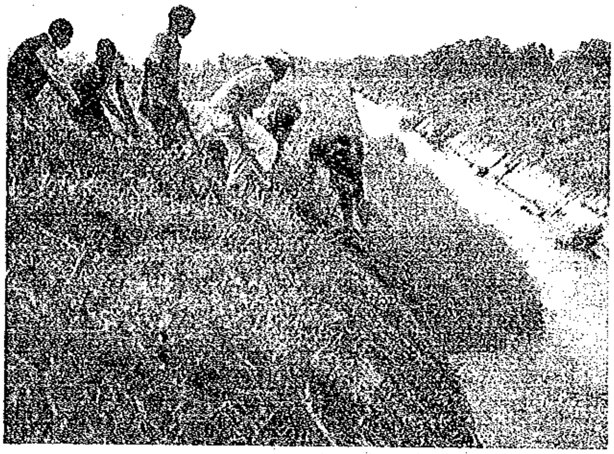
Farmers practice the modern paddy farming:
Adopting improved varieties (i. e. IR54)
Raising seedlings in group nursery
Straight line transplanting

Water shortage is a serious problem for Lower Moshi Irrigation Project:
All the river water is introduced to the project area sometime (s) in a year



Paddy is harvested from about 1,500 ha in a year through planting 3 times of 400 to 600 ha in rotation (total paddy area of Lower Moshi Irrigation Project is 1,100 ha)

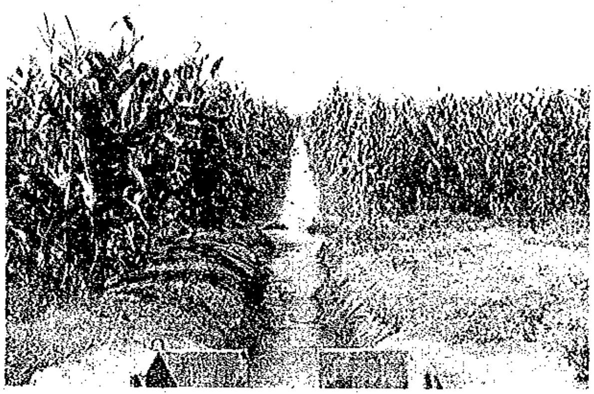




Maintenance of canals and roads is quite important for prolonging the life of Lower Moshi Irrigation Project

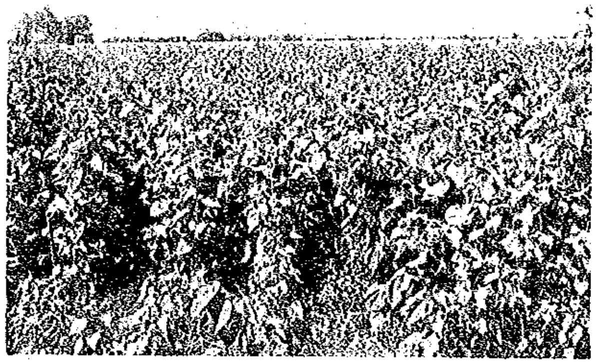
Paddy cultivated areas are expanding outside Lower Moshi Irrigation Project through self-help land reclamation:

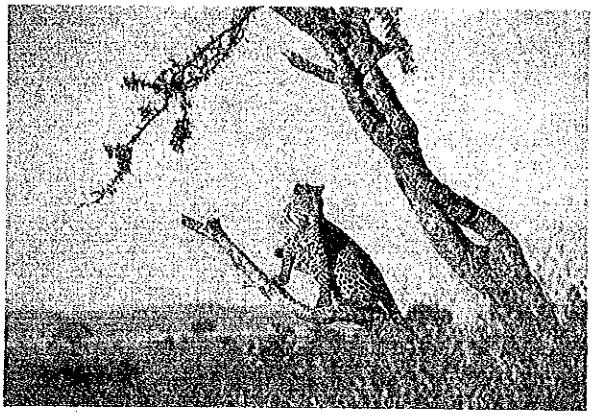
Positive effect of the project?
Additional problem for water shortage of the project?

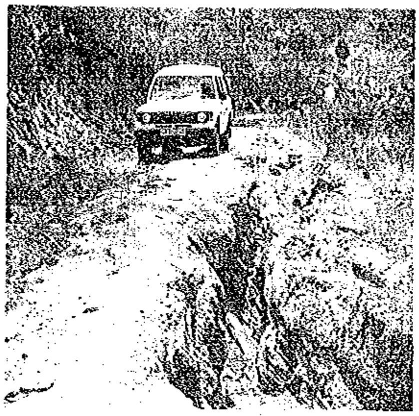


Prospects of upland crops in
Lower Moshi Irrigation Project
in the future:

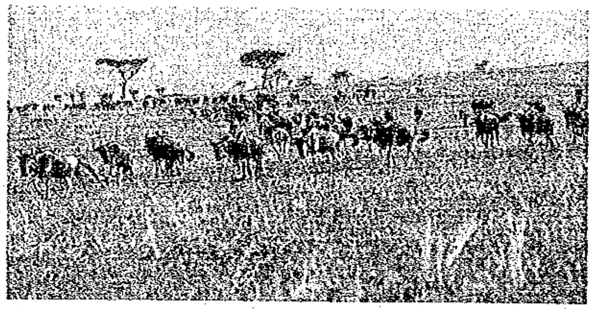
Supplementary irrigation for maize
Introduction of sunflower in upland field
Utilization of fallowed paddy plots
for soybean (and other beans) cultivation
Watermelon cultivation in dry season



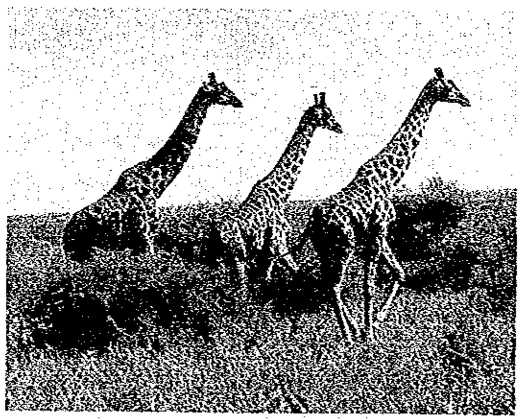




Safari, Safari, Safari

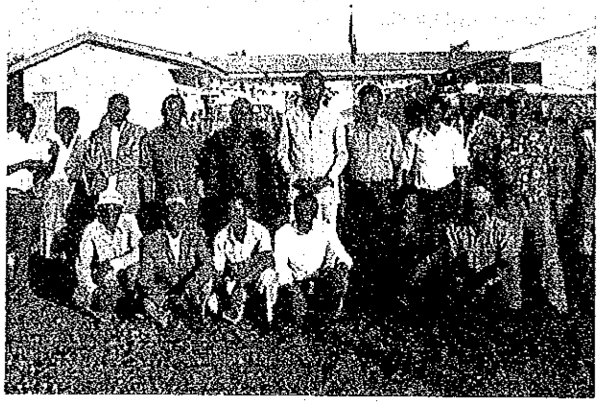


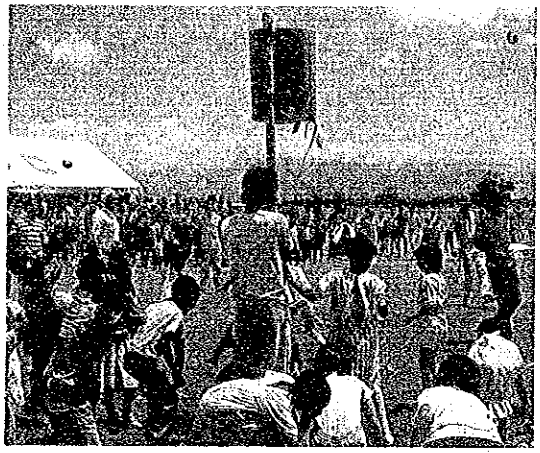
A bus—line with "ASANTE JAPAN"



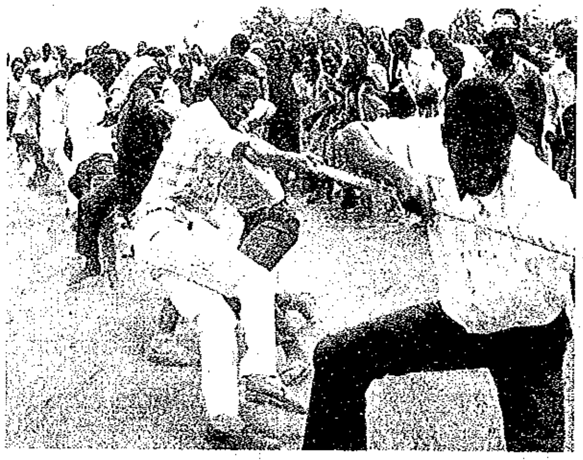
Warm welcome for JICA' s President

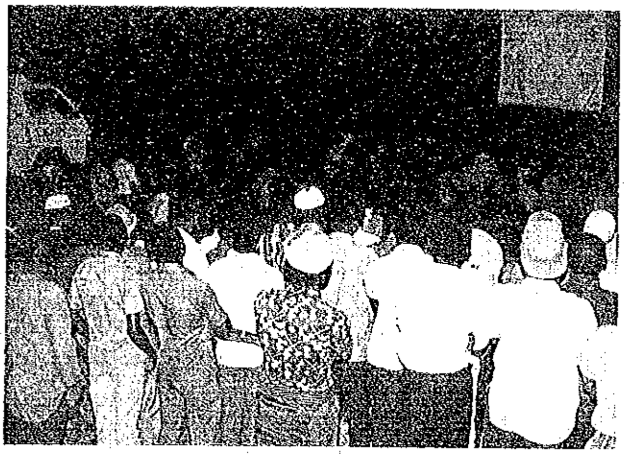
Inauguration of a village office in the project area





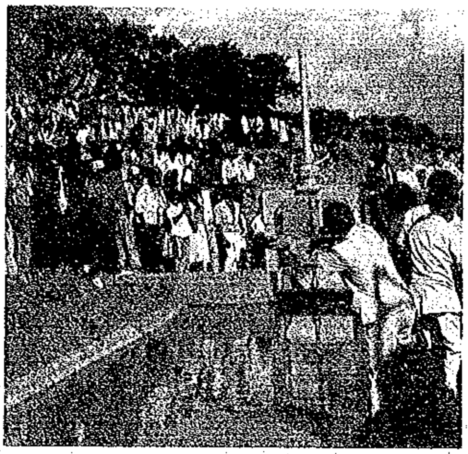
Game festival of Kilimanjaro Agricultural Development Project



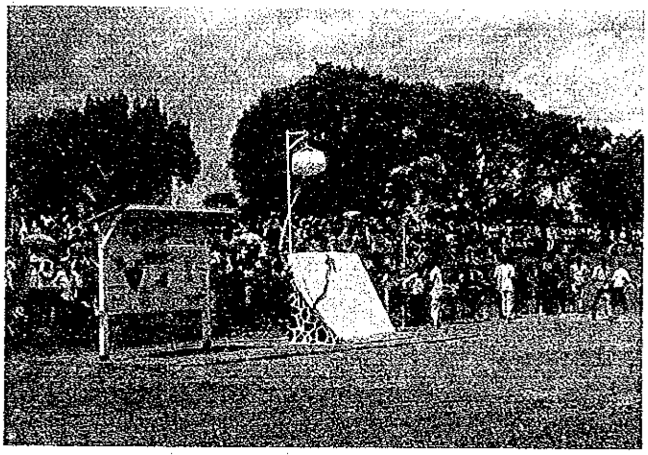


Movie show
after soybean promotion seminar
attracted people

Examples of activities of
Japanese none—government organizations
in northern Tanzania

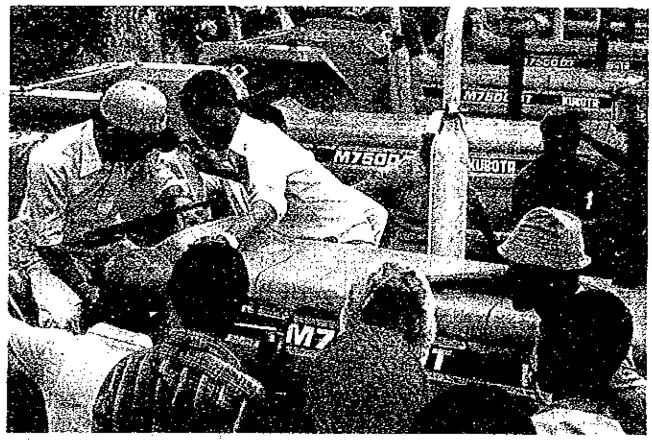


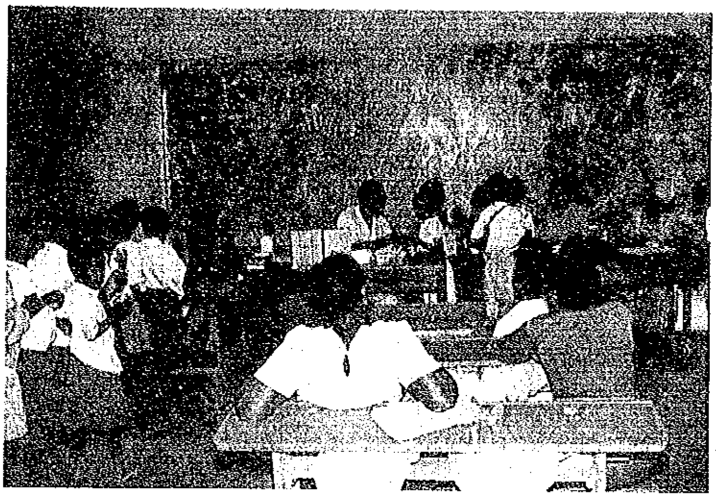
Inauguration ceremony of Lower Moshi Irrigation Project



Dance of high school students at the inauguration ceremony of Ndungu Irrigation Project

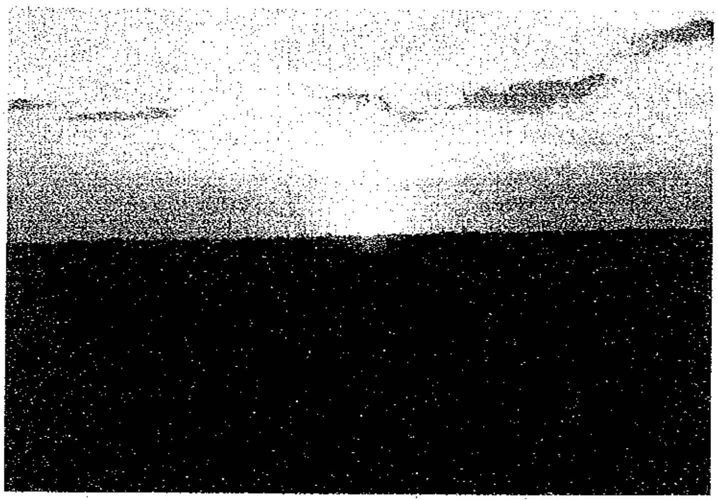
Maintenance service for the tractors donated by Japanese government





Health check against
water borne diseases:
An adverse effect of
irrigation project?

Night, dance,
night, dance



Dawn of African Continent

日本文レポート目次

I　SUMMARY IN JAPANESE：業務の要約

1．畑作物分野の業務内容

キリマンジャロ農業開発計画（ＫＡＤＰ：Kilimanjaro Agricultural Development Project）の討議議事録（Ｒ／Ｄ：Record of Discussion）に記されている畑作物分野の業務内容は以下の通りである。

（１）栽培技術の確立（野菜、大豆等）
（２）栽培技術の展示、普及
（３）カウンターパート、普及員、農民の研修

2．栽培技術の確立

（１）大豆

大豆はＲ／Ｄに作物名として記されており、品種比較、栽植密度、施肥量等の試験を通じて栽培技術の確立に努めた。その結果、根粒菌接種したBossier品種の種子を畝間50センチで条播（株間10センチに2～3粒播種）し、ヘクタール当り30キロの窒素を施肥して、ヘクタール当り2～2.5トンの子実収量をあげるまでになった。大豆の生産性はタンザニアで一般に栽培されている隠元豆、カウピー、緑豆に十分比較できるものであった。雨期休耕田に天水栽培した大豆は安定した生産を示した。

大豆の利用についても調査を行い、大豆粉をトウモロコシ粉と混ぜてウガリ、ウジ等に利用できるようにした。これらの食品は人々（特に生産者）に受け入れられた。大豆は蛋白含量が高く、大豆粉を加えた食品は栄養価が高まる。食品処理の機材（器具）が十分でない地域での大豆消費に当たっては、在来の機械（例えば製粉機）の利用を基本とした。

（２）野菜

ＫＡＤＰ発足当初には実験農場に多種類の野菜を栽培して適応性を検討した。しかし、深刻な灌漑水不足に直面したローア・モシ灌漑計画（ＬＭＩＰ：Lower Moshi Irrigation Project）内で野菜栽培地域を確立することが困難なこと、野菜試験栽培を行うための労働力が確保できないことのため、後半は野菜の種類を限って試験栽培を行った。キリマンジャロ州は変化に富んだ気候条件に恵まれ、その中でＬＭＩＰ地域は野菜栽培の最適地とはいいがたい。当地の野菜生産地帯は、気温が低く雨量と灌漑水に恵まれた標高の高い地域で発展している。実験農場で得たヘクタール当り最高収量は、トマトで77.7トン、キャベツで59.3トン、タマネギで27.0トン、スイカで19.0トンであった。

（３）トウモロコシ

トウモロコシ生産技術改良のために試験栽培を行った。品種間ではMH41の生産性が高かった。その他では、ＬＭＩＰの畑地で広く栽培されている在来品種と最近登録されたTMV-1の収量が高かった。天候に恵まれて管理が伴えば、MH41はヘクタール当り6～7トンの子実収量をあげた。不確実な降雨パターン（雨量、分布）とＬＭＩＰの畑地に灌漑水を配分することが困難な状況に対応するため、試験内容を天水条件下での栽培技術向上に変更した。

3．普及活動

（１）大豆

ＬＭＩＰへの大豆普及を1987年に開始した。パイロット農場の１ヘクタールに乾期終了前に播種した87年の収量は380キロ、雨期入り後に播種した88年の収量は1250キロであった。1989年にはＬＭＩＰ雨期休耕田５筆に栽培し、ヘクタール当り1884キロの収量を得た。

「大豆栽培・利用指針書」を印刷し、キリマンジャロ州内のいくつかの村で大豆普及講習会を開催した。講習会では、栽培技術に加えて、大豆（粉）の入った食品の試食も行った。農民

や普及員だけでなく、学校やミッショナリー関係者のなかにも大豆に興味を持つ人達が増えてきている。大豆の市場が形成されていないため、いかに消費するかを中心に普及を行った。大豆利用が広まるにつれて大豆生産面積も広がると期待している。

（２）スイカ

パイロット農場の農民に対するスイカ栽培普及を行った。圃場管理の不十分さから収量は低く、最高でヘクタール当り12.2トンであった。ＬＭＩＰの灌漑水不足からパイロット農場の畑地は乾期作に栽培しないと決定され、1989年と90年にはスイカ普及栽培は行わなかった。

４．研修

（１）カウンターパート研修

畑作物セクションには４名の職員が配属されている。彼らに対する研修は、（１）職務を通じて、（２）日本での研修を通じて（過去５年間に３名がＪＩＣＡの野菜栽培研修コースに参加）、（３）タンザニアの研修機関を通じて（１名が２年間研修しDiplomaを習得）行った。セクション内のスタッフの作物栽培試験に関する能力にはいくらかの向上がみられた。作物の種類の多さと、それらの組合せがあるため、スタッフは作物試験と作物生産についてなお一層の努力が求められる。

（２）農業改良普及員研修

キリマンジャロ州に配属されている農業改良普及員を対象に、畑作物栽培研修コースを毎年開講した（1990年は稲作部門と共同で作物栽培研修コースとして）。参加者は1986年に15名、87年に21名、88年に20名、89年に19名、90年に17名であった。農業研究機関より講師を招いて研修参加者だけでなくスタッフの知識の向上にも努めた。また、トウモロコシ、稲、油料作物についての参考資料を収集し、州内の農業改良普及員全員（約500名）に配布した。

５．その他の業務

国立の農業試験研究機関との連携を強化し、種子、根粒菌、資料等の収集に努めた。これらは試験栽培、研修、普及に利用した。

搾油施設を建設した。機材は日本から供与し、建物はタンザニアの予算で建設した（一部現地業務費で対応）。野菜育苗と畑作物研究のための施設がタンザニアの予算で建設中である。

作物実験計画法の統計処理プログラムを、青年海外協力隊の高津宏幸隊員の協力を得て完成した。その利用手引書を作成し、畑作物セクションのスタッフを研修した。

灌漑水不足に悩むＬＭＩＰに対して稲栽培パターンの変更を提案し、年間作付面積を1987年の1000ヘクタール弱から1988年以降の約1500ヘクタールに増大できるようにした。

ポンプ揚水に依存している実験農場の水田をＬＭＩＰの水路と連結させることを提案した。これにより、ポンプ故障や停電等の問題に直面する地下水への依存が少なくなる。

６．ＫＡＤＰの印象

ＫＡＤＰでの業務は快適であった。報告者自身の能力的な眼界とタンザニア人スタッフの厳しい生活環境のために、技術移転（適正技術の確立）は不十分であった。

ＬＭＩＰ安定化のために、ＫＡＤＰに配属されている日本人とタンザニア人スタッフは非常な努力を払ってきたたが、タンザニア上層部からの支援や、受益農民の役割分担は十分でなかった。関係機関や人々は、灌漑（機械化）稲作が長期的に生産性を維持するためには、施設と機材の保守・管理が重要であることを認識する必要がある。

この報告書には、ＫＡＤＰとＬＭＩＰの改善のための提案をいくつか含めた。農民と農民組織が「自助努力」意識を持って積極的に参画することなしに、農村開発計画が成功することは有り得ない。

SUMMARY IN KISWAHILI: MHUTASARI WA MAFANIKIO*

1. Majukumu ya Kitengo cha Mazao

Majukumu na shughuli za Kitengo aha Mazao kama ilivyoelezwa kwenye Taratibu za Makubaliano Ya Mkataba kuhusiana na Mradi wa Maendeleo ya Kilimo kwa Mkoa wa Kilimanjaro yalikuwa kama ifuatavyo:

(1) Kuanzisha mbinu bora za kilimo kwa mazao ya (mboga, soya, n.k.),
(2) Maonyesho na ushauri wa mbinu za kilimo bora, na
(3) Mafunzo kwa wafanyakazi wa ngazi ya kati kwenye mradi, mabwana shamba wa vijiji na wakulima.

2. Uimarishaji wa Mbinu za Kilimo Bora

2.1. Soya

Tokea zao la soya kutamkwa kwenye Taratibu za Mkataba, zimefanyika juhudi nyingi kwa ajili ya kuanzisha mbinu tofauti za kilimo cha zao hili kwa kufanya majaribio (kwa mfano uoanishaji wa aina mbalimbali za mbegu, nafasi za kupandia, Kiwango cha mbolea).Kwa hivyo matokeo yalionyesha kuwa kiasi cha tani 2 mpaka 2.5 kwa hekta zinaweza kuvunwa kwa kupanda mbegu aina ya Bossier na mbegu zake zikiwa zimewekewa wadudu wale wenye uwezo wa kutengeneza mbolea ya nitrogeni kwa kutumia hewa ya nitrogeni iliyopo angani (Kutumia mbolea ya Nitrogeni kwa kiwango cha kilo 30 kwa hekta) na kuoteshwa kwenye nafasi ya sentimeta 50 kati ya mistari kwa kusia (mbegu 2-3 kwenye nafasi ya sentimeta 10 katika mstari). Ilionekana kuwa mavuno ya soya kwa kiasi kikubwa yanakaribia kulingana na mavuno ya aina nyingine za mikunde ambayo ni maarufu hapa nchini (Kama vile maharage, kunde, choroko nk.). Mavuno ya soya ni thabiti zaidi kwenye mashamba yaliyokuwa yamelimwa mpunga kwenye msimu wa mvua.

Pamoja na hayo, njia mbalimbali za matumizi ya soya zilichunguzwa. Hivyo, ilionekana kuwa unga wa soya unaweza ukachanganya na unga wa mahindi kwa ajili ya kutengenezea Ugali ama Uji. Vyakula hivi (pamoja na aina nyingine za mapishi) vilikubaliwa na watu (hasa wanaolilima zao hili). Kwa vile lina kiwango kikubwa cha protini, unga uliochanganya kiwango chake cha lishe huwa ni cha juu zaidi ukilinganisha vile vyakula vya kawaida. Kwenye jamii ambayo vifaa kwa ajili ya maandalizi tofauti ya vyakula ni adimu, Njia za matumizi ya soya zisisitiziwe zaidi kwa vile vifaa vinavyopatikana kwa wakati huo (kwa mfano Mashine za kusaga).

2.2. Mboga

Aina nyingi za mboga zilipandwa kwenye Shamba la Majaribio mwanzoni mwa Mradi ili kuweza kupata aina mbalimbali za mboga ambazo zingeweza kusitawi kwenye eneo hili. Kutokana na sababu mbalimbali, kiasi kidogo tu cha aina tofauti za mboga zilichunguzwa baadaye. Kuna uwezekano mdogo wa kuweza kuanzisha

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*Translated by Macha, B. and Z.K. Sarakikya, KADP.

kilimo cha mboga kwenye eneo la Mradi wa Umwagiliaji wa Ukanda wa chini wa Moshi kutokana na hali halisi ya maji ya kumwagilia ilivyo sasa. Ukosefu wa vibarua kwenye Kitengo pia hukwamisha shughuli za kilimo cha mboga. Mkoa wa Kilimanjaro Umebahatika kuwa na aina tofauti za hali ya hewa kwa ajili ya kilimo, na Mradi wa Umwagiliaji wa ukanda wa chini wa Moshi si mzuri kwa kilimo cha mboga. Maeneo mengi kwa kilimo cha mboga yameendelezwa kwenye ukanda wa juu ambako hali ya hewa ni ya ubaridi na maji (yakiwa ni pamoja na ya mvua na ya kumwagilia) ni ya kuaminika. Baadhi ya mavuno ambayo yalipatikana kutoka kwenye shamba la majaribio ni haya: tani 77.7 kwa hekta kwa zao la nyanya, tani 59.3 kwa hekta kwenye zao la kabichi, tani 27.0 kwa hekta kwa zao la vitunguu na tani 19.0 kwa hekta kwa zao la matikiti maji.

2.3. Mahindi

Majaribio kadhaa yalifanywa kwa minajili ya kukuza mbinu za kilimo bora cha mahindi. Baadhi ya aina za mbegu zilizokuwa zinapatikana kwenye eneo hili, MH41 ilikuwa ni aina iliyokuwa na mavuno zaidi. Mbegu ya kienyeji iliyokuwa inapandwa kwenye mashamba ya wenyeji pamoja na mbegu aina ya (TMV-1) iliyotolewa karibuni pia zilikuwa zinatoa mavuno ya kuridhisha. Kwenye hali nzuri ya hewa na utunzaji mzuri,kiasi cha tani 6 mpaka 7 kwa hekta zinawezekana kupatikana kwa kupanda mbegu aina ya MH41. Ili kukabiliana na hali ya mvua zisizoaminika katika eneo hili (kwa kiwango pamoja na mzambazo wake) na hakuna maji yanayotengwa kwa mashamba ya mazao ya kawaida, kazi ya utafiti imebalishwa na kulengwa kwenye utafiti wa kukuza mbinu za kilimo bora kwa kutumainia mvua.

3. <u>Kazi ya Ushauri</u>

3.1. Soya

Ushauri kuhusiana na zao la soya ulianzishwa mwaka 1987 kwa kupanda hekta moja kwenye shamba la mfano Chekereni kwa miaka miwili. Mavuno yalikuwa kilo 380 katika mwaka wa 1987 (zilipandwa mwishoni mwa msimu wa kiangazi) na kilo 1,250 mwaka 1988 zilivunwa (zilipandwa mara baada ya msimu wa mvua kuanza).Katika mwaka wa 1989 ploti tano zilizokuwa zimevunwa mpunga kwenye Mradi wa Umwagiliaji wa ukanda wa chini wa Moshi zilipandwa kwa kutegemea mvua, na mavuno yalikuwa sawa na kilo 1,884 kwa hekta.

Kijitabu kidogo cha maelezo kuhusu uzalishaji na matumizi ya soya kilichapishwa. Kilitumiwa kwenye semina za uendelezaji wa zao hili ambayo ilifanyika kwenye vijiji kadhaa vya mkoa wa Kilimanjaro. Zaidi ya maelezo kuhusu uzalishaji, vyakula vilivyotengenezwa na vyenye mchanganyiko wa soya vilionjwa na wanasemina. Baadhi ya mashule na makanisa walilifurahia zao la soya mbali ya kwa wakulima na mabwana shamba. Ingawaje kuna soko dogo sana la soya kwa wakati huu, juhudi nyingi zielekezwe kwenye matumizi. Kama watu watakuwa wamezoea kutumia soya, eneo la kilimo cha soya litazidi kupanuka kadiri muda unavyopita.

3.2. Matikiti maji

Kazi ya ushauri kuhusu kilimo cha matikiti maji ilifanywa kwa wakulima kwenye shamba la mfano Chekereni wakati wa kipindi cha awali cha Mradi. Utunzaji wake ulikuwa duni, kwahivyo mavuno yake yalikuwa si ya kuridhisha (kwa mfano tani 12.2 kwa hekta yalikuwa ndio mavuno mazuri). Kutokana na tatizo la maji kwenya maeneo ya Mradi ilishauriwa kwamba kilimo kwenye shamba la mfano wakati wa kiangazi kwa mazao ya kawaida usimamishwe. Kwa hivyo kilimo cha matikiti maji hakikufanyika kwa miaka ya 1989 na 1990.

4. Mafunzo

4.1. Mafunzo kwa wafanyakazi

Kuna watumishi 4 wa Kitanzania wanaofanya kazi kwenye Kitengo. wamepatiwa mafunzo kwa njia zifuatazo (1) mafunzo kazini (2) Kwa kupelekwa Japani (3 walihudhuria kozi ya kilimo cha uzalishaji wa mboga inayoendeshwa na Shirika la Ushirikiano wa Kimataifa la Japani (JICA) katika kipindi cha miaka 5 iliyopita), (3) Kwa kuhudhuria masomo kwenya vyuo vya ndani hapa nchini (mmoja alisoma kwa miaka 2 na kupata Stashada ya Kilimo cha Mboga, Matunda na Maua). Uwezo wa shughuli za utafiti kwa watumishi wa Kitengo umeongezeka kwa kiasi. Kutokana na kuwa na mazao ya aina mbalimbali, watumishi waweke juhudi zaidi kwenye utafiti wa kuongeza viwango vya mavuno na uzalishaji.

4.2. Mafunzo kwa Mabwana shamba

Mafunzo ya kilimo kwa ajili ya mazao ya uwanda wa juu ilifanyika kila mwaka (isipokuwa mafunzo ya mpunga na mazao mengine ilifanyika mwaka 1990) kwa mabwana shamba wanaofanya kazi mkoa wa Kilimanjaro. Idadi yao ilikuwa 15, 21, 20, 19, na 17 ambao walihudhuria mafunzo kwa miaka ya 1986, 87, 88, 89 na 1990. Wahazili kutoka nje ya Kituo walikaribishwa kutoka vyuo mbalimbali nchini kutoa mafunzo kwa faida ya wahusika na pia wafanyakazi wa Kitengo. Nakala kadhaa za vitabu vya rejea kwa uzalishaji wa mazao ya (mahindi, mpunga, mazao ya mafuta) zilizambazwa kwa mabwana shamba wote (Kiasi cha 500) katika mkoa ili kuwafanya wawe na ufahamu zaidi kuhusiana na maelekezo ya karibuni kuhusu mazao.

5. Mafanikio Mengineyo

Uhusiano na vituo vingine vya kilimo vya taifa uliimarishwa, mbegu, wadudu kwa ajili ya kutengeneza mbolea ya nitrogeni kutoka kwenye nitrogeni ya anga kwa mazao ya mikunde, nakala kadhaa za rejea zilipatikana kutoka kwenye vyuo na sehemu nyingine. Zilitimika kwenye majaribio, mafunzo na ushauri.

Mtambo wa kukamulia mafuta ulijengwa. Vifaa vililetwa kutoka Japani, ujenzi wa jengo ulifanywa na serikali ya Tanzania. Ujenzi wa vifaa kwa ajili ya uzalishaji wa miche ya mboga na shughuli nyingine za utafiti kwa ajili ya Kitengo unaendelea.

Mpangilio kwenye komputa kwa ajili ya mchanganuo wa matokeo ya utafiti ulipatikana (ulitayarishwa na Bw. H. Kozu: Mjapani aliyekuwa anafanya kazi kwa kujitolea). Kijitabu chenye maelekezo ya jinsi ya kuitimia kilitayarishwa kwa ajili ya watumishi wa

Kituo kukitumia wakati wa kujifunza.

Kubadilishwa kwa mpangilio wa upandaji wa mpunga kwenye Mradi wa Umwagiliaji wa Ukanda wa chini wa Moshi ulipendekezwa ili kukabiliana na upungufu wa maji kwenye mradi. Mapendekezo yalikubaliwa na kuanza kutumika, na eneo lililopandwa mpunga liliongezeka kutoka pungufu ya hekta 1,000 kwa mwaka (1987) mpaka kufikia karibu hekta 1,500 kwa mwaka (tokea mwaka 1988).

Kuunganisha mfereji wa wa Mradi wa kumwagilia wa Ukanda wa Chini wa Moshi na ploti za mpunga kwenye Shamba la Majaribio ulipendekezwa. Kwa njia hii, ploti za mpunga hazitakuwa na umuhimu wa kutegemea maji ya kisima yanayosukumwa kwa pampu (ambayo hukabiliwa na matatizo ya kuharibika kwa na kukatika kwa umeme mara kwa mara).

6. Maoni

Kufanya kazi kwenye Mradi wa Maendeleo ya Kilimo Kilimanjaro kulikuwa kwa furaha kwa mwandishi wa taarifa hii. Kutokana kiwango cha mwandishi, na hali ngumu ya maisha kikazi kwa watumishi wa Kitanzania, utoaji wa utaalamu (uanzishaji wa shughuli za utaalamu unaohitajika) kulikuwa ni kwa kiasi tu.

Juhudi nyingi zimefanywa kwa pamoja Wajapani na watumishi wa Kitanzania kwa Mradi wa Maendeleo ya Kilimo kilimanjaro, lakini msaada kutoka ngazi za juu na mchango wa wakulima kwa ajili ya kuimarisha Mradi wa Umwagiliaji wa Ukanda wa Chini wa Moshi haukuwa wa kuridhisha. Idara na watu wanaohusika ni lazima wafahamu ukweli kwamba kilimo cha umwagiliaji kwa zao la mpunga una faida kwa muda mrefu ikiwa vifaa na nyenzo zake zitatumiwa kwa uangalifu.

Mapendekezo kadhaa kwa minajili ya kuuimarisha Mradi wa Maendeleo ya Kilimo Kilimanjaro na Mradi wa Umwagiliaji wa ukanda wa chini wa Moshi yameelezewa kwenye taarifa. Kanuni moja ya kuwa na mafanikio ya maendeleo vijijini ni kwa wakulima (vikundi vya wakulima) kuwa na moyo wa kufanya kazi kwenye misingi ya "kujitegemea wenyewe".

Table of Contents

I. SUMMARY OF ACHIEVEMENTS

1. Tasks for Upland Crops

Tasks of activities on upland crops mentioned in the Record of Discussions (R/D) on Kilimanjaro Agricultural Development Project (KADP) were as follows:

(1) Establishment of cultivation techniques (vegetable, soybean, etc.),
(2) Demonstration and extension of cultivation techniques, and
(3) Training of counterparts, extension staff and farmers.

2. Improvement of Cultivation Techniques

2.1. Soybean

Since soybean was a crop mentioned in the R/D, a lot of efforts have been paid for the establishment of its cultivation techniques through conducting trials (i.e. variety comparison, plant spacing, fertilizer rate). As a result, about 2 to 2.5 ton per ha of grain yield was obtained from planting Bossier variety seeds inoculated with Rhizobium bacteria (applied 30 kg per ha of nitrogen) at the spacing of 50 cm between rows and drilling (2 to 3 seeds in 10 cm). It was also found that soybean productivity was at least competitive with other kinds of beans common in the country (i.e. Phaseolus bean, cowpea, green gram). Soybean yield was more stable in fallowed paddy plot in rainy season.

Besides, ways of soybean utilization were investigated. Then, it was found that soybean flour could be mixed with maize flour for making <u>ugali</u> or <u>uji</u>. The foods (including some other ways of cooking) were accepted by people (especially growers). Since it contains high protein, the mixed flours enrich the nutritive values of original foods. In the society where there are limited kinds of processing equipments available, ways of soybean consumption should be based on the existing equipments (i.e. milling machine).

2.2. Vegetable

Many kinds of vegetable were planted at the Trial Farm during early stages of KADP to find out the adapted vegetable crops (varieties) in the locality. Due to several reasons, only limited kinds of vegetable were investigated later. There is a small possibility of establishing vegetable production area within Lower Moshi Irrigation Project (LMIP) under current situation of irrigation water. Lack of labor force at the Section also limits the work on vegetable cultivation. Kilimanjaro Region is blessed with diversified agro-climatic conditions, then LMIP area is not much suited to vegetable production. The vegetable production areas are developed in the high altitude zone where air temperature is comparatively low and water (both rainfall and irrigation) is reliable. Some of yield data obtained at the Trial Farm were: 77.7 ton per ha of tomato, 59.3 ton per ha of cabbage, 27.0 ton per ha of onion, and 19.0 ton per ha of watermelon.

2.3. Maize

Several trials were conducted for the improvement of maize cultivation techniques. Among the varieties available in the locality, MH41 was most productive. A local cultivar widely planted in upland plots of LMIP and a newly released variety (TMV-1) were also productive. Under good climatic and management conditions, 6 to 7 ton per ha of grain yield was obtained from MH41. To cope with the unreliable rainfall pattern in the area (both in amount and distribution) and no allocation of irrigation water to the upland plots, research work was shifted to the improvement of cultivation techniques under rainfed conditions.

3. Extension Work

3.1. Soybean

Soybean extension was initiated in 1987 and it was planted in 1 ha of the Pilot Farm for two years. The grain yield was 380 kg in 1987 (planted at the end of dry season) and 1,250 kg in 1988 (planted after the onset of rainy season). It was planted in five of fallowed paddy plots in LMIP in 1989 under rainfed conditions, then the yield was equivalent to 1,884 kg per ha.

Soybean Production and Utilization Manual was printed. It was used for Soybean Promotion Seminar conducted at several villages in Kilimanjaro Region. Soybean foods were prepared and participants tasted them at the introduction of crop. Some schools and missionaries became interested in soybean in addition to farmers and agricultural extension workers. Since there is only a limited scale of market for soybean at the moment, emphasis has been paid for its utilization. The cultivated area of soybean may be expanded gradually but steadily as people become familiar with soybean foods.

3.2. Watermelon

Extension services of watermelon cultivation was conducted for farmers in the Pilot Farm during early stages of KADP. Management of watermelon plot was poor, then fruit yield was not so attractive (e.g. 12.2 ton/ha was the best yield). Due to water shortage of LMIP, it was advised not to do cultivation of upland crops in the Pilot Farm in dry season. Then watermelon cultivation was not conducted in 1989 and 1990.

4. Training

4.1. Training of Counterparts

There are 4 Tanzanian staffs assigned to Upland Crops Section. They have been trained through (1) on the job bases, (2) sending to Japan (three of them attended Vegetable Production Course of JICA in the last 5 years), and (3) sending to a local institution (one of them studied 2 years and obtained Diploma in Horticulture). Research abilities of staffs working at the Section have been gradually improved. Because of many kinds of crops and their combinations, the staffs should pay more efforts for improving the capacities on crop research and production.

4.2. Training of Agricultural Extension Workers

The Upland Crops Cultivation Training Course was conducted every year (as Paddy and Upland Crops Cultivation Training Course in 1990) for agricultural extension workers assigned in Kilimanjaro Region. There were 15, 21, 20, 19 and 17 of them who attended the training course in 1986, 87, 88, 89, 90, respectively. External lecturers were invited from leading agricultural institutes in the country for the benefits of participants and staffs of the Section. References on crop production (i.e. maize, paddy, oil crops) were distributed to all agricultural extension workers (about 500 of them) in the Region to let them be familiar with the recent recommendations on crops.

5. Other Achievements

Communication with national agricultural institutions was reinforced. Seeds, Rhizobium inoculant, references were obtained from the institutes and other sources. They were used for the trial, training, and extension.

A oil extraction plant was constructed. Equipments were brought from Japan, and the building was mostly constructed by Tanzanian budget. Construction of facilities for vegetable seedlings production and other upland crops research is on going.

Computer programs for experiment data analysis became available (prepared by Mr. H. Kozu: former Japanese volunteer). An operation manual was prepared for the training of staff.

Change of paddy cropping pattern in LMIP was proposed to cope with water shortage of LMIP. It was adopted and paddy planted area increased from less than 1,000 ha per year (in 1987) to about 1,500 ha per year (since 1988).

Connection of paddy plots in the Trial Farm to the irrigation canal of LMIP was proposed. In this way, the paddy plots do not necessary depend on pumped up ground water (which faces troubles of pump and power failure).

6. Impressions

Working at KADP was comfortable to the reporter. Due to limited capacity of the reporter and severe working conditions of the staff, transfer of technology (or development of appropriate technology) was limited.

Lots of efforts were paid by both Japanese and Tanzanian staff at KADP, but supports from higher authorities and contributions of farmers for the maintenance of LMIP have been not enough. Concerned organizations and people have to recognize the fact that the irrigated paddy farming is profitable for a long time if the facilities and equipments are treated well.

Several suggestions for the improvement of KADP and LMIP are included in the report. One of prerequisites for the success of rural development is active participation of farmers (and farmer groups) under the sprit of "self-reliance".

II. INTRODUCTION

1. Outline of Japanese Cooperation to Kilimanjaro Region

1.1. Presentation of K.I.D.P.

Cooperation of Japanese Government to the development of Kilimanjaro Region started mid-1970s following the request from Tanzanian Government. Then field survey for the formulation of K.I.D.P. (Kilimanjaro Integrated Development Plan) and a Project Type Technical Cooperation (PTTC), which was also called Kilimanjaro Agricultural Development Project, were started in 1974. Final Report of K.I.D.P. was submitted to Tanzanian Government in November, 1977.

Based on the report, Tanzanian Government requested to Japanese Government for the implementation of some 14 projects (out of 45 projects mentioned in the report) in May, 1978. Japanese Government dispatched a implementation survey team (negotiation team), then the Record of Discussions (R/D) on Technical Cooperation for the Implementation of Kilimanjaro Agricultural Development Center and Kilimanjaro Industrial Development Center Projects was recommended by the implementation survey team and Tanzanian authorities concerned to their respective Governments (on 13 September, 1978). At the same time, implementation of some projects by Japanese cooperation had been agreed. This was the first step of Japanese cooperation to Kilimanjaro Region which has continued to this time.

Kilimanjaro Agricultural and Industrial Development Center Building (main office in Moshi), Kilimanjaro Agricultural Development Center Building, and Kilimanjaro Industrial Development Center Building were constructed by the assistance of Japanese Government (grant) and completed in 1981. It is written on a plate in each three buildings that "DONATED BY THE GOVERNMENT OF JAPAN AS A TOKEN OF FRIENDSHIP AND COOPERATION BETWEEN JAPAN AND TANZANIA".

1.2. KADCP to KADP

Following the R/D mentioned above, Kilimanjaro Agricultural Development Center Project (KADCP) was initiated. It was a PTTC which consists of (1) dispatch of experts, (2) training of counterpart personnel in Japan and (3) donation of equipments through Japan International Cooperation Agency (JICA: the official organization of Japanese Government for technical cooperation to developing countries). Main activities of KADCP were to conduct applied researches of paddy and upland crops together with irrigation method and farm mechanization at the Trial Farm and extension of the findings to the Pilot Farm. The cooperation period was from 13 September, 1978 to 12 March, 1986.

Kilimanjaro Agricultural Development Project (KADP) followed KADCP for the development of agriculture in Kilimanjaro Region especially Lower Moshi area (under a new R/D). It is also a PTTC of JICA and the initial period for cooperation was up to 12 March, 1991 (5 years). Main activities of KADP were dissemination of irrigated (mechanized) paddy cultivation to

Lower Moshi Irrigation Project (LMIP) area. After the evaluation of KADP by the Joint Evaluation Team consisted of members from concerned Tanzanian and Japanese organizations in November, 1990, it was recommended that the cooperation period would be extended up to 12 March, 1993 but with a reduced scale.

1.3. Other Cooperations of Japanese Government

Construction of LMIP was completed in 1987 (loan), construction of Kilimanjaro Rice Center (for LMIP) was completed in 1989 (grant), and construction of Ndungu Irrigation Project (NIP) was completed in 1990 (grant). Totally 265 number of tractors and their implements were donated in 1979 and 1985 (by 2KR: Food Production Aid) to Kilimanjaro Region, and 35 of them have been working in LMIP (the rest were distributed to primary cooperative societies in the Region). Spare parts for the tractors were donated in 1988. Some 27 number of tractors and implements for NIP arrived recently (under 2KR).

Besides the assistance to agricultural sector, Kilimanjaro Industrial Development Center (KIDC) Project (a PTTC) has been being carried out since 1978, Rural Electrification Project was completed in 1985 (loan) and Rehabilitation of KIDC was completed in 1990 (grant). There are other studies either finished or on-going by the assistance of Japanese Government.

Recently, there was a new R/D agreed between JICA's mission and Tanzanian authorities concerned on Kilimanjaro Village Forestry Project (a PTTC in Same District, started on 15 January, 1991). At the moment, all the three PTTCs of JICA in the country are in Kilimanjaro Region.

It should be mentioned that a lot of efforts have been paid by Japanese Government (especially through JICA) for dispatch personnel to field work of feasibility studies. Further, the above mentioned construction projects became realized with the efforts of Japanese and Tanzanian companies (and personnel).

