インドネシア農業研究協力プロジェクト
研 究 報 告 書

Research Report of Japan-Indonesia
Joint Agricultural Research Project

1982年4月

April 1982

国 際 協 力 事 業 団
農 業 開 発 協 力 部

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序

インドネシア農業研究協力プロジェクトは，作物保護を中心とした第１次協力（昭和４５年１０月から８年間）に引き続き，現在，豆類を中心とした畑作物の栽培体系に関する研究を目的に第２次協力（昭和５３年１０月から５年間）を実施中である。

第２次協力は，現在，第１期長期専門家７名及び短期専門家の成果を引き継ぎ第２期長期専門家７名が活動中である。

本報告書は，第１期長期専門家及びその間派遣された短期専門家計５名の研究報告をとりまとめたものであり，本プロジェクト前半の研究成果の結晶として高く評価できるものである。

これが今後のインドネシア農業研究の資料として広く御利用いただければ幸いである。

最後に，日本に比べ厳しい生活条件及び貧困な研究環境のなかでこのような研究成果をまとめられた専門家各位，及び本プロジェクトの実施に御支援いただいた外務省，農林水産省関係各位，在インドネシア日本大使館，ＪＩＣＡジャカルタ海外事務所並びにインドネシア政府，中央食用作物研究所関係各位に対し厚くお礼申し上げる。