2. <u>Kilimanjaro Agricultural Development Project (KADP)</u>

2.1. Objective and Task

The main objective of KADP mentioned in the R/D was such as: "the Project will be carried out, based on the successful achievements of KADC project, for the purpose of development of agricultural techniques and extension of techniques through training of counterparts, extension staff and farmers, thus contributing to further agricultural development in Kilimanjaro Region". Then the tasks of KADP were as followed:

2.1.1. Kilimanjaro Region, focusing in the Lower Moshi Area.
Technical advice and guidance to following items:

(1) Paddy
- a. Selection of appropriate varieties
- b. Establishment of cultivation techniques
- c. Demonstration and extension of cultivation techniques
- d. Training of counterparts, extension staff and farmers

(2) Upland Crops

a. Establishment of cultivation techniques (vegetables, soybean, etc.)
b. Demonstration and extension of cultivation techniques
c. Training of counterparts, extension staff and farmers

(3) Soil and Water Management
a. Establishment and extension of soil and water management techniques
b. Training of counterparts, extension staff and farmers
c. Technical advice for operation and maintenance

(4) Agricultural Machinery
a. Adaptability test, technical advice for operation and maintenance of agricultural machinery
b. Training of counterparts, extension staff and farmers

Note: - Demonstration and extension as mentioned (1) and (2) will be carried out through existing Pilot Farm and demonstration plots
- Number and size of demonstration plots will be determined at Joint Advisory Committee

2.1.2. Kilimanjaro Region, focusing at areas outside Lower Moshi area
Technical advice and suggestions on the agricultural development planning in the areas of:

(1) Study of surface and underground water resources for agricultural development
(2) Small scale rural agricultural development projects
(3) Transfer of techniques and experiences from KADC activities and Lower Moshi Project

2.2. Staff and Facilities

The organizational chart of KADP is shown in Fig. I-1. Although, the full of KADP has been cooperated with JICA in one way or another, so called the PTTC of JICA on KADP does not cover all of KADP in the chart. Project Construction and Development Office (PCDO) has been cooperated with other lines of JICA (Development Studies, Grant) and OECF (Japan's Overseas Economic Cooperation Fund) although there was a small space cooperated with the PTTC on agricultural development planning.

Regional Planning Officer of Kilimanjaro Region holds the post of Coordinator of KADP. There is a Project Director for KADC and Lower Moshi Irrigation Project Operation and Maintenance Office(LMIPOMO)(one Project Director holds both heads) and a Project Director for PCDO.

There are about 200 people working in KADP (KADC and LMIPOMO) as agricultural officers, agricultural field officers, tractor operators, drivers, laborers, so on.

There have been long term Japanese experts dispatched by JICA (usually 8 of them) to KADP. There were the team leader, 2 agronomists (one for paddy, one for upland crops), 2 irrigation engineers, 2 agricultural mechanical engineers, and a coordinator. In addition, 3 short term experts (in the field of soil chemistry, agricultural economics, and plant pathology) were dispatched by JICA to reinforce the activities in respective fields in the last 5 years.

KADP holds the main office in Moshi (in Kilimanjaro Agricultural and Industrial Development Center Building) and a field office in Chekereni village (for KADC and LMIPOMO), about 17 km on road from Moshi (main office). It has a Trial Farm (7.2 ha of upland plots and 2.4 ha of paddy plots), about 40 tractors and their implements, workshop, milling facilities (for rice and maize), and other necessary equipments and vehicles for operation and maintenance of LMIP.