１９８２年４月

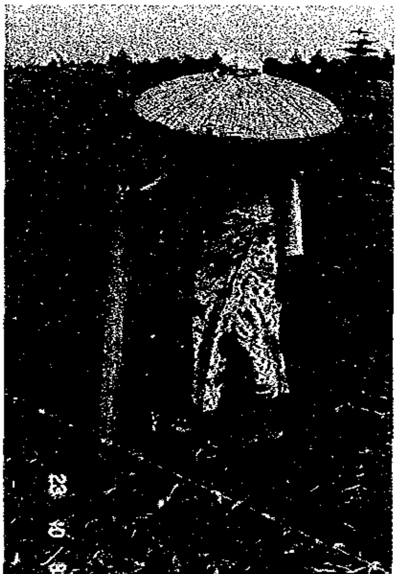
国際協力事業団
農業開発協力部長
村　田　稔　尚

大　豆　畑

水稲後作大豆の不耕起栽培（条播）

水稲後作大豆の不耕起栽培（散播）

水稲後作大豆畑の灌・排水溝



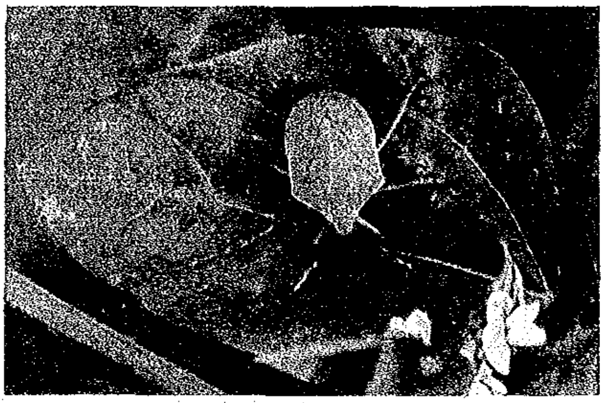
大豆のデブルド（穴播）用の突き棒

デブルド（穴播）播種の大豆

大豆子葉上のマメモグリバエ成虫

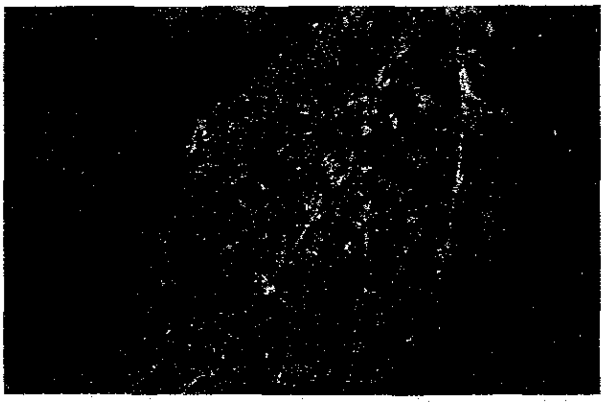
マメモグリバエ幼虫による茎の被害と蛹

マメモグリバエ加害によって枯死した大豆



大豆莢実害虫のミナミアオカメムシ

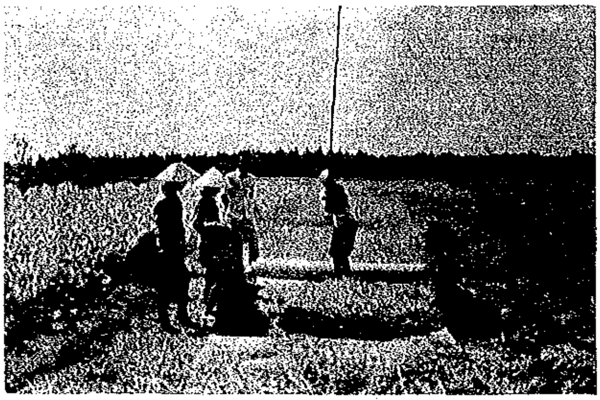
サビ病多発の大豆畑



サビ病被害の大豆葉身

ウイルス被害の大豆

ウイルス被害の大豆粒



大豆の脱穀

発芽不良・初期生育不揃いの大豆畑

（種子の発芽力の低下とマメモグリバエの加害等による）

畦畔大豆（採種用が多い）

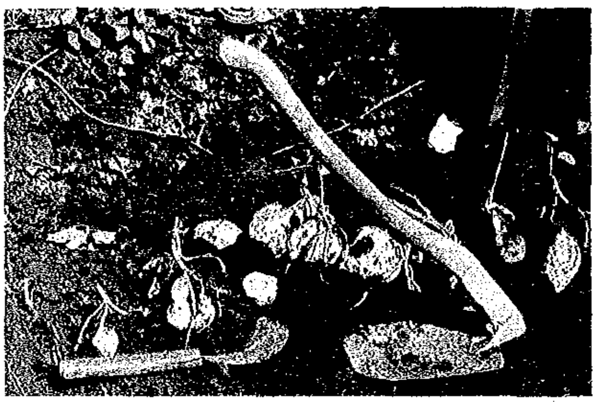
サルジャン・システム（島畑）による大豆の栽培

大豆とトウモロコシの混作

陸稲とトウモロコシの混作

陸稲畑（大規模単一栽培はスマトラに多い）

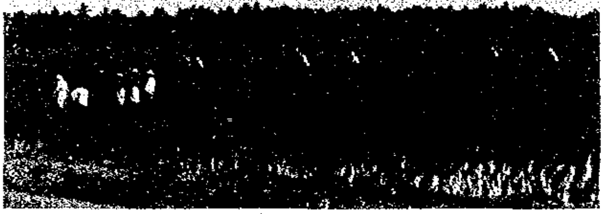
サツマイモ畑（水稲との田畑輪換栽培）



畑作用のクワとカマ（収穫したサツマイモ）

キャッサバ畑

水田の耕起作業



水田の除草作業

アニアニによる稲の収穫

稲の脱穀（カマの普及により，この風景が増えている）

鼠害を受けた水稲

棚　田

はじめに

インドネシアにおける研究協力「作付体系に係る豆類研究強化プロジェクト」は，昭和５３年１０月月２３日より５８年１０月２２日までの５ヶ年の期間で中央農業研究所（ＣＲＩＡ）一現食用作物中央研究所（ＣＲＩＦＣ）を協力機関として開始された。

本プロジェクトの目標は，同国における農業環境に適応した総合的技術の開発であり，具体的には普通作において作付体系を構成する豆類および他の食用作物（稲及び普通畑作物）に関する研究活動を強化することである。このため，研究分野は作物（畑作物・水稲）栽培，植物生理，植物病理，昆虫の５部門となっている。

昭和５４年２月～５月にかけて第一次の専門家７名（団長，５専門家，調整員）が着任し協力業務を始めたのである。

先ず，Ｒ／Ｄの線に沿って具体的な研究課題設定を行うため，協力機関のＣＲＩＡスタッフと討議を進めると同時に，資料の蒐集，現地調査などを実施した。その結果，昭和５４年１２月１３日，合同委員会を開催し「基本計画の細目および年間作業計画」の策定が行なわれた。

研究協力の目標を概括すれば次の如くである。

(1) インドネシアの風土及び社会的，経済的条件に適応した技術の開発を行う。

(2) 蛋白資源として最も重要な大豆を中心として，作付に係る普通作物について栽培研究を行う。

(3) 協力期間５ヶ年の中での第一次派遣チームであることを考慮し，先ず，農家が永年の試行錯誤を経て定着させた慣行栽培——大豆不耕起栽培等——の意義について解明する。

(4) 畑作物保護の立場から生産阻害要因の究明と防除対策，および新技術確立のための素材研究を行う。

ここに取りまとめたのは，第一次派遣チームの研究協力の成果である。２～2.5年の任期において，馴れない環境を克服して多くの研究成果が得られたのは，専門家の和と健康であり，それぞれのカウンターパートの努力であった。又，これを支えたＣＲＩＡスタッフと多くのインドネシアの人々からの直接間接の協力があったからである。

各専門家は帰国にあたり研究成果をＣＲＩＡのゼミナーで報告したが，高い評価と感謝を受けたことで苦労の一端はむくわれたものと思う。

この報告書の作成にあたり，外務省，日本大使館，農林水産省，国際協力事業団の関係各位に対し今日迄の御指導，御支援に深甚な感謝の意を表し，又，帰国後の多忙な用務を持ちながら早期にとりまとめの労をとられた中山兼徳氏，山口武夫氏，および寄稿された各専門家に敬意を表するものである。

インドネシアにて

団長　戸　田　節　郎

第一期派遣専門家一覧

氏名	専門分野	派遣期間	赴任時の勤務場所
松実成忠	団長	昭54. 2.22～54.11.30	農林水産省東北農業試験場
戸田節郎	〃	昭55. 4. 1～	〃 農事試験場
中山兼徳	畑作物栽培	昭54. 2.15～56. 5.14	〃 〃
石倉教光	水稲栽培	〃 ～56. 2.14	〃 四国農業試験場
山口武夫	植物病理	昭54. 2.22～56. 8.21	〃 北海道農業試験場
藤本堯夫	植物生理	昭54. 3.28～56. 3.27	〃 東北農業試験場
岡田斉夫	こん虫	〃	〃 中国農業試験場
土生幹夫	業務調整	昭54. 5.14～56. 5.13	国際協力事業団農業開発協力部
（短期）			
西山幸司	植物病理	昭55. 2.27～55. 5.26	農林水産省農業技術研究所
高城英雄	畑作物栽培	昭55. 7.18～55. 8.25	〃 北海道農業試験場
桑原真人	植物生理	昭55.10. 4～55.11.28	〃 〃
白石哲	野鼠	昭55.12. 8～56. 3. 7	九州大学農学部
吉野嶺一	植物病理	昭56. 2.25～56. 5.23	農林水産省農事試験場

目　　次

CONTENTS

1. ジャワ島の農業と大豆作

中 山 兼 德

K. Nakayama : STATUS ON AGRICULTURE AND SOYBEAN CULTIVATION IN JAVA

本稿は農業研究協力活動の背景であるジャワの農業と大豆作の概況について取りまとめたものである。

1. インドネシア農業におけるジャワの位置

インドネシアではジャワとそれ以外の島を分けて考えることが多く，ジャワ以外は外領と呼ばれている。この発想は，インドネシアの政治，経済を握り，文化推進の中心的役割りを果してきたジャワ住人（ジャワ人・スンダ人）から生れたものであろうが，文化，経済など各種の面でジャワと外領とは違っており，農業も例外ではない。