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                        ┌─ Paddy Section
           ┌─ KADC ─────┼─ Upland Crops Section
           │            └─ Machinery Section
           │
           │            ┌─ Water Management Section
           │            ├─ Maintenance of Facilities Section
RDD  KADP ─┼─ LMIPOMO ──┼─ Tractor Hire Service Section
           │            └─ Agronomy Section
           │
           │            ┌─ Agricultural Development Planning**
           └─ PCDO* ────┼─ Ndungu Irrigation Project
                        └─ Kilimanjaro Rice Center Project
```

Abbreviation

RDD: Regional Development Director

KADP: Kilimanjaro Agricultural Development Project

KADC: Kilimanjaro Agricultural Development Center

LMIPOMO: Lower Moshi Irrigation Project Operation and Maintenance Office

PCDO: Project Construction and Development Office

N.B. *Mostly cooperated with other lines of JICA's assistance (but not its Project Type Technical Cooperation: PTTC).

**Partly cooperated with the PTTC of JICA

Fig. I-1 Organizational structure of KADP.

3. Pilot Farm

Construction of the Pilot Farm was completed in 1983 by a grant of Japanese Government and a budget of Tanzanian Government. The net area of land for cultivation is 70.7 ha (51.8 ha of upland plots and 18.9 ha paddy plots). It belongs to Chekereni (Ujamaa) village as communal farming area. The Pilot Farm had faced water and management problems at the initial stages. With the assistance of KADCP (then) management of paddy plots has been stabilized. It had an independent irrigation system from Rau river at the beginning, but it was connected to that of LMIP in 1987.

There are 63 paddy plots and 15 upland plots in the Pilot Farm. At the moment, all the paddy plots are cultivated following the cropping calendar prepared by LMIPOMO. However, not all the upland plots are utilized because of salinity problems in some portions of the plots and unreliable irrigation water supply. Dry season cultivation of the upland plots has not been practiced since 1989 because of water shortage in LMIP. Maize is the main crop planted in the upland plots. Several kinds of vegetables (i.e. tomato, onion, watermelon), and other crops (i.e. soybean, sunflower, cotton, finger millet, cassava) were planted in the last 5 years.

Management practices of the Pilot Farm (i.e. share, number of person per plot) have been changed in the last years. At the moment average of 2 farmers are allocated to 1 paddy plot (0.3 ha), and a farmer is allocated to 1 acre of upland plot. For paddy cultivation, the village pays the tractor hire service charge for land preparation and irrigation water fee, provides seeds, fertilizer, and agricultural chemicals. Then it takes 7 bags of paddy at the harvest. On the other hand, the village gets 3,000 shillings per one acre of upland plot as land rent fee.

4. Lower Moshi Irrigation Project (LMIP)

LMIP was constructed by the assistance from Japan's Overseas Economic Cooperation Fund (loan) and local fund. The construction work was completed at the end of March, 1987. It covers 1,100 ha of paddy field and 1,200 ha of upland field. Irrigation canals for paddy plots are concrete lined up to tertiary level, and earth made quarterly canals introduce water to individual plots (standard size: 0.3 ha/plot). Earth made tertiary canals introduce water to upland fields (although it is seldom practiced).

Main activity of KADP has been the extension of irrigated (mechanized) paddy cultivation in LMIP area. Most of Japanese and Tanzanian staff have been engaged in the work (i.e. preparation of planting schedule, land preparation by tractors, supervising group nurseries for raising paddy seedlings, general extension services on paddy cultivation, observation of water balance, maintenance of facilities, maintenance of agricultural machinery and other machinery, etc.).

It was planned to irrigate 1,100 ha of paddy field and 1,200 ha of upland field in rainy season, and 800 ha of paddy field in dry season. But it was found that only about 500 ha of paddy field could be irrigated per season. To cope with this problem, the paddy cultivation pattern was changed in 1988 from the initial 2 seasons per year (1,100 ha in main season and 800 ha in off-season) to 3 seasons per year through rotating irrigation blocks (e.g. January-June, May-October, September-February). By this way, every paddy plot is covered with paddy at least once a year; the paddy planted area increased from 887 ha in 1987 to 1,288 ha in 1988, 1,431 ha in 1989, and 1,543 ha in 1990.

Due to the shortage of irrigation water even for paddy cultivation, the upland fields are not irrigated in general. However, supplemental irrigation can be practiced to some extent just after rainy season. Maize covers large portion of upland area (more than 90%). The rest are covered with beans, sunflower, and other crops.

Based on number of villages in LMIP, four Water Users' Associations (WUAs) were formed among paddy growing farmers for the purposes of facility maintenance, collection of irrigation and tractor hire service fees. KADP had conducted training for the farmers and farmer leaders for dissemination and stabilization of irrigated paddy cultivation.

III. TRIAL FARM

1. Location and Facilities

The Trial Farm of KADC is located about 17 km south-eastern side from Moshi (capital of Kilimanjaro Region). It is located at 3°28'S latitude and 37°25'E longitude, and 725 m altitude. It consists of 7.2 ha of upland filed and 2.4 ha of paddy field, farm road, irrigation facilities (i.e. pond, pipes), and related buildings (i.e. office, workshop, milling room). Ground water is used for irrigation; it is once pumped up and stored in the pond before distribution.

The upland field is divided into 3 Plots (called A, B, C Plots) and each of the Plot covers 2.4 ha (approximately 100 m x 240 m). The A Plot is further divided into 15 plots (1,600 m^2/plot) following the number of hydrants for sprinkler (overhead) irrigation. Each of the other 2 Plots are divided into 6 plots (4,000 m^2/plot) following the number of hydrants for furrow (surface) irrigation. Then, the paddy field (D Plot) is divided into 8 plots (3000 m^2/plot).

2. Climatic Conditions

Meteorological data have been taken at KADC (Chekereni) by Water Management Section of LMIPOMO (Lower Moshi Irrigation Project Operation and Maintenance Office) since October 1981 (initially by Irrigation Section, KADC). Air temperature and rainfall data from 1982 to 1990 are presented in Table III-1.

The mean temperature ranges from 22.1°C for June to 27.4°C for March. The diurnal temperature range is small in May (19.3-28.3°C) and high in January (19.2-33.2°C) and February (19.5-34.5°C). The highest temperature recorded in the 9 years was 38.8°C and the lowest temperature was 10.3°C.

As mean of 9 year observation, annual rainfall is 608 mm (ranged 401-933 mm). The amount was highest in 1990 and lowest in 1987. It was said that flood damage in April 1990 was the first time in 43 years. There were almost no harvests of upland crops under rainfed conditions in some years (i.e. 1987).

Rainy season usually starts in March (74.8 mm of rainfall in average), the peak rain amount falls in April (183.8 mm), declines in May (96.0 mm), and terminates in June (14.1 mm). Although there are some rains from November to February (i.e. 64.6 mm in December), the amount and distribution are not enough for the production of most annual crops under rainfed conditions.

3. Soil Conditions

Soils in the Trial Farm, Pilot Farm and Lower Moshi Irrigation Project were once analyzed by Mr. A. Iseki (Short Term Expert in Soil Chemistry) in 1986. Details of analysis were reported in "Report of the Study of Saline Soil in the Pilot Farm and Soil Analyses of Paddy and Upland Fields in Trial Farm, Pilot Farm, and Lower Moshi Area" (Iseki, 1986).

Table III-2 shows the chemical properties of surface soils at the Trial Farm. Both upland and paddy soils were neutral;

mean pH value was 7.70 in upland soil and 7.93 in paddy soil. Electric conductivities (ECs) indicated that there was no problem of salinity at the Trial Farm. Although humus content was low, it was comparatively high in upland plot (1.90%) than in paddy plot (1.06%).

Table III-3 shows the characteristics of soils in different layer of a upland plot (C-4). The soil contained much clay (48.2-59.2%) and coarse sand (25.6-31.2%), but little silt (11.0-18.6%) and fine sand (2.0-4.0). Particle distribution was rather constant regardless of the layers, and could be classified as HC (heavy clay) soil. Cation exchange capacities (CECs) taken from the 4 soil samples above 80 cm in depth fell within a small range; its mean was 22.59 me (mili-equivalent) per 100 g of soil (range: 21.76-23.76 me/100 g). Exchangeable cations of the surface soil (above 17 cm in depth) were more of calcium ion (Ca^{++}: 10.39 me/100 g), followed by magnesium ion (Mg^{++}: 5.13 me/100 g), potassium ion (K^{+}: 1.04 me/100 g), and sodium ion (0.32 me/100g). Base saturation of the soil was 77.3 percent.

Table III-4 shows the characteristics of surface paddy soils at the Trial Farm and upland soils at the Pilot Farm. All the soils were classified as clay soils (either HC or LiC). Surface soil of Pilot Farm 10-4 plot (upland) was high in base saturation (278%) and exchangeable sodium content (8.75 me/100 g).

Table III-1 Meteorological observation at KADC Chekereni during the period from 1982 to 1990[a].

Month	Air temperature (°C) Maximum	Minimum	Mean	Rainfall (mm/month)
January	33.2 (38.8)b	19.2 (14.0)c	26.2	37.3 (11.0-86.5)d
February	34.5 (38.8)	19.5 (15.0)	27.1	33.6 (0.0-138.9)
March	34.1 (37.5)	20.7 (15.0)	27.4	74.8 (4.1-268.3)
April	31.1 (36.5)	20.5 (15.0)	25.8	183.8 (58.0-456.3)
May	28.3 (33.0)	19.3 (15.0)	23.8	96.0 (19.9-267.3)
June	27.2 (30.0)	17.6 (10.7)	22.5	14.1 (1.2-56.7)
July	27.2 (30.5)	16.9 (10.3)	22.1	15.4 (0.0-49.4)
August	27.4 (31.2)	17.0 (12.1)	22.2	10.0 (0.0-40.6)
September	29.7 (34.0)	17.5 (12.0)	23.6	7.8 (0.0-23.8)
October	31.9 (35.0)	18.8 (13.0)	25.3	26.0 (0.0-137.6)
November	32.7 (36.6)	19.7 (15.0)	26.2	38.7 (2.7-119.3)
December	32.7 (37.0)	19.3 (13.5)	26.1	64.6 (0.0-154.2)
Total	-	-	-	602.1
Mean	30.8	18.8	24.9	-

Annual rainfall (mm)

1982: 797.4	1983: 417.3	1984: 509.9	1985: 567.5
1986: 597.0	1987: 401.1	1988: 545.5	1989: 656.8
1990: 932.8	Mean: 602.8		

N.B. [a]Data were obtained from Water Management Section.
[b]Figures in parentheses are extremely high temperatures.
[c]Figures in parentheses are extremely low temperatures.
[d]Figures in parentheses are ranges of rainfall.

Table III-2 Chemical properties of surface soils at the Trial Farm[a].

Kind of soil	pH (H_2O1:5)	Electric Conductivity (micro S/cm at 25°C)	Humus (%)
Upland soils (10 samples)			
Mean	7.70	119	1.90
Max.	8.20	162	2.3
Min.	7.52	74	1.5
s.d.	0.26	26	0.25
Paddy soils (8 samples)			
Mean	7.93	125	1.06
Max.	8.22	170	1.6
Min.	7.63	82	0.8
s.d.	0.17	35	0.23

Table III-2 .....continued[a].

Kind of soil	Exchangeable cations (mg/100g) CaO	K_2O	MgO	Available P_2O_5(mg/100g)	P-adsorption coefficient
Upland soils (10 samples)					
Mean	321	156	67	111	1,050
Max.	348	220	93	210	1,200
Min.	296	115	50	90	900
s.d.	16	35	16	37	108
Paddy soils (8 samples)					
Mean	314	87	104	34	1,188
Max.	340	120	130	46	1,400
Min.	300	62	80	22	1,100
s.d.	13	20	16	9	113

N.B. [a]Obtained from "Report of the Study of Saline Soil in the Pilot Farm and Soil Analyses of Paddy and Upland Fields in Trial Farm, Pilot Farm, and Lower Moshi Area" (Iseki, 1986).

4. Problems in Soil Management

As Table III-3 indicates, the soil at the Trial Farm is heavy clay. It becomes hard under dry conditions (especially at the end of dry season) and it becomes sticky when it is wet. Effective water holding capacity and percolation rate are apparently low.

Land preparation of the upland plots is usually done by tractors. It consists of plowing, rotary harrowing, and ridging (depend upon the cultivation trials). Hard soil at the end of dry season prevents the tractor run smoothly for plowing and rotary tilling. Many big clods remain after the operation. Wet soil after rains prevents the tractor from entering the plot for a long time.

The big clods which remained in field adversely effect the seedling emergence of some crops. The soil forms hard crust after rains which affects seedling establishment (especially soybean). Land leveling is one another problem. Because of poor percolation of rain water into the soil, the higher portions easily become dry and lower portions become waterlogged. This problem happens not only under rainfed conditions but also irrigated conditions (either with furrow or sprinkler). Some portions of the Pilot Farm (not Trial Farm) are saline soils.

Table III-3 Characteristics of soils in different depth of upland plot (C-4 plot) at the Trial Farm[a].

	Depth of soil (cm)				
	0-17	17-30	30-50	50-80	80-
Texture					
Clay (%)	50.8	48.2	52.8	53.0	59.2
Coarse silt (%)	15.2	18.6	17.6	17.4	11.0
Fine sand (%)	3.4	2.0	2.0	4.0	3.2
Coarse sand (%)	30.0	31.2	27.6	25.6	26.6
Soil textural class	HC	HC	HC	HC	HC
Organic Carbon (%)	0.83	0.73	0.36	0.26	0.31
CEC NH4OAc (me/100 g)	21.76	22.97	23.76	21.88	-
Exchangeable Ca (")	10.39	10.52	9.34	5.13	12.12
Exchangeable Mg (")	5.15	2.98	4.61	4.11	-
Exchangeable K (")	1.04	1.04	1.04	1.04	1.05
Exchangeable Na (")	0.32	0.50	0.51	0.24	0.42
Base saturation (%)	77.3	65.4	65.2	48.0	-

N.B. [a]Obtained from "Report of the Study of Saline Soil in the Pilot Farm and Soil Analyses of Paddy and Upland Fields in Trial Farm, Pilot Farm, and Lower Moshi Area" (Iseki, 1986). Samples were collected by Iseki, A. and analyzed at National Soil Service, Mlingano Research Institute.

Table III-4 Characteristics of paddy surface soils at Trial Farm and upland surface soils at Pilot Farm[a].

	Paddy Soils		Upland soils		
Plot number:	D-1	D-4	10-1	10-4	10-5
Texture					
Clay (%)	44.2	45.2	47.4	46.2	39.2
Silt (%)	13.2	14.0	15.8	13.0	12.2
Fine sand (%)	4.8	2.0	7.0	2.2	4.2
Coarse sand (%)	37.8	38.8	29.8	38.6	44.4
Soil textural class	LiC	HC	HC	HC	LiC
Organic carbon (%)	0.53	0.55	1.35	1.39	1.21
CEC NH4OAc (me/100 g)	20.47	19.99	24.49	18.49	21.00
Exchangeable Ca (")	10.51	9.09	19.01	24.37	10.75
Exchangeable Mg (")	12.87	7.46	9.98	16.46	5.46
Exchangeable K (")	1.03	1.02	1.03	1.03	1.02
Exchangeable Na (")	0.68	1.65	2.42	8.75	0.26
Base saturation (%)	122	96.1	132	278	83.2

N.B. [a]Same as that of Table III-3.

IV. ACTIVITIES ON SOYBEAN

Several soybean varieties were brought to KADC and planted at the end of former project (KADCP). The cultivation techniques were not well established yet at the beginning of KADP; the grain yields obtained from 3 varieties were within the range from 236 kg per ha to 573 kg per ha in 1986 rainy season. Besides, there was no information on soybean in the country. Trials were conducted using not adapted varieties to the local environment at that time. Objectives of soybean introduction were not clear or it was included as one of the crops for KADP by chance.

Soybean was not sold at Moshi Public Market. It was (is) not a food stuff to the people. Soybean grains contain much protein, but they should be processed (i.e. soaked long time in water, milled to flour) before properly utilized. It has odor which some people do not like. In short, soybean was neither produced nor marketed in Kilimanjaro Region.

It took sometime to develop ideas and to formulate the ways of approach of how soybean could be introduced both for cultivation and utilization. Through collecting information about soybean and exchanging ideas with soybean researchers in the country, a way of approach to this crop has developed especially for soybean utilization. There was a recommended variety of soybean (Bossier) and there were national institutes which deal with this crop.

1. Materials and Methods

Different varieties of soybean were planted according to the availability of varieties and purposes of cultivation. They were planted under irrigation (sprinkler, furrow) and rainfed, with and without ridge construction, in upland plots and fallowed paddy plots, in rainy season and dry season. After confirming that Bossier variety was most adapted to the local environment, many experiments were conducted using this recommended variety.

Plant spacing of 75 cm between rows, 20 cm within rows, and 2 plants per hill was used at the initial stage. Later, plant spacing of 50 cm between rows, 10 cm within rows, and 2 plants per hill has been commonly used because of small plant size of Bossier variety.

Yield survey was conducted from small sampling area (sometimes 1 m^2) at the initial stage because of poor seedling establishment. It has been changed to 3 m^2 or 4.5 m^2 (3 m of 2 rows) later with improvement of crop management.

Plant characteristics recorded were depending on kind of trials and availability of manpower. In most cases, however, days to one half germination, days to one half flowering, days to 95 percent of maturity and number of plants per sampling area were taken from every plot. Plant height, number of node per plant, and number of branches per plant were taken from 10 plants per plot.

After harvesting, the samples were air dried and threshed. Total grain yield per sampling area and 100 grain weight (through weighing 100 grains once) were obtained. Number of grains per unit area (m^2) was calculated using these two values. Then, 100 grain weight (g), grain yield per unit area (kg/ha) and grain yield per plant (g) were obtained at 12 percent of moisture content through using soybean moisture tester "Daizer".

The data were subject to statistical analysis; analysis of variance was commonly used. Some of the data were combined in this terminal report.

2. Variety Comparison

As many as about 100 soybean varieties and lines were planted at the Trial Farm in the last 5 years. Majority of them were obtained from Ilonga Agricultural Research and Training Institute (IARTI) and some of them were from Sokoine University of Agriculture. In addition, few of them were obtained from Kenya, Paraguay, Thailand, Indonesia, and Japan.

At the initial stage of cooperation, when it was not known much about soybean research in Tanzania and there was poor communication with national institutes, soybean varieties were collected from other countries. After the establishment of communication and collaboration with IARTI, the varieties (lines) multiplied at the institute have been used.

Four varieties of soybean were planted under an experiment design of randomized complete block (RCB) with 4 replications in 1986 dry season. This was the first time of planting Bossier variety (recommended variety to the lower altitude zone) at the Trial Farm; the seeds were obtained from Msimba Foundation Seed Farm. Other 3 varieties were kept and maintained at KADP.

They were planted under sprinkler irrigation, with 30 kg of nitrogen per ha (applied at planting), at the plant spacing of 75 cm between rows, 20 cm within rows and 2 plants per hill, and ridge was constructed every after 2 seeding rows (before planting). The seeds were inoculated with Rhizobium bacteria brought from Japan but it was not effective. Results of the experiment are shown in Table IV-1.

Table IV-1 Grain yields and other characteristics of 4 soybean varieties planted in October, 1986.

Variety	Days to maturity	Plants /1.5m^2	100 grain weight(g)	Grains per m^2	Grain yield (kg/ha)	Grain yield (g/plant)
Bossier	95.8a	18.3a	16.4ab	1,252b	2,100a	17.4
Lawrence	88.3b	9.8b	18.5a	527c	997b	15.6
Orba	92.8a	17.8a	11.6c	1,931a	2,257a	19.1
William's82	86.0b	11.8b	13.7bc	764c	999b	13.1
Observed F						
Rep.	0.44ns	2.64ns	0.97ns	0.43ns	0.12ns	0.51ns
Trt.	19.8**	31.6**	6.79*	21.8**	6.43*	0.87ns
cv (%)	2.2	10.6	15.4	23.8	33.9	34.0

N.B. Any two means having a common letter in a column are not significantly different at the 5% level of significance.

Although the quality of data was poor, Bossier and Orba varieties produced more than 2 ton per ha. However, Orba variety showed high shattering habit, then it was not advisable to plant the variety in farmers' fields. Both Lawrence and William's82 varieties were poor in grain yield either per unit area or per plant. The poor grain yield per plant under less number of plants in the sampling area indicated poor adaptability of the varieties to the local environment or poor yield potential.

Six varieties of soybean were planted under an experiment design of RCB with 4 replications in May 1988. All the seeds were inoculated with Rhizobium bacteria produced at Sokoine University of Agriculture, then planted at the spacing of 50 cm between rows, 20 cm within rows, and 2 plants per hill. Ridge was constructed every after 2 rows (before planting), sprinkler irrigation was practiced, and nitrogen fertilizer (30 kg N/ha) was applied at 3 weeks after planting. Table IV-2 presents the results.

Table IV-2 Grain yields and other characteristics of 6 soybean varieties planted in May, 1988.

Variety[a]	Days to maturity	Plants /3 m^2	100 grain weight(g)	Grains per m^2	Grain yield (kg/ha)	Grain yield (g/plant)
Bossier	99.3e	47.0a	21.6b	1,026a	2,222a	14.3b
Cristalina	120.0a	37.8bc	17.9de	1,073a	1,908abc	15.3b
Elgon	99.0e	21.0e	15.0f	987a	1,480e	19.0a
Hill	107.5cd	25.0de	21.2bc	735b	1,553de	19.2a
IAC8	114.5b	27.0d	23.5a	787b	1,838bcd	20.5a
N-1	108.0c	43.0ab	18.3d	1,181a	2,149ab	15.0b
Observed F						
Rep.	0.34	0.37ns	0.94ns	0.94ns	1.35ns	3.40*
Trt.	346**	21.1**	38.6**	7.01**	8.68**	5.27**
cv (%)	0.8	13.8	5.1	13.4	11.0	13.5

N.B. [a]Cristalina and IAC8 were from Paraguay, Elgon and Hill from Kenya, and N-1 (Nakornsawan-1) from Thailand.
Any two means having a common letter in a column are not significantly different at the 5% level of significance.

All the varieties formed nodules on their roots. Bossier and Elgon matured in 100 days. The difference in number of plants harvested from the sampling area made difficult to analyze data. Hill and Elgon varieties (from Kenya) had shattering habit which was not attractive. Cristalina and IAC8 varieties (from Paraguay) were late maturing which was also not attractive.

Some 44 lines (41 self-nodulating lines) obtained from IARTI and Bossier variety were planted without Rhizobium inoculation in March, 1990 under rainfed conditions at the plant spacing of 75 cm between rows, 10 cm within rows and 2 plants per hill. Table IV-3 shows the results.

Bossier variety matured most early (91 days) and it did not form nodules. The growth period of those which produced high yields (10 lines) ranged from 100 to 108 days. Among 41 self-nodulating lines, 37 lines formed nodules at 8 weeks after planting.

Table IV-3 Grain yields and other characteristics of 44 soybean lines (41 self-nodulating lines) and Bossier variety planted without Rhizobium inoculation in 1990 rainy season.

Line number	Days to flowering	Days to maturity	Nodule formation[a] 4 WAP	8 WAP	Stem height (cm)
Top 10 yielding lines					
IL-141-2	45	108	3	5	65.5
IL-338	48	104	3	5	62.3
IL-159-1	45	100	3	3	59.5
IL-243-1	43	103	5	5	62.6
IL-186	44	103	5	5	62.6
IL-146-2	44	103	3	5	50.7
IL-338-1	44	105	1	3	66.3
IL-258	45	108	5	5	72.2
IL-141-1	47	108	3	5	63.8
IL-130	42	103	3	5	49.5
Bossier	39	91	0	0	53.2
All the 45 entries					
Mean	45.3	104	1.9	3.6	63.1
Maximum	55.0	114	5	5	88.6
Minimum	35.0	91	0	0	42.4
s.d.	3.8	5.0	(1.6)	(1.8)	11.8

N.B. [a]Figures of nodule formation are 0 for none, 1 for poor, 3 for fair, and 5 for good (WAP: week after planting).

Table IV-3 .....continued.

Line number	Plants /4.5 m^2	Pods/ Plant	100 grain weight(g)	Grains per m^2	Grain yield (kg/ha)	(g/plant)
Top 10 yielding lines						
IL-141-2	61	58	18.7	1,800	3,365	24.8
IL-338	82	67	15.8	2,024	3,194	17.5
IL-159-1	67	93	13.4	2,330	3,129	21.0
IL-243-1	69	63	18.6	1,655	3,082	20.1
IL-186	77	49	17.2	1,714	2,958	17.3
IL-146-2	59	81	15.6	1,871	2,923	22.3
IL-338-1	92	55	17.5	1,648	2,894	14.1
IL-258	83	52	20.6	1,367	2,824	15.3
IL-141-1	70	66	16.8	1,664	2,799	18.0
IL-130	74	47	17.1	1,625	2,790	17.0
Bossier	62	53	19.0	1,336	2,543	18.4
All the 45 entries						
Mean	66.4	59.4	16.1	1,452	2,322	16.3
Maximum	105	112	22.4	2,330	3,365	25.7
Minimum	36	32	10.7	768	1,011	7.0
s.d.	14.2	16.7	2.6	320	414	4.6

The highest grain yield was obtained from IL-141-2 (3,365 kg/ha). There were 4 IL lines which produced more than 3 ton per ha of grain yield. The yield of Bossier variety was 2,543 kg per ha; 16 IL lines produced more grain yield than Bossier and all of them took more than 100 days of growth period.

Six self-nodulating lines (which showed good performance in 1989/90 dry season), one SGP line and Bossier variety were planted with Rhizobium inoculation in March 1990 under rainfed conditions. Plant spacing of the trial was 50 cm between rows and drilling (later thinned). Table IV-4 presents the results.

Table IV-4 Grain yields and other characteristics of 8 soybean lines planted with Rhizobium inoculation in 1990 rainy season.

Line number	Plants /3 m^2	Pods/ Plant	100 grain weight(g)	Grains per m^2	Grain yield (kg/ha)	Grain yield (g/plant)
IL-141-1	41	101	17.1	1,496	2,552	28.0
IL-186	35	91	17.6	1,708	3,012	38.7
IL-258	46	62	22.7	1,153	2,621	25.6
IL-297	59	89	12.1	2,013	2,441	18.6
IL-318-1	44	117	12.9	2,170	2,802	28.7
IL-392-2	59	80	14.6	1,916	2,796	21.3
SGP451	46	101	16.3	1,856	3,233	31.6
Bossier	35	64	19.7	1,097	2,160	27.8

All the varieties formed nodules on the roots. SGP451 produced the highest grain yield of 3,233 kg per ha; it produced 2,385 kg per ha in the trial of 45 line comparison mentioned above. The lowest grain yield was obtained from Bossier (2,160 kg/ha). One of the reasons for relatively low yield of Bossier variety was probably due to less number of plants in the sampling area.

Some varieties (lines) produced better grain yield than Bossier variety in some variety comparison trials (without replications). But they had longer growth periods than Bossier. Since soybean is planted under rainfed conditions in farmers' fields, adaptability of the late maturing lines should be further checked.

3. Fertilizer Rate

Several fertilizer experiments were conducted for Bossier variety, but not all the trials were successful. One of them was planted in July, 1987 under a latin square experiment design with 4 treatments: (1) control, (2) 30 kg of nitrogen per ha, (3) 30 kg of phosphorus (as P_2O_5) per ha, and (4) 30 kg each of nitrogen and phosphorus per ha. The seeds (not inoculated with Rhizobium bacteria) were planted at the spacing of 60 cm between rows, 20 cm within rows, and 2 plants per hill. Ridge was constructed every after 2 rows, and sprinkler irrigation was practiced.

Table IV-5 shows the results. The difference in grain yield, which ranged from 1,616 kg per ha of the control to 2,344 kg per ha in the treatment of 30 kg of nitrogen per ha, was statistically not significant. Both mean values of number of grains per unit area and grain yield per plant were also high in the treatments with nitrogen. But they are also not significantly different from those with the control and the treatment of phosphorus.

Table IV-5 Grain yields and yield components of soybean (Bossier variety) planted at different fertilizer rates in July, 1987.

Fertilizer rate(kg/ha)	Plants /2.4m^2	100 grain weight(g)	Grains per m^2	Grain yield (kg/ha)	Grain yield (g/plant)
Control	39.0	16.0	1,002	1,616	10.0
30N	39.3	17.3	1,328	2,344	14.4
30P_2O_5	40.3	16.1	1,071	1,776	10.6
30N+30P_2O_5	39.0	16.4	1,273	2,099	13.0
Observed F					
Row	2.90ns	10.6**	2.10ns	4.29ns	4.00ns
Column	1.30ns	2.58ns	1.75ns	1.54ns	1.54ns
Treatment	1.70ns	0.88ns	3.20ns	2.31ns	2.24ns
cv (%)	2.3	8.0	15.0	21.9	23.0

An experiment of Rhizobium inoculation and nitrogen rate on Bossier variety was conducted under a 2 x 3 factorial in RCB design with 3 replications. It was planted at the spacing of 50 cm between rows, 20 cm within rows, and 2 plants per hill in May, 1988. The treatments were: (1) without and (2) with Rhizobium inoculation, and nitrogen rates (kg/ha) of 0, 30, and 60. Nitrogen fertilizer was applied at 3 weeks after planting. Table IV-6 shows the results.

The grain yield per unit area in the treatment of Rhizobium inoculation (1,986 kg/ha) was higher than that of without Rhizobium inoculation (1,599 kg/ha). The difference was statistically significant at the 5 percent level of probability. The treatment of Rhizobium inoculation showed more number of plants harvested from the sampling area, bigger grain size, more number of grains per unit area, and heavier grain weight per plant than those of without Rhizobium inoculation. But, the differences were statistically not significant.

Other fertilizer experiments conducted in 1989 and 1990 seasons failed. Rhizobium inoculation was not always successful. Chances of irrigation water were not always same among the plots within the experiment area. Undulation of surface soil adversely effected the data, in addition to soil heterogeneity (i.e. effects of plant residue). Potassium was not included in any experiments.

However, based on the experience of cultivation trials, it may be safe to state that grain yield of soybean can be increased either with nitrogen fertilizer, Rhizobium bacteria inoculation, or both of them. Roughly the effect of Rhizobium inoculation is equivalent to about 30 kg of nitrogen per ha, and either of them increase the grain yield by about 400 kg per ha, and the combination of Rhizobium inoculation and nitrogen fertilizer is also additive to the grain yield if the environment and management conditions are favorable.

Table IV-6 Grain yields and other characteristics of soybean (Bossier variety) planted under different nitrogen rates in May, 1988.

Treatment[a]	Days to maturity	Nodule 8 WAP	Plants /3 m^2	100 grain weight(g)	Grains per m^2	Grain yield (kg/ha)	Grain yield (g/plant)
Without Rhizobium inoculation (RI): A							
0	96.7	None	52.3	20.2	679	1,381	8.0
30	96.7	None	55.3	18.4	939	1,714	9.4
60	97.3	None	42.3	19.0	893	1,702	12.2
Mean	96.9b	-	50.0	19.2	837	1,599b	9.9
With Rhizobium inoculation (RI): A							
0	97.0	Fair	56.7	19.7	878	1,722	9.4
30	99.7	Good	52.0	20.9	1,033	2,145	12.5
60	99.7	Fair	56.7	21.0	994	2,091	11.0
Mean	98.8a	-	55.1	20.5	968	1,986a	11.0
Mean of nitrogen rate: B							
0	96.8	-	54.5	19.9	779	1,551	8.7
30	98.2	-	53.7	19.7	986	1,930	11.0
60	98.5	-	49.5	20.0	944	1,896	11.6
Observed F							
Rep.	1.77ns	-	0.18ns	0.27ns	0.92ns	1.71ns	0.74ns
Trt.	5.50*	-	1.21ns	0.63ns	2.26ns	2.71ns	2.25ns
A	14.2**	-	1.62ns	1.55ns	3.79ns	7.56*	1.29ns
B	4.12*	-	0.59ns	0.04ns	3.51ns	2.95ns	3.36ns
AxB	2.55ns	-	1.62ns	0.76ns	0.25ns	0.03ns	1.63ns
cv (%)	1.1	-	16.2	11.2	15.9	16.7	19.7

N.B. [a]Rhizobium inoculation at planting, nitrogen fertilizer (kg N/ha) applied at 3 weeks after planting (WAP).
Any two means having a common letter in a column are not significantly different at the 5% level of significance.

4. Plant Spacing

Two plant spacing experiments, one in 1987 and the other in 1988, were conducted for Bossier variety. Spacing of between rows was 60 cm for the experiment in 1987 and it was 50 cm in 1988. Fertilizer application was 30 kg of nitrogen and 60 kg of phosphorus (as P_2O_5) per ha at planting for the former experiment (without Rhizobium inoculation). It was 30 kg of nitrogen per ha at 3 weeks after planting for the later experiment (with Rhizobium inoculation to seeds).

Tables IV-7 and IV-8 present the results. Stem height increased as increasing plant density in general. Although the intended plant population was not obtained especially at the higher densities, the results indicated that the grain yield increased as plant population increased. The highest grain yield was obtained in the highest plant density in both of the experiments; it was 2,365 kg per ha in the former and 2,474 kg per ha in the later trial. The grain size decreased as increasing plant density in the former experiment but it did not change in the later experiment. Number of grains was more and grain weight per plant was less in the dense spacings.

Table IV-7 Grain yields and other characteristics of soybean (Bossier variety) planted at different spacings in July, 1987.

Plant spacing[a]	Stem height(cm)	Plants /2.4 m^2	100 grain weight(g)	Grains per m^2	Grain yield (kg/ha)	Grain yield (g/plant)
60,10,2	50.2a	73.8a	17.6b	1,347a	2,365a	7.8c
60,10,1	45.6b	39.5b	18.1b	1,192bc	2,165a	13.2b
60,20,2	45.8b	39.3b	17.6b	1,258ab	2,213a	13.6b
60,20,1	40.4c	21.0c	20.9a	884d	1,848b	21.2a
Observed F						
Row	8.59*	2.23ns	1.18ns	2.27ns	3.06ns	1.13ns
Column	3.59ns	1.27ns	0.98ns	0.03ns	1.00ns	2.61ns
Trt.	18.0**	216**	5.95*	17.4**	5.57*	41.5**
cv (%)	4.2	6.9	6.9	8.2	8.6	12.3

N.B. [a]Indicates cm between rows, cm within rows, and number of plant(s)/hill.
Any two means having a common letter in a column are not significantly different at the 5% level of significance.

Table IV-8 Grain yields and other characteristics of soybean (Bossier variety) planted at different spacings in May, 1988.

Plant spacing[a]	Stem height(cm)	Plants /3 m^2	100 grain weight(g)	Grains per m^2	Grain yield (kg/ha)	Grain yield (g/plant)
50,10,2	40.9a	64.5a	21.1	1,177a	2,474a	11.6d
50,10,1	28.5c	36.0c	21.9	817bc	1,784bc	14.9bc
50,20,2	33.0b	53.3b	21.0	989b	2,064b	11.7cd
50,20,1	30.1bc	25.8d	21.7	782c	1,690c	19.7a
50,30,2	30.8bc	35.3c	20.5	830bc	1,705c	15.0b
50,30,1	27.4c	21.3d	20.6	733c	1,500c	21.2a
Observed F						
Rep.	1.55ns	1.70na	0.35ns	2.22ns	1.60ns	0.46ns
Trt.	15.5**	31.5**	0.48ns	8.55**	9.65**	13.3**
cv (%)	7.7	15.0	7.8	12.8	12.0	14.1

N.B. [a]Indicates cm between rows, cm within rows, and number of plant(s)/hill.
Any two means having a common letter in a column are not significantly different at the 5% level of significance.

Table IV-9 presents multiple linear correlations of grain yield and other characteristics of Bossier variety planted in May, 1988. The increasing of plant population per unit area also increased the stem height, number of grain per unit area, and grain yield per unit area, but decreased the number of branches per plant, number of pods per plant, and grain yield per plant. On the other hand, the grain yield was positively highly correlated with the number of grains per unit area, number of plants per unit area, and stem height, but negatively highly correlated with the number of pods per plant.

Table IV-9 Multiple linear correlations of grain yield and other characteristics of soybean (Bossier variety) planted at different spacing in May, 1988.

	1	2	3	4	5	6	7	8
1	1.0000							
2	.9084**	1.0000						
3	-.9210**	-.8157*	1.0000					
4	-.9876**	-.8707*	.9454**	1.0000				
5	-.0164	-.0707	.1567	-.0135	1.0000			
6	.9800**	.9684**	-.8900**	-.9486**	-.0387	1.0000		
7	.9749**	.9574**	-.8708*	-.9491**	.0889	.9918**	1.0000	
8	-.9240**	-.7161	.8848**	.9598**	-.0147	-.8339*	-.8351*	1.0000

N.B. 1: Number of plants per unit area, 2: Stem height, 3: Number of branches per plant, 4: Number of pods per plant, 5: 100 grain weight at 12% moisture content (MC), 6: Number of grains per unit area, 7: Grain yield per unit area at 12% MC , 8: Grain yield per plant at 12% MC.

Although it was not obtained higher densities in the spacing experiments, high plant densities of soybean extension plots (i.e. Tables IV-15, IV-16) indicate that there is less possibility of increasing the grain yield of Bossier variety above the plant density of 333,333 plants per ha in the environmental and soil conditions. To obtain this plant population, about 2 to 3 seeds should be placed as drilling in every 10 cm of the seeding row (taking the germination rate into account) with 50 cm between the rows. Cultural practices, especially weeding, become difficult under the condition of less than 50 cm between rows.

5. Comparison with Other Beans

Different kinds of beans were planted in 1988, 89 and 90 rainy seasons under rainfed conditions to compare the productivity of soybean with other kinds of beans. In 1989 rainy season, a set of beans were planted under rainfed conditions. All of the varieties were recommended in the country. Bossier and Canadian Wonder were planted both with and without Rhizobium inoculation. Table IV-10 shows the results.

Except Bossier planted without Rhizobium inoculation, numbers of plants harvested from the sampling area were low. Beans other than soybean were more attacked by insects under the conditions of without insecticide spray. Although Bossier variety without Rhizobium inoculation produced the highest grain yield (1,783 kg/ha), it apparently benefited from the more number of plants per sampling area comparing with others and better water holding of the plot where it was allocated. Rainy season of the year started late and ended early and amount of rainfall was also small. As a result, germination was generally poor and growth period was short. All of the factors adversely effected the grain yield.

Table IV-10 Grain yields and other characteristics of different kinds of beans planted in April, 1989[a].

Kind of bean Variety[b]	Growth period	Plants /3 m^2	100 grain weight(g)	Grains per m^2	Grain yield (kg/ha)	Grain yield (g/plant)
Soybean						
Bossier	87(37)[c]	80.5	15.6	1,160	1,783	6.7
Bossier(RI)	87(37)	32.0	15.2	852	1,300	12.7
Phaseolus bean						
CW	70(36)	23.0	39.1	225	884	11.8
CW(RI)	75(36)	21.5	45.1	337	1,517	17.6
L85	76(36)	21.5	37.2	307	1,165	15.2
Cowpea						
Fahari	75(51)	33.5	13.7	843	1,150	10.4
Tumaini	75(51)	31.0	11.0	1,056	1,150	11.4
Vuli-1	69(40)	21.0	15.4	899	1,384	19.8
Green gram						
Imara	70(37)	38.0	8.3	1,917	1,583	12.5
Nuru	70(41)	33.5	5.6	2,738	1,533	13.7

N.B. [a]Yield data are means of 2 samplings per treatment.
[b]RI stands for Rhizobium inoculation (the rest are without RI). The varieties of cowpea and green gram attached indigenous Rhizobium well, Phaseolus bean to some extent, soybean none under without RI condition. CW and L85 stands for Canadian Wonder and Lyamungu 85, respectively.
[c]Figures in parentheses are number of days to flowering.

In 1990 rainy season, same kinds and varieties of beans were planted in March under rainfed conditions. The plot used for the trial was same as that of soybean lines comparison in the year. Results are shown in Table IV-11.

Quite poor grain yields of cowpea varieties (especially Fahari and Tumaini) were due to rat attack. Relatively high grain yields were obtained from Phaseolus bean and soybean. Bossier plants without Rhizobium inoculation formed nodules. It was probably due to movement of the bacteria after rains; there was heavy rains in mid-April.

Based on the trials, it may be safe to state that soybean is competitive with other kinds of beans planted in the area in terms of production per unit area. Soybean was least attacked by diseases and insect pests; which is one of the advantages of soybean cultivation (at the moment).

6. Cultivation in Fallowed Paddy Plot

After the observation of fallowed paddy plots in rainy season due to the shortage of irrigation water in Lower Moshi

Table IV-11 Grain yields and other characteristics of different kinds of beans planted in 1990 rainy season.

Kind & variety of beans	Plants /3 m^2	100 grain weight(g)	Grains per m^2	Grain yield (kg/ha)	Grain yield (g/plant)
Soybean					
Bossier (RI)[a]	56	18.7	1,742	3,266	17.5
Bossier	69	18.1	1,655	2,990	13.0
Phaseolus bean					
Canadian Wonder	120	38.6	893	3,455	8.6
Lyamungu 85	84	47.8	656	3,139	11.2
Green gram					
Imara	49	7.4	1,550	1,149	7.0
Nuru	65	4.7	2,021	964	4.4
Cowpea					
Vuli-1	65	12.9	601	774	3.6
Fahari[b]	29	14.2	132	186	1.9
Tumaini[b]	-	-	-	-	-

N.B. [a]RI stands for with Rhizobium inoculation.
[b]Attacked by rats.

Irrigation Project, soybean cultivation trial in fallowed paddy plot was initiated as one way of utilization of the fallowed plots in rainy season. The first cultivation trial was conducted in 1988 using a fallowed paddy plot at the Trial Farm. Soybean seeds (Bossier variety) inoculated with Rhizobium bacteria were planted on 16 March at the plant spacing of 50 cm between rows and 10 cm within rows. Fertilizer was applied at the rate of 30 kg of nitrogen per ha at planting. There were initially 6 treatments, but two of them with irrigation were discarded from the trial because of poor performance caused by excess soil moisture conditions.

Effects of rice straw mulch (i.e. improving soil moisture retention and soil physical property especially for germination) was not observed. Instead of the positive effects, leaves of the soybean plant with rice straw mulch were paler green color than those of without rice straw mulch. It was probably due to nitrogen immobilization at the beginning of rice straw decomposition and lack of air space in the soil especially after rains. Weeding was also a problem in the areas with rice straw mulch. Yield data were taken from 3 spots (of relatively better grown portions) per treatment. Inoculation of Rhizobium bacteria was successful in all the treatments. Table IV-12 shows the results of 4 treatments.

The soybean plant flowered about 33 days after planting, and matured in 97 days after planting. The mean grain yield was 2,296 kg per ha (ranged 1,883 kg/ha-2,774 kg/ha). The yield data indicated that the grain yield of soybean planted in fallowed paddy plot under rainfed conditions was attractive. It encouraged the work of soybean introduction to fallowed paddy plots.

In 1989 rainy season, soybean seeds (Bossier variety) with Rhizobium bacteria were planted on 15 April at the plant spacing of 50 cm between rows and drilling. Treatments were with and without ridge construction and with and without 30 kg of nitrogen per ha. Because of early stoppage of rainy season in the year, the plot was once irrigated on June 5.

Table IV-12 Grain yields and other characteristics of soybean (Bossier variety) planted under different conditions of paddy plot in March, 1988[a].

Treatment[b]	Days to maturity	Stem height	Plants /2 m^2	100 grain weight(g)	Grains per m^2	Grain yield (kg/ha)	Grain yield (g/plant)
A	97	38.0(cm)	34.3	16.8	1,413	2,372	13.8
B	97	40.9	41.7	18.0	1,538	2,774	13.3
C	97	41.4	36.0	17.9	1,243	2,206	12.3
D	97	35.1	20.0	18.4	994	1,833	18.3
Mean	97	38.9	33.0	17.8	1,297	2,296	14.4

N.B. [a]Yield data are means of 3 samplings per treatment.
[b]A: With ridge every after 2 seeding rows and with rice straw mulching, B: With ridge but without mulching, C: Without ridge but with mulching, D: Without ridge and without mulching.

Table IV-13 shows the results. More than 2 ton per ha of grain yield was obtained in all the treatments. Ridge construction (every after 2 seeding rows) and nitrogen fertilizer application apparently contributed to the increase of grain yield to some extent.

Table IV-13 Grain yields and yield components of soybean (Bossier variety) planted with Rhizobium inoculation in fallowed paddy plot in April, 1989[a].

Treatment (kg N/ha)	Plants /3 m^2	Pods/ plant	100 grain weight(g)	Grains per m^2	Grain yield (kg/ha)	Grain yield (g/plant)
Without ridge construction						
Nil	75.5	32.1	15.0	1,380	2,058	8.4
30	94.5	34.3	16.3	1,327	2,471	8.0
Mean	85.0	33.2	15.7	1,454	2,264	8.2
With ridge construction						
Nil	75.0	31.5	16.7	1,325	2,232	8.9
30	79.0	34.0	19.1	1,407	2,694	10.3
Mean	77.0	32.8	17.9	1,366	2,463	9.6
Mean of fertilizer rate						
Nil	75.3	31.8	15.9	1,353	2,145	8.7
30	86.8	34.2	17.7	1,476	2,583	9.2

N.B. [a]Yield data are means of 2 samplings per treatment. It was irrigated once in early June.

The trial in 1990 rainy season was shifted to the comparison of different beans. The trial plot faced excess water conditions after the heavy rains in April. Table IV-14 presents the results.

Table IV-14 Grain yields and other characteristics of different kinds of beans planted on fallowed paddy plot in March, 1990.

Kind & variety of beans	Plants /3 m^2	100 grain weight(g)	Grains per m^2	Grain yield (kg/ha)	(g/plant)
Soybean[a]					
Bossier (RI)	120	13.1	470	616	1.5
Bossier	129	13.8	576	796	1.9
Phaseolus bean					
Lyamungu 85[b]	-	-	-	-	-
Green gram					
Imara	88	7.4	1,482	1,102	3.8
Cowpea					
Vuli-1	61	14.5	890	1,289	6.3

N.B. [a]RI stands for with Rhizobium inoculation.
[a]Lyamungu 85 plants died due to waterlogged conditions.

There was no harvest from Phaseolus bean (Lyamungu 85 variety) because of early death of the plant caused by waterlogged conditions. The yield of soybean (Bossier variety) was poor either planted with or without Rhizobium inoculation.

7. Extension of Cultivation Techniques in LMIP

Soybean was planted at the Pilot Farm in 1987 as the first extension service of the cultivation techniques. It produced only 380 kg of grains from 1 ha. Main cause of the failure was lack of experience on the cultivation practices in the area. It was planted before the onset of rainy season (March), then furrow irrigation was practiced. However, irrigation water was not properly distributed. As a result, the seedling establishment was poor and the plants were later suppressed by weeds.

Next extension of the crop was also conducted at the Pilot Farm in 1988. From the year, Rhizobium inoculant became available (from Sokoine University of Agriculture). Then about one third of the area (1 ha) was planted with the seeds inoculated (due to lack of the inoculant, it could not cover all the area).

Soybean was planted at the spacing of 75 cm between rows and drilling in April (after the onset of rainy season). It was first tried to plant 50 cm between rows. But because of the difficulty of constructing an irrigation furrow every after 100 cm by a small tractor pulled ridger, later the furrows were constructed by 150 cm interval by a big tractor pulled ridger. Nitrogen fertilizer (30 kg N/ha) was applied at planting. Furrow irrigation was practiced toward the end of grain-filling period. Due to the problem of land leveling, it was not properly distributed. Yield samplings were taken from relatively well grown 3 spots each of the areas with and without Rhizobium inoculation.

Results are presented in Table IV-15. Nodule formation was checked several times from plants outside of the sampling area.

The difference in nodule formation was quite distinct. Although it was not mentioned in the Table, there was not much differences between the treatments on stem height (56.6-58.7 cm), number of nodes per plant (9.5-9.8), number of branches per plant (3.2-3.4), and number of pods per plant (31.6-31.8). As it was mentioned in the Table, the mean number of plants per sampling area and 100 grain weight were not much different. It indicates that the difference in grain yield of 2,048 kg per ha of the treatment with Rhizobium inoculation and 1,601 kg per ha of the treatment without Rhizobium inoculation was due to the difference in number of grains per unit area. The grain yield per plant was also higher in the treatment with Rhizobium inoculation.

Actual grain yield from the total harvesting area (1 ha) was 1,250 kg. It was far better than the yield of previous year (380 kg). The difference was contributed by the more number of plants per unit area at harvesting. Since it was the second time of soybean extension, better crop husbandry was practiced.

Table IV-15 Grain yields and other characteristics of soybean (Bossier variety) planted at the Pilot Farm in 1988.

Sampling spot	Plants /3 m^2	Nodules at 8WAP	100 grain weight(g)	Grains per m^2	Grain yield (kg/ha)	Grain yield (g/plant)
Without Rhizobium inoculation						
1	83	None	19.2	885	1,699	6.1
2	93	None	17.6	735	1,293	4.2
3	68	None	20.4	888	1,812	8.0
Mean	81.3	None	19.1	836	1,601	5.9
With Rhizobium inoculation						
1	65	Good	18.8	1,226	2,304	10.8
2	131	Good	18.3	1,160	2,122	4.9
3	55	Good	18.7	919	1,719	9.4
Mean	83.3	Good	18.6	1,102	2,048	7.4

Actual grain yield: 1,250 kg from 1 ha of planted area

Third extension of soybean cultivation was carried out for fallowed paddy plots in Lower Moshi Irrigation Project in 1989 rainy season. Five paddy plots in MS5-1 Irrigation Block were used for the purpose. Land preparation (plowing and harrowing) was done by tractor and seeding rows were prepared by farmers (no ridge construction). Soybean seeds inoculated with Rhizobium bacteria were planted in April (after the onset of rainy season). No other fertilizer was applied. Because of short rainy period in the year, the plots were once irrigated at the grain filling period through flooding.

Table IV-16 shows the results. It was the best soybean field managed by farmers so far. Actual grain yield of about 1.9 ton per ha was obtained. The results indicated that it would be possible to produce soybean of 2 ton per ha under farmers' conditions if climate and management were favorable. Grain yields of the areas where late planted and late weeded were comparatively poor. Correlation analysis of the yield and yield components (Table IV-17) indicates that increasing the plant density above a certain level (i.e. 100 plants/3 m^2 or 333,333 plants/ha) would not contribute to the increase of grain yield. The grain yield per unit area was highly correlated with the number of grains per unit area, but it was not correlated with other parameters.

Table IV-16 Grain yields and other characteristics of soybean (Bossier variety) planted in fallowed paddy plots in Lower Moshi Irrigation Project in 1989 rainy season.

Plot No.	Plants /3 m^2	Plant height	Pods/ plant	100 grain weight(g)	Grains per m^2	Grain yield (kg/ha)	(g/plant)
1 (1)	92	58.0(cm)	29.9	17.6	1,242	2,186	7.2
(2)	101	57.8	19.7	17.1	1,000	1,710	5.1
2 (1)	91	48.8	26.3	19.1	766	1,463	4.8
(2)	69	37.2	32.5	17.0	949	1,613	7.1
3 (1)	88	44.5	23.6	17.0	1,087	1,848	6.3
(2)	105	51.1	23.8	19.5	909	1,773	5.0
4 (1)	113	53.0	20.1	16.5	853	1,407	3.7
(2)	149	47.7	18.3	15.6	1,349	2,104	4.3
5 (1)	88	56.4	30.0	17.2	1,304	2,243	7.8
(2)	111	64.3	27.9	18.4	1,063	1,955	5.3
Mean	100.5	52.9	25.2	17.5	1,052	1,830	5.66
s.d.	21.5	7.8	4.9	1.2	196	292	1.36

Actual grain yield: 2,600 kg from 1.38 ha (1,884 kg/ha)[a]

N.B. [a]By total weighing for the grain yield and information of the farmers on planted area.

Table IV-17 Multiple linear correlations of Table IV-16.

	1	2	3	4	5	6	7
1	1.0000						
2	.2704	1.0000					
3	-.7492**	-.0673	1.0000				
4	-.3305	.2330	.3433	1.0000			
5	.3070	.2124	.0536	-.5256	1.0000		
6	.1787	.3663	.2319	-.2008	.9362**	1.0000	
7	-.7077**	-.0826	.8072**	.0151	.4405	.5477	1.0000

N.B. 1: Number of plants per unit area, 2: Plant height, 3: Number of pods per plant, 4: 100 grain weight at 12% moisture content (MC), 5: Number of grains per unit area, 6: Grain yield per unit area at 12% MC, 7: Grain yield per plant at 12% moisture content.

Soybean extension in the fallowed paddy plots was not conducted in 1990. Rainy season of the year started earlier than usual, then the farmers were not ready to prepare the plots. Lower Moshi Irrigation Project's Operation and Maintenance Office is requested to prepare the irrigation calendar (allocation of irrigation blocks for the first and second paddy cultivation) in advance (at last by the end of December) and to inform to the farmers in early January if the fallowed paddy plots in rainy season will be used for crop production in the future. Only the blocks which continuously give rest to paddy cultivation in the first and second paddy seasons will be planted with upland crops under rainfed conditions (not necessary soybean).

8. Extension to Other Areas in Kilimanjaro Region

Although soybean was introduced to the country early in this century, but not as a commodity crop. Majority of Tanzanian people have no experiences of either seeing soybean plant or eating soybean food. Soybean is known as "meat in the field" in oriental countries because of its high protein content. However, the potentiality of soybean was not recognized long time in the country except some limited scales of trials for its introduction as a substitute of milk and food additives to uji.

It was quite difficult to find Tanzanians who have experience of eating soybean except those who had been in Japan under training programs of JICA. Then, the main obstacle of soybean introduction in Kilimanjaro Region was not establishment and diffusion of its cultivation techniques but orientation and extension of its utilization.

Soybean can be processed in many ways for different purposes. However, the concept of soybean utilization adopted was its introduction into Tanzanian diet with minimum processing. After the observation of typical Tanzanian foods, it was found that many of them were once made into flour (not necessary wheat) before cooking (i.e. ugali, uji, chapati, maandazi). Then, an idea of soybean flour mixing with other foods made by different kinds of flours had developed. Soybean flour was mixed with either maize flour (for ugali and uji) and wheat flour (for chapati and maandazi) to see the difference of taste. Initial samples were tasted by staff of the Upland Crops Section and some other staff of KADP. They preferred the foods with soybean flour to the ordinary ones.

A soybean promotion party was held on 13 December, 1986 for KADP staff and leaders of Water Users' Association. In addition to different kinds of soybean foods common in Japan, those Tanzanian foods with and without soybean flour were prepared. It was confirmed that the taste of Tanzanian foods mixed with soybean flour was not inferior but better than the ordinary ones. The foods mixed with about 10 to 20 percent of soybean flour enrich the food nutritive value because of high protein content of soybean. Results of the party are presented in Appendix IV-1.

Soybean flour mixed ugali has been served to the participants of different kinds of training courses held by KADP. There have been no complains from the participants about the taste of ugali served. Introduction of soybean cultivation and utilization has been conducted not only for the trainees of Upland Crops Cultivation but also others who participated in other training courses.

Based on the results of cultivation trials and food testing, "Kilimo bora cha soya na matumizi yake" (Soybean Cultivation and Utilization Manual) was printed early 1988 to be used for soybean extension in Kilimanjaro Region. The manual (English version) is presented in Appendix IV-2.

Soybean Promotion Seminar was conducted at several villages in last 3 years using the manual and providing samples of foods cooked with and without soybean flour. Soybean flour mixed *ugali* and *chapati* were always prepared for the seminar, and other soybean foods (i.e. soy-milk, roasted ground soybean, fried soybean) were served at some cases. In general, more than 60 percent of the participants preferred the foods with soybean flour to the ordinary ones. Table IV-18 and Table IV-19 shows the places where the seminar was conducted and response of farmers to the sample foods, respectively.

Table IV-18 Places of and attendants to Soybean Promotion Seminar.

Date	District	Village	Attendants	Persons concerned[a]
27/4/88	Mwanga	Kigonigoni	200	Farmers, EWs
22/7/88	Mwanga	Kigonigoni	30	Farmers, EWs
1/9/88	Rombo	Mriti	80	Farmers, EWs, STs
7/2/89	Hai	Kware	40	Farmers, EWs
14/3/89	Moshi	Kindi	80	Farmers, EWs, STs
13/4/89	Rombo	Mriti	20	Farmers, EWs, STs
29/11/89	Same	Ndungu	200	Farmers, EWs
21/2/90	Mwanga	Usangi	50	STs, EWs
1/11/90	Mwanga	Kigonigoni	40	Farmers, EWs

N.B. [a]EW and ST stands for extension worker and school teacher, respectively.

Table IV-19 Response of farmers to tastes of foods prepared with and without soybean flour (%)[a].

	Ugali	Uji	Maandazi	Chapati
Prefer with soybean flour	61	58	68	58
Prefer without soybean flour	32	39	26	32
No difference in taste	6	3	6	6

N.B. [a]Obtained from 31 farmers attended Soybean Promotion Seminar at Kigonigoni, Mwanga District on 1 November 1990.

At the moment, the local soybean market is quite small; it is quite difficult to sell a big amount of soybean to the market. Then, farmers are advised to grow soybean mainly for home consumption. When 2.6 ton of soybean was produced from the fallowed paddy plots in Lower Moshi Irrigation Project, the farmers could not sell it to the market. Neither of two cooperative unions in Kilimanjaro Region nor the National Milling Corporation are interested in this crop at the moment.

There have been some other requests from schools, missionaries, extension workers, and individual farmers on soybean seeds and they were provided accordingly.

Soybean extension work was once reported in "Farming Japan" in 1989 (Appendix IV-3). Soybean extension in Mwanga District and soybean extension in Rombo District were reported by respective extension workers at the Paddy and Upland Crops Training Course in 1990 as case studies of soybean extension at the village level; they are included in Appendix IV-4 (Soybean Extension at Village Level).

9. Discussion

Soybean was first introduced at Amani, Tanga, by Germans, in 1907 and during the second world war (1939-1947) British people tried to grow it in West Lake Region but their efforts were vain. The potentiality of soybean was realized later and a breeding program was initiated in 1955 and completed in 1963 at Nachingwea. Nachingwea varieties proved suitable for low altitude. To obtain strains suitable for medium- and high-altitude areas, introductions were made from Kenya, Uganda, the United States and Colombia in 1969 and 1971 (Mmbaga, 1974).

Most of the varieties developed at Nachingwea in the early sixties take about 4 months to reach maturity, while some introduced varieties take only 3 months. Among these varieties, Bossier has performed the best at most locations. It can perform fairly well under a wide range of climatic condition, ranging from low altitude to more than 1,500 m above sea level (Mbowe, 1988).

The advantages of Bossier variety were confirmed at the Trial Farm. It is a early maturing variety (mature in less than 100 days) which is one of the important plant characteristics of the crop because of short rainy season in the area. It takes 35 to 40 days to flower and 90 to 100 days to mature depending on the climatic and management conditions. Grain yield of 2.5 ton per ha can be expected under experiment conditions, while 2.0 ton per ha is possible in farmers' conditions with good management.

At the moment soybean research is conducted as a part of the National Grain Legumes Research Program which includes cowpea, green gram and soybean (and other beans except Phaseolus bean). Main station of the soybean research work is Ilonga Agricultural Research and Training Institute (IARTI) and some trials are conducted at other research institutes (i.e. Selian, Katrin, Gairo, Naliendele, Nachingwea) in collaboration with IARTI. Besides, it is also conducted at Sokoine University of Agriculture.

There is an opinion that "the legume research program could concentrate solely on Phaseolus beans for the high potential areas and cowpeas for the marginal areas" (Semuguruka, 1988). The opinion is probably based on the importance of kinds of beans in the country and budgetary and manpower limitations. At the moment, number of staff working for the National Grain Legumes Research Program is quite limited (i.e. two breeders, one agronomist and supporting staff at IARTI). In the previous years the amount of work for soybean had been less comparing with other beans (see TARO, 1988 for the volume of works conducted on different species of beans).

It is difficult to find reliable information on planted area of soybean in the country. According to FAO, soybean is annually planted (harvested) in an area of 5,000 ha and average production is 260 kg per ha (FAO, 1989). Based on the amount of soybean purchased by GAPEX (General Agricultural Products Export Corporation) and Cooperative Unions, main production areas are Mtwara, Lindi, and Morogoro Regions. There were some small amounts of soybean purchased in Kilimanjaro Region in 1978/79 (2 ton) and 1983/84 (5 ton) (see Table 8 in Appendix V-1).

Some people said that soybean was once becoming popular among farmers in 1970s but because of the government decision of paying a priority to cotton production, its production reduced. They said that soybean was invading the areas of cotton production, then it threatened the production of cotton. There was a reduction of the purchase of soybean in early 1980s.

In general, Bossier variety is poor in germination comparing with some other varieties (i.e. Orba) especially in the plot with big clod remaining after land preparation or with crust formation caused by rains after planting (before seedling emergence). Plant size of the variety is also small, and it is easily defeated by weeds in young seedling stages if weeding is not properly done. Purple seed stain disease was also found in 1989 dry season harvest. In other words, there is a need of replacing Bossier by other varieties in the future.

Grain yields of some of self-nodulating lines (and one not self-nodulating line) obtained in 1989/90 dry and 1990 rainy seasons are encouraging. Since they required about 10 to 14 days longer growth period comparing with that of Bossier, further trials on finding adaptability in the local environment (especially under rainfed conditions) are necessary.

One of the pre-requisites for high grain yield of soybean is to obtain adequate plant densities (depending on variety and soil fertility). Seedling emergence of the crop is adversely affected by either too dry or too wet soil conditions. It may be better to plant soybean densely in farmers' fields (until they become familiar with the crop) to ensure number of seedlings per unit area. Amount of the seeds mentioned in Soybean Production and Utilization Manual is about two times of the number of plants necessary at harvest.

Table IV-20 shows the best soybean yields obtained from upland (excluding 1990 data). The plant spacing of 60 cm x 5 cm (333,333 plants/ha) has been recommended for Bossier variety by the National Grain Legumes Research Program (Mbowe, 1988). Results of the cultivation trials of the variety at the Trial Farm indicated that higher grain yields (about 2.5 ton/ha) could be obtained if it was planted with Rhizobium inoculation and 30 kg of nitrogen per ha at the plant population of 250,000 to 300,000 plants per ha in upland field and that of 200,000 to 250,000 plants per ha in fallowed paddy plot (both in 50 cm between rows).

Table IV-21 shows different yield levels of Bossier variety theoretically obtained (based on the data at the Trial Farm). Under good management conditions, it produced grains yield of about 2.5 ton per ha. Following the growth period of 95 days and grain filling period of 57 days, the daily accumulation of grain weight was 26.3 kg per ha and 43.9 kg per ha for total growth period and grain filling period, respectively.

Table IV-20 Possibilities of soybean (Bossier variety) to produce 2.5 ton per ha on upland and fallowed paddy plots.

Fertilizer rate(kg/ha)[a]	Plants (,000/ha)	Pods/ plant	100 grain weight(g)	Grains per m^2	Grain yield (kg/ha)	Grain yield (g/plant)
Upland plot[b]						
1:RI,30N+30N	259	31.9	19.6	1,414	2,750	11.0
2:RI,30N	284	31.2	19.1	1,392	2,701	9.4
3:RI,30N	315	34.3	16.3	1,327	2,471	8.0
Fallowed paddy plot						
1:RI,30N	209	-	18.0	1,538	2,774	13.3
2:RI,30N	263	34.0	19.1	1,407	2,694	10.3
3:RI,30N	215	31.3	21.1	1,177	2,474	11.6
Possible combination to 2,500kg/ha						
	300	(31.0)	17.5	1,429	2,500	8.3
	250	(32.5)	18.5	1,351	2,500	10.0
	200	(34.0)	19.5	1,282	2,500	12.5

N.B. [a]RI stands for Rhizobium inoculation.
[b]Yield data of 1 and 2 were taken from First Quarter Report of Upland Crops Section in 1989/90.

Table IV-21 Different grain yield levels of soybean (Bossier variety) theoretically obtained.

Case	Grain yield (kg/ha)	Grain yield (g/plant)[a]	Growth period (days)	Growth period (kg/day)	Grain filling period (days)	Grain filling period (kg/day)
1	1,000	3.3	95	10.5	57	17.5
2	1,500	5.0	95	15.8	57	26.3
3	2,000	6.7	95	21.0	57	35.0
4	2,500	8.3	95	26.3	57	43.9

N.B. [a]Grain weight per plant at the plant population of 300,000 per ha.

One problem associated with the extension of soybean cultivation is seed supply. At the moment, there is no official organizations selling soybean seeds in Kilimanjaro and Arusha Regions. If soybean cultivation is to be promoted in the near future, initial seeds should be supplied by KADC. In this connection, soybean seed multiplication at the Trial Farm is quite necessary.

Another problem associated with soybean extension is short period of viability of the soybean seed after harvesting. As it is indicated in Table IV-22, the seed germination rate reduces considerably within the storage period of a year under ordinary storing conditions. To cope with this problem, soybean should be planted both in rainy and dry seasons; the seeds in a rainy season should be those produced in the previous dry season and those in a dry season should be obtained from the previous rainy season.

The result indicates that soybean production in low altitude areas (i.e. LMIP) is quite unstable unless new seeds are obtained from high altitude area (where soybean grows two times a year) or other sources (i.e. KADC) every year. Other alternatives are: (1) to plant soybean in a small scale under irrigated conditions in dry season for seed production, and (2) to have seed storage facilities. Since it is costly to manage the storage facilities, planting soybean for seed production in some of fallowed paddy plots in dry season may be more acceptable when there arise a need for soybean seeds in the future.

Table IV-22 Germination rates of soybean seeds (Bossier variety) harvested from 1988-90 rainy seasons and stored under room temperature at different periods (%)[a].

Date of of harvest	Weeks after harvesting												
	4	8	12	16	20	24	28	32	36	40	44	46	50
12/7/1988	97	85	76	62	55	36	46	33	39	-	-	-	-
10/7/1989	96	94	93	88	85	84	85	89	84	86	76	59	47
26/6/1990	94	91	90	87	81	90	80	-	-	-	-	-	-

N.B. [a]Figures are means of 4 replications. Some of the figures of weeks after harvesting are approximate values.

Soybean utilization to human diet is not popular in the country despite some introduction trials conducted in the last years (Daily News, 1987). There was a soybean project in Morogoro Region (cooperated with UNICEF) in 1970s. The main aim of the project were: (1) the promotion of soybean production primarily for human consumption at village level, and (2) the production of full fat soybean flour for use in the production of baby weaner food as well as for incorporation in the various dishes and recipes (Kaijage et al., 1986). Some Japanese volunteers also worked for soybean utilization (i.e. at Morogoro Livestock Training Institute). When the reporter visited the Institute in 1987, the equipment of soy-milk production was not working. There was some information on soybean utilization that it was used at hospitals and for animal feed. Topics on soybean seldom appear in the news paper in last 4 years, e.g. soybean utilization for animal feed (Daily News, 1990-1) and substitute for meat (Daily News, 1990-2). But there is no information on practical utilization cases of soybean for human diet.

The National Grain Legumes Research Program had initiated Soybean Village Production and Utilization Project in Kilosa District, Morogoro Region in 1989. It was stated that "Ignorance of most of Tanzanian small holder farmers on how to process soyabeans, has been one of the reasons why the crop is still unpopular. It is now a feeling that research to develop improved cultivars should go hand in hand with education to farmers on processing and utilization of the crop" (Myaka, 1990). This small project is quite similar to the one which KADP have conducted in the last 3 years.

At the moment, it is advised that soybeans produced by farmers are first consumed by themselves. Milling of soybean grains to flour is not difficult even at village level, because they mill maize to maize flour before making "ugali". Another way of consumption is to be used at schools, day care centers, and other organizations (i.e. KADC dormitory) where some amount of soybean flour is consumed at once. In either cases, high protein content (about 40%) of soybean will enrich the quality of food and improve the health of people who lack protein.

An oil extraction plant was constructed at KADC in 1990. It may be better to use this plant for the oil extraction from sunflower grains but not from soybeans. It is said that soybean contains about 20 percent of oil, and soybean oil in one of the most popular oils for cooking. However, the installed machine can recover about 50 percent of oil because it extracts oil by pressure (not by solvent which can extract almost 100% of oil). In other words, out of 100 kg of soybean, 10 kg of oil can be obtained by the plant. Then it is necessary to find the ways of utilizing the 90 kg of soybean cake produced every after 10 kg of oil production. As it was mentioned earlier, it can be utilized for animal feeds or protein can be extracted from the oil cake before it is used for animal feeds. Ways of soybean cake use should be practically confirmed before starting the oil extraction.

10. Toward Extension in the Future

Although soybean extension method was established in the last 5 years, it still requires supports from either Tanzanian Government or JICA for some more years. Materials for expanding soybean cultivation (i.e. seeds, Rhizobium inoculant) are lacking at the village level. Most of the farmers are still not familiar with soybean cultivation and utilization. Continuous supports for conducting Soybean Promotion Seminar (i.e. fuel for vehicles and travel allowance to the staff) are also necessary. Verification of soybean introduction in mixed farming (or intercropping) should be continued not only at the Trial Farm but also at the village level to find out the useful combination of soybean with other crops (including animal husbandry). If production of soybean increase in the future, other ways of utilization should be further studied.

Introduction of soybean has been based on locally available material and resources. Comparing with the investment for extension work on paddy cultivation in LMIP, a small amounts of input and manpower were spent for soybean introduction. It may also require only a small amount of investment for its extension work in the future.

It is a feeling of the reporter that soybean production in Kilimanjaro Region will be increased if there is a proper motivation and orientation of the farmers for cultivation and utilization. Tanzanian staffs at Upland Crops Section have accumulated enough knowledge and experience for soybean extension, but they can not do anything at the village level without material and moral supports from the higher authorities.

Recently, Tanganyika Farmers Association and FAO Fertilizer Program (both based in Arusha) became interested in soybean production and utilization. The former is conducting a study on soybean production for its utilization in animal feed. The later is trying to introduce the crop at the village level. There may be a possibility for the Section to work together with them.

11. References

Daily News. 1987. Dar professor produces: Palatable, faster to cook soyabeans). 27 February, 1987.

Daily News. 1990-1. Poultry company to use soya for animal feeds. 25 May, 1990.

Daily News. 1990-2. Soya beans substitute for meat. 19 September, 1990.

FAO. 1989. Production year book Vol. 43

Kaijage, P., S.A. Shayo, M. Fivawo, Y.B. Chabruma, R.Z.G. Tuvana. 1976. Evaluation and feasibility study of the soybean project in Morogoro - Tanzania.

Mbowe, F.F.A. 1988. National grain legume research program. In: Proceedings of the national workshop of national agricultural and livestock research in Tanzania. (Ed.) F.M. Shayo, A.N. Minjas, J.M. Haki, M.A. Kaale, F.E. Tollervey. United Republic of Tanzania and others. pp: 168-177.

Mmbaga, E.T. 1975. Highlights of Soybean Production in Tanzania. In: Soybean production, protection, and utilization --Proceedings of a conference for scientists of Africa, the Middle East, and South Asia, October 14-17, 1974, Addis Ababa, Ethiopia--, (Ed.) D.K. Whigham. INTSOY Series Number 6, University of Illinois at Urbana-Champaign. pp. 252-253.

Myaka, F.A. 1990. Paper presented at Annual Grain Legume Research Coordinating Committee Meeting held at Dodoma on 6 November, 1990.

Semuguruka, G.H. 1988. An appraisal of agricultural research in Tanzania. In: Proceedings of the national workshop of national agricultural and livestock research in Tanzania. (Ed.) F.M. Shayo, A.N. Minjas, J.M. Haki, M.A. Kaale, F.E. Tollervey. United Republic of Tanzania and others. pp: 37-49.

TARO (Tanzanian Agricultural Research Organization). 1988. Grain legume research highlights 1982-1986 --With reference to cowpea, greengram, soybean and Phaseolus bean--.

Appendix IV-1

REPORT OF SOYBEAN PROMOTION PARTY

Soybean is one of leguminous crops currently under cultivation trial at KADC in accordance with the Record of Discussions agreed by the authorities of Government of United Republic of Tanzania and Government of Japan on 14 February, 1986. This is a new crop in Tanzania (or in Africa), and most Tanzanian people are not familiar with this crop. In spite of its high nutritive value, only some limited Tanzanian people have experiences of cooking and/or eating soybeans.

A soybean promotion party was held at KADC on 13 December, 1986. The purposes of the party were: (1) to examine the possibility of introducing soybeans into Tanzanian diet and (2) to introduce some soybean products and cooking methods.

1. Soybean Foods Prepared

The following kinds of soybean foods were prepared for the party. Tanzanian dishes were ugali, uji, chapati, and maandazi. They were prepared with or without mixing soybean flour. There were respectively 3 kinds of ugali, uji, and maandazi: (1) without soybean flour, (2) with 10 percent of soybean flour, and (3) with 20 percent of soybean flour. Then 5 kinds of chapati: 3 kinds of the above mentioned, (4) without soybean flour but with eggs, and (5) with 10 percent of soybean flour and eggs. Other oriental (or Japanese) soybean foods were also prepared through cooperation of wives of the JICA's experts assigned to KADP. They were soybean curd, fried soybean curd, roasted soybean, roasted soybean flour, soybean plate, boiled soybean, soybean paste, fermented soybean, green soybean, and soybean curd by-product.

2. Preparation for the Party

Since it was a trial of introducing an exotic ingredient into the Tanzanian diet, the Tanzanian dishes with soybean flour were once prepared and tasted by staff at the Upland Crops Section prior to the party. In the preparation of ugali, that with 20 percent of soybean flour was more sticky comparing with the other two dishes. In the preparation of chapati and maandazi, those with 20 percent of soybean flour were some how difficult in making dough than others due to stickiness. Uji with 20 percent of soybean flour tended more water like. Preparation of soybean sprouts was initially intended. Due to the poor germination, however, it was not included.

3. Procedure of the Party

Brief explanation of soybean products was done at the beginning of the party. Then, the questionnaire (Table 1) was distributed to the participants. Procedure of food tasting was explained; participants were requested to taste each of the foods and to fill the form according to the taste. Only Tanzanian people (KADC staff and leaders of Water Users' Association of Lower Moshi Irrigation Project) were requested to participate in the tasting. For Tanzanian dishes, it was not mentioned that which of the samples contained soybean flour until the end of tasting.

4. Results and Discussion

Eighty-six sheets, 23 from KADC senior staff (so called counterparts) and 62 from others, were collected. Some parts in some sheets were not filled correctly (probably due to not familiar with this kind of food tasting).

Table 2 presents the results. All the Tanzanian foods, with or without soybean flour, were accepted by most of the participants. There was no distinct differences in taste between the KADC senior staff (some of them have experience of eating soybean foods in Japan) and others. On the other hand, the response to Japanese soybean foods ranged widely not only among the dishes but also within the dish. In general, fried soybean curd, roasted soybean flour, boiled soybean and soybean curd by-product received high acceptability, while fermented soybean and soybean paste received low acceptability.

The results show that the Tanzanian foods with soybean flour are not inferior in taste comparing with the original ones. It means that there is a possibility of accepting soybean flour added foods by the people. Some of the participants were interested in soybean because of its high nutritive value (much protein) comparing with Phaseolus bean (kidney bean) which is the main leguminous food in Tanzanian diet. They asked how they could obtain soybean seeds and how they could know the cooking methods.

Among Japanese foods, it is reluctant to introduce those with fermented process partly because of difficulty in producing soy-sauce and soybean paste and partly because of low acceptance of fermented soybean and soybean paste.

As the Section which concerns with soybean introduction, the results encourage the efforts of introducing this crop not only for cultivation but also for its utilization. It is necessary to check how soybean flour can be produced by different kinds of milling machines and how it can be mixed with maize flour (for ugali and uji) and wheat flour (for chapati and maandazi). It is also necessary to find other ways of soybean and soybean flour utilization in the Tanzanian diet.

Since it is rather difficult to find equipments for soybean processing especially in rural areas, it may be better to introduce processing (or cooking) methods with locally available equipments.

Table 1 Taste of food at soybean promotion party.
(Uonjaji wa chakula kwenye tafrija ya uenezaji wa zao la soya.)

Name (Jina): ______________________________

Number of soybeans in a cup (Idadi ya soya kwenye kikombe): ______

Kind of food (Aina ya chakula)		Good (Nzuri		Fair Wastani		Poor Mbaya)	Comment (Maoni)
Ugali	A: ----------------	1	2	3	4	5	--
	B: ----------------	1	2	3	4	5	--
	C: ----------------	1	2	3	4	5	--
Uji	A: ----------------	1	2	3	4	5	--
	B: ----------------	1	2	3	4	5	--
	C: ----------------	1	2	3	4	5	--
Chapati	A: ----------------	1	2	3	4	5	--
	B: ----------------	1	2	3	4	5	--
	C: ----------------	1	2	3	4	5	--
	D: ----------------	1	2	3	4	5	--
	E: ----------------	1	2	3	4	5	--
Mandazi	A: ----------------	1	2	3	4	5	--
	B: ----------------	1	2	3	4	5	--
	C: ----------------	1	2	3	4	5	--
Soybean curd: Tofu ---------------		1	2	3	4	5	--
- with soy sauce -							
Fried soybean curd: Atsuage -----		1	2	3	4	5	--
- with soy sauce -							
Roasted soybean: Irimame --------		1	2	3	4	5	--
Roasted soybean flour: Kinako ---		1	2	3	4	5	--
A: With Ugali --------------		1	2	3	4	5	--
B: With Uji ----------------		1	2	3	4	5	--
C: With rice ---------------		1	2	3	4	5	--
Soybean plate: Mameita ----------		1	2	3	4	5	--
Boiled soybean: Nimame ----------		1	2	3	4	5	--
A: Japanese style ----------		1	2	3	4	5	--
B: With tomato sauce -------		1	2	3	4	5	--
Soybean paste: Miso -------------		1	2	3	4	5	--
- as miso soup -							
Fermented soybean: Natto --------		1	2	3	4	5	--
- with soy sauce -							
Green soybean: Edamame ----------		1	2	3	4	5	--
Soybean curd by-product: Okara --		1	2	3	4	5	--

What is the best taste food?
(Ni chakula kipi kizuri zaidi kwa upande wako?)

What are not acceptable foods?
(Ni chakula kipi ambacho hukukipendelea?)

Any suggestions/opinions on soybean utilization in the diet?
(Tao mapendekezo au mawazo kuhusiana na matumizi ya soya kwenye mlo?)

Table 2 Taste of soybean foods (%)[a].

Kind of food	Good[b] 1	2	Fair[b] 3	4	Poor[b] 5
Ugali					
Without soybean flour	31(24)	21(24)	33(33)	10(10)	6(10)
With 10% soybean flour	32(36)	35(45)	24(14)	4(5)	4(0)
With 20% soybean flour	45(20)	21(52)	21(19)	7(10)	6(0)
Uji					
Without soybean flour	54(37)	21(37)	10(11)	6(5)	10(11)
With 10% soybean flour	40(35)	31(35)	29(30)	0(0)	0(0)
With 20% soybean flour	50(52)	26(24)	20(19)	5(5)	0(0)
Chapati					
Without soybean flour	36(19)	32(52)	20(5)	6(14)	6(10)
With 10% soybean flour	41(29)	21(14)	23(43)	14(14)	2(0)
With 20% soybean flour	34(27)	30(41)	24(23)	12(9)	0(0)
W/o soybean but with eggs	31(30)	36(35)	13(20)	14(15)	6(0)
With 10% soybean and eggs	35(30)	34(43)	18(22)	4(4)	9(0)
Mandazi					
Without soybean flour	44(59)	34(18)	16(14)	4(5)	1(5)
With 10% soybean flour	32(18)	47(59)	16(18)	5(5)	0(0)
With 20% soybean flour	40(23)	25(36)	26(36)	4(5)	4(0)
Soybean curd	27(30)	27(13)	25(30)	7(13)	15(13)
Fried soybean curd	54(57)	20(35)	13(4)	5(49	9(0)
Roasted soybean	29(27)	24(18)	26(27)	4(14)	16(14)
Roasted soybean flour					
Served with Ugali	40(26)	28(30)	16(17)	5(13)	11(13)
Served with Uji	43(36)	35(36)	13(9)	3(5)	7(14)
Served with rice	59(43)	23(35)	11(13)	6(9)	0(0)
Soybean plate	53(50)	24(32)	15(18)	0(0)	6(0)
Boiled soybean					
Japanese style	53(39)	22(35)	18(17)	3(4)	4(4)
With tomato source	53(55)	32(32)	11(9)	0(0)	5(5)
Soybean paste	13(27)	22(18)	27(23)	12(23)	26(9)
Fermented soybean	6(4)	6(9)	13(17)	15(22)	59(48)
Green soybean	25(21)	21(32)	28(32)	13(11)	13(5)
Soybean curd by-product	52(41)	24(12)	19(41)	2(6)	3(0)

Good taste foods[c] - Soybean plate: 4(2), Fried soybean curd: 3(3),Green soybean: 2(2), Boiled soybean: 2(1), Roasted soybean flour: 2(1)

Poor taste foods[c] - Fermented soybean: 16(9), Soybean Paste: 5(3), Roasted soybean: 3(1), Green soybean: 2(0), Soybean curd: 2(1)

N.B. [a]Based on answers of 85 persons (23 KADC senior staff).

N.B. [b]Figures in parentheses are percent of KADC senior staff reported.

[c]Figures are number of persons (number of KADC senior staff in parentheses) reported.

Appendix IV-2

SOYBEAN CULTIVATION AND UTILIZATION MANUAL

Upland Crops Section
Kilimanjaro Agricultural Development Project (KADP)

I. BASIC SOYBEAN CULTIVATION PRACTICES

1. Environmental Requirements

Availability of rainfall or irrigation water is the critical factor for soybean cultivation in Kilimanjaro Region. Soybean requires moist but not wet soils for at least 80 days for obtaining good grain yield. It should be planted in rainy season in the soils where maize generally produce good yield. Supplemental irrigation is necessary if rainfall is limited. Soybean cultivation in hot season is risky because of adverse effects of high temperature and low moisture availability.

2. Variety

Bossier is the only recommended soybean variety for low altitude areas in the country. It flowers about 35 days after sowing, matures about 95 days after sowing, and produces about 2.5 ton of grains per ha under good management.

3. Land Preparation

Start land preparation at the end of dry season. It can be done almost same as for maize, but big clods should be destroyed into small sizes for good and uniform germination. Pay attention for leveling for furrow irrigation fields; drainage for water-logged portions.

4. Planting

Start planting after the onset of rainy season (cool season); after the soil holds enough moisture for germination. Plant 2 to 3 seeds at the spacing of about 50 to 60 cm between rows and about 10 cm within rows. For furrow irrigation fields, construct ridges every 100 to 120 cm and accommodate 2 planting rows between the ridges. Then, do planting just along the both sides of ridges to ensure water supply to the seeds and seedlings. Planting depth should be 3 to 4 cm, and about 70 kg of seeds per ha is necessary.

5. Fertilizer Application

Apply 30 kg of nitrogen per ha (65 kg of urea per ha) just after the seedling establishment (about 2 weeks after planting); apply it between rows and mix with soils. If *Rhizobium* inoculant is available, inoculate the seeds with it just before planting.

6. Field Management

Under irrigable conditions, irrigate the field whenever necessary (i.e. at planting and once or twice per week), but not to apply too much water. Seed germination and seedling growth become poor under water-logged conditions because of limited oxygen supply to the root. Availability of soil water influences the soybean grain yield; performance of soybean plants is always poor under either too dry or too wet conditions.

Weeding is one of the most important practices in soybean cultivation. At least 2 times of weeding are necessary: first weeding at 2 weeks after planting and second weeding at 4 weeks after planting. Weeds compete with soybean plants for water, nutrients and sunlight, and good grain yields can not be obtained without proper weed control. After flowering, soybean plants suppress weeds if they cover soil surface well.

Although many insects and diseases are known for soybean, they are not serious in the area at present except purple stain seed disease. Continuous soybean cultivation in the same plot usually reduces the yield due to soil borne pests (i.e. nematodes) and diseases. It is better to plant soybean in rotation (not plant soybean in the same plot continuously).

7. Harvesting

As soybean plants approach maturity, the leaves turn yellow and drop, pods become dry and seeds lose moisture rapidly. Soybean plants should be harvested (through uprooting or stem cutting) when pods become yellow and moisture content becomes low enough for handling and storage. After harvesting, thresh them either mechanically or manually, then store seeds in dry and cool places.

If some portions of the harvest are to be used as seeds for next cultivation, they should be carefully processed, well dried, and kept in cool and dry place. Soybean seeds easily lose their viability under hot and humid conditions. There is no serious insect damage observed during the storage period.

II. FOOD MIXED WITH SOYBEAN FLOUR

1. Ugali with Soybean Flour

1) Ingredients: Maize flour and soybean flour.
2) Cooking Procedure
   (1) Mix maize flour and soybean flour at the rate of 9 cups of maize flour and 1 cup of soybean flour. Total amount of the mixed flour depends on family size.
   (2) Boil water for ugali.
   (3) Make some porridge (make it thick) with water, then stir into boiling water. Leave it until well boiled.
   (4) Add the mixed flour little by little to boiling water as common ugali cooking.
   (5) When it is well cooked, serve it (with soup).

2. Uji with Soybean Flour

1) Ingredients
   (1) Maize flour and soybean flour.
   (2) Sugar, fresh milk (or yoghurt), and margarine (or cooking oil: optional).
2) Cooking Procedure: Example of making uji with 1 cup (200 ml) of maize flour.
   (1) Prepare 1 cup of maize flour, 1/4 cup of soybean flour, 1/2 cup of sugar, 2 cups of fresh milk (or yoghurt), and

2 table spoons of margarine (or cooking oil): optional.
(2) Add little amount of water in fresh milk (if use yoghurt add some amount of water) and boil.
(3) Make some porridge (make it thick) with water, then put it into boiling milk. Leave it until well boiled.
(4) While it is boiling, add sugar and margarine (cooking oil) if you prefer.
(5) Move the porridge from the fire and add yoghurt. Serve while hot.

3. Chapati with Soybean Flour
1) Ingredients
(1) Wheat flour and soybean flour.
(2) Cooking oil (or fat), egg (optional), and salt.
2) Cooking Procedure: Example of making chapati with 4 cups of wheat flour (200 ml/cup).
(1) Prepare 4 cups of wheat flour, 1/2 cup of soybean flour, 1 cup of cooking oil (or fat), one egg, and little salt.
(2) Mix wheat flour and soybean flour well.
(3) Break one egg and mix up in 2 cups of water.
(4) Make dough of the mixed flour using egg mixed water. Add small amount of salt while making dough.
(5) Cut the dough into pieces and make flat round shape (size of the piece depends on the size of frying pan to be used).
(6) Spread oil (or fat) on the frying pan, then fry the dough of flat round shape.

4. Maandazi with Soybean Flour
1) Ingredients
(1) Wheat flour and soybean flour.
(2) Yeast, sugar, milk (optional), and cooking oil.
2) Cooking Procedure: Example of making maandazi with 6 cups of wheat flour (200 ml/cup).
(1) Prepare 6 cups of wheat flour, 1 cup of soybean flour, 1 table spoon of yeast, 1/2 cup of sugar, 3 cups of cooking oil, and 3 cups of fresh milk (if you prefer).
(2) Mix wheat flour and soybean flour well.
(3) Raise yeast.
(4) Make dough of the mixed flour with water (or fresh milk). Add sugar while making dough (amount depends on your taste.
(5) Roll the dough and cut it for desirable size and shape. Leave the cuts for 1/2 hour for raising yeast.
(6) Pour cooking oil into the frying pan and heat it.
(7) Do deep frying of the cuts.

5. Cautions for Soybean Grain Cooking

Prior to cooking soybean grains, they should be soaked in clean water until they absorb enough water. The soaking period should be about 6 hours; soybean will have swollen to about twice of its size. Many people complain about the hardness of soybean even after cooking (boiling). It is due to short or no time of soaking soybeans before cooking. After the soaking, soybean are ready to be boiled with other ingredients commonly used by people.

Appendix IV-3

EXTENSION WORK ON SOYBEANS IN TANZANIA*

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1. Kilimanjaro Agricultural Development Project (KADP)

The Kilimanjaro Agricultural Development Project (KADP) is a technical cooperation program mainly for the establishment and extension of paddy cultivation techniques among farmers in the Lower Moshi Irrigation Project (LMIP) area. This area was developed by the funds offered by Japan as a part of the country's cooperation with the Tanzanian government in its integrated development plan of Kilimanjaro Region. In June 1986, I was assigned to this Project as an expert in upland farming. Since then, I have been working with my Tanzanian colleagues for technical cooperation relating to soybeans and vegetables included in the Record of Discussions of KADP as well as to maize, the main crop in the Region.

2. Those Who Have Not Taken Soybeans

Soybeans have not been included in the Tanzanians' list of foods. It is rear that we can find this crop in the main market of Dar es Salaam, not to mention in those of Moshi and Arusha in northern Tanzania. A dealer in Dar es Salaam market, who have dealt with soybeans, said to me: "Soybean? I don't care to sell that sort of stuff again. It took me much time to get rid of them." Not only Tanzanians; Indians, including Tanzanians of Indian decent, who form the largest group of foreign residents in Tanzania, also have no habit of eating soybeans. In general, Tanzanians introduce a wide variety of legumes, mainly kidney beans, into their dietary life, but soybeans are an exception. Most peoples in Tanzania have never seen nor tasted this bean.

3. In Search of Information on Soybeans

My work started with the collection of information on soybeans in Tanzania and planning of soybean cultivation and utilization. I visited soybean researchers at the Ilonga Agricultural Research Institute and at the Sokoine University of Agriculture to collect data and soybean varieties. I also went to a Livestock Training Institute which had once produced soya milk, factories making oil from sunflower and cotton seeds, and a Cooperative Union in the area where some soybeans were produced. These visits helped me obtain information not only soybeans but on agriculture in the country as a whole as well. I could also build up cooperative relationship with Tanzanians which facilitated my activities thereafter.

In the past, Tanzania had exported a small volume of

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*From "Farming Japan" (Vol.23-5, 1989), pp:55-58

soybeans, but this crop is not the country's major farm product. One of the oil factories I visited had manufactured oil from soybeans about ten years ago, but now does not produce it because it is difficult to obtain a sufficient supply of soybeans. They said that the government-supported producers' price of soybeans was lower than that of other legumes and that research and extension efforts did not give much stress on this crop. But I felt that most people involved in soybeans were much interested in this crop since it had a great possibility in the future.

4. Toward the Establishment of Soybean Cultivation Techniques

After collecting fundamental data, I decided to direct my efforts to the establishment of soybean cultivation techniques by conducting experiments on varieties, fertilizer rates, plant spacing and others. I inoculated soybean seeds with the Rhizobium bacteria brought from Japan, but this trial did not work well. In 1987, the Sokoine University of Agriculture began the production of Rhizobium bacteria on an experimental bases, and from the rainy season of 1988 on, we could obtain these bacteria from the University. When I first found nodules grown on soybean roots, I felt that there was a possibility of expanding soybean cultivation area in this country.

After about three years of cultivation trial, we reached a stage where we could expect a grain yield of 2.5 tons or so per hectare of field. The experiment results were affected by poor land leveling and problems of field management. The inoculation of Rhizobium bacteria, however, seems to help increase the yield by about 400 kilograms per hectare. The optimum cultivation practices will be to plant Rhizobium bacteria inoculated seeds of the Bossier variety at the plant spacing of 50 centimeters between rows, 10 centimeters between hills and 2 plants per hill. Nitrogen fertilizer application at the rate of 30 kilograms per hectare is also effective in the area where we have enough rain or irrigation water. Soybeans are less susceptible to diseases and insects than other legumes, and will be able to compete well with them in cultivation.

5. Toward the Establishment of Soybean Utilization

In December 1986, a soybean promotion party was organized and a total of about 100 people were invited from the KADP staff and leaders of the Water Users' Association for LMIP. At the party, to study the possibility of soybean being accepted by Tanzanians as daily food, participants were served with Japanese soybean foods and Tanzanian dishes with and without soybean flour added. A noteworthy fact was that the participants liked ugali, Tanzanian common food made from maize flour, which was cooked with soybean flour added.

If Tanzanians accept ugali to which soybean flour is added at a ratio of 10 to 20 percent, the consumption of soybeans will increase greatly. Because soybeans contain much protein, soybean-added ugali will have a higher nutritious value. Ugali with soybean flour was also accepted favorably by the participants in KADP training courses. They said that this ugali was softer and more pleasant to the palate and sweeter than ordinary one and that is whetted their appetite even if it became cool down.

6. Toward Promotion of Soybean Cultivation

To promote soybean cultivation, we prepared 3,000 copies of the "Soybean Cultivation and Utilization Manual," a booklet in Swahili. This manual aimed to introduce Tanzanian farmers to the methods of raising and using soybeans effectively.

In 1987 and 1988, we established and cultivated a soybean extension plot of 1 hectare in the pilot farm. In 1989, another extension plot of 1.5 hectare in the fallowed paddy plots in the LMIP area in the rainy season. Most of the soybeans harvested in these plots in 1987 and 1988, which totaled to 380 kilograms and 1,250 kilograms, was bought by an elementary school to use for school lunches. In 1989, the school planted soybeans in part of its farm.

In 1988, we began soybean promotion activities in several villages in Kilimanjaro Region. Soybean promotion seminars have been held in four villages, and the number of farmers and extension workers who have come to be interested in soybeans through sampling soybean-based foods increasing. We tell them: "Just as you have not taken soybeans, most people do not know how to eat this legume. Because of this, soybeans do not sell well on the market. So, please have your relatives and friends sample soybean foods to promote this crop."

7. Future Tasks

Tanzanian people are not accustomed to soybean both as a crop and as a food. So, it will take much time for soybeans to take root among them. In the country's lowland area, it is often impossible to secure a sufficient supply of irrigation water, and any harvest of this crop cannot become possible due to drought. As soybean production increases, there will arise the need of finding market.

In Tanzania, transport cost is fairly large comparing to the producers' prices of crops. Thus, the soybeans produced in Kilimanjaro Region should preferable be consumed within the Region as much as possible. In addition, since not many means of food processing are now available in the country, the best strategy will be to try to consume soybeans at low level of processing. We can use maize flour mill, which have widely been used in Tanzania, for the production of soybean flour. Thus, we will be able to recommend the cultivation of this crop not only to farmers but to the consumption at elementary schools and hospitals. Cooked soybeans are popular among elementary school students, but more firewood is needed to cook soybeans than kidney beans. In the future, we can consider their use for oil production, soya milk, feed and other applications. At present, however, our goals are to expand cultivation areas and introduce Tanzanians to soybean foods so that this crop may come to stay in their dietary life.

Appendix IV-4

SOYBEAN EXTENSION AT VILLAGE LEVEL

I. INTRODUCTION OF SOYBEAN IN MWANGA DISTRICT, KILIMANJARO REGION

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1. Preface

Before 1987 soybean was not found in Mwanga District, neither at farmers' plots nor at the market. In 1987 the crop was introduced in the District through extension workers who attended the Upland Crops Cultivation Training Course at KADP (Kilimanjaro Agricultural Development Project). Since then, interested extension workers conducted several cultivation trials at their respective demonstration plots to raise farmers' awareness. At the same time, seeds together with information of how to cultivate and utilize soybean have been disseminated to some number of farmers through farmers' group training.

Although it is a new crop in the District, it has been attracting people (farmers). This report is prepared to show a case study of how soybean introduction has been conducted in Mwanga District and what are constraints of its introduction at the village level.

2. People's Awareness on Soybean

Many farmers have been requesting for seeds of soybean after they saw soybean plants at the demonstration plots and heard it from some other farmers who had planted and tasted. According to the farmers, the crop has advantages of (1) adaptability to wide range of altitude, (2) relatively tolerant to drought, (3) less attack of diseases and insects comparing with other leguminous crops, and (4) alleviate nutritional problem of children through mixing its flour with maize flour prior to cooking uji, ugali, etc. However, they also point out a disadvantage of soybean; it requires longer cooking time comparing to other beans (i.e. Phaseolus beans) when its grains are cooked.

3. Climatic Conditions of the District

Mwanga District is classified into three agro-ecological zones: eastern low altitude zone, high altitude zone, and western low altitude zone. Based on the cultivation/demonstration trials conducted at different locations, soybean is adapted to all the climatic conditions especially to the eastern low altitude zone. Relatively small amount of rainfalls in the western zone, as a result of rain-shadow caused by local topography and wind direction, apparently affects the performance of soybean in the zone. It is a relatively dry area except Kileo where there is a river running and seasonal flood covers part of the area. In addition to dryness, soils in the area are poor in nutrient and water holding capacities.

There is more than enough rainfall, in general, for soybean cultivation in the high altitude zone (Ugweno and Usangi). Due to sloping feature of the land, however, the surface soil is subject to erosion. Part of the eroded soils/nutrients are deposited in the eastern low altitude area following the natural drainage system. In three year data obtained at Lomwe Secondary School (about 1,200 m above sea level), mean amount of rainfall in Masika (main rain) season is 880 mm (ranged 460-1,600 mm) and it is 630 mm (ranged 400-860 mm) in Vuli (short rains) season. Daily mean maximum temperature is 25.3^{o}C and mean minimum temperature is 20.0^{o}C.

4. Soil Conditions of the District

Soil fertility changes from place to place in the District. Farmers are told to use farm yard manure and fertilizer depending on ability and availability. However, green and compost manure are not widely applied yet.

Where farm yard manure is not applied for some reasons, chemical fertilizer, supplied by the cooperatives, is usually used. The farmers are told to apply 40-60 kg of P_2O_5 per ha and 50-60 kg of K_2O per ha at planting. Top dressing of 25 kg of N per ha is recommended under good climatic and management conditions.

5. Soybean Cultivation

(1) Variety

Bossier is the only variety introduced in the District. It is a recommended soybean variety in Tanzania for relatively short rainy season areas. It has characteristics of (1) resistant to lodging, (2) resistant to shattering, (3) early maturity, and (4) tolerant to drought, insect and pest to some extent.

(2) Land Preparation

It is important that the land should be prepared early and where possible before the onset of rains because it is difficult to work with the soils after heavy rains. Ploughing of 15-20 cm in depth is enough for a fertile land. Construction of ridges depends on farmers' preference and feature of the land. It will be very suitable for sloping land to prevent erosion of soils and nutrients after heavy rains and to keep small amount of rains.

(3) Time of Planting

The District experiences two rain seasons: "Masika" (main rains) season normally lasts from February to May and "Vuli" (short rains) season from October to mid-December. It has been observed that early planting of soybean in Masika season is not so good because the soybean plant matures before the end of the rains, hence rotting of pods becomes a problem. In general, 2 weeks after the onset of Masika and just after the onset of Vuli are appropriate times for soybean planting in the District. Approximate dates of soybean planting for different areas in the District are listed in Table 1 (although there are some changes of onsets of rainy seasons year after year).

Table 1 Approximate dates of soybean planting in different agro-climatic zones in Mwanga District.

Agro-climatic zones	Masika (main rains)	Vuli (short rains)
Eastern low altitude (Kigonigoni)	9-22/February	10-15/October
Western low altitude (Mwanga, Kileo, Lembeni)	13-15/February	10-15/October
High altitude (Usangi, Ugweno)	15-28/February	15-20/October

(4) Inoculation

Water and nitrogen are the most commonly encountered limiting factors in crop production. There are three ways of increasing soil nitrogen: (1) by adding organic matter, (2) by adding nitrogenous fertilizer, and (3) by biological nitrogen fixation. The biological nitrogen fixation is significant because it does not require any cost if there are appropriate soil microorganisms which conduct symbiotic relationship of nitrogen fixation with plants.

Rhizobium are bacteria capable of forming nodules on legume roots. However, not just any Rhizobium will form nodules on any legume. For this reason, Rhizobium are classified into species or inoculation groups on the basis of the legumes that they infect. In other words, the bacteria (*Rhizobium japonicum*) forming nodules on the roots of soybean do not form nodules on the roots of other beans (i.e. Phaseolus bean, cowpea, green gram). Besides, there are cases that not adequate races or not enough densities of Rhizobium bacteria are in the soil especially when a certain leguminous crop is newly introduced to an area.

Bossier variety usually does not form nodules on the roots when it is planted without inoculation of *Rhizobium japonicum* in the country. The Rhizobium inoculant for soybean is produced at the Sokoine University of Agriculture, and it can be obtained through KADP. The inoculation procedure is as follows:

(a) Rhizobium inoculant obtained should be kept in cool and dark condition until the date of inoculation.

(b) One package of inoculant is enough for 50 kg of seeds (good for 0.5 ha).

(c) Place seeds in a container (tray) and add a small amount of water (for adhesion).

(d) Add inoculant and mix with seeds.

(e) Start planting immediately after the inoculation. The seeds should be kept in shade; as the bacteria are killed by direct sunshine, hot temperature, and dryness.

(5) Planting Depth and Plant Spacing

Place the seeds about 3 cm in depth. The soil should not be too dry or too wet. Too deep planting not only retards germination but also decreases germination rate. If rains are not enough (i.e. the western low altitude zone), cover the seeds with more soils.

Many farmers in the District do not plant crops dense enough to meet appropriate plant density. Intercroppings of different crops (i.e. maize and common beans) are also popular especially in high altitude areas. To cope with their farming practices, two plant spacings of soybeans are recommended to the farmers: one for sole planting and the other for intercropping.

The plant spacing of 50-60 cm between rows, 10 cm within rows and 2 plants per hill is recommended for sole planting; 3 seeds should be planted taking germination rate into account. The plant spacing of 75 cm between rows and 35 cm within rows are generally recommended for maize, sunflower and sorghum. Then it is temporally advised to accommodate 3 rows of soybean plants every after 2 rows of either maize, sunflower or sorghum plants; 150 cm in width each for soybean and the companion crop. The appropriate plant arrangement including planting periods of different crops in intercropping should be further checked.

Farmers in the District should understand that planting at random has disadvantages of (1) reduces labour efficiencies for some operations (e.g. weeding, fertilization, spraying, harvesting) and (2) uneven plant spacing, although it has an advantage of finishing planting work in a short time. It is also necessary to check whether crop rotation (including soybean) or intercropping (with soybean) is beneficial in terms of production and management.

(6) Weed Control

Different places posses different crop-weed competitions in the District. For instance, weeds grow faster in Kigonigoni and Butu Ugweno compared to Langata area. It grows faster in Kileo compared to Mwanga and high altitude areas.

Few number of farmers use herbicide in the District; more than 90 percent of them practice hand-hoe-weeding. The use of animals for weeding, introduced through "Mixed Farming Integrated Project" at Kigonigoni, is being practiced by a small number of farmers at the moment.

It is important for soybean plots to be weed free, especially at early stages, because weeds compete with the crop in nutrient, water and light. Some weeds may also play as host of some diseases and pests. First weeding should be done about 2 weeks after germination; second weeding will depend on the growth vigour of weeds.

(7) Harvesting

Harvesting of soybean can be done when the pods change color from green to yellow. Common harvesting way is uprooting or cutting the base of the stem. Late harvesting reduces the grain yield in quantity (through shattering) and in quality (through purple seed stain and other diseases).

6. Soybean Utilization

Since it is a new crop not only for cultivation but also consumption, extension of soybean cultivation has been conducted together with introduction of its utilization through providing pamphlets and explaining cooking methods. However, mis-handling of crop has been observed; many people complained after cooking soybean grains for the hardness and fuel consuming. Incorporation of soybean flour into ordinary foods is the main course of soybean utilization in the District. Milling facilities for maize available in the locality can be used for milling soybean, hence there is no need of additional equipments. There are several ways of soybean cooking both introduced by the extension workers and developed by people themselves. Soybean Cultivation and Utilization Manual (in Kiswahili) prepared by KADP provides general ideas on how to use soybean in diet.

For cooking uji or ugali, 1:3 ratio of soybean and maize flour is commonly practiced. It is better to start cooking soybean flour first then add maize flour for minimizing cooking time. The same rate of soybean and wheat flour is used for cooking chapati or maandazi.

For cooking soybean grains, they are soaked for some period (e.g. overnight) before cooking. After soaking, the grains become swollen twice of the original size. This practice reduces the cooking time and fuel consumption. Besides, green pods are boiled, then salt is added prior to eating young soybeans out of the pods. Matured soybean grains are roasted on the oiled frying-pan before they are served.

7. Advantages of Soybean Cultivation and Utilization

Soybean is not fully exploited its potentialities of cultivation and utilization in the District at the moment. However, advantages of soybean introduction can be mentioned as follows:

(1) Ability of utilizing atmospheric nitrogen through symbiotic nitrogen fixation.
(2) Less attack by insects and disease comparing to other kinds of beans.
(3) Early maturity, therefore escaping from the early stoppage of rainy season in addition to adaptation to wide agro-climatic zones.
(4) Easier cultural practices and storing comparing to other kinds of beans except poor germination under some

conditions.

(5) Nutritional improvement to humans by providing high protein (soybean) foods.

(6) To be used as a protein supplement to dairy cattle and other domesticated animals.

8. Constraints of Soybean Introduction

Soybean is just one of commodity crops and it has not being eaten by most of the people in the country. Constraints of soybean introduction are as follows:

(1) Low income of farmers to meet initial production costs.

(2) Lack of reliable agriculture policy to guide the crop.

(3) Poor awareness of farmers about the crop.

(4) Lack of seeds and authorized seed dealers at village level.

(5) Poor understanding of people on soybean for its nutritional value.

(6) Limited number of extension workers and progressive people staying in villages for dissemination of knowledge.

(7) Poor means of transport to and from the field. On foot transport limits production of farmers and contribution of extension workers. In the District, one extension worker covers approximately 6,000 people.

(8) Insufficient cooperation of farming groups to rehabilitate natural/irrigation streams.

(9) Erratic rains let farmers to loose initiatives because of seed rotting and additional land preparation work.

(10) Lack of or not timely supply of input materials for farming.

(11) Low prices of farm products.

(12) Lack of teaching materials (i.e. audio visual aids) to elaborate the improvement of farming practices.

(13) Lack of competitive farming groups and institutions in the District.

(14) Poor initiatives of extension workers for solving farming problems.

(15) Top-to-down implementation of agricultural extension.

9. Results of Soybean Cultivation Trials

Since 1987 Vuli season, several cultivation trials have been conducted for the purpose of finding the possibility of soybean introduction in the District. The author, however, has not collected all information of the trials because he stays at Usangi and it is not easy task for him to collect all of them. Results of cultivation trials are presented in Table 2.

It was planted in Demonstration Plot, Schools' farms, Church's farm and farmers fields. Performance of the crop in grain yield was not always attractive due to poor germination and seedling establishment.

10. Discussion

Soybean is a new crop not only production wise but also utilization wise in the District (or in the country). Then how to cook soybean has been simultaneously introduced to the schools and farmers where the crop has been grown. Those who have tasted soybean become interested in the crop because soybean flour mixed foods (i.e. <u>ugali</u>, <u>uji</u>, <u>chapati</u>, <u>maandazi</u>) not only improve nutrition but also they are better in taste.

Two children admitted at Kilaweni District hospital for malnutrition were treated with soybean flour mixed <u>uji</u> (porridge) in 1989. The <u>uji</u> improved their nutritional status, then they recovered from the malnutrition.

Table 2 Results of soybean cultivation trials in Mwanga District.

Date of planting	Site	Area (m^2)	Cultural practices	Grain yield (kg/plot)	Grain yield (ton/ha)
23/11/87	Usangi	400	5 kg of SA	-[a]	
23/11/87	Usangi	121	5 kg of urea	-	
24/11/87	Usangi DP	100	2 kg of SA	-	
24/11/87	Usangi	100	2 kg of SA	-	
24/11/87	Usangi	100	2 kg of urea	-	
4/3/88	Usangi	400		-	
5/3/88	Usangi	400		-	
11/3/88	Usangi	400		30	0.75
15/11/88	Usangi	400	With Rhizobium	-	
16/11/88	Usangi	400		-	
7/3/89	Kivindu PS	525		26	0.50
17/11/89	Lomwe SS	900	With Rhizobium	120	1.33
18/11/89	Usangi	200		18	0.90
19/11/89	Kividu LP	400		15	0.38
22/2/90	Kigonigoni	6,000		120	0.20

N.B. [a]- indicates no yield data obtained.

One of the constraints in soybean extension in the District is lack of seeds. Because of poor marketing for soybean, it is advised to plant it for home consumption only. However, the farmers sometimes even eat all the soybeans produced without storing seeds for next cultivation. As a result, soybean seeds are sold at the price of 100 shilling per kg.

Apparently, soybean is more adapted in Vuli (short rains) season comparing to Masika (main rains) season. Then, seeds produced in the previous Vuli season are used in the following Vuli season cultivation. This creates the problem of poor germination because soybean decreases its germination ability within relatively short period after harvesting. For solving these seed problems the extension workers are trying to set up a seed farm at Lomwe Secondary School.

Rhizobium inoculant is currently produced at Sokoine University of Agriculture, and it is also stored at KADC. If soybean cultivated area expands, it may be necessary to find the solution of how the Rhizobium inoculant can be acquired (or provided) until some areas build up the population of appropriate Rhizobium bacteria.

Directions of soybean extension were discussed among the concerned extension workers, teachers, and KADP staff when Soybean Promotion Seminar was held at Lomwe Secondary School (on 15/11/1989). To increase people's awareness on the crop, it may be better to introduce not only to farmers but also to pupils and students. Further cooperation between extension workers and KADP staff is necessary for the dissemination of soybean cultivation and utilization in the rural community.

It seems that there is no clear policy on soybean introduction either at the District level or at national level. Since it is a nutritious crop which improves nutritional status of people with comparatively low cost, the Government should pay more attention to this crop. Introduction of soybean in Mwanga District already providing a positive impact and receiving an active response to and from the people.

11. Future Prospect

(1) Extension of the Message

Soybean cultivation area is increasing yearly and seasonally. Therefore, we expect that more number of extension workers will become interested in the crop to disseminate its cultivation and consumption knowledge to farmers. Soybean Promotion Seminar for extension workers and interested farmer groups may help the dissemination.

(2) Seeds

To cope with seeds demand the District is supposed to initiate three seed production centers in different agro-ecological zones. At the moment, Lomwe Secondary School and Lomwe Primary School are interested and they include soybean in their priority lists. It is proposed to have other seed centres at Kigonigoni (Mixed Farming Project) and Kisangara Sisal Estate.

(3) Direction

Although soybean provides a variety of foods, firstly it should be utilized as whole grain or flour not only because of its nutritive value but also because of minimizing extra processing. Information on soybean foods should be sent to schools, nursery schools and Mother Child Health Care Centers.

12. Acknowledgment

The District is indebted to the Upland Crops Section of KADP for its technical guidance and material support for the introduction of soybean. The author would like express his sincere gratitude to the staff of Upland Crops Section for their assistance during the preparation of this report.

II. INTRODUCTION OF SOYBEAN IN ROMBO DISTRICT, KILIMANJARO REGION

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1. Preface

Introduction of soybean in Rombo District was a result of Upland Crops Cultivation Training Course conducted at KADP (Kilimanjaro Agricultural Development Project). I attended the training course in 1987 for two months. Participants of the course were 21 agricultural field officers from the five Districts of Kilimanjaro Region.

Soybean, the highly nutritious crop with 40 percent of protein, is one of the crops grown by the Upland Crops Section in KADP. The participants of the course got the knowledge of soybean production and consumption including how to prepare different kinds of soybean foods. By the end of the training course, the extension workers have shown interest in producing soybean in their respective areas.

In Rombo District, the crop was initially grown by the extension workers, those who participated the training course, at Maida area (Mahango and Holili villages). This report has been prepared to show how soybean has been introduced in the District, its progress and constraints in production and utilization.

2. Landscape and Land Use

The major food crops produced in the District are banana, maize, finger millet (mainly for local brews), groundnuts, Phaseolus beans, green gram, cowpeas and pigeon peas. The major cash crops in the District are coffee and sunflower. Pyrethrum is also produced in small scale. Farming in the District is classified into 4 belts as follows:

(1) Lower Dry Belt: Mainly used for animal keeping under semi-intensive system. Main crops grown in this belt are sorghum, millet, and pastures.

(2) Leached and Overworked Belt: Mainly used for animal keeping and crop growing. Crops grown in this belt are maize, legumes, coffee, banana, and millet.

(3) Mid-land: Mostly utilized for coffee and banana mixed farming.

(4) Upper Belt: Upland crops such as Irish potato, fruits, green vegetables, beans and maize (hybrids) are planted together with animal keeping under zero-grazing.

3. Assistance from KADP

KADP staff, particularly those of Upland Crops Section, played a big role during the initial stage of soybean introduction in the District. They trained not only extension workers (in Upland Crops Cultivation Training Course) but also people through conducting seminars (2 times).

First soybean promotion seminar was held at Mriti Primary

School on 1 September, 1988. There were about 80 farmers who attended the seminar. Several extension workers under the District Agricultural Development Office (then) also attended. The farmers were very much satisfied to the explanation of KADP staff for soybean cultivation and utilization. Besides, 100 kg of soybean seeds and 2 bags of urea were presented from KADP to the extension workers.

Another soybean promotion seminar was conducted at the same primary school on 13 April, 1989 after the first harvest of soybean. The main topic was how the crop be utilized in rural community.

The seminars were quite practical using soybean food samples for tasting. Both Ugali and Uji cooked with and without soybean flour adding were served to the participants of the seminar. They tasted the food samples without knowing which ones contained soybean flour. Most of the participants judged that the foods with soybean flour were better in taste. They said that the soybean flour added foods were soft, good in taste, and good at looking (i.e. color).

Nutritive value of soybean was emphasized because improvement of nutritional status was the main purpose of introducing the crop. It was said that soybean was not a cash crop; soybean would not be sold to the market because almost all of Tanzanian people did not eat it.

4. Farmers' Awareness on Soybean

The crop in demonstration plots conducted by the extension workers showed a good adaptability to the area comparing with other beans (i.e. Phaseolus bean). Farmers became interested in the crop, then they wanted to know the following:

(1) What was the name of the crop?
(2) How could it be produced?
(3) What were methods of consumption/utilization?
(4) Where could they obtain the seeds?

The extension workers tried to answer these questions using the knowledge obtained from KADP. The major problems were where to get seeds for cultivation and information on practical methods of soybean utilization.

5. Soybean Cultivation

(1) Variety

Bossier variety is the only variety so far introduced in Rombo District. This variety has shown good adaptation to the climatic conditions especially in the lower belt. There are two rainy seasons in the District, namely long rainy season (Masika) and short rainy season (Vuli), and the variety tends to perform better in Vuli than Masika.

(2) Land Preparation

This operation starts from August to October and January to February for Vuli and Masika, respectively. It is better to plant Bossier variety on moderately fine soils because big soil clods tend to hinder emergence of the cotyledons. Land preparation is quite important for obtaining good seedling establishment. Construction of ridges is also necessary in the slopes.

(3) Time of Planting

The time of planting depends upon rainfall pattern; whether it is short or long rainy season. In case of short rainy season, the planting starts just after the onset of rains (i.e. from mid-October to early November). For long rainy season, it is better to start planting 3 weeks or one month after the onset of rains (i.e. later March to early May). Attention should be paid for planting; excess soil moisture during germination period will decrease the germination rate. Late planting of the variety in Masika helps to adjust the time of harvesting; it is better to harvest in dry days. Harvesting in rainy days leads soybeans to spoil.

(4) Plant Spacing and Seed Rate

The plant spacing of 50 cm between rows, 10 cm within rows and 3 seeds per hill is recommended; planting 3 seeds at every 10 cm of row for simplicity. Using this spacing, about 100 kg of the seeds is needed for planting 1 ha. Thinning is usually not necessary. Germination takes place 3 to 5 days from planting under favourable conditions.

(5) Weeding and Fertilizer Application

The first weeding should be done about 2 weeks after planting. Unlike other kinds of beans (i.e. Phaseolus bean, cowpea, green gram), Bossier variety does not form nodules without Rhizobium bacteria inoculation; it does not attract indigenous Rhizobium bacteria. To obtain good yield, it is better to apply 30 kg of nitrogen per ha (65 kg of urea/ha) during weeding if Rhizobium inoculant is not available. Apply fertilizer between rows just before the first weeding. Then the fertilizer can be incorporated with soil while doing weeding by hoe. The second weeding depends upon the intensity of weeds, but it is usually necessary to do 3 to 4 weeks after the first weeding. The soybean plants can compete well with weeds if the canopy covers all the soil surface (during and after flowering: about 35-40 days after planting).

(6) Rhizobium Bacteria Inoculation

All legumes have the ability of fixing atmospheric nitrogen through the nodules on the root formed by Rhizobium bacteria. It is called symbiotic nitrogen fixation. However, the nitrogen fixing bacteria differ from one species of legume to another (i.e. Rhizobium japonicum for soybean, Rhizobium phaseoli for Phaseolus bean). In case of soybean (Bossier variety), it does not form nodules because of not attracting indigenous Rhizobium bacteria existing in the soil.

For solving this problem, there is Rhizobium inoculant available. In Tanzania, it is produced at the Soil Science Department of Sokoine University of Agriculture. The inoculum is in small package of about 100 g, which is enough for 50 kg of seeds. The inoculum is mixed with seeds through adding small amount of sugar solution (preferably of 10% sugar content) just before planting. After the inoculation, the seeds should be kept under shade during planting. The bacteria will be killed by direct sunshine, hot temperature, or dry conditions.

(7) Pest and Disease

The soybean plant is less attacked by pests and diseases compared with other kinds of beans. If the plant is attacked by insect pests, Diazinon can be used for control.

(8) Harvesting

The soybean plant (Bossier variety) matures in 90 to 95 days after planting. Harvesting takes place when the crop dries; it is harvested by uprooting (or cutting the stem base). Drying of the cuttings is necessary for efficient threshing. After threshing, the seeds should be winnowed to separate them from husks and foreign matters.

(9) Storage

If the products are to be used as seeds, they should not be stored more than 6 months because soybean viability decreases in rather short period. If they are used for food, just store in the same ways as any other grains.

(10) Yield

In 1988/89 short rainy season (Vuli), soybean yields of different growers were recorded. It was equivalent to 1.5 to 1.7 ton per ha, although actual planting areas were not large. The results are shown in the following Table.

Table Soybean yield performances in 1988/89 short rainy season.

Plot No.[a]	Area (m^2)	Branches /plant	Pods/ plant	Plant height(cm)	Grain yield (kg/plot)	Grain yield (ton/ha)
1	100	7	53	32	16	1.60
2	300	6	35	25	50	1.67
3	400	7	40	30	60	1.50
4	1,225	7	50	27	208	1.70

N.B. [a]1: Mriti Primary School, 2: Wilbad Swai, 3: Village Chairman, 4: Extension Staff.

6. Soybean Marketing

Due to the fact that soybean is a new crop not only in Rombo District but in Kilimanjaro Region, its market is limited. Hence, the farmers have been educated the nutritive value of soybean so as to use for their home consumptions; this will help to reduce the problem of malnutrition which is a big problem in the Region.

7. Soybean Utilization

Farmers and pupils started to eat soybean through mixing its flour with other flours before cooking uji, ugali, chapati, maandazi, etc. Soybeans are also roasted and grounded, then served as soybean-drink.

8. Prospects of Soybean Extension in the Future

Because of the good adaptability of the crop in the District and farmers' interest, both area and number of farmers planting this crop will be increasing throughout the District. However, it will depend very much on the extension work i.e. educating the farmers in those areas where soybean in not introduced yet. They should be educated on:

(1) The importance of the crop within the families.
(2) Production techniques.

If there is an emphasis on the crop from National, Regional and District levels, the production will very much increase in the coming years. Then there will be a need for a reliable market rather than selling in the rural communities.

9. Acknowledgment

I would like to express my sincere gratitude to KADP staff, especially those in Upland Crops Section, for their cooperation of soybean introduction in Rombo District. I would also like to express thankfulness to Rombo District Agricultural and Livestock Development Office for giving me a chance of attending the Upland Crops Cultivation Training Course in 1987 and providing information for the preparation of this report.

V. ACTIVITIES ON VEGETABLES

Establishment of cultivation techniques of vegetables and extension of vegetable cultivation were parts of the activities of Upland Crops Section mentioned in the Record of Discussion on KADP. Several kinds of vegetables (i.e. watermelon, melon, onion, cabbage, etc.) were planted during the cooperation period of the previous project (KADCP: Kilimanjaro Agricultural Development Center Project), and it found a possibility of watermelon introduction to the area (Nezu, 1986).

Many kinds of vegetables were planted during early stages of KADP, but later both kinds of vegetables and areas for their cultivation were reduced. Emphasis was paid on watermelon, onion, tomato and cabbage. It was because watermelon is adapted to dry and hot climate and the others had high market demand. One of the reasons for the reduction was management problem (i.e. lack of manpower). Many trials of vegetables failed due to mis-management, lack of irrigation water (caused by power failure), flood (caused by poor drainage of the plot with inverse slope), and so on.

Results of the cultivation trials of watermelon, onion, tomato, and cabbage are included in this report (one best trial per crop).

1. Watermelon

Watermelon was one of vegetable crops which KADCP paid effort for its introduction. It found that Sweet Favorite was most adapted variety in the area. It is one of vegetables which adapted to dry and hot climate (with irrigation water). It was planted every year, but performance of the crop was usually poor due to management problems (including steeling of fruit).

Six varieties of watermelon were planted in October, 1988 for a variety and cowdung manure rate trial. The varieties were: (1) Charleston Gray, (2) Festival Queen, (3) Sugar Baby (Kenyan seeds), (4) Sugar Baby (Tanzanian seeds), (5) Sweet Favorite, and (6) You-Sweet-Thing. The rates of cowdung manure application (ton/ha) were: (1) 0, (2) 5, (3) 10, (4) 15, and (5) 20. The manure was applied to the planting spot just before direct seeding. Plant spacing of the trial was: 4.5 m width of bed and planting every meter of alternate sides of the bed (each side every 2 m). Rice straw was used as mulching material. Some number of fruits were either stolen or destroyed with knives. There was also a problem of water distribution (furrow irrigation) to some portions due to undulation of the plot.

Table V-1 shows the results. High sugar contents were observed in Festival Queen (11.23%) and Sweet Favorite (11.08%). It was less in Sugar Baby (<10%) either seeds obtained in Tanzania or Kenya. The difference in sugar content among the rates of cowdung manure application (ranged 9.90-10.62%) was smaller than that of among the varieties (ranged 9.43-11.23%). It indicated that the sugar content of watermelon is much controlled by genetic factors rather than management.

Number of fruits harvested was least in the treatment of without cowdung manure. Fruit size was big in Charleston Gray

(10.88 kg) and Sweet Favorite (8.78 kg), but small in other varieties (ranged 5.15-6.05 kg).

Festival Queen variety planted with 20 ton per ha of cowdung manure produced the highest fruit yield (18,958 kg/ha), followed by the same variety planted with 10 ton per ha of the manure (17,167 kg/ha). Festival Queen also showed the highest mean fruit yield over the rates of cowdung manure (13 ton/ha). Although the mean fruit yield of the treatment with 20 ton per ha of cowdung manure was highest (11,053 kg/ha), there was no much difference from those of 5 to 15 ton per ha of cowdung manure (8,479-9,525 kg/ha).

Table V-1 Results of 6 watermelon varieties planted at different rates of cowdung manure in October, 1988: Brix reading (sugar content, %).

Variety	Cowdung manure rate (ton/ha)				
	5	10	15	20	Mean
Charleston Gray	10.7	(10.4)[b]	7.6	9.0	9.43
Festival Queen	10.7	11.4	11.1	11.7	11.23
Sugar Baby (K)[a]	10.6	(10.3)[b]	9.2	8.9	9.75
Sugar Baby (T)[a]	8.9	10.4	10.1	10.4	9.95
Sweet Favorite	10.6	11.1	11.6	11.1	11.08
You-Sweet-Thing	11.0	10.2	9.8	10.6	10.40
Mean	10.42	10.62	9.90	10.28	

Table V-1 .....continued: Number of watermelon harvested.

Variety	Cowdung manure rate (ton/ha)					
	0	5	10	15	20	Mean
Charleston Gray	0	9	2	8	8	5.4
Festival Queen	8	19	20	14	18	15.8
Sugar Baby (K)[a]	2	9	3	9	11	6.8
Sugar Baby (T)[a]	0	10	9	6	9	6.8
Sweet Favorite	1	9	15	16	15	12.2
You-Sweet-Thing	6	9	15	16	15	12.2
Mean	2.8	10.8	9.7	10.2	11.5	

Table V-1 .....continued: Mean fruit size (kg).

Variety	Cowdung manure rate (ton/ha)					
	0	5	10	15	20	Mean
Charleston Gray	-	11.7	12.3	9.9	9.6	10.88
Festival Queen	5.5	4.7	6.2	5.7	7.6	6.05
Sugar Baby (K)[a]	4.5	5.0	5.4	5.8	5.9	5.53
Sugar Baby (T)[a]	-	5.5	5.8	4.4	5.3	5.25
Sweet Favorite	5.8	7.3	8.4	8.8	9.6	8.78
You-Sweet-Thing	4.2	5.5	5.0	5.1	5.0	5.15
Mean	-	6.62	7.18	6.62	7.17	

Table V-1 .....continued: Watermelon yield (kg/ha).

Variety	Cowdung manure rate (ton/ha) 0	5	10	15	20	Mean
Charleston Gray	0	14,681	3,403	11,042	10,667	7,959
Festival Queen	6,097	12,528	17,167	11,056	18,958	13,161
Sugar Baby (K)[a]	1,250	6,278	2,250	7,194	8,944	5,183
Sugar Baby (T)[a]	0	7,681	7,250	3,653	6,639	5,045
Sweet Favorite	806	9,153	10,458	9,750	10,708	8,175
You-Sweet-Thing	3,486	6,819	10,347	11,407	10,403	8,492
Mean	1,940	9,525	8,479	9,017	11,053	

N.B. [a](K) and (T)stands for seeds obtained in Kenya and Tanzania, respectively.
[b]Figures in parentheses are means of < or = 4 watermelons in Brix reading.

Based on the field observation and yield survey, it may be safe to state that Festival Queen and Sweet Favorite are more adapted to the local environment than other varieties tested. One problem of Festival Queen was that it produced fruits with air space (puffy fruit). This characteristic was also observed in You-Sweet-Thing. The local variety (Sugar Baby) was not attractive either for the taste or for the yield. For obtaining good yield it may be better to apply about 10 ton per ha of cowdung manure.

Extension of watermelon cultivation was conducted for some farmers in the Pilot Farm in 1986, 87 and 88. Management of watermelon plot (1 ha) was poor, then the fruit yield was not attractive (e.g. 12.2 ton/ha was the best yield). Due to water shortage at LMIP, it was advised not to do cultivation of upland crops in the dry season since 1989. The decision not only affected the dry season maize cultivation but also watermelon extension to the Pilot Farm.

2. Onion

An onion cultivation trial was conducted in 1990. Seedlings of 3 varieties were raised (sowing date: 25/5/1990) and transplanted on 10 July, 1990 under different soil treatment conditions. Plant spacing of the trial was 20 cm between and within rows in 120 cm width of bed and 30 cm width of passage (and irrigation water ditch). The treatments were: (1) Control, (2) 100 kg of nitrogen per ha (N), (3) N + Rice husk (5 ton/ha, RH), (4) N + Cowdung manure (20 ton/ha, CM), (5) N + RH + CM, (6) 50 kg of P_2O_5 per ha (P), (7) N + P, (8) N + P + RH, (9) N + P + CM, and (10) N + P + RH + CM. They were harvested on 7 November.

Table V-2 shows the results. Mean number of bulbs harvested from the sampling area (1.28 m^2: 1.6 m in length and 0.8 m in width) ranged from 27.5 (Credo variety) to 31.2 (Ringo RS variety). Red Creole variety started bolting about 6 weeks before harvesting; then both percentages of marketable bulb number and weight were low. Mean bulb size was big in Red Creole (153 g) and small in Credo (94 g).

Red Creole produced the highest bulb yield as mean of variety (21.7 ton/ha: after taking the area for passage into account) followed by Ringo RS (17.4 ton/ha). Credo produced the least yield (13.0 ton/ha). Yield difference among means of the soil treatments were not wide; it ranged from 15.1 ton per ha of the treatment with 100 kg of nitrogen per ha and 19.5 ton per ha of the treatment with 100 kg of nitrogen, 50 kg of phosphorus (as P_2O_5), 5 ton per ha of rice husk and 20 ton per ha of cowdung manure application. Among the variety and soil treatment combinations, Ringo RS planted with nitrogen, phosphorus and cowdung manure produced the highest bulb yield (27.0 ton/ha).

Table V-2 Bulb yields of 3 onion varieties planted under different soil treatments in 1990[a].

Treatment[b]	Bulbs/ 1.28m^2	% marketable bulb number	% marketable bulb weight	Mean bulb weight(g)	Bulb yield (ton/ha)[c]
Credo Variety					
1	27	78	81	64	8.4
2	25	84	96	79	10.4
3	26	81	88	90	11.9
4	34	76	76	89	14.5
5	25	76	80	108	12.9
6	25	80	75	84	10.5
7	29	79	75	79	11.4
8	30	80	79	117	17.6
9	21	71	68	108	10.1
10	33	91	94	120	22.4
Mean	27.5	79.6	81.2	94	13.0
Red Creole variety[d]					
1	28	79	83	142	19.5
2	32	84	81	143	24.1
3	33	85	86	151	26.4
4	31	68	60	161	21.1
5	32	72	67	142	20.4
6	30	83	86	148	23.1
7	30	80	74	163	24.4
8	29	76	73	151	20.7
9	35	49	47	176	18.7
10	25	80	78	149	18.6
Mean	30.5	75.6	73.5	153	21.7
Ringo RS variety					
1	31	97	89	103	18.1
2	24	79	90	92	10.9
3	27	78	73	99	12.4
4	33	91	93	98	18.4
5	31	87	86	115	19.4
6	35	74	71	107	17.3
7	33	67	66	128	17.6
8	32	81	84	97	15.8
9	35	66	68	188	27.0
10	31	94	94	96	17.5
Mean	31.2	81.4	81.4	112	17.4

Table .....continued[a].

Treat-ment[b]	Bulbs/ $1.28m^2$	% marketable bulb number	% marketable bulb weight	Mean bulb weight(g)	Bulb yield (ton/ha)[c]
Soil treatment					
1	28.7	84.7	84.3	103	15.3
2	27.0	82.3	89.0	105	15.1
3	28.7	81.3	82.3	113	16.9
4	32.7	78.3	76.3	116	18.0
5	29.3	78.3	77.7	122	17.6
6	30.0	79.0	77.3	113	17.0
7	30.7	75.3	71.7	123	17.8
8	30.3	79.0	78.7	122	18.0
9	30.3	62.0	61.0	157	18.6
10	29.7	88.3	88.7	122	19.5

N.B. [a]Sowing date: 25 May, 1990. Transplanting date: 10 July, 1990. Harvesting date: 7 November, 1990.
[b]1: Control, 2: 100 kg N/ha (N), 3: N + Rice husk (5 ton/ha, RH), 4: N + Cowdung manure (20 ton/ha, CW), 5: N + RH + CM, 6: 50 kg P_2O_5/ha (P), 7: N + P, 8: N + P + RH, 9: N + P + CM, 10: N + P + RH + CM.
[c]Adjusted including the area of passage.
[d]About one third plants bolted before harvesting (started about 6 weeks before harvesting).

Based on the field observation, onion survived in dry condition; it is a drought tolerant vegetable (for growing). Apparently the bulb yield is more influenced by the materials which improved soil physical properties. The soil in the Trial Farm is heavy clay and it becomes very hard when it is dry. It was difficult to uproot by hand, then harvesting work was done using hoe (jembe).

3. Tomato

Seedlings of 3 tomato varieties (Marglobe, Money Maker, Roma) were raised in 1990; they were planted in nursery pots on 25 May and transplanted to the plot on 5 July (transplanting was late due to the problem of pump). Plant spacing of the trial was 75 cm between row and 50 cm within rows. Two rows were accommodated in 150 cm width of bed, and furrow irrigation was practiced. Both nitrogen (60 kg N/ha) and phosphorus (60 kg P_2O_5/ha) fertilizers were applied at transplanting. Supports (stakes) were provided. Yield data were collected from 4.5 m^2 each of sampling area during the period from 8 September to 19 October, 1990. Table V-3 shows the results.

Number of plants harvested from the sampling area (4.5 m^2) ranged within a small difference (13.0-13.5 as mean of variety). Number of fruits harvested per plant was highest in Roma (22.9) followed by Money Maker (20.4); that of Marglobe was comparatively less (13.2).

The highest fruit yield was obtained by Marglobe variety planted with 60 kg of nitrogen per ha; it was 77.7 ton per ha and

2,498 g per plant. Fruit size was big in Marglobe (163 g), medium in Money Maker (88 g), and small in Roma (62 g). Among the fertilizer treatments, the highest fruit yield was obtained from that of 60 kg per nitrogen per ha (61.7 ton/ha). Quality of the fruit was generally good; Marglobe was the best in taste followed by Money Maker. It is said that Marglobe is for short transport, Money Maker for long transport, and Roma for food processing industries.

Table V-3 Fruit yields of 3 tomato varieties planted with different fertilizer rates in 1990[a].

Varieties Fertilizer rate	Plants /4.5 m^2	Fruits /plant	Mean fruit size (g)	Fruit yield (ton/ha)	 (g/plant)
Marglobe					
Nil	12	12.3	154	50.6	1,898
60 N/ha (N)	14	14.7	170	77.7	2,498
60 P_2O_5/ha (P)	14	12.8	167	66.6	2,139
N + P	14	13.1	159	64.7	2,081
Mean	13.5	13.2	163	64.9	2,154
Money Maker					
Nil	14	21.2	94	62.2	1,998
60 N/ha (N)	13	22.1	85	54.2	1,876
60 P_2O_5/ha (P)	13	15.8	84	38.5	1,332
N + P	14	22.6	88	62.2	2,001
Mean	13.5	20.4	88	54.3	1,802
Roma					
Nil	12	17.5	60	28.2	1,058
60 N/ha (N)	14	25.3	68	53.2	1,711
60 P_2O_5/ha (P)	12	24.2	60	45.0	1,446
N + P	14	24.5	60	39.4	1,477
Mean	13.0	22.9	62	41.5	1,423
Mean of Fertilizer rate					
Nil	12.7	17.0	103	47.0	1,651
60 N/ha (N)	13.7	19.7	108	61.7	2,028
60 P_2O_5/ha (P)	13.7	17.6	104	50.0	1,639
N + P	13.3	20.1	102	55.4	1,853

N.B. [a]Sowing date: 25 May, transplanting date: 5 July, harvesting period: 8 September to 19 October 1990.

4. Cabbage

Seedlings of 7 cabbage varieties (Arixos, Copenhagen Market, Early Drumhead, Greyhound, Prize Drumhead, Matchless F1, Romenco) were raised in 1990; they were seeded to nursery pots on 25 May and transplanted to the plot on 4 July, 1990. Due to the same problem mentioned in the tomato trial, the transplanting was late. A randomized complete block design with 3 replications was used for the trial. Plant spacing of the trial was 75 cm between rows and 50 cm within rows. Nitrogen fertilizer (60 kg N/ha) was applied at the transplanting time. Table V-4 shows the results.

Copenhagen Market and Greyhound varieties matured most early; Early Drumhead and Prize Drumhead were late maturing. The difference in growth period was more than one month. Number of heads harvested from the sampling area (7.5 m^2) ranged within a small difference (19.0-20.7). Matchless F1 variety produced the highest yield in terms of per unit area (59.3 ton/ha) and per head (2.16 kg). The data indicate that the difference in yield is statistically significant at 1 percent level. The yield may be further improved if smaller size of seedlings are transplanted and better management (especially irrigation) are practiced.

Table V-4 Cabbage yields of 7 varieties planted in with 60 kg of nitrogen per ha in 1990[a].

Variety	Harvesting date	Number of heads per 7.5 m^2	Mean head size (g)	Yield (ton/ha)
Arixos	12/9/90	19.0	1,287c	32.3c
Copenhagen Market	4/9/90	20.3	1,217cd	34.9c
Early Drumhead	20/10/90	20.0	1,722b	44.4b
Greyhound	4/9/90	19.3	836d	21.2d
Prize Drumhead	20/10/90	19.3	1,581bc	42.0b
Matchless F1	17/10/90	20.7	2,160a	59.3a
Romenco	17/9/90	19.7	1,723b	44.2b
Observed F				
Replication	-	0.86ns	0.89ns	0.64ns
Treatment	-	0.69ns	12.8**	36.6**
cv (%)	-	6.3	13.9	8.6

N.B. [a] Sowing date: 25 May, transplanting date: 4 July, 1990.
Any two means having a common letter in a column are not significantly different at the 5% level of significance.

5. Discussion

Kilimanjaro Region has scattered market gardening in Rombo, Moshi and Hai Districts at the foot of mount Kilimanjaro. Banana is a staple food and by far the most important horticultural crop, usually grown in combination with coffee (Verheij, 1982).

The Region is blessed with diversified topography and climate. Then, major vegetable production areas have been developed at the foot of the mountains (i.e. 1,000-1300 m above the see level). The Trial Farm is located at 725 m above the sea level; it is dry and hot comparing with those vegetable production areas.

Watermelon varieties of Sweet Favorite and Festival Queen are adapted to the local environment, and they are good in taste. One of the problems in watermelon production is that they are hybrids, then the seeds depend on import from Japan (or other countries). Recently watermelon seeds of some other varieties became available. Adaptability of the varieties should be investigated.

The Section has been trying to fix Festival Queen variety in the last years. After harvesting watermelon from an isolated plot, the F-2 seeds were planted in 1989/90 dry season.

Unfortunately (or fortunately) only one fruit was harvested in the season (due to poor management and stealing of fruit). The F-3 seeds were planted in 1990/91 dry season at the back of the office (for isolation and close supervision) and harvested in February 1991. Although it is still early to judge, the fruit size (5-8 kg) and the taste (about 10.5% sugar content in Brix reading) are attractive. Under the limited manpower of the Section, it may be better to concentrate on this ex-Festival Queen cultivar in watermelon cultivation in the immediate future. If it successes, it is not necessary to rely on the imported seeds.

Another watermelon variety (Crimson Sweet) became available at TFA (Tanganyika Farmers Association) in 1990. It was planted in 1990/91 dry season together with other 3 varieties. Although results of the trial are not ready yet, taste of the variety was better than Sugar Baby and competitive to other varieties (i.e. Festival Queen, Sweet Favorite). Fruit size is bigger than Sweet Favorite: around 10 to 15 kg per fruit.

Watermelons produced by farmers of the Pilot Farm were sold at the price of 20 shillings per kg in 1988 (e.g. 200 shillings for a 10 kg of watermelon). There were many Indians, Europeans, and Japanese who wanted to buy them. If the quality of watermelon is good, it can be sold at 50 shillings per kg at the moment (or 1 kg of watermelon price may be equivalent to that of 1 bottle of soft-drink). As the living standard of people improves, watermelon market will expand.

Yield data of tomato (77.7 ton/ha) and cabbage (59.3 ton/ha) are attractive. These yields are probably competitive to those of vegetable producing areas in the Region. Collection of yield data from the vegetable producing areas are necessary.

Onion is apparently adapted to the local environment, then the yield (27.0 ton/ha) may further increase if it is planted in cool season on the soils of improved physical properties. One of the reasons for poor performance of onion is that the plant does not show wilting sign under water stress conditions to some extent (irrigation was usually late and not evenly distributed).

There may be a possibility of setting up a vegetable farm for a small area (i.e. one or two upland plots of Trial Farm for demonstration and training purposes). However, it is impossible to conduct the extension services to the upland field of LMIP (including the Pilot Farm) under the situation of irrigation water shortage.

Good time of planting vegetables in the area is probably May except watermelon (around August). Early preparation of vegetable seedlings sometime faced the difficulty of transplanting. Land preparation of heavy clay soil is a problem when the land is wet. Further research should still be on variety (for all the vegetables mentioned), improvement of soil physical properties (especially for onion), and fixing of ex-Festival Queen cultivar for watermelon.

Under the conditions of no irrigation water allocation to the upland field in LMIP and limited manpower for field management of the Trial Farm, main crops to be studied in the future are those which grow even under rainfed conditions (i.e. soybean, maize, sunflower). Only limited emphasis can be paid on the improvement of production techniques of vegetables (i.e. onion, tomato, cabbage, watermelon).

Since all of the staff at Upland Crops Section attended the JICA's vegetable production training course, they have some knowledge on vegetable cultivation (both theory and practice). If KADC will play as training center of agricultural extension workers in the Region, at least several kinds of vegetable should be planted every year.

There is a possibility for the improvement of vegetable production in the Region. The diversified climatic conditions will be exploited in many ways (e.g. onion seed production, strawberry production) if environmental factors and variety responses are studied.

The process of watermelon variety fixing created an interest among the staff. On the other hand, bolting of onion (Red Creole variety) was observed in 1990 season. The seeds were collected for further investigation. Although KADP (KADC) is not authorized as a center for plant breeding (or seed production), there are something which it can try to do within a limited capacity.

Staff of the Section attended the Vegetable Crop Coordinating Committee Meeting held at Moshi on 22 February, 1991. Activities on vegetable crops of the Section in 1990 were reported at the meeting. Although it is quite difficult to increase the volume of work on vegetable crops at the moment, communication and collaboration with the national research organizations should be strengthened.

6. References

Nezu, M. 1986. Upland crops cultivation. In: Terminal reports of experts to Kilimanjaro agricultural development center project (vol. 1). pp: 1-49. JICA. (in Japanese with Annex in English).

Verheij, E.W.M. 1982. Horticulture in Tanzania - Position and perspective. Communication 74. Department of Agricultural Research, Royal Tropical Institute Amsterdam.

Appendix V-1

PRICES OF AGRICULTURAL PRODUCTS AND INPUT MATERIALS

1. Prices of Agricultural Products at Moshi Market

Agricultural product prices at Moshi Public Market have been monitored monthly (mostly end of the month) since July, 1986. The prices were taken at per kg as much as possible except some items which were commonly sold in other units (i.e. per piece, liter, bunch, etc.). The market survey was mostly conducted by Mrs. G. Mshanga of Upland Crops Section. Exchange rate of US dollar to Tanzanian shilling was obtained at the National Bank of Commerce (Kibo Branch, Moshi). Minimum wage of the government employee was obtained from the budget speech (Daily News). Table 1 presents a summary of the price change in last 4 and half years (details of the prices are in Table 5).

Table 1 Price changes of some agricultural products from mid-1986 to end-1990.

Item (unit)	Price in 1986: X	Price in 1990: Y	Y/X[a]
Maize (Shs/20 liters)	150-250	300-550	2.00
Rice (Shs/kg)	30-40	80-100	2.67
Phaseolus bean (Shs/kg)	25-40	60-75	2.40
Cabbage (Shs/kg)	20	50-80	2.50
Tomato (Shs/kg)	15-40	80-180	5.30
Onion (Shs/kg)	30-50	80-200	2.67
Irish potato (Shs/kg)	18-30	50-80	2.78
Egg (Shs/piece)	7-8	17-22	2.43
Beef (mixed, Shs/kg)	80-100	180-250	2.25
Goat (Shs/kg)	100-150	250-300	2.50
Exchange rate (Shs/US$)	40-51	192-196	4.80
Minimum wage (Shs/month)[b]	1,055	2,500	2.37

N.B. [a]Obtained using the lowest values.
[b]As of July in respective year.

Although maize price fluctuated considerably, it was about 180 shilling (per 20 liters) in 1986, then it became 400 shilling in 4 and half years. The price of white rice increased from 40 to 100 shillings per kg. Among beans, Phaseolus bean price was about 30 shillings per kg in 1986, it became about 70 shillings in 1990. Soybean was not found at the market until November, 1987. It is still not a common item at the market.

Prices of vegetable fluctuated and increased. Cabbage price was 20 shilling per kg in 1986; it increased to about 80 shilling in 1990. Tomato was sold around 20 to 30 shillings per kg in 1986; it increased to about 100 to 150 shilling in 1990. The highest price of tomato was observed in April, 1990 (180 shillings/kg) after a heavy rainfall (and flood) attacked Kilimanjaro Region. Price of onion was increased from about 30 to 50 shillings per kg to about 150 to 200 shilling during the same period. Irish potato was sold at about 20 to 25 shillings per kg in 1986, it became 60 to 70 shillings in 1990. All the animal products also increased considerably: Egg from 7 to 20 shillings per piece; beef (mixed) from 80 to 220 shilling per kg; goat from 120 to 300 shillings per kg.

Tanzanian shilling had been devaluated in the last 4 and half years. It was about 40 shillings per US dollar in mid-1986; it became about 200 shillings per US dollars toward end-1990 (devaluation of 4.80 in the period). Minimum wage for the government employee was changed every year after the approval of national budget; it was 1,055 shilling in mid-1986 (changed in July) and 2,500 in mid-1990 (increasing rate of 2.37). In other words, the minimum wage increased in shilling but its dollar value decreased to about one half.

Among the selected agricultural products, the increase rate of the price was least for maize (2.00 times) and most for tomato (5.30 times). The rest were within the range from 2.25 to 2.78. Comparing with the difference of shilling value to US dollars, the fluctuation of agricultural product price was quite small (except that of tomato). The increase rate of minimum wage payment was almost coincide with that of food items (except tomato); the increase of minimum wage did not alleviate the burden in living.

The result indicates that if the farm gate price increased at the same rate of market price in the last years, income of the farmers increased considerably in shilling value. However, because of high devaluation of the shilling, the income value in US dollar decreased.

2. Cost and Income of Upland Crop Production

Based on the market prices of tomato, cabbage, and onion, if the yield levels of the Trial Farm were realized at on-farm level, vegetable production is profitable. Simple comparison of total incomes from paddy, maize and some vegetable productions is presented in Table 2.

Table 2 Comparison of paddy, maize and vegetable productions and total incomes per ha.

Item	Yield (ton/ha)	Estimated farm gate price (Shs/kg)	Total income (Shs/ha)
Paddy (irrigated)	6.0	45 (paddy)	270,000
Maize (rainfed)	1.5	20	30,000
Maize (irrigated)	4.0	20	80,000
Tomato	50.0	30	1,500,000
Cabbage	40.0	20	800,000
Onion	20.0	40	800,000

If farmers can manage these vegetable crops and there is irrigation water, it seems that vegetable cultivation is not inferior to paddy cultivation in terms of even net income.

Although vegetable production is labor intensive, the wide difference in total income indicates that it may be profitable provided the planting area is not large. Further study on economic analysis is necessary in addition to improving vegetable cultivation techniques.

Table 3 Production costs of different kinds of food crops in 1989/90 crop season (shillings/acre)[a].

	Maize[b]	Bean[c]	Wheat[d]	Sunflower[e]
Seeds	837.50	4,350.00	4,350.00	80.00
Plowing	1,400.00	1,400.00	1,400.00	1,400.00
Harrowing	1,400.00	1,400.00	1,400.00	1,400.00
Planting	700.00	1,400.00	1,000.00	1,000.00
Herbicide	2,319.00	-	750.00	-
application	200.00	1,000.00	100.00	500.00
Insecticide	1,600.00	-	-	-
application	200.00	-	-	-
Fertilizer	1,258.40	471.00	584.00	471.00
application	300.00	-	-	-
Harvest bag	3,294.00	1,098.00	1,098.00	1,830.00
Harvesting	1,400.00	1,000.00	2,000.00	1,000.00
Shelling	1,000.00	-	-	-
Transport	1,000.00	500.00	-	-
Storage	1,000.00	200.00	-	-
Management	2,000.00	1,000.00	1,500.00	1,500.00
Total cost	19,909.00	14,319.00	14,182.00	9,181.00
Cost/bag	1,106.05	2,386.50	2,363.67	918.10
Gross income	25,200.00	30,000.00	27,000.00	10,800.00
Gross margin	5,291.00	15,681.00	12,818.00	1,619.00
Government price	13.03/kg	27.30/kg	13.00/kg	-

N.B. [a]Original data are from: "Data for preparation of cash flows and budgets for food crops for 1989/90", Production Department, Kilimanjaro Native Cooperative Union (1984) Ltd. Labor cost is 100 shilling per person per day. Gross income is based on the price at open market.

[b]10 kg of seeds (hybrid), 1.5 liter of 2,4D and 1.5 liter of Gramoxon, 8 kg of Thiodan 4%, 1 bag of 20:10:10 and 2 bags of CAN, and at the yield of 18 bags (90 kg/bag). The government price includes 2.03 shilling per kg for bag. Additional cost of 3,000 shilling (30 man-days) is necessary for irrigation in poor rain years.

[c]Phaseolus bean, 87 kg of seeds, hand weeding and 1 bag of 20:10:10, and at the yield level of 6 bags (100 kg/bag).

[d]87 kg of seeds, 1.5 liter of 2,4D, 1 bag of TSP and harvested by combine harvester, and at the yield level of 6 bags (90 kg/bag).

[e]4 kg of seeds (Record variety), 1 bag of 20:10:10 and hand weeding, and at the yield level of 10 bags (60 kg/bag).

Prediction of upland crop production economy for 1989/90 season reported by KNCU (Kilimanjaro Native Cooperative Union) is adopted as Table 3. Gross income per acre was 25,200 shillings, 47,250 shillings, 27,000 shillings and 10,800 shillings for maize, Phaseolus bean, wheat and sunflower, respectively. Under open market price, the net income per acre was 5,291 shillings, 15,681 shillings, 12,818 shillings, and 1,619 shillings, respectively following the same order of the crops. If the product was sold at the government price, there was no profit from maize and wheat productions.

Prices of agricultural input materials were taken occasionally at TFA (Tanganyika Farmers Association) shops at Arusha and Moshi. Table 4 shows the prices in November 1990. Tables 6 to 9 present other information on agricultural production and marketing.

Table 4 Prices of agricultural input materials at TFA Moshi in November 1990 (shillings/unit).

1. Fertilizer
   - Ammonium sulfate: 550/50 kg
   - Urea: 595/50 kg
   - TSP: 700/50 kg
   - CAN: 475/50 kg
   - NPK (20:10:10): 530/50 kg
   - NPK (6:20:18): 660/50 kg
2. Agricultural Chemical
   - Gramoxon: 1,2866/liter
   - Roundup: 2,800/liter
   - Gesaprim: 1,150/liter
   - Actellic 50EC: 3,240/liter
   - Actellic super dust 5%: 93/100 g or 538/kg
   - Hogos: 1,470/liter
   - Dithane M-45 WP: 1,687/kg
   - Mancozeb 80% WP: 1,345/kg
   - Sandofan: 7,345/4 kg
   - Ridomil 63.5%: 1,720/(1/2 kg)
3. Vegetable Seeds
   - Onion (Bombay Red variety): 980/100g
     - (Credo variety): 1,300/100 g or 400/25 g
     - (Red Creole variety): 1,080/100 g
   - Tomato (Money Maker variety): 1,400/100 g
     - (Roma VS): 317/25 g
   - Cabbage (Drumhead variety): 980/100 g
     - (Red cabbage): 840/250 g
   - Carrot (Nantes variety): 486/25 g or 845/100 g
     - (Chatney variety): 486/25g g
   - Cucumber (Ashley variety): 1,425/250 g or 3,423/kg
   - Cauliflower (Kibo Giant variety): 4,955/100 g
   - Chinese Cabbage (Granaat variety): 450/100 g
   - Sweet Pepper (Yolo Wonder variety): 1,200/100 g
   - Hot Pepper (Cayne variety): 785/100 g
   - Eggplant (Long purple variety): 370/250 g
   - Watermelon (Sugar Baby variety): 605/100 g
   - Okra (Clemson variety): 1,10/250 g or 180/25 g
   - Lettuce (Prado variety): 980/100 g
4. Upland Crop Seeds
   - Maize (Kilima, Staha, Tuxpeno varieties): 1,062/10 kg
   - Maize (H632, H622 varieties): 1,097/10 kg

Table 5 Prices of agricultural products at Moshi Market from July 1986 to December 1990[a].

Product	1986 7	8	9	10	11	12
1 Maize (Grain, Shs/20 liters)	-	250	190	150	160	180
2 White rice (Shs/kg)	40	40	40	40	40	30
3 Wheat (Shs/kg)	30	30	20	20	20	20
4 Maize flour (Shs/liter)	15	15	15	15	15	15
5 Wheat flour (Shs/liter)	35	35	40	45	45	55
6 Cowpea (Shs/kg)	-	-	-	-	-	-
7 Phaseolus bean (Shs/kg)	30	30	30	25	40	40
8 Green gram (Shs/kg)	25	25	30	50	35	40
9 Soybean (Shs/kg)	ns	ns	ns	ns	ns	ns
10 Groundnut (Shs/kg)	50	50	50	65	70	70
11 Cabbage (Shs/kg)	20	20	20	20	20	20
12 Amaranth (Shs/lot)	4	4	4	4	4	5
13 Tomato (Shs/kg)	15	20	30	30	20	40
14 Eggplant (Shs/kg)	40	35	30	25	30	25
15 Cucumber (Shs/kg)	30	30	40	40	30	40
16 Sweet pepper (Shs/kg)	40	35	50	40	35	ns
17 Hot pepper (Shs/kg)	30	ns	ns	120	150	100
18 Cauliflower (Shs/kg)	50	40	ns	ns	ns	ns
19 Sweet potato (Shs/lot	-	-	-	-	20	ns
20 Irish potato (Shs/kg)	18	20	20	25	30	25
21 Cassava (Shs/lot)	-	-	-	-	-	-
22 Onion (Shs/kg)	50	50	50	40	30	30
23 Carrot (Shs/kg)	40	40	30	30	30	30
24 Beet root (Shs/kg)	-	-	-	-	-	40
25 Taro (Shs/lot)	-	-	-	-	-	-
26 Ginger (Shs/kg)	70	60	60	80	100	80
27 Garlic (Shs/kg)	220	160	160	80	100	100
28 Orange (Shs/piece)	-	-	-	-	3	3
29 Lemon (Shs/piece)	-	-	-	-	1	1
30 Pineapple (Shs/piece)	-	-	-	-	35	40
31 Papaya (Shs/piece)	-	-	-	-	20	20
32 Mango (Shs/piece)	-	-	-	-	2	2
33 Avocado (Shs/piece)	-	-	-	-	5	5
34 Banana (Shs/piece)	-	-	-	-	2	2
35 Plantain (Shs/full bunch)	-	-	-	-	220	240
36 Egg (Shs/piece)	-	-	-	-	7	8
37 Chicken (Shs/piece)	-	-	-	-	290	290
38 Beef (Mixed, Shs/kg)	80	80	90	80	90	100
39 Beef (Steak, Shs/kg)	100	90	100	100	100	120
40 Goat meat (Shs/kg)	120	100	120	120	150	150
41 Sugar (Shs/kg)	-	-	-	-	-	-
42 Salt (Shs/liter)	-	-	-	-	-	-
43 Oil (Margarine, Shs/liter)	-	-	-	-	-	-
44 Charcoal (Shs/bag)	-	-	-	-	-	-
45 US dollar exchange rate (Shs/US$)	39.6	42.2	44.3	46.6	48.0	51.2
46 Minimum wage (Shs/month)	1,055 ------------------------->					

N.B. [a]ns: not being sold, -: price not checked (including ns).

Table 5 .....continued[a].

Product	1987 1	2	3	4	5	6	7	8	9	10	11	12
1	180	190	190	220	250	230	260	250	200	200	200	200
2	40	45	40	45	40	40	30	45	45	40	45	45
3	20	25	22	25	20	25	20	20	20	40	25	25
4	15	15	15	15	15	15	30	20	18	30	30	30
5	50	55	50	45	45	40	50	35	40	50	40	45
6	-	-	-	-	-	-	-	25	30	30	40	60
7	30	-	30	30	35	30	30	30	30	20	30	35
8	35	35	40	50	50	50	40	40	40	40	50	50
9	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	40	ns
10	75	70	75	60	55	70	70	65	70	75	80	100
11	30	30	30	30	40	40	30	30	30	20	30	40
12	2	2	5	5	5	5	10	10	5	10	20	10
13	40	30	35	40	70	60	40	30	30	30	25	30
14	30	30	40	40	30	40	40	30	40	20	30	40
15	30	55	30	40	40	40	70	40	40	30	40	60
16	40	40	50	40	60	60	60	60	40	60	40	60
17	120	120	100	80	50	60	100	100	150	-	100	100
18	40	ns	ns	60	ns	60	60	50	50	40	50	-
19	20	20	10	20	10	20	20	20	20	10	20	-
20	30	20	30	30	30	30	30	30	30	20	25	40
21	15	-	15	-	-	-	20	20	20	10	20	-
22	50	60	50	70	80	80	60	50	60	40	35	50
23	40	50	60	80	80	80	60	50	50	40	50	50
24	-	-	40	-	-	-	ns	ns	45	50	ns	-
25	-	-	-	-	-	-	20	20	25	-	20	-
26	140	ns	150	120	100	60	60	60	70	75	100	40
27	150	200	250	300	250	160	200	150	120	100	100	150
28	-	-	-	2	3	3	3	3	3	5	5	-
29	1	0.5	-	-	1	1	1	ns	0.5	-	1	-
30	40	-	-	-	-	-	40	40	40	40	20	50
31	30	10	40	20	-	20	40	30	10	20	5	10
32	5	2	-	-	-	5	-	5	ns	ns	3	10
33	-	2	7	4	5	5	7	5	10	4	5	2
34	2	2	2	2	2	2	2	2	2	2	2	2
35	250	250	140	-	150	-	-	-	250	-	250	200
36	8	8	9	9	9	9	10	9	8	8	8	12
37	300	250	250	300	300	300	200	250	250	250	150	250
38	100	100	100	100	100	100	90	100	100	100	120	120
39	120	120	120	120	120	120	100	120	120	100	140	150
40	150	150	150	150	150	150	150	150	150	150	150	140
41	-	-	-	-	-	-	80	80	-	80	80	80
42	-	-	-	-	-	-	25	20	20	25	20	20
43	-	-	-	-	-	-	-	200	200	200	200	100
44	-	-	-	-	-	-	-	-	-	-	-	-
45	53.2	55.0	56.9	58.9	61.0	63.2	64.3	67.6	69.7	73.0	76.2	83.3
46	1,055 ----------------->						1,370 ------------------------>					

N.B. [a]ns: not being sold, -: price not checked (including ns). Refer items and units in those of 1986.

Table 5 .....continued[a].

Product	1988											
	1	2	3	4	5	6	7	8	9	10	11	12
1	270	450	400	400	380	300	300	200	200	200	300	300
2	45	50	45	45	45	45	50	50	65	65	65	70
3	25	25	18	55	30	30	30	30	30	30	30	30
4	20	-	-	20	20	20	20	20	20	20	20	20
5	-	-	-	50	-	80	40	40	60	70	70	70
6	80	60	75	100	100	45	60	40	60	70	50	60
7	-	45	50	55	45	40	45	45	45	45	50	60
8	80	50	-	100	-	80	60	70	60	90	70	70
9	ns	40	ns	ns	ns	ns	ns	ns	50	40	45	50
10	90	150	120	80	80	110	75	70	130	70	ns	150
11	40	40	50	40	50	40	40	30	40	40	50	40
12	15	20	20	20	10	10	20	20	10	20	20	20
13	60	50	50	60	70	40	40	40	40	50	60	60
14	60	50	50	25	40	60	40	30	40	40	50	40
15	40	40	50	40	45	40	40	20	40	60	60	40
16	60	40	40	60	60	60	50	100	50	60	80	60
17	120	120	40	150	80	50	120	100	130	120	120	120
18	60	ns	ns	50	50	80	50	45	50	60	ns	60
19	20	20	20	-	-	30	20	20	-	20	30	20
20	60	40	40	40	40	50	40	25	40	40	50	40
21	-	20	20	-	-	30	20	20	-	20	20	20
22	80	80	50	100	80	60	45	35	50	60	80	60
23	80	80	80	60	70	80	40	40	50	60	60	50
24	60	ns	ns	ns	ns	ns	ns	ns	-	40	ns	ns
25	20	20	10	-	-	-	20	20	-	20	30	25
26	80	150	100	100	100	200	100	120	70	120	130	120
27	100	150	100	100	150	150	120	80	100	120	130	120
28	-	-	-	5	5	5	5	10	5	10	10	10
29	1	1	1	1	1	2	2	3	-	2	-	2
30	50	80	20	ns	ns	40	80	40	40	40	80	30
31	30	20	35	50	20	20	15	15	20	30	80	50
32	5	5	5	5	5	20	5	10	ns	10	10	10
33	5	5	-	5	5	5	7	10	3	10	10	5
34	-	2	-	2	2	-	2	2.5	2.5	2.5	-	5
35	-	-	-	-	-	600	450	-	400	-	-	-
36	10	12	12	12	12	12	12	12	8	12	12	12
37	300	350	300	300	300	250	300	350	300	350	350	300
38	120	120	120	120	120	120	150	150	120	140	150	150
39	150	150	150	130	150	150	200	200	130	150	200	200
40	150	160	150	150	150	150	250	200	150	150	200	200
41	-	80	80	80	80	150	200	-	-	140	ns	130
42	40	60	45	45	40	45	50	45	40	45	50	50
43	-	120	220	230	230	240	220	220	-	250	300	270
44	-	-	-	-	-	-	-	-	-	-	-	
45	91.0	92.1	92.2	94.4	94.6	96.5	96.8	95.8	97.6	98.4	122	122
46	1,370 ----->						1,500 ----->					

N.B. [a]ns: not being sold, -: price not checked (including ns). Refer items and units in those of 1986.

Table 5 .....continued[a].

Product	1989											
	1	2	3	4	5	6	7	8	9	10	11	12
1	300	500	300	300	250	300	350	360	250	300	300	350
2	75	65	70	65	75	80	75	80	80	80	70	80
3	30	30	50	40	-	60	60	65	50	50	50	40
4	50	25	40	30	25	-	50	40	40	50	30	40
5	70	70	100	100	50	-	90	100	60	100	100	110
6	70	45	70	80	40	80	60	80	60	60	60	60
7	50	60	65	50	70	60	50	45	60	50	60	60
8	70	70	90	80	80	80	60	80	80	80	70	60
9	50	50	50	50	ns	ns	60	60	-	60	60	60
10	200	200	200	150	ns	150	80	120	120	140	150	150
11	50	40	50	50	50	60	40	60	30	50	50	60
12	40	30	10	-	20	-	40	10	-	40	40	40
13	60	40	100	60	100	100	50	60	60	60	60	80
14	40	40	60	40	80	100	40	60	40	60	60	50
15	40	45	100	80	60	50	40	60	80	80	80	100
16	60	45	30	80	120	120	60	100	60	100	80	100
17	100	140	50	100	70	200	120	120	150	100	100	120
18	80	60	ns	ns	100	ns	ns	100	-	70	ns	ns
19	60	30	40	70	-	-	50	-	50	50	50	-
20	60	40	40	40	50	60	40	50	60	50	50	50
21	40	40	50	60	-	-	40	50	50	-	40	40
22	40	60	40	60	100	100	50	70	40	50	60	70
23	60	60	80	80	100	100	60	80	70	80	80	100
24	ns	ns	-	ns	ns	ns	ns	ns	ns	ns	ns	ns
25	40	40	40	60	60	60	40	40	40	50	30	40
26	130	200	100	100	100	220	120	100	120	120	100	100
27	120	140	150	-	150	180	100	100	100	100	200	120
28	10	10	10	5	5	-	10	10	10	5	10	8
29	2.5	5	-	2	1	1	2	-	-	3	5	2
30	60	-	70	150	80	150	40	ns	120	80	150	120
31	40	15	40	80	50	50	20	50	40	50	50	50
32	5	15	20	15	5	20	20	20	10	ns	20	10
33	5	10	10	10	10	-	5	5	5	ns	ns	ns
34	-	2.5	3.3	5	-	-	-	5	-	-	5	-
35	-	-	-	-	250	-	-	400	-	-	400	-
36	15	12	15	15	15	15	15	15	13	16	15	16
37	400	350	400	320	350	400	400	500	400	700	450	800
38	200	200	200	200	180	200	200	200	200	200	200	250
39	250	250	-	220	200	240	220	220	250	250	250	300
40	300	250	300	250	ns	250	250	250	250	250	250	300
41	120	140	140	130	180	160	200	150	360	200	200	120
42	45	50	45	100	100	100	55	100	60	80	60	60
43	300	300	300	300	-	340	400	450	400	450	350	350
44	-	-	-	-	-	-	-	-	-	-	-	-
45	128	130	132	136	137	144	145	144	144	146	152	189
46	1,500 ----------------------> 2,075 ------------------------>											

N.B. [a]ns: not being sold, -: price not checked (including ns).
Refer items and units in those of 1986.

Table 5 .....continued[a].

Product	1990 1	2	3	4	5	6	7	8	9	10	11	12
1	300	300	380	400	400	350	300	350	-	400	550	550
2	80	80	80	90	100	90	100	100	90	100	100	100
3	55	50	60	70	70	70	60	60	-	70	80	70
4	50	40	40	60	50	30	40	40	60	50	50	50
5	120	110	120	150	150	150	150	150	130	150	130	140
6	60	60	-	60	50	100	50	50	70	70	80	100
7	60	60	60	60	60	60	60	60	60	70	75	70
8	100	-	60	80	100	80	80	100	100	100	110	-
9	60	ns	ns	ns	90	ns	ns	ns	60	ns	ns	ns
10	150	120	120	130	100	120	120	120	130	140	170	-
11	60	60	50	60	80	80	80	70	80	60	80	80
12	20	40	30	20	50	20	40	60	30	40	30	20
13	80	120	150	180	150	80	80	100	100	100	100	100
14	50	60	60	ns	100	100	80	80	100	80	80	100
15	80	80	100	80	80	80	80	100	80	100	80	120
16	100	80	80	100	100	100	120	150	150	150	150	100
17	120	100	80	150	100	100	100	500	400	100	200	300
18	100	ns	80	ns	100	100	120	100	80	120	ns	-
19	50	60	80	100	-	50	60	50	50	50	50	-
20	60	60	60	50	60	80	80	60	60	70	60	70
21	50	60	80	50	-	50	60	50	60	50	50	-
22	80	80	80	150	150	120	200	150	200	150	130	100
23	100	120	100	100	100	100	100	100	100	100	100	200
24	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
25	40	60	80	100	50	50	50	50	50	50	50	-
26	120	120	120	200	120	600	100	100	120	200	200	160
27	120	80	120	200	300	500	600	600	400	500	400	-
28	8	10	8	8	8	5	10	10	10	20	ns	ns
29	2	5	-	5	2.5	10	ns	-	10	5	10	7
30	120	ns	ns	ns	ns	ns	120	ns	120	150	100	100
31	30	40	-	ns	50	50	60	40	40	70	60	50
32	15	20	15	ns	ns	30	ns	20	ns	ns	10	10
33	ns	ns	5	10	15	20	10	-	30	ns	20	20
34	-	-	5	-	-	-	-	-	-	-	-	7
35	-	350	800	350	600	600	600	600	800	800	600	300
36	17	20	-	20	20	20	20	20	20	20	20	22
37	800	600	800	1000	600	-	800	800	400	1000	1000	700
38	250	220	220	220	220	220	220	220	180	250	250	250
39	300	280	250	250	250	250	250	250	200	300	300	270
40	350	300	300	300	250	300	300	300	250	300	300	300
41	200	200	220	220	240	230	250	220	200	200	200	220
42	80	80	80	100	80	80	80	80	100	80	100	80
43	450	350	380	360	360	350	350	350	400	400	450	-
44	500	500	800	800	650	600	600	600	600	600	800	700
45	192	194	193	193	193	193	196	196	196	196	196	196
46	2,075 ---------------------->						2,500 ----------------------->					

N.B. [a]ns: not being sold, -: price not checked (including ns).
Refer items and units in those of 1986.

Table 6 Producer prices of domestic crops (1971/72 to date)[a].
A: Current Prices: Tanzanian shillings per kg (Shs/kg)

	75/76	76/77	77/78	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
Preferred staples														
Maize	0.80	0.80	0.85	0.85	1.00	1.00	1.50	1.75	2.20	4.00	5.25	6.30	8.20	9.00
Paddy	1.00	1.00	1.20	1.20	1.50	1.75	2.30	3.00	4.00	6.00	8.00	9.60	14.40	17.30
Wheat Grain	1.00	1.20	1.25	1.25	1.35	1.65	2.20	2.50	3.00	4.50	6.00	7.20	9.00	10.35
Drought staples														
Sorghum/millet	0.75	0.90	1.00	1.00	1.00	1.00	1.00	1.60	2.00	3.00	4.00	4.80	6.00	6.60
Cassava Gr. I	0.40	0.50	0.60	0.65	0.65	0.65	0.70	0.90	1.20	2.00	3.00	3.60	4.50	4.95
Oilseeds														
Sunflower Black	1.00	1.10	1.50	1.70	1.70	1.80	2.00	2.90	4.00	6.00	8.40	10.10	12.65	13.90
- Jupiter	1.00	1.10	1.50	1.50	1.50	1.60	1.80	2.60	3.50	5.25	7.40	8.90	11.15	12.25
- Mixed	0.75	0.80	1.25	1.30	1.40	1.50	1.70	2.50	3.20	4.80	6.70	8.00	10.00	11.00
Sesame	2.00	2.50	3.00	3.30	3.50	4.00	4.50	5.70	7.00	10.50	14.70	17.65	22.10	24.30
Groundnuts	2.00	2.50	4.00	4.00	4.00	4.20	4.38	5.80	8.00	12.80	17.90	21.50	26.90	29.60
Copra	2.20	2.30	2.50	2.30	2.30	2.50	3.00	4.20	6.00	9.00	12.60	15.10	18.90	20.80
Soya	2.00	2.25	2.25	2.25	2.25	2.25	2.25	3.00	4.50	6.75	9.40	11.30	14.15	17.00
Other Crops														
Bean Gr. I	1.50	2.00	3.50	3.50	3.50	3.50	3.50	3.50	5.00	8.00	12.00	14.40	21.60	24.85
Sugarcane	0.07	0.09	0.10	0.10	0.10	0.11	0.14	0.17	0.24	0.32	0.36	0.46	0.60	0.75
Grape Gr. A	2.50	3.50	3.50	3.50	4.00	4.00	5.00	6.00	9.00	13.00	14.30	18.50	26.90	35.00

Table 6 .....continued.
B: Constant Price: 1986/87 = 100

	75/76	76/77	77/78	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88
Preferred Staples													
Maize	8.72	7.98	7.60	6.55	6.04	4.79	4.76	5.01	5.20	6.80	6.95	6.30	6.55
Paddy	10.90	9.98	10.73	9.25	9.06	8.38	8.83	8.59	9.46	10.19	10.59	9.60	11.52
Wheat Grain	10.90	11.97	11.18	9.63	8.15	7.90	8.44	7.16	7.09	7.65	7.94	7.20	7.20
Drought Staples													
Sorghum/millet	8.17	8.98	8.94	7.71	6.04	4.79	3.84	4.58	4.73	5.10	5.30	4.80	4.80
Cassava Gr. I	4.36	4.99	5.37	5.01	3.92	3.11	2.69	2.58	2.84	3.40	3.97	3.60	3.60
Oilseeds													
Sunflower Black	10.90	10.98	13.42	13.10	10.26	8.62	7.68	8.31	9.46	10.19	11.12	10.10	10.12
- Jupiter	10.90	10.98	13.42	11.56	9.06	7.66	6.91	7.45	8.27	8.92	9.80	8.90	8.92
- Mixed	8.17	7.98	11.18	10.02	8.45	7.18	6.52	7.16	7.57	8.15	8.87	8.00	8.00
Sesame	21.79	24.95	26.83	25.43	21.13	19.15	17.27	16.33	16.55	17.84	19.46	17.65	19.68
Groundnuts	21.79	34.95	35.77	30.83	24.15	20.11	16.81	16.61	19.91	21.75	23.70	21.50	21.52
Copra	23.97	22.95	22.36	17.73	13.89	11.97	11.51	12.03	14.18	15.29	16.68	15.10	15.12
Soya	21.79	22.45	20.12	17.34	13.59	10.77	8.64	8.59	10.64	11.47	12.45	11.30	11.32
Other Crops													
Bean Gr. I	16.34	16.96	31.30	26.98	21.13	16.76	13.43	10.02	11.92	13.59	15.89	15.40	17.28
Sugarcane	0.79	0.94	0.86	0.74	0.61	0.51	0.53	0.49	0.56	0.55	0.47	0.46	0.48

N.B. [a]From Tanzanian Economic Trends Vol. 2 No. 1 (April, 1989)
(Original source: Market Development Bureau).

Table 7 Productions and imports of main food crops[a].

	79/80	80/81	81/82	82/83	83/84	85/86	87/88	88/89	89/90
Total Production of Main Food Crops (000 mt)									
Maize	1,726	1,839	1,654	1,651	1,939	2,067	2,127	2,359	
Paddy	291	200	320	350	356	425	496	644	
Wheat	87	90	95	58	74	83	71	72	
Mixed Pulses	310	272	297	282	281	406	345	424	
Total Imports (000 ton)									
Maize	32.5	274.6	231.6	123.4	194.3	128.5	6.1	93.8	85.0
Rice	54.7	65.2	66.5	29.4	57.1	36.1	32.9	63.5	44.5
Wheat Grain	32.5	48.7	70.9	11.4	46.3	33.4	21.8	53.5	33.7

N.B. [a]From Tanzanian Economic Trends, Vol. 2 No. 1 (April, 1989).

Table 8 Regional collection of soybean (metric ton)[a].

	74/75	75/76	76/77	77/78	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88
Cost/DSM	-	-	3	-	-	-	-	-		-	-	-	-	-
Iringa	-	-	-	-	-	-	-	14		15	20	-	35	-
Kilimanjaro	-	-	-	-	2	-	-	-		5	-	-	-	-
Morogoro	-	30	72	109	349	55	212	70		46	70	96	135	154.1
Mwanza	-	-	-	8	1	-	-	-		-	-	-	-	-
Mtwara	-	8	-	246	334	23	239	16		180	190	273	877	967.2
Lindi	750	-	785	243	372	739	447	77		23	25	66	122	379.4
Rukwa	-	-	2	-	1	18	-	-		32	90	26	-	27.5
Ruvuma	-	-	-	-	-	-	-	10		-	-	-	129	0.3
Singida	-	6	-	-	-	-	-	-		-	-	-	-	-
Tabora	-	-	-	-	1	3	1	-		-	-	4	-	0.4
Kagera	-	-	-	-	-	-	-	-		-	-	-	-	-
Tanga	-	5	1	1	-	-	-	-		-	-	-	2.3	-
Total	750	49	860	603	1,059	838	899	187		301	395	465	1,300.3	1,528.9

N.B. [a]From: Bulletin of Crop Statistics 1981-82 and Basic Data Agriculture and Livestock Sector 1983/84-1987/88 (1982/83 data were not obtained). Collection by GAPEX (General Agricultural Production Export Corporation) up to 1986/87, and collection by Cooperative Unions in 1987/88.

Table 9 World prices of selected agricultural products (US$/ton).

Product	1988[a]	1989[b]	1990[c]
Soybean	-	225 FOB	253 CIF
Green gram	310 CIF	310 FOB	-
Sunflower seeds	-	200 FOB	165 CIF
Chick peas	400 CIF	400 FOB	450 CIF
Pigeon peas	235 CIF	260 FOB	300 CIF
Sesame seeds	560 CIF	570 FOB	700 CIF
Red kidney beans	-	-	480 CIF

N.B. [a]Tanzania Trade Currents, November/December, 1988.
[b]Tanzania Trade Currents, November/December, 1989.
[c]Export Market Information (Daily News, 21/12/1990).

VI. ACTIVITIES ON MAIZE

Maize is the most important food crop grown and consumed in Tanzania. It is produced by over 50 percent of Tanzanian farmers on approximately 1,700,000 ha (Moshi and Marandu, 1985). In Kilimanjaro Region, although farmers in high altitude areas live on coffee-banana mixed cropping, maize is a most important crop for farmers in low altitude areas. It is usually planted under rainfed conditions and productivity is generally not high especially in the areas where rainfall is not reliable.

Maize had been cultivated at the Trial Farm and nitrogen rate experiments were conducted before arrival of the reporter. However, there was no reliable information obtained yet on variety and agronomic practices.

Maize was not included as a crop to be studied in the Record of Discussions (R/D) on KADP (which mentioned vegetable, soybean, etc. in the field of upland crops). Reasons of not including maize in the R/D were not clear. But some people said that there were enough information and data on maize cultivation in Tanzania, then it might be not attractive to work along maize.

There were 2 reasons for maize to be included in the activities of Upland Crops Section. It was rather difficult to find crops other than maize which could cover wide upland field in Lower Moshi Irrigation Project (LMIP) in a short time. Many agricultural extension workers, whom the Section conducted training on upland crops, worked along maize. If staff of the Section knew about maize less than the extension workers, it might be a problem in conducting the training. In addition, it is known that continuous soybean cultivation in a same plot creates problem of soil fertility (especially building up of nematode population). To avoid this problem, soybean should be planted in rotation with gramineous crops.

Capacity of the Section on maize research was limited during early stages of KADP. It has improved to some extent in the last years.

1. Materials and Methods

Most of commercial maize varieties available in the locality (Moshi and Arusha) for the lower altitude area were used in trials (especially variety comparison experiments). Some local varieties were also included.

It was planted in rainy and dry seasons, under irrigation (sprinkler, furrow) and rainfed, under with and without ridge construction according to the purpose of cultivation. Most of the trials in early stages were conducted under sprinkler irrigation conditions. Later they were gradually shifted to under rainfed conditions. Plant spacing for maize cultivation was usually 75 cm between rows but distance within rows and number of plants per hill varied depending on varieties and other reasons.

Days to one half germination, days to one half silking, days to 95 percent maturity, plant height, ear node height, percent of lodging, number of plants per sampling area (6 m^2 in most cases), number of ears harvested, and number of barren plants were usually taken while the plants were in the field.

After harvesting, ear weight and grain weight per sampling area (and % of shelling) were obtained. One hundred grain weight and grain yield per unit area (ha) were obtained at 15 percent moisture content using a maize moisture meter. Number of grains per unit area (m^2) was calculated based on the 100 grain weight and grain yield (kg/ha).

2. Variety Comparison

Several variety comparison trials were conducted in the last 4 years both rainy and dry seasons and both with and without replications. Seeds were obtained at TFA (Tanganyika Farmers Association) Moshi shop and TANSEED (Tanzania Seed Company) in Arusha. Some local cultivars were also included in the trials. Table VI-1 shows grain yields of maize varieties planted in different environments.

Table VI-1 Grain yields of maize varieties planted in different seasons under different management conditions.

Date of planting:	16/10/86	21/4/87	8/10/87	16/3/88	23/3/89
Nitrogen rate (kg/ha):	80	80	80	120	120
Time of application[a]:	KH	P	KH	KH	P
Irrigation method[b]:	S	S	S	R	S
Variety					
H632	3,974c-h	-	-	-	-
ICW	2,782h	3,640	582	-	-
Katumani	4,599b-g	3,801	3,294	3,689	4,764c
Kilima	-	-	2,020	3,766	4,835c
Kito	4,962b-e	3,600	2,285	2,837	4,705c
LICW	5,026bcd	4,982	3,855	5,176	5,850bc
LT	-	4,366	-	-	-
MH41	7,147a	6,317	5,268	6,893	7,608a
Mwanga Local	-	-	932	-	-
Mogire	-	-	672	-	-
Rombo Local	5,154bc	-	-	-	-
SR52	5,498bc	5,182	1,801	-	-
Staha	4,749b-f	3,281	-	3,711	5,011bc
TMV-1	-	-	3,485	4,696	6,840ab
Tuxpeno	5,761ab	4,199	-	2,800	6,428abc
Observed F					
Replication	5.40**	2.04ns	-	-	1.40ns
Treatment	4.68**	2.69ns	-	-	3.66*
cv (%)	21.2	27.0	-	-	17.4

N.B. [a]KH for knee-high stage and P for planting.
[b]S for sprinkler irrigation R for rainfed conditions.
Any two means having a common letter in a column are not significantly different at the 5% level of significance.

MH41 variety always produced the highest grain yield. Among others, LICW (Local Ilonga Composite White; local cultivar), TMV-1 and Tuxpeno produced good yields. Although MH41 was most productive, but there was a problem of seed supply. The seeds were imported from Malawi (MH41 means Malawi Hybrid 41), then there has been no supply of the seeds since 1988. Seeds of the variety used since then were those kept at the Section.

3. Fertilizer Rate

Using different varieties in different seasons, fertilizer experiments were conducted under sprinkler irrigation conditions. Table VI-2 shows the grain yields in different experiments.

Table IV-2 Grain yields of maize varieties planted at different fertilizer conditions under sprinkler irrigation conditions.

Date of planting:	19/9/86	21/4/87		21/4/87
Variety used:	H632	Staha		Tuxpeno
Fertilizer application:	Knee-high	Knee-high		Planting
Nitrogen rate (kg/ha)			Fertilizer rate (kg/ha)	
0	2,288d	3,497	Control	3,266c
40	4,026b	4,588	80 N (N)	5,685a
80	3,705bc	4,480	40 P_2O_5 (P)	3,780bc
120	5,744a	5,099	N + P	5,214ab
Observed F				
Replication	-	3.04ns		0.22ns
Column	10.8**	-		-
Row	0.75ns	-		-
Treatment	14.7**	3.52ns		4.06*
cv (%)	18.9	16.2		25.4

N.B. Any two means having a common letter in a column are not significantly different at the 5% level of significance.

The variety used for the first experiment (planted on 19/9/1986) was not the one recommended to the lower altitude zone. It is difficult to get conclusion from these trials. Two fertilizer experiments (i.e. N-rate, N and P rate) were conducted for Kito variety in 1989 rainy season, but they were discarded because of poor plant establishment caused by poor germination and early growth (due to poor leveling and improper distribution of sprinkler water).

Another nitrogen rate experiment was conducted in 1988 using MH41 variety under a randomized complete block (RCB) design with 8 treatments and 4 replications. The treatments were: (1) without fertilizer application, (2) 40 kg of nitrogen per ha, (3) 80 kg of nitrogen per ha, (4) 120 kg of nitrogen per ha, (5) 160 kg of nitrogen per ha, and (6) 200 kg of nitrogen per ha of 1 plant per hill, and (7) 120 kg of nitrogen per ha and (8) 200 kg of nitrogen per ha of 2 plants per hill at the spacing of 75 cm between rows and 40 cm within rows. Number of seeds planted was one seed more than the intended number of plant(s), then thinning was done at 24 days after planting. Nitrogen fertilizer was applied at the knee-high stage (26 days after planting). Table VI-3 presents the results.

Although intended plant population of the dense spacing was 2 times higher than that of ordinary one, the results indicated that the former was about 1.82 times denser than the later (in average). Leaf area index (LAI), taken from 2 replications, at 2 weeks after silking were high in the dense spacing (4.27 and 4.34) and low in the ordinary spacing (ranged 2.22-2.43). The LAI was constant regardless of the differences in nitrogen rate but increased as plant density increased. The treatment of 200 kg of nitrogen per ha with dense spacing produced the highest grain yield (6,788 kg/ha); rather high grain yields were obtained in all the treatments (i.e. 5,081 kg/ha from the control).

Table VI-3 Grain yields and other characteristics of maize (MH41 variety) planted under different nitrogen rates and plant spacings in March, 1988.

N-rate (kg/ha)	LAI at 2 WAS[b]	Plants /6 m^2	Ears /6m^2	100 grain weight(g)	Grains per m^2	Grain yield (kg/ha)
0 (1)[a]	2.34b	17.8b	17.0b	38.4ab	1,331c	5,081b
40 (1)	2.26b	17.5b	17.3b	38.7ab	1,329c	5,143b
80 (1)	2.22b	17.0b	17.0b	39.0ab	1,443c	5,613b
120 (1)	2.36b	17.8b	18.0b	41.7a	1,436c	5,968ab
160 (1)	2.43b	18.0b	18.0b	38.4ab	1,541bc	5,922ab
200 (1)	2.34b	17.3b	18.8b	35.0bc	1,667b	5,834ab
120 (2)	4.27a	31.8a	29.0a	32.5d	2,038a	6,633a
200 (2)	4.37a	32.8a	28.0b	33.0cd	2,034a	6,778a
Observed F						
Rep.	12.9**	2.50ns	1.72ns	1.43	0.12ns	0.49ns
Trt.	56.7**	108**	32.2**	5.64**	14.5**	2.60*
cv (%)	6.2	6.2	9.2	7.3	9.5	13.0

N.B. [a]Figures in parentheses are number of plant(s) at 75 cm between rows and 40 cm within rows.
[b]WAS: Week after silking, taken only from 2 replications.
Any two means having a common letter in a column are not significantly different at the 5% level of significance.

4. Plant Spacing

A plant spacing experiment was conducted using 4 varieties in 2 spacings under rainfed conditions in 1988. A 4 x 2 factorial in RCB design with 4 replication was used in the experiment. Varieties of Katumani, Kito (both early maturing varieties) LICW (Local Ilonga Composite White: a local cultivar), and MH41 were planted at the plant spacings of 75 cm between rows, 40 cm within rows, and either single or double plant(s) per hill. Nitrogen fertilizer at the rate of 120 kg per ha was applied at the knee-high stage (26 days after planting). LAI was taken at the silking stage. Table VI-4 shows the results.

The periods to silking and maturity were less in Katumani and Kito; both of them matured in about 100 days. It was about 108 days for MH41 and 110 days for LICW. The LAI increased as days to silking and plant population increased; it was low in the sparse spacing of Katumani and Kito and high in the dense spacing of LICW. LAIs of the early maturing varieties at the high density were still lower than those of medium maturing varieties at the low plant density. The increase of plant density did not influence the plant height and ear node height of the early maturing varieties but increased those of LICW and MH41.

The densely planted MH41 produced the highest grain yield (6,305 kg/ha); the sparsely planted Kito produced the lowest (3,043 kg/ha). The ear size and grain size were rather constant for the early maturing varieties, but they decreased as plant population increased in MH41 and LICW. The number of grains per unit area increased as the population increased in all the varieties. The results indicate that the grain yield of the early maturing varieties increased through increasing plant population but it did not change in other varieties. The optimum plant spacing for early maturing varieties might be denser if environment conditions are favorable. The adequate plant spacing for medium maturing variety might be just between the treatments (i.e. 75 cm x 60 cm, 2 plants/hill).

Table VI-4 Grain yields and other characteristics of 4 maize varieties planted in 2 spacings in March, 1988.

Treatment[a]	Days to silking	Days to maturity	LAI at silking	Plant height (cm)	Ear node height (cm)	Plants[b]/ m^2
Variety: (A)						
Katumani						
(1)	47.5	100.5	1.63	270	110	17.5
(2)	45.8	97.5	2.96	272	123	31.0
Mean	46.6d	99.0c	2.30c	270c	116c	24.3
Kito						
(1)	49.5	98.3	1.76	247	99	16.8
(2)	50.3	99.5	3.25	256	97	32.5
Mean	49.9c	98.9c	2.50c	252d	98d	24.6
LICW						
(1)	61.3	110.5	3.19	320	153	17.8
(2)	60.8	111.0	5.83	333	171	31.3
Mean	61.0a	110.8a	4.51a	326a	162a	24.5
MH41						
(1)	54.5	109.0	2.40	289	124	17.5
(2)	55.3	108.0	4.54	313	149	35.5
Mean	54.9b	108.5b	3.47b	301b	137b	26.5
Plant spacing: (B)						
75,40,1[c]	53.2	104.5	2.24b	281b	121b	17.4b
75,40,2	53.0	104.0	4.14a	294a	135a	32.6a
Observed F						
Rep.	1.81ns	1.28ns	1.09ns	1.66ns	1.20 ns	0.59ns
Trt.	61.2**	67.0**	154**	61.9**	38.4**	62.8**
A	141**	152**	159**	136**	79.5**	1.98ns
B	0.13ns	1.24ns	557**	18.9**	19.5**	427**
AxB	1.29ns	3.44*	14.0**	2.38ns	3.58*	2.15ns
cv (%)	2.8	1.4	7.1	2.8	6.8	8.3

Table VI-4 .....continued.

Treatment[a]	Ears /6m^2	Mean ear weight(g)	% of shelling	100 grain weight(g)	Grains per m^2	Grain yield (kg/ha)
Variety: (A)						
Katumani						
(1)	17.3	126	84.3	35.7	868	3,090
(2)	28.0	106	84.2	35.1	1,319	4,635
Mean	22.6b	116c	84.2a	35.4ab	1,094d	3,863c
Kito						
(1)	17.0	133	80.8	27.4	1,109	3,043
(2)	28.8	119	81.0	27.6	1,662	4,573
Mean	22.9b	126c	80.9c	27.5c	1,386c	3,808c
LICW						
(1)	17.3	204	77.5	31.0	1,433	4.423
(2)	25.8	144	76.9	26.8	1,728	4,628
Mean	21.5b	174b	77.2d	28.9c	1,580b	4,525b
MH41						
(1)	18.0	247	82.3	44.2	1,428	6,287
(2)	32.5	143	82.0	31.0	2,040	6,305
Mean	25.3a	195a	82.2b	37.6a	1,734a	6,296a
Plant spacing: (B)						
75,40,1[c]	17.4b	177a	81.2	34.6a	1,209b	4,211b
75,40,2	28.9a	128b	81.0	30.1b	1,687a	5,035a
Observed F						
Rep.	0.21ns	1.39ns	(0.50ns)	0.12ns	3,16*	2.55ns
Trt.	48.6**	38.1**	(23.1**)	14.2**	32.4**	30.8**
A	5.97**	47.6**	(53.7**)	20.0**	36.7**	55.6**
B	311**	81.9**	(0.36ns)	16.3**	110**	28.0**
AxB	3.72*	14.1**	(0.15ns)	7.74**	2.30ns	7.03**
cv (%)	7.9	10.2	(1.4)	9.6	8.9	9.5

N.B. [a]Figures in parentheses are number of plant(s) at 75 cm between rows and 40 cm within rows.
[b]Indicates cm between rows, cm within rows, plant(s)/hill.
Any two means having a common letter in a column are not significantly different at the 5% level of significance.

5. Other Trials

Katumani and Kito were crossed in 1988/89 and 1989/90 dry seasons to produce the hybrids of Katumani (silk) x Kito (pollen) and Kito (silk) x Katumani (pollen). The original varieties, their off-springs and 2 hybrids were planted in 1989 rainy season under sprinkler irrigation. Main objective of the trial was to let Tanzanian staff familiarize with the procedure of maize hybrid production practically. They were planted under an experiment design of split-plot where variety was main plot and nitrogen rate (0, 40, 80, 120 kg/ha) was sub-plot. Table VI-5 shows the results.

Because of the drifting of irrigation water, some plots faced drought. As a result, high CVs (coefficient of variation) were observed for yield and yield components. Although rather high grain yield was obtained from the treatment of without nitrogen application, application of nitrogen fertilizer increased the grain yield; it was statistically highly significant. Difference in grain yield among the entries (3,425-5,136 kg/ha) was statistically not significant. Similar experiment conducted in 1990 failed due to flooding of the plot.

Table VI-5 Grain yields and other characteristics of early maturing maize varieties and their hybrids planted in March, 1989.

Treatment	Plants /6 m^2	Ears /6m^2	100 grain weight(g)	Grains per m^2	Grain yield (kg/ha)
Katumani Original	35.4b	29.8	35.2a	1,218bc	4,314
Katumani Offspring	35.1b	28.0	35.5a	957c	3,425
Kito Original	39.9a	33.9	27.9b	1,678a	4,720
Kito Offspring	37.6ab	31.6	28.0b	1,588a	4,544
Katumani x Kito	37.7ab	31.1	33.3a	1,405ab	4,677
Kito x Katumani	39.1a	32.1	33.5b	1,522ab	5,136
Sub-mean					
0 kg N/ha	36.6	29.5	31.5	1,207b	3,741b
40 kg N/ha	38.6	32.1	32.8	1,494a	4,886a
80 kg N/ha	38.2	31.4	31.7	1,389ab	4,376a
120 kg N/ha	36.2	31.6	32.8	1,489a	4,876a
Observed F					
Variety	2.98*	2.76ns	16.9**	5.83**	1.98ns
N rate	2.26ns	2.06ns	2.04ns	4.40**	5.96**
Interaction	1.21ns	1.39ns	1.93*	1.16ns	1.64ns
cv (%): Variety	12.0	15.7	10.4	31.7	36.8
: N rate	10.3	12.2	7.6	22.5	24.3

N.B. Any two means having a common letter in a column are not significantly different at the 5% level of significance.

Sweet corn was planted in a small area in 1988/89 dry season. The product was tasted by some Tanzanian staff, but it was not so attractive to them. Since maize is one of the staple foods in the country (including grilled one for snack), sweet corn may not be regarded as a snack food. Productivity of sweet corn was also not attractive.

6. Discussion

Most of the area of LMIP was probably savannah until 3 to 4 decades ago. Population pressure in high altitude areas on the slopes of Kilimanjaro and Pare mountains created the necessity of utilizing the land of low altitude area for crop production. It was reported that many people moved to the area in 1950s and 1970s (Katsuki, 1988).

Soils in the area are generally fertile except some areas where soils are either saline or alkaline (Iseki, 1988). The main problem in crop production in the low altitude area is not soil fertility but availability of water (especially rainfall for upland farming).

Among the maize varieties tested at the Trial Farm, MH41 was most productive. However, there was a shortage of seeds for this variety because it has been imported from Malawi. Recently a seed company has been trying to establish a seed farm for MH41 variety in the country (personal communication with the seed company).

All the varieties recommended to the low altitude area are composites. Since LMIP area is marginal area for maize cultivation under rainfed condition, emphasis was paid for the the improvement of cultivation techniques through introduction of early maturing varieties (Katumani, Kito). But, due to several reasons (i.e. poor leveling of the plot, flood, etc.), reliable data were not obtained. Newly released TMV-1 variety (medium maturing variety) seems more productive in favorable years comparing with other varieties recommended to the low altitude area (e.g. ICW, Staha, Tuxpeno).

Most commonly planted maize variety in the area, so called LICW, is a local cultivar and usually called as Ilonga Composite White (ICW) by farmers. There are distinct differences between LICW and ICW. LICW has wide adaptability to the change of environment (especially drought).

Although it is difficult to get a conclusion from the fertilizer (nitrogen) rate trial, 40 kg of nitrogen per ha may be enough for maize cultivation under rainfed conditions. A relatively dense plant spacing (i.e. 75 cm x 40 cm, 2 plants/hill) for the early maturing varieties (Katumani, Kito) and a comparatively sparse plant spacing (i.e. 75 cm x 60 cm, 2 plants/hill) for the medium maturing varieties (MH41, TMV-1, LICW) can be a general guideline for the plant spacing. The spacings are same as those recommended from the national agricultural research institute (TARO, 1987).

Demonstration of maize cultivation under irrigation conditions in LMIP was included in the Tentative Schedule of Implementation for KADP. It was once tried to conduct in 1987, but it was not realized because of several reasons (i.e. land leveling, payment for land rent, etc.). After the completion of LMIP in 1987, it was found that there was not enough water even for paddy production (1,100 ha). As a result, the demonstration of irrigated maize cultivation was canceled.

There is 1,200 ha of upland field in LMIP. Irrigation canals were constructed but land leveling was not done for upland plots. Due to severe water shortage they are generally used for rainfed maize cultivation as same as before the construction of LMIP. Irrigation water is utilized for the expansion of paddy planted area because irrigated paddy cultivation is more profitable than upland crops (i.e. maize, soybean, sunflower). Consequently, there is almost no water for upland farming.

As mentioned earlier (Chapter III), rainy season of the area is short and maize yield depends on the distribution of rainfall. However, there is some volume of excess water running in Njoro and Rau rivers in April, May and June (and July depending on year) because of rains in upper streams and less water requirement of paddy plots (due to low temperature and cloudy days).

In the last years, supplement irrigation to maize field was practiced in late May, June and early July depending on the distribution of rains and availability of excess irrigation water. Irrigating once or twice in early grain filling period prevents the reduction of yield caused by drought to some extent. Since there is 1,200 ha of upland field in LMIP, supplement irrigation for upland field should be practiced as much as possible. Otherwise, there is no benefit from the construction of irrigation canals for the upland field.

It may be better to continue some trials of maize (i.e. variety comparison, intercropping with soybean) as long as the Section's duties are applied research of upland crops and training of extension workers. However, it may be not a main crop for the Section in the future, because some other crops require more research (i.e. sunflower) and extension (i.e. soybean). Communication with national research organization should be maintained for obtaining information and seeds.

If there is a better cooperation with the Regional Agricultural and Livestock Development Office (RALDO), a maize variety comparison trial in different Districts may be conducted as the first step of joint work. In this way, KADC (Upland Crops Section) can serve to the farmers more directly, and there will be interactions between KADC and RALDO for the agricultural development in the Region.

7. References

Iseki, A. 1988. Soil and fertilizer. In: Reports of short term experts to Kilimanjaro agricultural development project. JICA. pp: 1-34. (in Japanese).

Katsuki. 1988. Agricultural economy. In: Reports of short term experts to Kilimanjaro agricultural development project. JICA. pp: 35-84 (in Japanese).

Moshi, A.J. and W. Marandu. 1985. Maize research in Tanzania. In: To feed ourselves -- A proceedings of the first eastern, central and southern Africa regional maize workshop--. Lusaka, Zambia, March 10-17, 1985. The Government of Zambia and CIMMYT. pp: 112-117.

TARO (Tanzania Agricultural Research Organization). 1987. Recommendations for maize production in Tanzania.

VII. ACTIVITIES ON SUNFLOWER

After knowing that there would be no irrigation water allocated to the upland plots of Lower Moshi Irrigation Project (LMIP), cultivation trials of sunflower was initiated in 1989. An oil extraction machine arrived in the same year initially for extracting oil from soybean. Since it is a multi-purpose machine, sunflower can be one of raw materials.

Sunflower is an important oilseed crop which is widely distributed in Tanzania. The seed contains 20 to 55 percent oil and 15 to 20 percent protein depending on variety. It is adapted to a wide range of environments. In Tanzania it can be grown from sea level up to over 2,000 m, but grows best at medium to high elevations. Sunflower is reputed to be drought resistant relative to some other crops. It will grow well and give a reasonable yield with only 400 to 500 mm of rain distributed throughout the growing season (TARO, 1987).

Record variety (one of two recommended varieties in the country) seeds were obtained from Ilonga Agricultural Research and Training Institute (IARTI) in 1989, then planted in March, 1989 under sprinkler irrigation conditions. A split-plot experiment design with 4 nitrogen rates (main plot), 2 plant spacings (sub-plot) and 3 replications was used. The nitrogen rates were: (1) Nil, (2) 30 kg per ha, (3) 60 kg per ha, and (4) 90 kg per ha; all the fertilizer was applied at planting. Plant spacings were: (1) 75 cm (between rows) x 30 cm (within rows) x 1 plant per hill and (2) 75 cm x 60 cm x 2 plants per hill (2 additional seeds were planted, then later thinned).

Table VII-1 presents the yield data. The days to flowering ranged between 60 to 62. Due to heavy bird attacks and shattering, most off the heads were not harvested. Yield data were taken only from 4 plants (3 plants in some treatments) which were not attacked by birds. The grain yield (g/plant) indicated that there was a possibility of good yield if birds were properly controlled.

Same variety was planted in November, 1989 at the plant spacing of 75 cm between rows and 30 cm within rows (about 2 plants/hill at harvest). Fertilizer was applied 4 weeks after planting at the rate of 30 kg of nitrogen per ha. At the time of flowering, off type plants were taken away. Birds scaring had been practiced. Yield sampling were taken from relatively good growing areas (less bird attacked, less drought faced).

Table VII-2 shows the results. The average grain yield of 4 sampling spots was 3,169 kg per ha at air dried moisture content. The results of two trials encouraged the work of sunflower introduction.

Sunflower cultivation trial was not conducted as sole crop but conducted as soybean/maize/sunflower intercropping trial in 1990 rainy season (under rainfed conditions). The results are reported in Cropping Systems (Chapter VIII); its pure stand yield was 1,675 kg per ha under without fertilizer application.

Besides, sunflower was planted in a portion of fallowed paddy plot in 1989 and 1990 under rainfed conditions. The growth was quite poor under waterlogged conditions after rains. It may be be not advisable to plant the crop in paddy plots of LMIP.

Table VII-1 Yields and yield components of sunflower (Record variety) planted under different nitrogen rates and spacings in March, 1989[a].

Treatment Plant spacing[b]	Plants /4.5m^2	Head diameter(cm)	100 grain weight(g)	Grain yield (g/plant)
0 kg N/ha				
75,30,1	13.7	20.9	9.8	108
75,60,2	16.0	21.6	9.3	118
30 kg N/ha				
75,30,1	15.0	21.1	9.8	126
75,60,2	18.0	21.1	9.7	109
60 kg N/ha				
75,30,1	11.7	21.1	9.6	108
75,60,2	15.7	19.6	9.0	107
90 kg N/ha				
75,30,1	13.3	20.7	9.9	119
75,60,2	16.7	21.0	9.4	138
Observed F				
N rate	2.27ns	0.46ns	0.26ns	1.13ns
Spacing	8.35*	0.04ns	1.08ns	0.08ns
Interaction	0.10ns	0.58ns	0.07ns	0.68ns
cv (%)				
N rate	12.6	7.1	10.9	17.7
Spacing	17.9	7.3	10.7	19.2

N.B. [a]Because of birds attack, yield data were obtained from 3-4 plants without attack; yield per unit area was not taken.
[b]Indicates cm between rows, cm within rows, plant(s)/hill.

Table VII-2 Yield and yield components of sunflower (Record variety) planted with 30 kg N per ha in November, 1989[a].

Spot number	Plants /3 m^2	100 grain weight(g)	Grains per m^2	Grain yield (kg/ha)	Grain yield (g/plant)
1	26	6.5	4,851	3,153	36.4
2	21	6.8	4,872	3,313	38.2
3	30	5.8	7,431	4,310	49.7
4	24	4.3	4,419	1,900	21.9
Mean	25.3	5.9	5,393	3,169	37.5

N.B. [a]63 days for 1/2 flowering, 107 days for the maturity.

Research on sunflower was initiated recently, and it is too early to judge whether sunflower is productive in the locality or not. However, it may be one of potential crops if bird attack is properly controlled. If Upland Crops Section is requested to deal with another crop next to soybean, sunflower should be the one under present situations of irrigation water in LMIP.

Sunflower planted area has been expanding not only in upland plots within LMIP but also in Kilimanjaro Region although the Region itself is not a major sunflower producing area at the moment (it is widely purchased in Singida, Dodoma, Ruvuma, and Shinyanga Regions). Although it is difficult to obtain planted area of sunflower, the amount of purchase increased from 4,451 ton in 1983/84 to 13,256 ton in 1987/88 (according to Ministry of Agriculture and Livestock Development: Basic Data Agriculture and Livestock Sector 1983/84-1987/88).

Research work of sunflower is conducted by the National Sunflower Research Program (main station at Ilonga Agricultural Research and Training Institute: IARTI); it has received an assistance from ODA (Overseas Development Administration, United Kingdom) in the last years. The Program is planning to release new varieties (i.e. CCA75) in the near future (National Sunflower Research Program, 1990). The Section has obtained the seeds of CCA75 for planting in 1991 rainy season.

There is a shortage of vegetable oil in the country. Then sunflower production became popular in recent years owing to the production and dissemination of a simple oil extraction machine (called Bielenberg ram press after the name of innovator). The ram press normally sold at 60,000 shillings is relatively easy machine to operate and maintain, and is now widely available (Daily News, 1990). There are two other oil extraction machines (operated by electricity) available in the country they were displayed at the Arusha Agricultural Fair held in early September, 1990.

If sunflower becomes one of main crops to be studied at the Upland Crops Section in the future, same as soybean, utilization of product should be accompanied with the introduction of cultivation techniques. The oil extraction plant constructed at KADC can be used for oil extraction out of sunflower. It can extend services for those who produce sunflower nearby.

Sunflower introduction at the village level may be much easier than that of soybean because: (1) farmers are more familiar with sunflower comparing with soybean, (2) oil content is higher (more than 40% depends on variety, according to the data of National Sunflower Research Program), and (3) oil extraction machines are available. Sunflower seeds (Record variety) are sold at Tanzania Seed Company (TANSEED) in Arusha.

Bird attack will be probably the most serious problem in sunflower introduction. It may be minimized to some extent if the crop is planted in wide areas at the same time (short duration of harvesting period) and the grain-filling period is coincided with that of paddy.

References

TARO (Tanzanian Agricultural Research Organization). 1987. Recommendation for improved production of oilseeds in Tanzania.

National Sunflower Research Program. 1990. National sunflower research program 1989/90: Progress report presented to the national sunflower research coordinating committee meeting held at Arusha on 23 November, 1990.

Daily News. 1990. Arusha villages produce edible oil. 20 November, 1990.

VIII. ACTIVITIES ON CROPPING SYSTEMS

At the initial stages of KADP, it was considered that KADP was Kilimanjaro (Irrigated) Agricultural Development Project. Then, getting a consent for conducting trials under rainfed conditions was not easy. To cope with this circumstances, the term of "cropping systems" was initially used for the trials to be conducted under rainfed conditions especially for comparisons of beans, maize and sorghum. Some of the results are included in the report of respective crop.

After accumulation of data on individual crops, it became possible to conduct trials of cropping systems in 1990 rainy season. There were 2 trials conducted in the season; they were (1) soybean/maize intercropping, and (2) soybean/maize/sunflower intercropping. Variety used in the trials were: Bossier (soybean), Kito (maize), and Record (sunflower). Fertilizer was not applied because of flooding.

Treatments (spacings) of soybean/maize intercropping trial were: (1) soybean pure stand (50 cm between row and drilling), (2) maize pure stand (75 cm x 40 cm, 2 plants/hill), (3) soybean/maize 1 (MS1: 50 cm between rows, 3 rows for soybean and 2 rows for maize in sequence), (4) soybean/maize 2 (MS2: 50 cm between rows, 2 rows for soybean and 1 row for maize in sequence). Those of soybean/maize/sunflower intercropping were similar to the soybean/maize intercropping except (a) sunflower pure stand (75 cm x 30 cm, 1 plant/hill) and (b) maize/sunflower (75 cm between rows, 2 rows each for maize and sunflower in sequence).

The first trial was planted on 22 March, and the second one on 30 March, 1990. Soybean seeds were inoculated with Rhizobium for the first trial but they were not inoculated for the second one (due to mis-management). Flood in mid-April adversely effected performances of the crops.

Table VIII-1 shows grain yields of the soybean/maize intercropping trial. The yield of pure stand was 2,019 kg per ha and 1,075 kg per ha for soybean and maize, respectively. The quite low grain yields of maize were due to waterlogged conditions of the plot. LUR (land utilization ratio) of 1.16 was obtained from the soybean/maize (0.60:0.60) plant arrangement.

Table VIII-1 Grain yields of soybean/maize intercropping trial in 1990 rainy season (adjusted to kg/ha).

Treatment	Soybean	Maize	LUR[a]
Soybean pure stand	2,109	-	1.00
Maize pure stand	-	1,075	1.00
Soybean/maize(0.60:0.60)[b]	1,301 (59)[c]	618 (57)[c]	1.16
Soybean/maize(0.67:0.50)	1,031 (49)	475 (44)	0.93

N.B. [a]Land utilization ratio.
[b]Figures in parentheses are rates of plants to the pure stand (pure stand = 1).
[c]Figures in parentheses are rates of yields to those in the pure stands (%).

Table VIII-2 presents results of the soybean/maize/sunflower intercropping trial. The grain yield of pure stand was 1,758 kg per ha, 2,053 kg per ha and 1,675 kg per ha for soybean, maize and sunflower, respectively. Same as the result of soybean/maize intercropping trial, high LURs of 1.37 and 1.26 were obtained from the plant arrangements of soybean/maize (0.60:0.60) and soybean/sunflower (0.60:0.60).

Table VIII-2 Grain yields of soybean/maize/sunflower intercropping trial in 1990 rainy season (adjusted to kg/ha).

Treatment	Soybean	Maize	Sunflower	LUR[a]
Soybean pure stand	1,758	-	-	1.00
Maize pure stand	-	2,057	-	1.00
Sunflower pure stand	-	-	1,675	1.00
Soybean/maize(0.60:0.60)[b]	1,147(65)[c]	1,487(72)[c]	-	1.37
Soybean/maize(0.67:0.50)	1,195(68)	520(25)	-	0.93
Soybean/sunflower(0.60:0.60)	942(54)	-	1,214(72)c	1.26
Soybean/sunflower(0.67:0.50)	528(30)	-	1,067(64)	0.94
Maize/sunflower(0.50:0.50)	-	516(25)	1,359(81)	1.06

N.B. [a]Land utilization ratio.
[b]Figures in parentheses are rates of plants to the pure stand (pure stand = 1).
[c]Figures in parentheses are rates of yields to those in the pure stands (%).

Mixed cropping (mostly that of maize and Phaseolus bean) is a popular farming practice in Kilimanjaro Region especially in mid-altitude zone. Besides, there is widely practiced mixed farming (coffee, banana and other crops) in the high altitude zone. In other words, farmers in the area are accustomed with planting different crops in a same plot.

It is said that the mixed cropping has several advantages comparing with solo cropping. They are: (1) prevention of soil erosion, (2) utilization of soil minerals in different layers, (3) utilization of solar radiation, and (3) nitrogen supply form leguminous crops to other crops. Weakness of mixed cropping is difficulty of farming operations (i.e. planting, weeding, harvesting).

The two trials conducted in 1990 were the first ones at the Trial Farm, and the results were affected by flood and other management problems. However, it indicates that there may be a possibility of finding good plant arrangements for soybean/maize and soybean/sunflower intercroppings.

It may take time for soybean to become a major crop in the area under the present situations of marketing (it is not consumed much by the people at the moment). Intercropping with maize (or sunflower) may create the interest of farmers for home consumption of soybean and improvement of soil nitrogen status (for companion crops).

IX. TRAINING OF KADP STAFF AND EXTENSION WORKERS

1. Movement of Staff at Upland Crops Section

There are 4 Agricultural Field Officers (AFOs) assigned to the Upland Crops Section of KADC at the moment (March, 1991). Table IX-1 presents general information of the Tanzanian staff who have worked at the Section in the last 5 years.

Table IX-1 Tanzanian staff assigned to Upland Crops Section from mid-1986 to early 1991.

Mr. Z.K. Sarakikya: AFO II (Head of the Section)
- Graduated from Faculty of Agriculture, University of Dar es Salaam (Diploma in General Agriculture) in 1973.
- Worked as Assistant District Agricultural Development Officer (Hai District, Kilimanjaro) before joining to KADC
- Joined KADC in January, 1982

Mrs. G. Mshanga: AFO III
- Graduated from MATI-Ilonga (Certificate) in 1974
- Graduated from UAC (Diploma in Home Economics) in 1980
- Worked in Tanga Region before joining to KADC
- Joined KADC in June, 1982

Mr. B. Macha: AFO IV
- Graduated from UAC (Certificate) in 1977
- Graduated from MATI-Tengeru (Diploma in Horticulture) in 1989
- Worked in Hai District, Kilimanjaro before joining to KADC
- Joined KADC in August, 1981

Mr. M.G. Rugemalira: AFO IV
- Graduated from MATI-Ukiriguru (Diploma in Crop Production) in 1986
- Joined KADC in September, 1987

Mr. B. Mrisha: AFO IV
- Upland Crops Section ---> Agronomy Section
- Graduated from MATI-Ukiriguru (Diploma in Crop Production) in 1988
- Worked in Moshi District, Kilimanjaro before joining to KADC
- Joined KADC in March, 1990
- Transferred to Agronomy Section (KADC) as head of the Section in September, 1990

Mrs. L. Chihongo: Ex-staff
- Worked from August, 1982 to December, 1987

Mr. G. Sichali: Ex-staff
- Worked from June to August, 1988

N.B. AFO: Agricultural Field Officer
MATI: Ministry of Agriculture Training Institute
UAC: Uyole Agricultural Center

2. Training of Staff at the Upland Crops Section

JICA offers different kinds of training courses for personnel working with the experts either under the project type technical cooperation or individual dispatch. Most of the Tanzanian staff (so called counterparts) assigned to KADP have participated the training programs in Japan. All of the staff at Upland Crops Section have attended the training courses in Japan. Table IX-2 shows the details of the training courses that staff of the Section attended.

Table IX-2 Training for staff at Upland Crops Section under JICA's training program.

Individual Training Course on Bean Cultivation
- Mr. Z.K. Sarakikya: 9 months in 1981

Vegetable Crops Production Course (Group Training)
- Mr. B. Macha: 10 months in 1984
- Mrs. L. Chihongo: 10 months in 1985
- Mrs. G. Mshanga: 10 months in 1986
- Mr. Z.K. Sarakikya: 10 months in 1988
- Mr. M.G. Rugemalira: 10 months in 1990

Besides attending the training courses in Japan, Mr. B. Macha took an in-country training at MATI-Tengeru on vegetable production for 2 years (1987-1989) and obtained Diploma in Horticulture. This kind of staff training should be utilized for upgrading educational backgrounds and improving technical knowledge of the staff at KADP.

3. Training of Agricultural Extension Workers

The Section had been conducting a training course every year since 1983 for agricultural extension workers assigned in Kilimanjaro Region. It was called Vegetable Cultivation Training Course initially. The training course was modified in the last 5 years. Firstly, it was changed to Upland Crops Cultivation Training Course after knowing the diversified activities of extension worker. Secondly, the participants were limited to those who finished Certificate or above levels of education for having a homogeneous group. Table IX-3 presents the number of participants and duration of the training in the last 5 years.

Table IX-3 Training of agricultural extension workers under Upland Crops Section from 1986-1990.

Year	Name of the training course	No. of attendance	Duration
1986	Vegetable Cultivation	15	2 months
1987	Upland Crops Cultivation	21	2 months
1988	Upland Crops Cultivation	20	4 weeks
1989	Upland Crops Cultivation	19	4 weeks
1990	Paddy & Upland Crops Cultivation[a]	17	6 weeks

N.B. [a]Jointly conducted with Paddy and Agronomy Sections (because of reduction of JICA's fund for training).

There were totally 92 extension workers who participated the training. Since there are about 500 agricultural extension staff assigned under the regional agricultural and livestock development office (excluding those assigned at KADP), about 1/5 of them attended the training in the last 5 years.

Duration of the training course was 2 months in 1986 and 1987, but it was shortened to 4 weeks in 1988 and 1989 due to the conflict of time and space with other training courses (created by late release of fund for training). The training was jointly conducted with Paddy and Agronomy Sections in 1990 because there was a reduction of JICA's training fund.

The training consisted of lectures on agronomy and individual crops, field practices on different kinds of crops, and a study tour. In 1986 and 1987, participants are requested to report "Agriculture and Agricultural Extension of (Respective) District. Since 1988 it was not requested because of shortened training period.

Some resourceful persons were invited to the training as external lectures since 1988. Table IX-4 presents the external lectures invited and their titles of lectures. The lectures were not only attractive to the participants but also useful for the training staff. Besides the lecturing, the external lecturers visited Lower Moshi Irrigation Project (LMIP) for exchanging ideas on the management of LMIP and improvement of KADP.

Table IX-4 External lecturers invited for the training courses conducted by Upland Crops Section[a].

Year	Name	Organization[b]	Title of lecture
1988	M.P. Salema	SUA	Soil and fertilizer
1988	A.J. Moshi	IARTI	Maize cultivation
1888	A.A. Massawe	KRALDO	Agricultural extension
1989	M.P. Salema	SUA	Soil and fertilizer
1989	J.A. Assenga	IARTI	Soybean cultivation
1989	E. Kuandika	THRTI	Vegetable cultivation
1989	A.A. Massawe	KRALDO	Agricultural extension
1990	J.M. Nguma	TPRI	Water borne diseases
1990	A.S.M. Ijani	TPRI	Rice disease control
1990	J.Kessy	KRALDO	Agricultural extension
1990	A.O. Swai	MDALDO	Soybean extension case study
1990	I.A. Ngowo	RDALDO	Soybean extension case study

N.B. [a]raining in 1990 was jointly conducted with Paddy and Agronomy Sections.
[b]SUA: Sokoine University of Agriculture, IARTI: Ilonga Agricultural Research and Training Institute, KRALDO: Kilimanjaro Regional Agricultural and Livestock Development Office, THRTI: Tengeru Horticultural Research and Training Institute, TPRI: Tropical Pesticide Research Institute, MDALDO: Mwanga District Agricultural and Livestock Development Office, RDALDO: Rombo District Agricultural and Livestock Development Office.

Two of the ex-participants of the training were invited in

1990 as speakers on soybean extension case studies at village level. They became interested in soybean extension after attending the training course in 1987. They presented well arranged reports on their soybean extension works (in Rombo and Mwanga Districts). The reports are attached as Appendix IV-4 (Soybean Extension at Village Level).

4. Collection of References

During the initial stages of KADP, there were few references for staff and trainees. It was a surprise that several kinds of training were conducted without enough references. References were obtained from different sources (i.e. international and national agricultural research organizations). One room was secured as a reference room where they were arranged.

There are several books (booklets) of more than 50 copies which can be used by every participant attending a training course. Since KADP does not have enough capacity of producing all the required teaching materials (hand-outs) for any kind of training, it should utilize those available in the country.

The purposes of collecting the references are not only for the trainees but also for KADP staff. Although there are some of them who have borrowed books from the reference room, they are, in general, not so interested in reading technical books. Research and training capacities of KADP do not improve merely by collecting the references but it improves only if the staff become interested in for the development of individual ability.

5. Improvement of Quarterly Report

KADP has been publishing Quarterly Report since Kilimanjaro Agricultural Development Center Project (KADCP). Upon the arrival of the reporter, improvement of the Report was suggested through modifying "table of contents", writing style, and way of presentation. An editing committee was once organized and did editing work on few of them. However, the improvement was quite minimum at last; the committee is not working at the moment.

Improvement of Quarterly Report is quite important as a research and extension organization. Lack of concentration during report writing is the main cause of errors. Ironically the Report is not sent to JICA headquarters (including its Tanzania Office) because of poor quality. If the Report is not sent to even one of the most important organizations (donor agency), what is the purpose of publishing it?

6. Computer Use in Research and Training

A personal computer (PC9801, NEC) was used for research and training purposes. Owing to the efforts of Mr. Hiroyuki Kouzu (a former member of Japan Overseas Cooperation Volunteers, worked in Zanzibar), data processing programs of experimental designs and statistics commonly used in agricultural research became available. All the programs were written in English for easy use among Tanzanian staff. Operation manual of data processing programs are in Appendix IX-1.

Staff of the Section have been taught how to use the computer in data processing and report writing. They gradually have become familiar with the computer. Then, they can at least use a set of utilities mentioned above at the moment. Although it takes some time to be familiar with the utilities and requires practices for mastering them, it requires less hours comparing with using calculators for data processing or editing paragraphs in a report with correction fluid. Most of the training materials for handout are kept in a floppy disk for future use.

The reporter would like to advise the staff to have a mind of personal development even under quite severe working conditions. It is a matter of how to use time for official duties, private farming, and self-development. Abilities equipped by formal education should be improved and sophisticated through practice and application.

7. Training in Future

For the improvement of the capacities of KADP staff, training system in the country should be more actively utilized. Difficulty of staff recruitment is not only the problem for KADP but also even for national research programs; it is one of the topics always discussed at Crop Research Coordinating Committee Meeting. It is quite difficult for KADP (or KADC: Kilimanjaro Agricultural Development Center) to be recognized as an agricultural research and training organization unless there are some number of qualified staff (not only in educational background but also in actual performance).

It should be stated that the importance for KADC is not what the Tanzanian staff and Japanese experts work together during the cooperation period but what Tanzanian staff can do after the cooperation period. Both donor agency (JICA) and recipient organization should be more serious on this matter and have to find long (and short) term perspective on staff training (and recruitment).

For obtaining latest information on agricultural research in the country, visiting leading agricultural organizations and attending Annual Crop Coordinating Committee Meeting are also important in addition to inviting resourceful persons to the project site. Unless KADP (KADC) pays attention (or respect) to national agricultural research organizations, it may be quite difficult to obtain information on research and training. The practices of visiting and inviting researchers are quite important for the staff in KADP as part of their training.

It may be the time to review the roles of KADC in relation to agricultural research, training, and extension in Kilimanjaro Region. It may be also necessary to review the organizational structure, including the jurisdiction, based on the roles and duties of KADC.

Appendix IX-1

OPERATION MANUAL FOR USING COMPUTER PROGRAMS OF STATISTICAL PROCEDURES FOR AGRICULTURAL RESEARCH

1. Programs Available

1) CRD: Completely Randomized Design and DMRT (Duncan's Multiple Range Test)
2) RCBD: Randomized Completely Block (RCB) Design and DMRT
3) LATIN: Latin Square Design and DMRT
4) SPLIT: Split Plot Design and DMRT
5) AxB: A x B Factorial in RCB Design and DMRT
6) AxBxC: A x B x C Factorial in RCB Design and DMRT
7) MCORRE: Multiple Correlation
8) MREG: Multiple Regression
9) REGMAP1: Simple Linear Regression Graph
10) REGMAP2: Simple Non Linear Regression Graph
11) SPAROM: Statistical Procedure of Agricultural Research Operation Manual

2. Procedures for Running the Programs of CRD, RCBD, LATIN, SPLIT, AxB, and AxBxC

2.1. General Procedure

1) Place the floppy disk of "Statistical Procedures for Agricultural Research" on Disk Drive No. 1 of the computer (NEC9801).
2) Push the power button, and set the floppy (with lever locking).
3) Hit RETURN key when the computer asks "How many files?"
4) Type FILES and hit RETURN, then the files (programs) available appear on screen.
5) Load the file name to be used for data processing.
   e.g. Type LOAD"RCBD", and hit RETURN.
6) Type RUN and hit RETURN. The computer asks :OUTPUT:LP (1) or CRT (2). Type 2 and hit RETURN, then the example appears on screen.

7) Read information carefully and respond to the questions of:
   Number of treatments? Type 6 and hit RETURN.
   Number of replications? Type 4 and hit RETURN.
8) Analysis of Variance of the sample appears on screen.
9) The computer ask: DMRT y/n?
10) Type y and hit RETURN if proceed to Duncan's Multiple Range Test (DMRT), otherwise type n and hit RETURN.
11) Results of DMRT appear on screen (if typed y).
12) If not familiar with the data processing, refer pp.20-30 and pp.207-215 of "Statistical Procedures for Agricultural Research, by K.A. Gomes & A.A. Gomes, IRRI".

2.2. Practical Utilization

1) Load the program to be used.
   e.g. Type LOAD"RCBD" and hit RETURN.
2) Follow the general procedure mentioned above to be familiarized with the data processing.
3) Let the list of the program (RCBD) appear on screen.
   e.g. Type LIST and hit RETURN. or
   Type LIST 4000- and hit RETURN.
4) List of the program appears on screen.
5) Change messages on the DATA lines of 4010 to 4060. The messages should be less than 6 lines and within the space of " " as it is shown in the example. The length of each line can be extended within the space of " ". Delete unnecessary messages through using SPACE key.
6) Change data on the lines of 5010 and above. Accommodate all the replications of one treatment on one line. Type , (comma) after every datum inputting. After the last datum of each treatment, do not type , but hit RETURN. Either add or delete the DATAs depending on the number of treatments (adding or deleting lines of 5000s) and/or replications (extending/reducing each DATA line).
   e.g. Change to 4 treatments and 3 replications.

```
5010 DATA 32.3,34.0,36.5
5020 DATA 33.3,33.0,36.3
5030 DATA 42.0,38.2,40.6
5040 DATA 26.9,28.4,27.5
```

7) Type RUN and hit RETURN. The computer asks same questions but of the data changed.
8) Type 1 and hit RETURN for printing out, otherwise type 2 and hit RETURN.
9) Follow the general procedure of the data processing.
*) Pay caution when input data of LATIN. Allocation of treatments is not following DATA line because of Column, Row and Treatment of the latin square design. Then all the treatments once appear on each DATA line. Use DATA lines of 5110 and above for the allocation of treatments. Type "a", "b", "c", "d" and so on for the allocation of treatment on each DATA line (see the example).

3. <u>Procedure of MCORRE</u>

1) Type LOAD"MCORRE" and hit RETURN for loading the program.
2) Type RUN and hit RETURN key, then the example appears on screen. Type 2 and hit RETURN to see the example.
3) Respond to the questions appeared on screen.
   e.g. How many items? Type 5 and hit RETURN.
   How many data? Type 6 and hit RETURN.
4) Total, Mean, Maximum, Minimum, Variance, and SD (standard deviation) of the example appear on screen.
5) The computer asks 'Correlation y/n?'. Type y and hit RETURN if proceed, otherwise type n and hit RETURN.
6) Multiple correlations among different items (5 in the example) appear on screen (if typed y).
7) Type LIST 4000- and hit RETURN. Messages (on DATA 4000s) and data (on DATA 5000s) appear on screen.
8) Change messages: Maximum 6 lines are available.
9) Change data: Input one set of data on each DATA line; put , between the data but not after the last datum on each DATA line. Hit RETURN after completing data input on every DATA line.
10) After inputting all the data, type RUN and hit RETURN. Type 1 (for print out) or 2 (for on screen) when the computer asked OUTPUT:LP (1) or CRT (2).
11) Respond to the questions of the computer based on the set of data inputting.

4. Procedure of MREG

1) Type LOAD"MREG" and hit RETURN key. Type RUN and hit RETURN. Type 2 and hit RETURN.
2) Read messages of the sample and respond to the questions?
   e.g. Number of independents? Type 2 and hit RETURN.
   Number of data? Type 8 and hit RETURN.
3) Results of the sample are shown on screen.
4) Type LIST 4000- and hit RETURN. There are messages on the DATA lines from 4010 to 4060 and data on the DATA lines from 5010 to 5080.
5) Change the messages and data. The dependent should be inputting as the last item of a set of data on each DATA line.
6) After inputting all the data, type RUN and hit RETURN. Type 1 and hit RETURN for printing out, otherwise type 2 and hit RETURN.
7) Respond to the questions appear on screen.
8) At last the computer asks: Independent numbers if END 0 key? If some of the independents to be checked, type number of independents to be checked (i.e. 2, 3, etc.), and hit RETURN. The computer asks: Independent number? Type each of independent number to be checked.

5. Procedures of REGMAP1 and REGMAP2

1) Type LOAD"REGMAP1" or LOAD"REGMAP2" and hit RETURN key.
2) Type LIST 4000- and hit RETURN to see data of the example. Type RUN and hit RETURN.
3) Respond to the questions appeared on screen.

"Independent number?" Type 1 and hit RETURN.
"Number of data?" Type 7 and hit RETURN for REGMAP1.
Type 5 and hit RETURN for REGMAP2.

4) List of the example data appears on screen, and the computer asks: Hit any key.
5) Regression graph and equation of the sample are shown.
6) The computer asks "Copy y/n?" Type n and hit RETURN.
7) Type LIST 4000- and hit RETURN. Change data on the DATA lines of 4000s and messages on the DATA lines of 5010-5030. Only 3 lines within " " are available for messages. Either add or delete DATA lines on 4000s depending on the number (set) of data to be processed.
8) Number of independents is not necessary one, but the computer only process one independent at one time.
9) The dependent datum should be entered after the last independent datum of each set of data.
10) Put , between the data but hit RETURN after the dependent.
11) Type RUN and hit RETURN after entering all the data and messages. Type 1 and hit RETURN for printing out, otherwise type 2 and hit RETURN.
12) Respond to the questions based on the changed data.
13) After showing a regression graph and its equation, the computer asks "Copy y/n?" Type y and hit RETURN for printing out, otherwise type n and hit RETURN.
14) If 2 or more independents are to be checked (one independent at one time), response the question of "Independent number?" following the order of the independents.

6. Other Information

1) The programs have no data disk. If data are to be kept in the floppy disk, change file name and save it as a different file.
   e.g. Changing RCBD to 90m-ps (i.e. 1990 maize plant spacing experiment).
   (1) Load RCBD and get the list. Change messages and data following the procedure mentioned above.
   (2) Type LIST and hit RETURN. Press STOP key immediately after coming out the program list.
   (3) Move the cursor to 100 line, and change RCBD to 90m-ps. Hit RETURN.
   (4) Move the cursor to 100 line again and delete 100 '.
   (5) Hit RETURN key. Then it (90m-ps) is saved.
   (6) Type FILES and hit RETURN. It can be confirmed that 90m-ps is saved as one file.
2) Changing space of data input (especially for MCORRE).
   (1) The programs (MCORRE, MREG, REGMAP1, and REGMAP2) can accept up to 10 items (i.e. 10 items for MCORRE and 9 independents for others, for printing out on A4 size paper).
   (2) The form of output (printing out) can be modified through changing the figure 79 of STRING$(79,) in the programs to a bigger

figure (depending on the number of items).

(3) If datum size is too large and create errors, all the data of the item should be divided by 10, 100, or any other appropriate 10s.

(4) The length of each message line (DATA 4010 to 4060) can be extended for printing out of the result. However, message of each data line should be typed within " ". Message space of REGMAP1 and REGMAP2 can not be extended.

3) Always put , (comma) between the data, but do not put , after the last datum on each DATA line (only hit RETURN key).

4) Use SPACE key or type such as DELETE 5050-5060 for deleting. Or type such as 5070 DATA for adding DATA lines. Always hit RETURN key after changing data on DATA lines.

5) Hit HELP key and ROLLUP (or ROLLDOWN) key for seeing the programs without cutting (use in changing DATAs).

6) The programs were prepared for NEC9801 series. For REGMAP1 and REGMAP2 not all kinds of PC9801 series computer present the graph. Some computers (i.e. PC9801LV) only show the equation without graph.

7. <u>Acknowledgment</u>

The programs were written by Mr. Hiroyuki Kouzu who once worked in Zanzibar as a volunteer (member of Japan Overseas Cooperation Volunteers: JOCV). He had spent a part of his last annual leave for making the initial version of the programs in 1989. After he had finished the contract with JOCV, he visited Tanzania again in 1990. Then he had improved the programs. I am very much thankful for his efforts of making the useful programs for KADP's agronomy research work.

Ideas of the programs were obtained from "BASIC" APPLICATION MANUAL (PC-8001 mk II), by Dr. Tetsujiro Sugahara, published at Suphan Buri Experiment and Training Center, Farming System Research Institute, Department of Agriculture, Ministry of Agriculture and Cooperative, Thailand. Dr. Sugahara worked at Thai Irrigated Agriculture Development Project of JICA (Japan International Cooperation Agency) as an Expert in Agronomy from 1978 to 1985. I worked at the same project, then the programs were presented from him. I am thankful to him for providing ideas on how to use computer for experiment data analysis.

Most of the examples for data processing were taken from the book of "Statistical Procedures for Agricultural Research, Kwanchai A. Gomes & Arturo A. Gomes, 2nd edition, an International Rice Research Institute Book, A Wiley-Interscience publication, Johy Wiley & Sons". This is the most popular book of agricultural experiment design and data analysis. It is quite useful if KADP staff become familiar with this book before conducting field experiments and when using the programs for data analyses. Twenty copies of the said book are available at the reference room.

X. LOWER MOSHI IRRIGATION PROJECT: PRESENT AND FUTURE

Lower Moshi Irrigation Project (LMIP) has contributed to the development of irrigated (mechanized) paddy production area. It is a remarkable farming area where the modern paddy production technology is practiced by Tanzanian farmers (and farm laborers) in a part of the skirt of Mt. Kilimanjaro (or in Savannah).

Several suggestions, including three season paddy production in a year through rotating irrigation blocks, were proposed by the reporter at the Joint Advisory Committee Meeting, during the visit of Japanese Consultation Team for sustainable development of LMIP. There are several problems which should be solved or taken into account for prolonging the life of the irrigated (mechanized) paddy production project.

1. Government Support

Tanzanian Government has been supporting LMIP not only for the construction but also for the maintenance despite its severe budgetary conditions. The support covers the items of: (1) no payment of farmers for construction cost, (2) low rates of tractor hire service (THS) charge (2,016 shillings/plot for land preparation) and irrigation water fee (1,000 shillings/plot per season for the maintenance of irrigation facilities), and (3) allocation of lot of manpower (i.e. agricultural field officers, tractor operators). However, the support is not enough for the maintenance of irrigation facilities and tractors (including implements) in a long run.

Heavy machines (i.e. bulldozer, grader, back-hoe, damp-truck) have been used not only for the initial purpose (maintenance of the facilities of LMIP) but also for other purposes. If the Government recognize the significance of LMIP, the practice of using the equipment for other purposes should be abandoned. In addition, it is necessary to pay more efforts for the maintenance of tractors and other equipments (including the management of spare parts).

Although THS charge is sent to the treasury, there is not enough fund allocated for the operation of THS. Irrigation water fee is kept at LMIP for the maintenance of the facilities. But due to small fund allocation, the irrigation water fee is used for purchase of fuel for the THS. As a result, maintenance work of irrigation facilities is always late; there are weeds along the concrete lined irrigation canals. It is also very difficult to acquire laborers for cleaning the canals because of low rate of payment by the Government.

Poor contribution of the farmers for the maintenance of irrigation facilities is partly due to mis-orientation of the Government. Water Users' Association (WUA) meeting was sometimes canceled due to poor arrangement of LMIP Operation and Maintenance Office (LMIPOMO). Since it may be quite difficult for the Government to increase (or even maintain) the subsidy for paddy production in LMIP, it is the time to review the system of operation and maintenance. Revolving funds, which LMIP can directly use a part of THS charge for operation and maintenance, should be seriously considered in this connection. At the same time, the THS charge should be increased to meet the necessary expense of operation.

2. Position of Pilot Farm

The Pilot Farm obtained the water right of 140 liter per second in the Rau river under the Water Law enacted in 1975 (Nozaka, 1984). In the design of LMIP, it is mentioned the allocation of 100 liter per second of irrigation water to the Pilot Farm (Nippon Koei Co. Ltd., 1986). At the moment, amount of water allocated to the Farm is even less than that mentioned in the design (good for only 18.9 ha of paddy plots).

The Pilot Farm is a communal field of Chekereni village, then its management is quite different from other plots in LMIP. The difference indicates that it can not be the pilot area of LMIP in terms of land tenure system. Besides, irrigation canals of the Farm (especially for paddy plots) are not as the same level of those in LMIP. The canals of LMIP are concrete lined up to the tertiary level, but even the secondary canal of the Pilot Farm is not fully concrete lined.

Under the current situation of LMIP, allocation of irrigation water to the upland plots is impossible without reducing the paddy planted area. Since paddy farming is more profitable comparing with upland farming, it may be better to utilize the limited amount of irrigation water for the expansion of paddy planted area as much as possible.

It may be the time to review roles of the Pilot Farm whether it exists as the pilot area of LMIP or not. If it exist as the pilot area, roles of the Farm may be: (1) variety comparison at on-farm level (i.e. introduction of new varieties), and (2) seed production center.

3. Water Balance

Although the amount of water taken to LMIP fluctuated, it was not much different from that expected in the design (for paddy cultivation). In September 1987, an area of 473.29 ha was planted with paddy with 1,326 liter per second of water taken at the two intakes; where 800 ha was planned to be planted with paddy with 1,310 liter per second of water in the design (Seko, 1989). Discrepancy of the areas indicated that one of the reasons of water shortage in LMIP was high water requirement of the paddy plot (especially percolation) than that expected in the design. It may be difficult to expand the paddy cultivated area through the improvement of water management; rotational irrigation is practiced and only a small volume of water is running in the main drainage canal.

There is an expansion of paddy plot in the upper streams of Njoro and Rau rivers (water sources of LMIP). There is about 500 ha of paddy field (visually checked in early 1990) already developed. Expansion of the paddy cultivated area may affect the amount of water flowing to LMIP in the future.

It is said that "Kilimanjaro have most likely contributed to the decrease in dry season water discharge of many streams and rivers." (Daily News, 1990-1). According to the news paper report, "a change of climate is not responsible for the decrease in dry season discharge....the most likely cause has been increased diversion of water from the rivers...." It further stated that "in addition to the increase in authorized diversion of water streams and rivers on mount Kilimanjaro, there has most likely been an increase in unauthorized diversions as human population has increased."

Rau river (Njoro river joins to Rau river) is one of tributaries of Pangani river which flows to Indian Ocean through Tanga. There are several streams originated from Mt. Kilimanjaro, but they are small in volume of water. There are several studies conducted by JICA for irrigated agricultural development in Kilimanjaro Region and two of them were materialized. But there is no agreement on how the limited water resources will be utilized for domestic, farming, and industrial purposes and how much to be discharged to the down stream.

Besides, LMIP is not vested with a water right yet. It is quite unbelievable that a considerably large irrigation project was constructed without obtaining water right and it has been operating without receiving any pressure. Expansion of paddy field in the upper stream may affect the volume of water flow to LMIP, but it can not claim for the reduction without having the right to claim. It is urgently necessary to obtain the water right and to discuss the direction of water utilization around LMIP (including those in upper and lower streams).

All the amount of water running from Njoro and Rau rivers are introduced to LMIP at least some periods in a year (i.e. March, September). It has created a conflict between LMIP and those in down stream. Since paddy cultivation is profitable and at the same time requires a lot of water, water conflict exists among the farmers of upper stream, LMIP, and down stream.

There is an idea of introducing irrigation water from Miwaleni spring for increasing the volume of water for LMIP. It is necessary to study whether the idea is valid or not. LMIP is already taking a considerable amount of water in the area where water resources are limited. If water from Miwaleni spring is developed, the first priority area will be around the spring. If water is introduced to LMIP, whether the main and secondary canals have capacities of conveying the increased amount of water. Sections of the canals were decided based on the amount of water flow under the design. It seems that some of the secondary canals may not have capacities of conveying water if all the irrigation blocks attached to the canal are planted with paddy in the same season.

If there is enough water and capacities of the irrigation canals, the paddy cultivated area will reach to that mentioned in the design (1,900 ha) or even to be the maximum area of 2,200 ha per year(2 times of 1,100 ha). It is about 400 ha or 700 ha more than the cultivated area at the moment. However, these areas are not realized unless the capacity of tractors for land preparation (harrowing and puddling) is accompanied with. It is also necessary to review the capacity of tractors (i.e. increasing the number of tractors, finding alternative methods of land preparation, increasing actual working hours per tractor, ect.).

4. Economics of Irrigated Paddy Farming

Paddy farmers in LMIP can be classified into 5 categories based on the number of plots holding (standard plot size: 0.3 ha). They are: (1) large scale holders (more than 10 plots), (2) medium scale holders (5-10 plot), (3) small scale holders (1-4.9 plots), (4) marginal holders (less than 1 plot), and (5) tenants. It was reported that there were more marginal holders in Upper Mabogini and Chekereni areas comparing with Lower Mabogini and Rau ya Kati areas (Katsuki, 1988). There are 11 farmers who have more than 10 paddy plots (3 ha) in LMIP; the biggest farmer hold 79 plots, fallowed by 36, 31, 22 plots, and 7 farmers have between 10 and 20 plots (according to B. Mrisha, Agronomy Section). They can be also classified into 2 categories; those who settle in LMIP area and those who stay outside the area (i.e. Moshi town, on the slope of Mt. Kilimanjaro).

In case of Ndungu Irrigation Project (NIP), another irrigation project (680 ha of paddy field) constructed at Ndungu, Same District by the cooperation with Japanese Government, there is a farmer who has 19 plot and one another farmer who has 18 plots. Most of the farmers hold 2 to 3 plots, few about 10 plots and others less than a plot including tenants (according to R. Samanya in NIP).

Table X-1 presents the economics of paddy production in LMIP and NIP. The examples are based on the standard plot size (0.3 ha) and all the possible input costs. Difference in number of plots holding influences the paddy production economy of individual farmers (especially land rent cost and farm labor cost). Some of the items (i.e. fertilizer application, weeding, etc.) depend on whether the farmer hire farm laborers or not.

Profitability of paddy farming attracted people and there have been lots of requests for renting paddy plots. Paddy farming of one plot (0.3 ha) produced about 5 times net income comparing with 1 acre (0.40 ha) of maize farming (Katsuki, 1988). As a result, plot rent fee increased from 2,500 to 3,000 shillings per plot per season in 1986 to 15,000 to 20,000 shillings in 1990. Sometimes it is 60,000 shillings for one plot each in 3 seasons in a year. Besides, many medium and large scale farmers became farm managers and they just hire laborers for most of the farming activities (i.e. nursery management, transplanting, weeding, fertilizer application, chemical spraying, bird scaring, harvesting). Paddy farming in LMIP is not a commodity crop production but a cash crop especially for those who have many number of plots.

The table indicates that the paddy production cost increased in LMIP in the last 4 years. The increase rate was high in plot rent cost but comparatively low in farm labor cost. The plot rent cost in NIP (10,000 shillings/plot/season) was just one half of that in LMIP. One another contrasting feature was land preparation cost; it is only about 3,500 shillings per plot in LMIP (including plot cleaning) but about 7,000 shillings in NIP. Main reason of the differenc(is relatively low payment for THS charge in LMIP. Considering the efficiency and quality of work done by tractor, there is a possibility of increasing its rate in LMIP.

Table X-1 Rice production economy of Lower Moshi Irrigation Project (LMIP) in November, 1986 and October, 1990 and Ndungu Irrigation Project (NIP) in December, 1990 at the yield level of 25 bags of paddy per plot (about 6.7 ton/ha, shilling/plot/0.3 ha)[a].

	LMIP		NIP
	Nov 1986	Oct 1990	Dec 1990
1. Plot rent	3,000(21.1)	20,000(34.4)	10,000(17.2)
2. Canal cleaning	100(0.7)	800(1.4)	3,000(5.2)
3. Plot cleaning	400(2.8)	1,500(2.6)	-
4. Land preparation[b]	670(4.7)	2,016(3.5)	7,000(12.0)
5. Water charge: KADP	-	1,000(1.7)	-
6. Water charge: WUA	-	660(1.1)	4,500(7.7)[c]
7. Seeds	180(1.3)	700(1.2)	-
8. Nursery making	600(4.2)	1,200(2.1)	1,200(2.1)
9. Nursery management	20(0.1)	515(0.9)	-
11. Transplanting[d]	1,500(10.5)	5,000(8.6)	5,000(8.6)
12. Fertilizer	800(5.6)	1,800(3.1)	-
13. Application (3 times)	100(0.7)	600(1.0)	-
14. Agricultural chemical	75(0.5)	900(1.5)	-
15. Spraying (3 times)	150(1.1)	600(1.0)	900(1.5)
16. Weeding (2 times)	1,000(7.0)	4,000(6.9)	6,000(10.3)
17. Bird scaring	1,000(7.0)	3,000(5.2)	5,000(8.6)
18. Harvesting (25 bags)	2,500(17.6)	6,250(10.7)	5,000(8.6)
19. Paddy bag (25 bags)	1,625(11.4)	5,000 8.6)	5,000(8.6)
20. Transport (25 bags)	500(3.5)	2,500(4.3)	2,500(4.3)
21. Miscellaneous	-	-	3,000(5.2)
Total	14,220(100)	58,141(100)	58,100(100)
Total labor cost/Total input[e]	(51.8)[f]	(40.4)[f]	(57.0)[f]
Paddy price			
Official (Shs/kg)	14.4	26.0	26.0
Parallel market (Shs)	20/kg	46/kg	3,200/bag
Gross income	40,000	92,000	80,000
Shilling/US dollar	46.6	196	196
Net income			
Tenant farmer	25,780	33,859	21,900
Owner farmer	28,780	53,859	31,900
Total input/Total income (%)			
Tenant farmer	35.6	63.2	72.6
Owner farmer	28.1	41.8	60.1

N.B. [a]Data of LMIP and NIP were obtained from H. Horibata and R. Samanya, respectively.
[b]Done by tractor hire service and manually for LMIP and NIP, respectively.
[c]Including costs of seeds, fertilizer and pesticides.
[d]Including uprooting.
[e]Total labor cost includes canal cleaning, plot cleaning, land preparation (only NIP), nursery making and management, transplanting, fertilizer application, agricultural chemical spraying, weeding, bird scaring, and harvesting.
[f]Figures in parentheses are percent to the total cost.

Production cost of the tenant farming in 1990 was about 63 percent for LMIP and 73 percent for NIP; they drop to 42 percent for LMIP and 60 percent for NIP if farmers produce paddy on their own plots. The paddy farming is more profitable in LMIP (53,859 shillings/plot/season without plot rent) than in NIP (31,900 shillings). One of the reasons for more profitability of LMIP is its low cost of land preparation.

5. Water Users' Association

Water Users' Association (WUA) was formed in respective 4 villages after the construction of irrigation facilities as a body which deals with irrigated paddy cultivation (i.e. collection of THS charge and irrigation water fee, maintenance of irrigation facilities) following the Operation Manual of LMIP (Nippon Koei Co. Ltd., 1985). There is a block leader selected for each irrigation block (totally 43 blocks excluding the Pilot Farm). There is chairman and secretary for each WUA. The WUAs hold a joint meeting (usually once a month) with KADP to discuss concerned matters (i.e. paddy cultivation schedule, collection of expenses for THS and irrigation water, canal cleaning, etc.). There are the central water users' committee and the project implementation committee above the WUAs.

Table X-2 present the economic status of 4 WUAs of LMIP in December 1990. They collected 660 shillings per plot for water charge (except Rau ya Kati: 550 shillings/plot) and 500 shilling per plot for seeds (except Chekereni: 565 shillings/plot) for running expense of the WUAs. Besides, they collected 1,000 shillings per plot as water charge and 2,016 shillings per plot as THS; they were later transferred LMIPOMO.

Contribution of the farmers for the maintenance of terminal irrigation facilities has been poor. They expect government subsidy as much as possible for the maintenance of irrigation facilities and land preparation services. They just think that the maintenance of the facilities and equipments are obligations of the Government.

Management of WUA is also poor. There are several examples of poor management. In 1990, more than one million shillings was not paid for long time from one of the WUA offices to LMIPOMO apparently because of misuse of the collected money by the WUA leaders. It was merely due to lack of discipline among them. Without proper orientation and motivation of the WUAs, they will collapse in the near future.

It should be mentioned that, in general, government oriented cooperatives are not running well in the country. When a meeting of Cooperatives General Council was held in December, 1990, a high ranking government officer expressed a concern over the management of cooperatives: "The Premier also said that current co-operative leadership, beginning at the primary society level to co-operative union level was unsatisfactory. He noted that the way co-operative leaders were appointed caused various donor countries to hesitate to help the co-operatives." (Daily News, 1990-2). Management of farmers organization is not an easy task in the country at the moment.

Table X-2 Revenues and expenditures of Water Users' Associations in Lower Moshi Irrigation Project (as of December, 1991)[a].

Individual Water Users' Association (WUA)

1. Revenue (shillings/plot/planting season)

	Water charge	Seeds
Mabogini	660	500
Rau ya Kati	550	500
Chekereni	660	565
Oria	660	500

2. Expenditure(shillings/person/month)[b]

	Chairman	Secretary	Accountant	Block leader	Waterman
Mabogini	5,000	4,500	4,800	2,100	2,075
Rau ya Kati	2,400	2,300	2,300	1,500	1,500
Chekereni	2,500	2,000	3,000	1,800	1,600
Oria	2,500	2,200	2,200	2,100	2,100

3. Management of Water Charge

(1) Deposited in the account of respective WUA.
(2) Mostly being spent for salaries.
(3) No money was spent for repairing tertiary and water course canals and roads. No money remaining for repairing work.

4. WUA Office

Mabogini: Have
Chekereni: Have
Rau ya Kati: Not have
Oria: Not have

5. Number of Watermen

Ordinary irrigation block: 2 persons (1 for day-time, 1 for night-time)
Large irrigation block: 4 persons (2 for day-time, 2 for night-time)

Central Water Users' Committee
Collection of money: 50 shillings/plot/season
Expenditure: 2,500 shillings/person/month for Chairman, Secretary, Accountant

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Collection of Money for Government
Irrigation water fee: 1,000 shillings/plot/season
Tractor hire service: 2,016 shillings/plot/season

N.B. [a]Obtained through cooperation of B. Mrisha (Agronomy Section).
[b]Payments for Block leader and Waterman are only for paddy planted period (about 6 month/season).
Total area planted with paddy in 1990 was 1,543 ha (approximately 5143 plots of standard size).

Irrigation farming has been practiced long time in the farm lands on the slopes of Mr. Kilimanjaro and Pare mountains. It is called "traditional furrow" and it has more than 100 years of history (Yoshida, 1985). However, they had no experience of irrigated paddy cultivation (except some people in water-logged areas near rivers). In other words, a paddy farming society has been just developing after the construction of LMIP (including outside of the project area).

It may take some time until the people pay respects for water resources as a mutual property for farming and living, and form an organization which can properly manage the irrigated (mechanized) paddy production resources. The importance is whether efforts for the maintenance and improvement of the resources are paid by farmers or not.

6. Impact

Most of the area was used for rainfed upland crop cultivation (especially maize) before the construction of LMIP. There were some farmers in Upper Mabogini who planted paddy since before LMIP; it started in 1950s (Masubuchi, 1986). The upland farming has been being practiced under marginal conditions where total amount of rainfall is small and its distribution is erratic. There was almost no practice of "traditional furrow" in the low altitude area.

Construction and operation of irrigated paddy farming of LMIP created a great impact to the people of not only direct beneficiaries but also others. Many people became interested in paddy farming. It was reported that one plot (0.3 ha) of paddy cultivation was 4.5 to 5.7 times profitable comparing with 1 acre (0.4 ha) of maize cultivation in normal year (Katsuki, 1988). Further more, the irrigated paddy production is quite stable farming method; maize production is much influenced by the availability of rainfall.

There is about 500 ha of paddy field around (upper stream of) LMIP at the moment. Most of the area was developed after the construction of LMIP. Paddy growing farmers in the upper stream plant the same variety (IR54) and adopt similar cultivation methods (i.e. straight line planting) introduced to LMIP. Main differences are: (1) plot size (small), (2) land preparation (manual), and (3) irrigation (plot to plot). The expansion of paddy farming area has mixed effects. It is a positive extension effect of LMIP; it enhances a seriousness of water shortage for LMIP. It is an irony that the paddy plots in LMIP are not planted with paddy two times a year, but those outside plots are.

Based on paddy yield of 6 ton per ha in LMIP (1,500 ha of annual production area) and assumed paddy production of 5 ton per ha from the upper streams of LMIP (1,000 ha of annual production area), total paddy production from and around LMIP is about 14,000 ton. The total product is not small volume in the country where total paddy production was expected about 644,000 ton in 1988/89 and 44,5000 ton of white rice was imported in 1989/90 (see Table 7 in Appendix V-1). Assuming paddy price of 45 shilling per kg, annual gross income from the paddy production will be 630 million shillings (405 million shillings from LMIP). This is a remarkable contribution not only to the farmers themselves but also local and national economy.

There are some side effects of the paddy farming. It created opportunities of employment in one view, but also created class separation in another view. Farmers who had upland plots within the project area (within 1,100 ha of paddy area) could obtained paddy plots; those who did not have plots (including those who had plots in 1,200 ha of upland area) were excluded from obtaining paddy plots. The plots were re-allocated (based on the previous holding record) after reduction of the the area for the facilities (i.e. canal, road). At the moment total number of plots held by the 11 large scale farmers is 268 plots (about 80.4 ha or 7.3% of the total paddy area). It may or may not be large in the total paddy area of 1,100 ha, but it is safe to state that they have got a lot of benefit from LMIP.

Only small portion of product was purchased by Cooperative Unions. It was reported that ".....in spite of the increase of production due to the presence of two big irrigation projects, Ndungu and the Lower Moshi, the two unions' purchases did not show a corresponding increase. KNCU purchased only 10 tonnes while Vuasu bought only 17.5 tonnes out of season's targets of 500 and 3,000 respectively." (Daily News, 1990-3).

Kilimanjaro Rice Center was completed its construction in 1989 for the purpose of handling all the paddy produced in LMIP, but it has not been fully operated yet. The farmers do not want to sell paddy to the cooperative union (KNCU: Kilimanjaro Native Cooperative Union) because of low price, severe inspection (i.e. moisture content), and late payment (paid by check). It has been reported that some volume of rice (and other foodstuff) is smuggled to Kenya where rice price is higher than Tanzania (Daily News, 1988 and Daily News, 1990-4).

Another possible side effect is health hazard. When the President of JICA visited KADP in October, 1990, a representative of farmers expressed the concern on health hazard: "In their message, they said there had been an increase in cases of malaria, bilharzia and amoebae after take off the Project." (Daily News, 1990-5). There is an investigation going on by a team of TPRI (Tropical Pesticide Research Institute) on water borne diseases such as bilharzia and malaria (Mosha et al., 1990). Increase of paddy production should not be at the expense of human health. Both donor organization (JICA) and KADP should pay attention on their findings.

7. Possibility in the Future

There are only two ways for stabilization of LMIP: one is increasing subsidy from the Government and the other is active participation of the farmers for the maintenance of facilities and equipments. Both concerned organizations and farmers should recognize that the irrigated (mechanized) paddy farming is profitable in a long run if adequate investment is accompanied with for the maintenance of facilities and equipments.

Payments of the farmers for THS (2,016 shilling/plot) and irrigation water fee (1,000 shilling/plot excluding that for WUA) are too small. The irrigation facilities do not last long if they are not properly maintained. It is not the Government or donor agency (JICA) which faces the problem when the irrigation facilities (and tractors) are destroyed but the farmers who face the problems.

Payment by the product (paddy) for THS charge and irrigation water fee may be one of alternatives to be studied. Based on the paddy production of 6 ton per ha, it is possible to let the farmers contribute 400 kg of paddy per plot (0.3 ha) immediately after the harvest. They will be processed at Kilimanjaro Rice Center and sold to the public. Considering the land rent fee of 20,000 shilling per plot per season (about 400-450 kg of paddy/plot), the amount is reasonable. Part of the payment will be utilized for the maintenance of facilities and equipments (including acquiring spare parts). Since it may be difficult to increase the monetary contribution of farmers before planting paddy, at least some portion of the product should be contributed after the harvest.

"Self-reliance" is one of words most commonly found in Tanzanian news paper (i.e. Daily News). Since paddy farming in LMIP is profitable, there is a real possibility of prolonging the life of irrigated (mechanized) paddy farming under the sprit of "self-reliance". In this aspect, the WUAs should be reinforced through proper training on management affairs and improving discipline of leaders. Roles of the WUAs for the maintenance of LMIP should be seriously discussed among farmers, farmer leaders, and government personnel. Without creating farmers' awareness on the improvement of farming, without farmer leaders having respects from the farmers and without government personnel who can provide practical guidance, any farmers' organizations will not be successful. It may be better to ask suggestions and advice from the Cooperative College in Moshi for the management of WUA.

Unless the on-going projects (LMIP, NIP, Kilimanjaro Rice Center) become stabilized, JICA should not start any new construction projects of agricultural development. Official development aid (ODA) of Japanese Government is shouldered by Japanese tax payers. As an ODA organization, JICA has to think whether a certain project is accepted or not by Japanese people. If the host country (or organization) and/or people do not pay efforts for what they are supposed to do (and what they can afford to do), it is not necessary for JICA to do what it is supposed not to do.

There is no donor organizations which cooperate forever with a rural development project. Everybody should recognize that LMIP is a Tanzanian project for the improvement of living standard of Tanzanian farmers through increasing paddy production. JICA has been cooperated with LMIP to guide the development but will not cooperate long period for its maintenance.

It is a feeling of the reporter that LMIP (also NIP) stands on good resources for irrigated paddy farming. The modern paddy farming practices have been already adopted by the farmers. Whether it will success in long run or not mostly depends on the farmers (including farmers' organizations) and government organizations (to some extent). One of prerequisites for the success of irrigated (mechanized) paddy farming is whether the farmers are ready to sacrifice a portion of today's income for the benefit in the future.

8. References

Daily News. 1988. Kilimanjaro food smuggled out. 25 October, 1988.

Daily News. 1990-1. Kilimanjaro loses vegetation, rivers disappear. 11 November, 1990. Quoted from "Historical change in dry season water discharge for rivers originating from the slopes of Mount Kilimanjaro-Africa's summit: Paper presented by Faraji, S and J, Sarmet to 12th annual water engineers conference held at Moshi, November, 1990".

Daily News. 1990-2. Co-ops must be competitive, says Malecela. 5 December, 1990.

Daily News. 1990-3. Unions purchase 2,200 tonnes of crops. 12 January, 1990.

Daily News. 1990-4. Mrema reiterates war against food smuggling. 31 December, 1990.

Daily News. 1990-5. Water shortage slows down project. 30 October, 1990.

Katsuki. 1988. Agricultural economy. In: Reports of short term experts to Kilimanjaro agricultural development project. JICA. pp: 35-84 (in Japanese).

Masubuchi, K. 1986. Paddy cultivation. In: Terminal reports of experts to Kilimanjaro agricultural development center project (Vol. 1). JICA. pp: 51-410. (in Japanese with Annex in English).

Mosha, F.W. et al. 1990. A study proposal on integrated control of malaria vectors and schistosomiasis host in smallhoder irrigation scheme (draft). TPRI.

Nippon Koei Co. Ltd. 1985. Lower Moshi agricultural development project (Rau river system): Operation and maintenance manual for project facilities.

Nippon Koei Co. Ltd. 1986. Lower Moshi agricultural development project (Rau river system): Design note on on-farm works.

Iseki, A. 1988. Soil and fertilizer. In: Reports of short term experts to Kilimanjaro agricultural development project. JICA. pp: 1-34. (in Japanese).

Nozaka, J. 1984. Study report on irrigation facilities and water management of KADC Pilot Farm (submitted by a short term irrigation expert in December, 1984).

Seko, Y. 1989. Terminal report of a expert to Kilimanjaro agricultural development project. JICA. (in Japanese with Annex in English).

Yoshida, M. 1985. Traditional furrow irrigation systems in the south Pare mountain area of Tanzania. In: Mascarenha, A. et al. Opportunities for irrigation development in Tanzania. Institute of Developing Economies, Japan. pp: 31-71.

XI. IMPRESSION AND SUGGESTION

1. Upland Crops Section

The reporter has not faced any serious problems (conflicts) with the staff at the Upland Crops Section. Due to good accountability of the Head of the Section and good moral of staffs and laborers, it was quite comfortable for the reporter to work with them. Problems in management (i.e. lack of funds for materials, lack of laborers) were due to beyond the capacity of the Section.

There were 4 agricultural field attendants in 1986. The number has been reduced, and at the moment there are only 2 of them (and few casual laborers). Lack of the laborers is a chronic problem for the Section. It creates difficulties in field management. Management of experiment plots requires more number of laborers than that of ordinary cultivation. In addition, vegetable cultivation is more labor intensive comparing with commodity crop production. Many experiments have been canceled or discarded on the way due to simply lack of labor force.

Since there is no prospect of irrigating upland area in LMIP in the near future, the major activities of the Section at the Trial Farm have been shifted to the trials of grain crop cultivation (i.e. soybean, maize, sunflower) under rainfed conditions. It took some time for the shifting.

Under the reduced scale of cooperation by JICA with KADP for the coming 2 years, it may be difficult to expand the activities. Since soybean cultivation techniques have been established in the last years, major activities of the Section will be: (1) soybean extension (including utilization), (2) improvement of sunflower cultivation techniques (and its extension), and (3) other trials (i.e. maize/soybean and sunflower/soybean intercropping under rainfed conditions, vegetable cultivation). Training of agricultural extension workers is also important as Kilimanjaro Agricultural Development Center (KADC).

2. Staff Training

If the regional authorities expect KADP (KADC) to play roles as a leading organization for agricultural development in the Region, it should pay efforts on upgrading of the staff. There is a possibility of pursuing higher education after being employed by the Government. The case of Mr. B. Macha can be applicable to any other staff who have graduated from Certificate Course. The reporter has advised young Diploma holders find the opportunities of further study and the management of KADP support them.

Besides pursuing formal training, there is a possibility of improving individual ability through "on the job training". Although the reporter tried to create awareness on computer use for documentation work and analysis of experiment results, only few of the staff became familiar with its utilization to some extent. If the staff of KADP are eager to upgrade their capacity (both educational background and practical skill), they should not only show their interests but also have to pay efforts.

3. Maintenance of Facilities and Equipments

Equipments donated by Japanese Government should be used for the purposes agreed and mentioned in the Record of Discussions (R/D) of KADP; it is written that "The Equipment will be the property of the Government of the United Republic of Tanzania upon being delivered c.i.f. to the Tanzanian authorities concerned at the ports and/or airports of disembarkation, and will be utilized exclusively for the implementation of the Project." The R/D also mentioned that "Supply or replacement of machinery, equipment, instrument, vehicles, tools, spare parts and any other materials necessary for the implementation of the Project other than those provided through JICA....."

Some people claim that the equipments donated by the Japanese Government become the properties of Tanzanian Government, then the Tanzanian Government (Regional Authority) has a right of using them. It is agreeable in one view if the equipments are properly managed. In that case, the Tanzanian Government ought to pay much more effort for their maintenance; the Government should acquire at least locally available spare parts (i.e. tires, batteries, etc.). It is quite understandable that any government organizations in the country face the difficulties caused by the budget deficit of the Government. However, the basic agreement for running a cooperation project (with foreign organization) should be respected as much as possible.

In fact, lots of spare parts have been supplied for the vehicles and heavy equipments through JICA's equipment donation program. Besides, some locally available spare parts are also purchased by the funds allocated by JICA to KADP Japanese Team. Even a portion of the expense for fuel and lubricant was shouldered by JICA. These material supports from JICA contributed a lot for running and stabilization of KADP (and LMIP). It is already the time that Tanzanian authorities should create the awareness on the life of LMIP. Materials for daily use (i.e. fuel and lubricant) and facility maintenance (i.e. cement) should be fully prepared by Tanzanian side.

Some vehicles (and tractors) have been broken merely due to poor supervision (i.e. driven by unauthorized persons, used for private purposes, etc.). Lots of equipments and spare parts had disappeared from the store. Much more efforts are necessary for the maintenance of facilities and equipments. It was quite funny that the Section sometimes could not obtained even seeds and farm tools by Tanzanian funds.

Even under the severe budgetary conditions of the Government, at least some funds have been allocated for the improvement of facilities (working environment). During the period of stay of the reporter, some of the ideas have been materialized using Tanzanian and Japanese funds. Constructions of fencing around the Trial Farm, oil extract plant and tractor shade were completed, and constructions of nursery facilities for upland crops and a canal from LMIP to paddy plots in the Trial Farm are on-going. There are some other items which can be requested for the improvement of facilities.

4. Joint Advisory Committee Meeting

Joint Advisory Committee Meeting on KADP was held once a year under the chairman of Regional Development Director. The main objective of the meeting was "to review the overall progress of the Tentative Schedule of Implementation in line with Master Plan for the Project" (according to the R/D).

It has been observed that some members of the committee did not attend the meeting. There are problems which can not be solved by KADP itself. The attention of the Tanzanian Government for the cooperation project should be shown at the meeting through reviewing the progress report, providing suggestions on the annual work plan, and supporting management affairs through solving the problems.

Awareness of the Tanzanian Government for the technical cooperation (and cooperation from Japan in general) should be expressed through attending the meeting, actively participating the discussion, and conducting follow up of what were agreed at the meeting. KADP (and LMIP) is a Tanzanian Project in principle.

Further, they should become familiar with kinds of cooperations offered by Japanese Government. There were several topics which were out of the scheme of Project Type Technical Cooperation (PTTC) of JICA being discussed because of unfamiliarity of Tanzanian staff to the procedure of JICA's cooperation. The Government base cooperation is decided at the national government level. If the Central Government does not pay attention or the Regional Government can not get priority in the request from the Tanzanian Government to Japanese Government, any cooperations will not be initiated.

5. Future Prospect

If KADP last for a long period, it may be better to be modified to a different organizational structure. Based on the experience and observation, the following ideas were derived.

It is necessary to find whether there is a possibility for KADC (not KADP) to be a Regional Agricultural Research, Training and Extension Center (probably the first of its kind in the country). It conducts research on crops (especially adaptability of pre-release varieties at the regional level) in collaboration with the national research organizations. Kinds of crops to be studied depend on the situation at a time (i.e. rice, soybean, maize, sunflower in the immediate future).

It conducts training of agricultural extension workers, farmer leaders, community leaders, and other leaders of formal and informal groups related to agricultural (and community to some extent) development in the Region. The training will be either directly conducted by KADC staff (for the fields which the staff have enough knowledge and experience) or in collaboration with other organization (depending on the subject and target group).

It also conducts extension services for some crops (including farming systems) in pilot areas in collaboration with Regional and District Agricultural and Livestock Development Offices. The main objective of extension work will be to find the validity (or do modification) of technical package at the village level prior to pass the package to the extension workers.

For the implementation of the above mentioned three objectives, it is necessary for KADC to improve and reinforce communication and collaboration with other organizations especially Regional Agricultural and Livestock Development Office and related national agricultural research institutes (including those of rural/community development). Through the procedure, KADC can be the resourceful organization on agricultural (and rural) development at the regional level. It has ample facilities of office, farm, and accommodation. There should be more discussions on how they (the facilities and staff) are to be properly utilized in the future.

6. Japanese Cooperation to Kilimanjaro Region

As it is mentioned Chapter II, Government of Japan initiated cooperation with Kilimanjaro Region through the formulation of K.I.D.P. (Kilimanjaro Integrated Development Plan) and extended its cooperation to the implementation of some of the projects (using her diversified aid programs). Besides construction projects, there have been two PTTCs (one for agriculture and one another for industry) since 1978 and Kilimanjaro Village Forestry Project was newly established (January, 1991).

Although the cooperation of Japanese Government contributed to the development of Kilimanjaro Region in one way or another, relationship between the different projects has been very poor. Further, there is a question that whether the projects are sustainable or not. The most important thing is whether the project can run (at least) or will develop further even after the completion of cooperation (either construction or PTTC).

More than 10 years has passed after the formulation of K.I.D.P. It may be the time for both Tanzanian and Japanese Governments to review the performance of K.I.D.P. and show directions. Any rural development programs require a long term perspective and commitment. Any donor agencies can not cover whole of Tanzania, then their will be priority areas (Regions) or priority sectors for respective donor agencies based on their interests and policies.

There are several western countries cooperating with other Regions (RIDP: Regional Integrated Development Plan) in the country. However, there is almost no chances of exchanging ideas on approaches among the donor organizations on the implementation of RIDP. It may be the time to find a possibility of formulating Annual Meeting of RIDPs among the donor agencies and concerned Tanzanian organizations. Although Japan is a late comer to the country, possibility of conducting this kind of meeting (including visiting cooperation sites) should be studied.

Appendix XI-1

SUGGESTIONS FOR SUSTAINABLE DEVELOPMENT OF KADP*

Roles and obligations of the government and the farmers for the maintenance of irrigation facilities and operation of tractor hire service should be identified and implemented. Management of WUA (Water Users' Association) should be oriented to be more self-reliant.

Equipments sent to KADP should be utilized for the smooth implementation of the Project, but not for other purposes. At the same time, Tanzanian authorities should pay more attention for the maintenance of vehicles, tractors, and heavy equipments. Quite a small amount of budget has been allocated/spent in the previous years for the maintenance of equipments.

Whether the Prime Minister's Office is responsible for all the works of planning, construction, and operation of irrigation project, or some other offices (i.e. Ministry of Agriculture and Livestock Development) are to be involved in the later stage. Communication and collaboration between KADP and the regional agricultural and livestock development office are poor.

Paddy cultivated areas have been expanding at the upper streams of the Project. What measures have been and to be taken for the control of irrigation water?

It seems that the rice post harvest processing facilities are not actively working. What are the reasons behind, and what countermeasures have been and to be taken?

It is a time to develop/exchange ideas of long term perspectives of Kilimanjaro Agricultural Development Center (KADC) and its relation to Lower Moshi Irrigation Project (LMIP). What will be the directions of KADC/KADP/LMIP in the future?

Although Operation and Maintenance Office of Lower Moshi Irrigation Project has been paying efforts for the maintenance of irrigation facilities, it has been facing the difficulties. Eradication of the weeds from the canals and minor repairing of the canals are quite important for prolonging the life of irrigation facilities. These pictures were taken in early August, 1990**.

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*Presented at the Joint Advisory Committee Meeting of KADP held at Moshi on 22 August, 1990.
**Four picutures are not included in this report.

Appendix XI-2

HOW LOWER MOSHI IRRIGATION PROJECT IS TO BE MANAGED*

Recently there are discussions on how Lower Moshi Irrigation Project (LMIP) and Ndungu Irrigation Project (NIP) will be managed in the future. "OPERATION AND MAINTENANCE OF NDUNGU AND LOWER MOSHI IRRIGATION PROJECTS" is in circulation; the reporter received a copy (translated into English) on 13 February, 1991.

It seems that the principle idea of re-organization is both LMIP and NIP will be managed under respective District Councils (Moshi Rural and Same for LMIP and NIP, respectively).

According to the report, "Regional Development Committee Meeting held on 17 January, 1990 thought to wise to strengthen O&M of these projects so to attain the expected production." The first proposal was submitted on 5 October, 1990. However, it was not adopted due to none-involvement of District ideas.

1. Main Contents in the Second Proposal

The second proposal includes the following ideas:

(1) Operation and maintenance of these projects to be under respective District Councils.

(2) The Regional Office (RDD - KADP) should remain to follow-up/to see that the projects are being operated as per design.

(3) Farm services for farmers (inputs, agricultural machinery, post harvesting facilities) to be used under KNCU and VCU.

(4) i. Tractors to be under District Councils.

ii. O&M buildings and O&M technical equipments should be utilized as per operation and maintenance manual of each project. Chief of operation and maintenance/Project Engineer should be incharge of all the O&M buildings and machinery.

iii. Permission to use these equipments outside the project should be granted by RDD (added from other part of the report).

(5) Farmers should pay all the running costs of the projects.

(6) KADC should continue to be under Regional Development Director.

KADP Office should make all efforts to see that the activities are performed as per design. There should be a Director who will be assisted by technical staff as per sections in the O&M office. Major activities of this office are as follows:

(1) To see/make sure that the projects are operated as per design.

(2) To give advice for operation & maintenance.

(3) To prepare/propose new projects which require external assistance.

(4) To supervise implementation of new projects being implemented by donors/external financiers.

(5) Co-ordination between central government and external financiers.

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*Submitted to the Project Director on 14 February, 1991.

2. General Impression

The amount of annual paddy production in LMIP is almost same as the amount expected in the design: it is 8,550 ton in the design (4.5 ton/ha, 1,900 ha/year) and about 9,000 ton in actual (6 ton/ha, 1,500 ha/year). The actual production has been attained after discarding the initial paddy cropping system in the design. The differences are mainly water requirement of paddy plot, rice varieties (growth period) and its planting seasons. If the project (LMIP) is to be operated following the design, there will be almost no harvest of paddy.

There were 205 tractors donated by Japanese Government in 1985. Out of them, 35 tractors have been used for land preparation of paddy plots in LMIP. At the moment, more than 30 tractors are working in LMIP (86%) but those under cooperative societies are in quite poor conditions (probably less than 40% for land preparation). It is not difficult to predict what will happen if the tractors for LMIP are transferred to KNCU.

Equipments (including vehicles) attached to the projects should be properly utilized. In actual, there are many cases of using them out of the initial purposes. It is necessary for the donor agencies (JICA, OECF) to find practical measures on how similar situation will be minimized.

It is quite important that the beneficiaries (farmers) pay more running costs of the projects. The opinion was expressed in the Joint Advisory Committee Meeting of KADP. Then, why can District Council do so while the Regional Office could not?

If LMIP and NIP belong to District Offices, is KADP still necessary? Can KADP play co-ordination work between government and external financiers? Does it have ability to prepare/propose new projects by itself?

Japanese and Tanzanian Evaluation Team had visited KADP in November, 1990 to review the performance of the project and recommended the direction. It was not disclosed that there was a study on organizational set up at that time.

Changing the organizational structure of LMIP will surely affect the Record of Discussions of KADP. This is not the first time of this kind; there was a similar case when construction of LMIP was completed.

3. Practical Option

The idea of transferring LMIP from Regional Office to District Office is valid. But it is too early to be realized in July 1991. Reinforcement of financial background for operation and maintenance of LMIP is one of pre-requisites for its smooth running. Then, the Regional Government should do follow-up for the matters discussed in the Joint Advisory Committee Meeting in August 1990 (i.e. establishment of revolving fund). Re-organization without preparations will not work well.

Active involvement of farmers for the maintenance of irrigation facilities and farm machinery was not included in the report. Importance is not how to set up new organization, but how the organization can lead and motivate people (farmers) for the maintenance of facilities and further development of farming.

ANNEX

REPORT IN JAPANESE ON ACCOMPLISHMENT OF UPLAND CROPS SECTION AND IMPRESSION ON KILIMANJARO AGRICULTURAL DEVELOPMENT PROJECT

ーキリマンジャロ農業開発計画における業務（畑作物栽培）と全体的な印象ー

１．はじめに

1986年６月から1991年３月まで、国際協力事業団（ＪＩＣＡ）よりタンザニア（東アフリカ）のキリマンジャロ農業開発計画（ＫＡＤＰ）に栽培（畑作）の専門家として派遣された。ＫＡＤＰは８人の長期派遣日本人専門家（リーダー、調整員を含む）とタンザニア人スタッフで運営され、主要業務はローアモシ灌漑計画地域（水田1100ヘクタール、畑地1200ヘクタール）に対する灌漑（機械化）稲作普及であった。報告者は、大豆、野菜、トウモロコシ、ヒマワリ等の畑作物栽培技術の改善と普及をタンザニア人スタッフと共同で行った。

水稲栽培普及については、多くの専門家（稲栽培、水管理、施設管理、農業機械）とタンザニア人スタッフの努力によって、ヘクタール当り約６トンの籾収量を得るまでとなった。ローアモシ灌漑計画での稲栽培技術は地域社会に大きなインパクトを与え、周辺部に開田ブームを引き起こした。その一方で、畑作分野についてみれば、ローアモシ灌漑計画地域に灌漑畑作を普及するという当初の目的は非現実的であった。灌漑水不足（計画以上の水田要水量）の中で、畑作分野での協力は天水条件下での栽培技術の改善に変更せざるを得なかった。

灌漑施設の建設、農業機械の供与を基本とした灌漑稲作普及の現場は、施設・機材の維持・管理、運営等の協力以前の問題に直面した。今後の課題は、生産性が向上した農地をどのように維持するかである。

大豆導入についても、タンザニアにおける大豆事情を調査しないままに決定され、利用方法も含めた形の大豆普及は、まだ定着したとはいえない。今後とも、種子や根粒菌、大豆普及講習会に対する支援が求められる。

ＫＡＤＰには、タンザニアの農業情報はほとんど収集されていなかった。報告者もある程度の資料収集を行ったが、十分とはいえない。東南アジアと異なり、ＪＩＣＡの事務所も小規模で派遣専門家の数も少ないタンザニアでの、技術協力を円滑に進めて行くための方策を確立する必要性を感じた。

総合報告書作成に当たっては、各種の資料を参考にするとともに、日本人専門家、タンザニア人スタッフの意見も聞いた。しかし、この報告書に述べられた意見はあくまでも報告者個人のものであり、必ずしもＪＩＣＡとＫＡＤＰのものではない。なお、邦文報告では業務の全体的な流れを述べる。関連したデータについては英文報告を参照願いたい。

長期に渡って各種の支援をして頂いたＪＩＣＡ本部、国際協力総合研修所と関係機関の方々、厳しい生活環境の中で業務を共にしたタンザニア人スタッフ、各種の情報、資料、種子、根粒菌等を譲って頂いたタンザニア関係機関（特にイロンガ農業試験場、ソコイネ農業大学）の方々に心から感謝したい。

また、キリマンジャロの麓で共に生活した妻と２人の子供たちが健康的に過ごせたことについて、ＫＣＭＣ（Kilimanjaro Christian Medical Center）の医師達に深謝したい。多くのＪＩＣＡ派遣専門家と家族が、ＫＣＭＣにお世話になり、厳しい医療事情（薬、器具、機材等の不足）の中で親切な治療をうけている事実を知って頂きたい。

２．栽培（畑作）専門家業務について

キリマンジャロ農業開発計画（ＫＡＤＰ）は、言外に灌漑と稲作という言葉を含み、キリマンジャロ（灌漑）農業開発計画、あるいはキリマンジャロ（灌漑稲作）開発というのが、着任当初からの印象である。

畑作物についても、灌漑を前提に実験農場における栽培試験やパイロット農場、ローアモシ灌漑計画畑地に対する普及を想定していた。まず、討議議事録（Ｒ／Ｄ）の記載内容（野菜、大豆等の栽培技術の確立、展示及び普及、訓練）を基に、　リーダー、プロジェクトダイレクター、カウンターパート達と意見交換を行い、サツマイモ、キャッサバ、パイナップル、パパイア等Ｒ／Ｄに馴染まない作物の整理と、天水条件下での栽培試験を加えるる必要性を述べた。計画打ち合せ調査団来訪時（1987年３月）には、すでにローアモシ灌漑計画での水不足は予想されていたが、「天水」という言葉に抵抗があり、作付体系という項目を暫定実施計画に入れることとした。

計画打ち合せ調査団、巡回指導調査団（２回）、評価調査団と年月が経過するにつれて最終的には灌漑畑作は諦めるという結論となった。着任当初は天水畑作の必要性を述べ、中間では（灌漑畑作をやるのならば）少なくともパイロット農場の畑地に灌漑水を回すように意見し、最後には天水畑作でやるしかないという結論を得るまで、多くの徒労を水のために費やした。

２－１　大豆

（１）大豆導入の背景

ＫＡＤＰの畑作分野に大豆が入った背景はあまり明確でない。キリマンジャロ農業開発センター計画（ＫＡＤＣＰ）からＫＡＤＰへと名称変更の機会には、協力対象作物を稲にしぼり、畑作分野への協力は中止するという意見もあった。その一方で、当時のアフリカブーム（アフリカの飢餓）の中で、稲作だけに協力をすることに疑問の声もあった。差し当たっての目玉となる畑作物がないままに、「大豆でもやってみたらどうだろうか」ということで、Ｒ／Ｄに「野菜、大豆等」という表現となったようである。

着任早々に、タンザニアにおける大豆栽培の状況をカウンターパートに聞いた。しかし、何の情報も得れなかった。タンザニアでの大豆事情を知らぬままに、ＪＩＣＡの調査団によって持ち込まれた品種が栽培されていた。ヘクタール当り子実収量は、生育良好なところの収量調査で236～573キロ（３品種）であった。

また、モシやアルーシャのマーケットを見ても大豆は販売されていなかった。大豆は日本や東アジアでは長年に渡って栽培、消費されてきた。西欧諸国でも油料作物としてだけでなく植物性高蛋白食品として注目されてきている。しかし、アフリカ（少なくともタンザニア）では多種類の豆（菜豆、カウピー等）が生産、消費される中で、大豆だけは彼らの食生活に入っていない。タンザニアに多いインド人も、多くの豆類を利用しながら大豆だけは例外である。

（２）大豆普及方法の確立

大豆導入に当たっては、消費方法の普及の方がより重要であると思われた。生産と消費をリンクした形の大豆普及を見いだせなかったら、たとえ栽培技術が確立したとしても、マーケットの壁に阻まれると予想された。大豆がタンザニア人の食生活に入るものかどかを調査する必要を感じた。このため、1986年末に「大豆普及パーティー」を開催し、ＫＡＤＰの職員や水管理組合の関係農民約100人を対象に食味調査を行った。豆腐、厚揚げ、味噌（汁）、納豆、煮豆、煎り豆、板豆、黄粉、枝豆、しょう油といった日本的な大豆食品に加えて、ウガリ、ウジ、チャパティといったタンザニアの食品に大豆粉を混ぜたり混ぜなかったりしたもの食味を調査した。日本的な大豆食品の多くも受け入れられたが（例外は納豆）、大豆粉を混ぜたタンザニア食品が受け入れられるという興味深い結果を得た。

1986年10月に、畑作物研修コースの一環として、イロンガ農業試験場を訪問し、その試験場で大豆の研究も行っていることを知った。また、近くのムシンバ種子農場からタンザニアの大豆奨励品種である'Bossier'を入手した。'Bossier'はそれ以後、ＫＡＤＣにおける主要品種

となった。
1987年２月に大豆紹介の記事が 'Daily News' 紙に掲載され、モロゴロ畜産大学校で豆乳を生産しているとのことであった。1987年３月に同校を訪問した時には、機材の老朽化のために、豆乳の生産は行われていなかった。かつて、青年海外協力隊の隊員達が、大豆食品導入の一貫として豆乳の普及を行おうとしたものであった。加えてソコイネ農業大学を訪問し、農学科のA.L.Doto教授からタンザニアの大豆事情についての情報を得るとともに、大学の図書室で大豆の資料を収集した。
また、同教授より土壌学科のM.P.Salema教授を紹介してもらった。同教授は根粒菌生産の準備を進めており、キリマンジャロ州における大豆導入に対する根粒菌の供給を依頼した。それまで日本から根粒菌を２回持ち込み接種を試みたが、着粒は認めらなかった。根粒菌の確保は、大豆栽培安定のために検討を要する課題であった。
大豆栽培に関する情報や資材の入手は、栽培技術確立のための土台となった。1988年雨期作に 'Bossier' 品種に初めて根粒が認められた時、大豆栽培普及の可能性がやっと具体的なものとなった。実験農場における大豆の子実収量は、ヘクタール当り2.5トン程度を得るまでとなった。こうした成果は、タンザニアで一般的に栽培・消費されている他の豆類（隠元豆、カウピー、緑豆）と十分対抗できるものであった。また、灌漑水不足のためにローアモシ灌漑計画の水田の一部が雨期でも休耕となるため、実験圃場の水田を利用して大豆栽培の可能性を検討した。雨期休耕田における大豆の生育は畑地より安定する傾向が認められた。トウモロコシやヒマワリについても雨期休耕田での栽培の可能性を検討したが、湿害の影響を受けて収穫にはいたらなかった。
1987年から大豆普及栽培を開始した。同年の雨期入り前にパイロット農場に播種した大豆のヘクタール当り子実収量はは380キロに過ぎなかったが、1988年に雨期入り後に栽培したものからは1250キロの収量を得た。また、1989年にはローアモシ灌漑計画の雨期休耕田の一部に栽培し、ヘクタール当り1884キロの収穫（１回灌水）を得た。大豆は水稲栽培に比較すると低収益であるが、市場があるならば有望な作物となり得ることが実証された。休耕田での大豆栽培は、雨期が早期に終了した場合に容易に補助灌漑が行える利点がある。また、雑草の繁茂を押え、次期稲作の本田準備（機械による耕起）も容易にする。

（３）大豆普及の実際

1988年に「大豆栽培・利用指針書」を作成し、キリマンジャロ州に向けての大豆普及を開始した。村や学校を訪問して「大豆普及講習会」を開催し、高蛋白質食品である大豆が栄養改善の見地からいかに素晴らしい食品であるかを紹介した。普通に料理したウガリやウジ、チャパティとそれらに大豆粉を混ぜて料理したものを現場で試食してもらうと、ほとんどの人達が大豆粉の入った食品の方がうまいと答えた。大豆粉を入れると、味がまろやかで甘くなるというのが多くの人の反応であった。大豆普及についての手ごたえを感じた。
しかし、大豆普及はなかなかスムーズには行かなかった。Ｒ／Ｄには大豆栽培技術の確立・普及は入っているが、大豆利用法の紹介や普及は入っていないという意見や、普及はタンザニア側が行うもので日本人専門家はタッチすべきでないという意見もあった。こうした意見のために「大豆普及講習会」の開催数は限られた。大豆栽培法を普及させるのはタンザニア人スタッフだけで可能だとしても、問題はその利用法であり、経験の薄いタンザニア人スタッフだけで村回りをするのは困難であった。人々からのコメント（賛成、反対を含む）や質問に対処するために、報告者は必ず「大豆普及講習会」に同行した。
大豆普及の基本としたことは、まず普及員と生産者に消費させることであった。人々に馴染みがなく、マーケットでもなかなか売れない大豆を普及するには、生産者に利点を理解してもらい、生産者自身が食べ始めることが第一の段階だと思った。ＫＡＤＰで行う各種の研修の給食に大豆粉入りのウガリを加えた。そして、研修に参加した普及員の中で大豆に興味がある者に協力することとした。最終的には1987年の農業改良研修に参加した内の２人は、1990年の研修には大豆普及についてのケーススタディを報告するまでになった。

ＫＡＤＰで大豆普及を行なっていることが徐々に知られるようになり、学校やミッシナリーの関係者からの問い合わせも受けるようになった。こうした中には、農場で大豆を栽培し、大豆粉をトウモロコシ粉と混ぜてウジ（おかゆ）を作り、幼稚園の子供（約５０人）におやつとして出すようになったミッショナリーもある。今後の課題は、大豆についての小さなうねりをうまく育てることができるかどうかである。

アフリカの自然は厳しい。天水条件下での大豆栽培は洪水や干ばつの影響を受け、時には種子すら確保出来ない場合もある。大豆栽培とその利用が定着するまでには、ある程度の時間と支援（種子、根粒菌、大豆普及講習会）が必要である。人々が築き上げてきた農耕形態の中に大豆を入れるためには、トウモロコシとの間作についても検討すべきであろう。業務を共にしたカウンターパートと大豆に興味を持っている普及員が協力し、そうした状況をKADPが支援するならば、大豆はタンザニアの食文化に入ってゆくと思う。

２－２　野菜

キリマンジャロ農業開発センター計画（ＫＡＤＣＰ）への協力時代（1978年９月～1986年３月）から数種類の野菜を試験栽培し、スイカについてはパイロット農場で普及栽培を行うまでになっていた。報告者は、タンザニアの北部には多種類の野菜（温帯野菜を含む）が導入されていることに注目し、基本的には現地で入手可能な品種の比較栽培を通じて適作物（適品種）の選定を目指すこととした。

ＫＡＤＰに着任した当初には多くの野菜を栽培したが、実験農場での人夫不足という運営上の問題と、ローアモシ灌漑計画での水不足という普及上の問題が重なり、対象作物を、スイカ、タマネギ、トマト、キャベツに減らした。野菜栽培は穀物栽培に比較して労働集約的であり、人夫不足と短い労働時間の中で多種類を行うことは困難であった。

例外的にスイカの種子だけは日本から導入した。スイカはSugar Babyという品種の種子が現地で入手できたが、日本から取り寄せたものに比較して収量、品質とも劣った。専門家が交替したことによってスイカ栽培を悪化させるわけにもゆかないので、日本からの品種も含めて対応することとした。品種的にはFestival QueenとSweet Favoriteが有望であり、最高収量はヘクタール当り19.8トンであった。パイロット農場でのスイカ普及栽培は1988年まで継続したが、灌漑水の確保が困難になり、それ以降は中止した。実験農場では、Festival Queen品種（F1）から固定種が育成できないものかを検討することとした。1990/91乾期作にF3の種子から収穫するまでとなり、果重、食味的にも定着する可能性が高い。また、1990/91乾期作には別の品種（Crimson Sweet）も市場に出回るようになった。スイカは高級野菜（果物）であり、栽培面積を限れば高収益が期待できる。将来的には圃場の均平度が保たれている水田の裏作としてスイカ栽培の可能性を検討する価値がある。

タマネギ栽培は品種と土壌処理（特に物理性の改善）を中心に栽培技術の向上に努めた。重粘土質の土壌で栽培するタマネギは、球肥大が阻害されるのではないかとの予想から、籾殻、牛糞堆肥と窒素、燐を組み合わせた土壌処理条件下で栽培した。灌漑条件の違い（水口からの遠近、圃場の高低）の影響を受けてはっきりした結果は得られなかったが、品種と土壌処理を組み合わせた試験を継続することにより、低地におけるタマネギ栽培技術の改善が期待できると予想される。実験農場での最高収量はヘクタール当り27.0トンであった。

1990年にトマト３品種について異なる窒素、燐の条件下で栽培したところ、ヘクタール当り収量の品種間差は41.5～64.9トンであり、最高収量はMarglobe品種をヘクタール当り窒素60キロ下で栽培して得た77.7トンであった。

1990年に７品種のキャベツを移植栽培して比較試験を行った。ヘクタール当り窒素60キロの条件下で栽培した結果、Matchless F1品種の収量が最高であった59.3トン／ヘクタール）。

キリマンジャロ州の野菜栽培地域は標高の高いところに位置し（1000～1300メートル）、実験農場を含むローア・モシ地域（標高：725メートル前後）は温帯野菜栽培に適しているとはいいがたい。しかし、こうした野菜栽培の結果は、灌漑、低温期栽培（スイカは乾期）、圃場管

理等の条件が整えば、野菜栽培は採算性、競合性とも十分にあることを裏付けた。ローアモシ灌漑計画における水事情を考慮すれば、実験農場でのデータが同地域に直接波及する見込みは薄い。ただ、カウンターパート全員（４人）がＪＩＣＡの野菜生産（集団）研修コースに参加しており、農業改良普及員研修への利用や将来他地域での栽培の参考として、ある程度の野菜栽培試験を継続すべきであろう。

２－３　トウモロコシ

実験農場では窒素試験を中心にトウモロコシ栽培が行われていたが、ＫＡＤＰのＲ／Ｄには明記されていなかった。トウモロコシはキリマンジャロ州の低地で広く栽培されており、ローアモシ灌漑計画地域の畑地（1200ヘクタール）もほとんどトウモロコシで占められている。ＫＡＤＰとしてはトウモロコシに代わる作物の選定を一つの目標としていた感があったが、（１）差し当たって広面積に有望な作物を発見できる見通しが薄いこと、（２）畑作物セクションのスタッフが農業改良普及員よりトウモロコシについて知識が乏しくては、研修をやる上で障害が予想されることの理由から、トウモロコシに関する試験栽培を行うこととした。大豆栽培における連作障害を防ぐこともトウモロコシ栽培の一因であった。

1986年に着任した当時のトウモロコシの栽培試験は、処理（窒素施肥量）より水管理の影響を強く受けていた。このため、それまで畝間灌漑圃場で行ってきた栽培試験をスプリンクラー灌漑圃場で行うこととした。スプリンクラー圃場での栽培試験も、圃場の均平度、スプリンクラー老朽化による水漏れ、風によるドリフティング等の影響を受けたものの、試験精度はある程度向上した。また、徐々に天水条件下で栽培試験を行うように変更した。一方、イロンガ農業試験場と接触を深め、トウモロコシに関する技術情報の蓄積に努めた。同農試からは登録間近の系統（後のTMV-1品種）の種子を入手し、新品種の適応性試験を早期に開始できた。

トウモロコシの栽培技術の向上については、適正品種の選択に重点を置いた。タンザニアの主要作物（食糧）であるトウモロコシについては研究者の数も多く、品種も低地向け（主に混合品種、早生、中生）と高地向け（主に交雑品種、晩生）が出ている。数回の品種比較試験（栽培)を通じて、MH41（マラウイ交雑41、中生品種）が高収量を示し（良好な栽培環境下でヘクタール当り6～7トン）、在来品種の収量性も高いという結果を得た。タンザニアの品種ではTMV-1（混合品種、中生）が有望であると思われた。施肥量試験ではあまりはっきりした傾向は得られなかったが、ヘクタール当り窒素40キロが適正と思われた。栽植密度試験の結果としては、早生品種では、畝間75センチ、株間40センチ、１株２本立てが、中生品種では同畝間で、株間60センチ、１株２本立てが適正と思われた。

ローアモシ地域の雨期は短く（一般に３月半ば～５月半ば）、経年変動も大きい。経年の平均収量はヘクタール当り約１トンと思われ、まず最低１トン、平均2.5トンの収量が確保されれば十分である。天水条件下でのトウモロコシ栽培を安定させるためには、干ばつ抵抗性の品種か早生品種の導入が望まれる。このためタンザニアで入手可能な早生２品種の栽培技術向上を目指すこととした。

トウモロコシ栽培試験は、前述した理由から継続されるべきだろう。全体の業務量の中に占める割合は減少すると思われるが、品種比較と大豆との間作を含めた天水条件下での栽培技術の向上が求められる。

２－４　ヒマワリ

ヒマワリは耐干性の作物として知られている。タンザニアでは最近注目されてきており、キリマンジャロ州でも栽培面積はさ程広くないものの、近年拡大の傾向にある。こうしたヒマワリ栽培面積拡大の背景には、最近の植物油の高騰と手動によるヒマワリ搾油機の普及が影響していると思われる。

一部の灌漑畑作地域（大規模農園のサトウキビ栽培）を除けば、ローアモシ地域の畑地では

天水条件下のトウモロコシ栽培が一般的である。大豆用に小型搾油機導入を計画した時（1987年）にヒマワリからの搾油の可能性を考慮し、1988/89年の乾期作からその栽培を開始した。栽培上の問題は鳥害である。また、雨期休耕田での栽培には適していない（過去２年間の経験）。今後、大豆との間作も含めてヒマワリ栽培の可能性を検討する必要がある。

２－５　研修

（１）カウンターパート研修

畑作物セクションのスタッフは過去５年弱の間に出入りがあったが、現時点では４人の農業改良普及員（Agricultural Field Officer）が配属されている。報告者がカウンターパート研修の基本したのは、各自の能力向上を通じてセクション全体としての技術的・運営的な能力の底上げを行うことであった。

まず、彼らの英文四半期報告書を読むとともに、意見交換を通じて運営上の問題を整理した。一言でいえば、過去の協力期間中に技能的な訓練は行われてきたけれど、技術的・運営的なものについては十分とはいえない印象であった。栽培試験の結果の整理や報告書作成能力も貧弱であった。英文四半期報告書の書き方について２、３回サンプルを示し、サンプルに沿って以後の報告書を作成させるようにした。報告書は報告者が添削し、全員が廻し読みした後提出することとした。栽培試験や各種のデータはセクションの共有物とし、私物化しないことを原則とした。データの整理に当たっては、それぞれの作物（作付体系）について何を記録しなければいけないかを徹底させ、当面は全作物を全スタッフで担当することとした。

圃場の運営については、人夫の管理者として人員を配置するだけではなく、人夫が指示通りに農作業を行うように現場での監督をするよう習慣付けた。「人夫の監督が出来ない者は人夫の分も自分で働け」が報告者の口癖であった。特に播種時の監督を徹底させるとともに、生育調査、収量調査は必ずカウンターパート（報告者も含む）がやることにした。当初は一部のカウンターパートから反発もあったが、データが取れない責任は人夫にあるのではなくスタッフにあるということを何度も伝えた。限られた人夫の数と労働時間（低賃金のために実労時間が短い）の中で、ある程度のデータを得れるまでになたのは、報告者を含めたスタッフが試験圃場の管理（特に除草）にまで時間を割いたことによる。

1987年、88年と報告者が中心に圃場管理を行った後、1989年雨期作からカウンターパートに任せるようにし、報告者は一歩さがって彼らのやり方を見守るように努めた。実験計画についても彼らにまず作成させ、妥当性や必要性を中心に助言した。派遣期間終了間近になって過去４年半の四半期報告を整理した。また、英文ワープロと統計処理のプログラムが使いこなせるように、コンピュータ利用についても実習させた。

こうした訓練を通じて、彼らはそれぞれの能力を向上させ、全体として畑作物セクションの能力も高まったと思う。公務員の給料で生活できない彼らに、勤務時間全てを業務のために費やすことを期待しても仕方ない。やらなければならないこと（ノルマ）としての業務に少しでも責任と興味が持てるようになったら、結果的に能力の向上（技術移転）につながると思った。

カウンターパートは全て日本での研修を受ける機会を得た（報告者の着任以前も含む）。彼らの日本研修の主目的は研修内容よりも小型トラックの入手であり、その点については研修機関（筑波国際農業研修センター）に御迷惑をかけたと思う。報告者としては、「何のためにＪＩＣＡは研修員を受け入れているのかを考え、少なくともＪＩＣＡの期待に沿ったことは最低やるように」ということで送り出した。

（２）農業改良普及員研修

1986年～90年にかけて92人の農業改良普及員の研修を行った。当初、「野菜栽培研修コース」の名称であったが、1987年より「畑作物栽培研修コース」に変更した。また、「中堅技術者養成対策費」の減少に対応するため、1990年は稲作部門（稲セクション、栽培セクション）と共同で「作物栽培研修コース」とした。研修期間は年によって異なるが、４週間～２カ月間の範

団であった。研修対象者についても、1987年から教育レベルを定め（Certificate以上）、研修がスムースに進行するよう努めた。
研修内容としては、農学一般（土壌、肥料、農業気象、作物生理等）や作物（大豆、トウモロコシ、トマト、タマネギ等）についての講義、圃場実習、外部講師（農業関係機関から招待）による講義、マーケット調査、配属地域の農業についての調査、農業研究機関や先進地域への研修旅行、等であった。報告者が研修の基本としたことは、学ぶだけではなく調べることの重要性と農民に対する共感を忘れないことであった。厳しい生活環境の中でも農業普及は行えること、農民に信頼される農業改良普及員となるには知識、情報、経験を深める必要があることを力説した。また、短い研修期間で達成できるもの（例えば肥料計算、収量計算等）と達成できないもの（農学知識）を仕分けし、前者については練習問題と試験を通じて慣れ、後者については配布資料を充実させて研修終了後も使える体裁（例えばファイルにとじる）とした。
研修コースを通じて普及員達がほとんど資料を持っていないことを知った。このため「中堅技術者養成対策費」の一部で農業関係資料の収集を行い、キリマンジャロ州に配属されている普及員全員（約500名）と地区農業開発事務所（５地区）に配布した。

２－６　ＫＡＤＰ全体に係わることとして

（１）資料収集

ＫＡＤＰに着任して驚いたことのひとつは、タンザニアの農業に関する資料がほとんどなかったことである。大豆を研究している機関はどこか、キリマンジャロ州の低地向けに奨励されているトウモロコシ品種は何か、といった情報すら手持ちになかった。報告者は国内や海外から資料の収集に努めるとともに、資料室の設置、整理を行なった。華表一夫調整員も各種資料収集について努力し、ケニア出張時に参考図書の入手を行なった。たとえ農村開発型のプロ技協であってもある程度の資料収集に努めるべきであると思う。

（２）英文四半期報告書

英文四半期報告書の体裁（内容も含む）の改善を行うように努めた。報告書に目次を設けること、書き方のスタイルを統一することを中心に改善案を提出し、発行委員会を設置して２、３回分について添削を行った。しかし、原文があまりにも貧しいこと、発行委員会に熱意がないことから活動は停止した。ＫＡＤＰの英文定期発行物（この他に簡略な年次計画、年次業務報告がある）が、読むに耐えないことは事実であり、そのためＪＩＣＡの担当部にも送付されていない。報告者は、英文報告書をＪＩＣＡに送付すべきだとの提案を行なったが、実現しなかった。現場も、担当事業部も、その重要性を認めなかった。
英文報告書の質が低いことは恥しいことではない。恥しいことは報告書の質を向上させようという努力をしないことである。技術協力を技術移転という言葉で表現するのならば、報告書作成能力の向上はそのひとつの成果であると思う。援助機関は被援助機関（援助の現場）の業務をモニターしようという姿勢を示すべきである。ＫＡＤＰをタンザニアの組織と見るのならば、英文四半期報告書に記されているのが正当な成果であり、日本人専門家が邦文で記した報告書は付属資料に過ぎない。タンザニア人スタッフが利用できない邦文の報告は意味が薄い。

（３）関係施設の整備

ＫＡＤＰの施設は、実験農場とパイロット農場に対する協力を想定したキリマンジャロ農業開発センター計画（ＫＡＤＣＰ）を引き継いだこともあって、ローアモシ灌漑計画の運営を行うには不十分であった。報告者は、業務をやり易い環境作りのため、計画打ち合せ調査団来訪時やその他の機会に改善案を提出した。日本から供与されたトラクターの車庫、実験農場のフェンス、実験農場の水田をローアモシ灌漑計画の用水路通じて灌漑できるようにすること、水道施設の改善、パイロット農場の水路補修（コンクリートライニング）、畑作物研究施設の充実（事務所移転、搾油施設建設等）がその主なものである。提案の多くは具体化されたりされ

つつあるが、パイロット農場の水路補修は一部が行われたに過ぎなかった。

（４）稲作付面積拡大

ローアモシ灌漑計画の水稲栽培は、年２作（雨期：1100ヘクタール、乾期：800ヘクタール）の作付を計画していたが、予想以上の水田要水量と限られた水資源のために１作当り約500ヘクタールしか作付できない状況となった。水田作付面積拡大についてさまざまなアイデアが出たが、報告者は1100ヘクタールの水田の一部づつ（約500ヘクタール）を場所を変えて年３作栽培することを提案し、1988年初めに派遣された巡回指導調査団の意見として採用された。以後、年間約1500ヘクタール（500ヘクタールｘ３回）の稲栽培が行われるようになった。稲作面積の拡大は、灌漑畑作の中止という結果をもたらした。まず、水稲栽培を安定化させることが重要であるとの判断から、畑作分野についての方向修正（天水栽培、雨期休耕田の活用）を促した。

３．協力の現場で考えさせられたこと

プロ技協が成功するかどうかについては、色々な要因が考えられる。各種の異なった形態のプロ技協がいろいろな国で行われていることを考慮すれば、技術協力は各論の積み重ねであり、総論は必ずしも各論がうまく積み重なったものではない。また一方で、協力を受ける側にとって相手国は日本だけではなく、協力の形態はどうしても他の先進国や国際機関と比較される。こうした中で、ＫＡＤＰへの専門家の経験を通じて、今後の日本の協力の改善について考えさせられたことを報告したい。

３－１　協力をする側の組織の問題

キリマンジャロ州の農業開発に対する日本の協力は、開発調査、一般無償、有償、プロ技協（専門家派遣、研修員受け入れ、機材供与）、個別専門家派遣、研修員受け入れ、食糧増産援助（２ＫＲ）等の形態で行なわれている。全体的な印象を述べるならば、ＪＩＣＡの関係部や農林水産省、民間（コンサルタント会社、商社等）がそれぞれの思惑で協力業務を行い、キリマンジャロ州への地域開発（全体の開発計画）への協力にまとめあげるという発想が薄い。

例えば、キリマンジャロ籾収穫後処理センターについてみれば、ローアモシ灌漑計画で生産された籾を集荷・処理して流通機構に乗せることを目的に建設（一般無償）されたが、プロ技協とは直接関係ない個別派遣専門家を中心に１年間の技術協力が行われた。また、ヌドゥング灌漑計画（680ヘクタール）が日本の無償資金協力で施工されたが、研修を除いて、プロ技協としては具体的な協力は行わなかった。

ローアモシ灌漑計画の施工中にタンザニア通貨の切下げから工事費に余裕がでたため、当初２次水路までコンクリートライニングに予定が３次水路まで出来ることになった。しかし、パイロットファーム水路のライニングは行われなかった。また、ローアモシ灌漑計画の維持管理事務所の運営方法についてＫＡＤＣと建設工事事務所の意見が食い違った。どのような組織で維持管理を行うかについて、タンザニア側には具体的な発想はなく、日本のプロ技協とコンサルタント（施工管理業者）の意見の相違によるものであった。しかし、議論は平行線をたどり、工事終了とともにコンサルタントが帰国した後、プロ技協の意見を取り入れる形で決着した。

ＫＡＤＣの本部と現場事務所は日本政府の無償資金協力で建設された。建物の外観は素晴らしいが、ちょっと注意をすると、施設の維持管理がうまく出来るような構造になっていない。

まず、水道施設が十分に機能しない。ＫＡＤＰの現場事務所の水道はモシから引かれているが、断水に悩まされている。現場事務所には実験農場の水源として井戸が掘られ、農場に利用するだけの地下水を組み上げながら、事務所への配管は行わなかった。ちょっとした注意を施設建設時に払えば、後の人々の業務環境は格段に違ったと思う。

実験農場の水源は地下水に依存し、停電やポンプ故障のため灌漑水の供給は不安定である。実験農場のすぐ横をローアモシ灌漑計画の水路が走っている。わずか500メートルの水路を付けた

ら、少なくとも水田の水供給は非常に安定したものとなったのにと残念である。現在、乏しいタンザニアの予算の中で水路工事が行われている。

3－2　協力を受ける側の組織の問題

協力の相手方をどの組織にするのが適当かは十分調査する必要がある。現在、ＫＡＤＰはキリマンジャロ州開発長官（Kimimanjaro Regional Development Director)の下に位置し、州計画担当官がＫＡＤＰの長を兼務している。これは総理府の系列であり、農業畜産開発省は関与していない。一方、ＫＡＤＰで働く多くの職員は州農業畜産開発事務所、地域灌漑事務所から出向した形となっている。

農業開発協力を行う相手方を州開発事務所にしたことの源は、キリマンジャロ州への協力が州総合開発計画の策定に始まったことによると思われる。プロ技協の協力も最初は農業と工業を合わせてＲ／Ｄを締結している。当初Ｒ／Ｄの締結から12年以上が経過した現在、はたして総理府の系列で協力を継続するのが望ましいのかどうかを再検討する時期にきていると思う。この再検討については中央政府、州政府の関連機関から十分な聞き取りが必要である。

ＫＡＤＰは討議議事録（Ｒ／Ｄ）に沿って協力を行ってきたが、タンザニア側にＲ／Ｄを尊重する意識がうすい。最大の問題は供与機材の目的外使用である。ＫＡＤＰの業務を円滑に遂行するために供与された機材（特に重機類）が他の道路工事に使用され、使用不可能になって返されてる。タイヤとかバッテリーとかタンザニアでも調達可能なものまで更新出来なく、機材供与や現地業務費を当てて修理してもすぐに目的外に使用されてしまう。　こうした供与機材の目的外使用はプロ技協にとどまらず、有償（ローアモシ灌漑計画）や無償（ヌドゥグ灌漑計画、籾収穫後処理施設）の事業ではさらに悪い。

こうした協力を受ける側のＲ／Ｄ違反については、ＪＩＣＡ本部からの姿勢もはっきりせず、日本人専門家の意見も統一されず、現場における混乱（相手側に対する意見の不統一）の原因となった。

灌漑施設の維持管理も十分には行われていない。草で埋まった幹線水路を見るたびに、なぜこんなにも自助努力をしないところに協力をしなければならないのかと思った。自助努力をやらないまま、水路が壊れればまた日本政府が水路修復の協力をやってくれると期待している。農業機械類のスペアーパーツ類にしても、調達する努力が感じられない。

3－3　よりよい協力に向けて

（１）協力現場における人材育成

協力現場における人材育成について、ＪＩＣＡもタンザニア側もより真剣に検討する必要を感じる。有能なタンザニア人をスタッフとして確保することが困難ならば、現在のスタッフの能力を向上させる方法も考えるべきである。日本での研修はそのための手段の一つであるが、学歴の付与を伴わない研修は能力の向上に寄与したとしても、より具体的な職位の向上（給与の増加）にはつながらない。

報告者は着任早々にカウンターパート全員と研修について意見交換し、Certificateの学歴しかなかったスタッフ一人をDiplomaコース（２年間）の研修に出した。技術協力の現場における人材育成について日本側もタンザニア側も検討する余地は十分にある。ＫＡＤＰを魅力ある職場にするよう知恵を出すことが求められている。現場で働く者が少しでも成長する方法を模索し具体化してゆくことが技術協力の側面の一つにあって良いのではないかと思う。カウンターパートとして苦楽を共にするタンザニア人スタッフの希望が日本へ研修に行き小型トラックを買うことだけでは悲しい。

タンザニアにおける教育システムを研究することにより、協力現場での人材育成はもっと有効的に出来るというのが報告者の印象である。若いカウンターパートには大学で研修する機会が得られるよう努力を促してきた。現場での経験は非常に重要であるが、現場経験だけでは昇級

につながらないし、知識の深みにも限界がある。カウンターパートが専門家の助手で終わらないためには、彼らの育成方法について技術協力の現場はもっと真剣になるべきである。「技術移転」の受け皿を育成できないままに技術協力を行うことにむなしさを感じないとしたら、何のために技術協力に参画しているのかと疑問に思う。

多くの問題に直面するたびに、タンザニアだから、そういう国だから援助を必要としている、といった愚痴とも諦めとも受け取れる言葉が日本側から出てくる。愚痴と諦めからは何も発展的な発想は出てこない。事実は事実として認めた上で、組織と人の発展についてタンザニア側と率直な意見の交換を行うべきであった。日本人専門家とタンザニア人スタッフとの意見交換の機会（会議、セミナー）が少なかったことは残念であった。

（２）総合開発計画へのより効果的な方法論確立

キリマンジャロ州に対する日本の協力は農業分野における具体的な成果（ローアモシ灌漑計画、ヌドゥング灌漑計画）もあって非常に注目されている。タンザニアのマスコミ報道（特に新聞）も好意的に成果を紹介している。

キリマンジャロ州に対する日本の協力に似た形の協力が、タンガ州（ドイツ）、ルクワ州（ノルウェー）、ムワンザ州（オランダ）等で行われている。こうした州総合開発計画についての協力はそれぞれの援助機関が個別に行っており、具体的な方法論や優先順位等についての意見交換はなされていない。州総合開発計画という視点から援助機関と受け入れ機関が合同で会議を持ち、より効果的な協力形態について意見交換を行うことは意義があると思う。ＪＩＣＡ事務所はこの種の会議開催を他の援助機関に呼びかけてもいいのではないだろうか。

（３）人間を相手の協力を

日本の農村開発型協力は自然環境と技術については注意を払うが、社会環境と農民組織についてはあまり注意を払わない感がする。農村開発型の協力が成功するかどうかの一つは、住民（農民）の積極的な参画が得られるかどうかであると思う。適切な農民組織の育成も重要である。日本の農業普及は同質の人間を相手に発展したため、農村社会学的な切口を持たない形の海外協力が一般的である。自然環境を変え、農業生産環境を変えた場合の人々の生活様式や思考の変化を適切に判断し、彼らが生産環境を維持するための方策を練ることと、そうした生産環境維持のための適切な農民組織の編成と育成が重要である。

また一方で農業生産の増大については注目するが、農業生産の増大がもたらす社会的不平等や生活環境の悪化については、できる限り目を向けまいとする。例えば、ローアモシ灌漑計画によって住血吸虫が広がっているという意見がタンザニア側から出されたが、はっきりしたデータがないという理由で評価報告書には掲載されなかった。日本の農業技術協力が稲栽培技術の確立と普及を通じてアフリカの農業に貢献しようというのならば、稲栽培普及がもたらす住民に対する負の影響についても配慮すべきであろう。残念ながら、開発協力の負の側面調査とその是正について、日本はまだ積極的でない。

３－４　協力現場での矛盾

協力の現場で感じた最大の矛盾は給料の差である。カウンターパートの月給は4,000円～5,000円程度である（日給ではない）。政府機関で働く人夫の日当では、１日働いて白米１キロ買えない。仕事に打ち込む以前に生活を考えなければならない状況の中で、仕事の成果（量）を期待することは酷である。朝７時半～午後２時半が政府機関の労働時間であるが、朝食も取らずに出勤してきた人夫達は昼前には伸びてしまう。植え付け時期や収穫時期になると作業の遅れにいらだつが、彼らの生活には同情を禁じ得ない。

こうした安い給料を補うために、水田を借りて稲栽培を行ったり、日本研修時の手当を貯めて買った中古トラックで運送業をやって必死に生活している。仕事に関する発想を練る時間を持つことを期待できる状況ではない。部品や事務用品、機材の盗難もある。真面目に働いて生

活の糧を得ようとする人々が居る一方で、安易に（危険は伴うが）生活資金を得ようとする人々がいることは悲しい現実である。

報告者は日本から調査団が来訪する度に、「プロジェクトが走っていればそれだけで成功であって、それ以上を期待することは無理である」という趣旨の意見を述べた。ＫＡＤＰについていえば、技術協力や技術移転という言葉はあまり似合わない。生活の保障を他の収入に頼らざるを得ないということは、言葉を変えれば、タンザニアの公務員はすべてボランティアであるともいえる。生活環境についての共感を持たずに彼らと業務を共にすることは困難である。

３－５　将来に向けて予想されるシナリオ

キリマンジャロ州に対する日本の（農業）協力は籾生産の増大を通じて受益農民の所得向上と地域経済の活性化に貢献した。しかし、この初期効果をタンザニア側だけで持続的農業生産地帯形成へとつなげれる保証はどこにもない。キリマンジャロ州についていえば、協力案件を発掘するより、これまで協力した案件をどのように連携させ、安定させ、発展させるかが問われている。

ローアモシ灌漑計画の稲作分野での成果（ヘクタール当り６トンの籾収量、年間延べ生産面積1500ヘクタール）は、灌漑施設建設だけによってもたらされたものではない。稲栽培技術の確立・普及や農業機械の維持・管理、水配分計画の見直し（年３作栽培）に対する支援があって具体化された。将来ともローアモシ灌漑計画が年間9000トンの籾を生産するためには、灌漑施設と農業機械が維持されなければならない。いうまでもなく、こうした維持に係る費用の財源は、タンザニア政府、受益農民、援助機関のどこかか、その組合せとして対応するしかない。施設や機材の維持に対する再投資の重要性は理解しながらも、タンザニア政府も農民に十分な手当を行わないままであった。タンザニアの国家財政を考慮すれば、政府からの補助が伸びることは期待できない。つまり、いかに受益農民からの負担金を増加させるかが課題となる。

ローアモシ灌漑計画には４つ村ごとに水管理組合が形成され、水利費やトラックタ賃耕代の徴収、末端水路の水管理・補修等を行なっている。また、水管理組合のリーダーとＫＡＤＰの関係職員は月に１回会議を持ち、灌漑計画や負担金徴収等について意見交換を行なっている。しかし、水管理組合の運営は貧弱で、農民から徴収した負担金はなかなかＫＡＤＰに支払わない。英文報告にも述べているようにタンザニアの協同組合運営は未成熟である。水利組合の運営を確立することなしにローアモシ灌漑計画が安定するとは考えられないが、この分野におけるＫＡＤＰの指導は十分でなかった。ＫＡＤＰには農民組織を担当する専門家もカウンターパートも配属されていない。このため、水管理組合強化については、モシにある協同組合大学の協力を依頼することも検討する必要がある。

タンザニア政府（キリマンジャロ州政府）としては、ローアモシ灌漑計画への支援を減少させる方向に進んでいる。しかし、ただ単にプロジェクトの担当機関をディストリクト事務所や協同組合（Kilimanjaro Native Cooperative Union）に移しただけでは問題の解決にはならない。州政府としてはローアモシ灌漑計画が円滑に運営できる方策を関係機関と協議し、具体的な対応策をまず州政府として実行すべきである。

キリマンジャロ農業開発センター（ＫＡＤＣ）はキリマンジャロ州における農業開発の拠点として設立されており、今後とも作物栽培技術の改善と農業改良普及員や農民に対する研修を継続することが望ましい。主要対象作物としては稲、大豆、ヒマワリ、トウモロコシと幾種類かの野菜となるだろう。それぞれの作物についての栽培技術改善だけでなく、ヌドゥグ農業開発計画に対する支援やローアモシ雨期休耕田の利用とか、大豆を含めた間作栽培試験も求められるだろう。ＫＡＤＣを発展させるためには、人材の確保と組織の強化が求められる。この点に関し、ＫＡＤＣの管轄をこれまで通り州政府とするのか、それとも農業畜産開発省（州農業畜産開発事務所）とするのか検討すべきである。ＫＡＤＣの業務をローアモシ灌漑計画の安定化のためにだけ利用する意義は薄いと思われる。ＫＡＤＣは何であるのか。今こそその存在意義を問われたことはない。

4．キリマンジャロでの仕事と暮らしを歌に込めて

キリマンジャロ旅情（井上淳二チームリーダーの帰国に際して）

キリマンジャロの麓が　稲穂の波に揺れる頃
思い出しておくれ　俺達のことを
タンザニアの大地に　日本人が
燃やした情熱（いのち）と　流した汗を
　　メイズ　バオバブ　マラリア　エイズ
　　サバンナの風に散る　ジャカランダの紫
　　アフリカ大陸　赤道直下に
　　白雪に抱かれ　天を突く頂き
我が青春のサファリにも　別れの日は来た
僕は出て行く　キリマンジャロを越えて
忘れておくれよ　エプロンカラスさん
恋しのタンザニア　忘れはしないさ

キリマンジャロ時代（瀬古良勝専門家の帰国に際して）

ローアモシの水路からキリマンジャロを望み
一枚でも多くの田圃に稲が植わるように
限られた水よ回れと願いを込めた日々
カウンターパートと築いた水管理技術
水利組合　農家研修
忘れ得ぬ　人々の息吹
さようならキリマンジャロ　我が青春時代
　　敦子と共に登ったよ　憧れの峰にも
　　紗矢香　亜矢香　とも遊んだ　セレンゲティの草原
　　過ぎ去ったタンザニアでの１０００日の日々が
　　今　心をよぎって行くよ　微笑みながら
　　タンガ　ザンジバル　ムベヤ　ビクトリア
　　忘れ得ぬ　空　海　サバンナ
　　さようならキリマンジャロ　我が青春時代

いい日キリマンジャロ（報告者の帰国に際して）

雪を抱いた高き峰に向かい
過ぎ去りし日々の夢を叫ぶとき
モシでの暮しが熱く胸をよぎる
大豆普及に賭けた日々　賭けた意地
ああ　アフリカの大地に　サバンナを吹く風に
キリマンジャロにも大豆の花は似合うよ
それは　僕と仲間達がした仕事
　　地平の彼方に牛を追う少年
　　遙か地平の彼方から水汲む少女
　　明日への希望とともに歌った歌は
　　大豆普及に賭けた日々　賭けた意地
　　ああ　アフリカの大地に　サバンナを吹く風に
　　キリマンジャロにも大豆の花は似合うよ
　　それは　僕と仲間達がした仕事

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