ジャワ島（マドウラ島を含む，以後も同じ）の面積は全インドネシアの僅か6.9％にすぎないが，人口は全インドネシアの約63％を占めている。その人口密度は634人／km²，外領の28人／km²と対比して極めて高い。ジャワ島の耕地率は約60％といわれてきたが，第1表に基づくと約47％である。後述するように，ジャワには火山が多く，その地形は日本と類似している。その条件を考えると，47％の耕地率は極めて高いものである。実際に，耕して天に至る段畑は各所で見ることができる。

インドネシアの農業は農民による土地利用（小経営）と政府，企業によるエステート（大経営）とに大別できる。また，農民による土地利用は，①作物を毎年作付する集約耕地，②エステートと同じく換金を目的として多年生作物を作付するプランテーション，③焼畑，休閑等の粗放耕地に分けることができる。その土地利用をみると，ジャワ，外領とも，食用作物の生産が中心である集約耕地の比率が最も高いのは当然であるが，その比率は外領の43％に対し，ジャワでは79％と極めて高い。一方，エステートとプランテーションを併せた多年生作物の農園は，ジャワでは16％にすぎないが，外領では38％に達している。また，焼畑等の粗放耕地は，外領では20％を占めているが，ジャワにはほとんどない。

以上のように，ジャワの農業は，外領のそれと異なり，農民による集約的な食用作物生産の農業といえる。主要な食用作物の作付面積は第3表に示すとおりで，大豆，落花生，キャッサバ，トウモロコシについては全インドネシアの作付の2／3以上を占めており，水稲は約57％，カンショも約47％がジャワに作付されている。野菜の作付面積も約60万*ha*といわれている。このような土地利用にみられるジャワ農業の特長は人口の多いことと関連していよう。ジャワにおける農家1戸当りの耕地規模は1*ha*以下が70％を占め，平均すると0.64*ha*にすぎない。土地をもたない農業労働者もかなりいる。

2. ジャワの農業概況

(1) 気候

ジャワは南緯6°から9°に位置するため，日長の年変化は少なく，気温も乾季に比べて雨季に1～2℃低下するものの年較差は小さい。年平均気温は標高によって異なるが，ほとんどの耕地は20℃（西部ジャワ・標高1.000*m*）から27℃（pasuruan・第2図）の間にある。

11月頃から3月頃までは西季節風と呼ばれる西ないし西北西の風が優勢となり雨をもたらす。いわゆる雨季である。4月頃から東からの東季節風に交代し，10月頃まで続く。雨が少なく，晴天が続く乾季である。雨季と乾季の長さは第2図のように場所によって異なる。全般的には，東西間では西ほど，南北間では南ほど，雨季の期間が長い。Bogor，Bandung を含む西部ジャワは北部海岸平野を除いて，雨季の期間は7，8か月からそれ以上に達し，その年降雨量は2,000*mm*以上のところが多い。Bogorでは4,000*mm*に近く，本質的な乾季はない。西部ジャワにつながる中部ジャワ西半分の高原，山岳地帯も西部ジャワと同様な降雨の配分，降雨量である。

一方，西部ジャワ，中部ジャワの北部海岸平野から東部ジャワにかけては雨季，乾季がはっきり分れ，両季の期間の長さが同程度か，むしろ乾季の長いところが多い。降雨量は，1,000～2,000*mm*で，東部ジャワの北部海岸地帯では1,000*mm*に達しないところもある。

Yogyakarta，Soloなど古くから開かれた中部ジャワの肥沃地帯は気候面からも前述した西部ジャワの高原地帯と東部ジャワの中間に位置している。すなわち，雨季と乾季の期間が同程度か，雨季がやや長く，年降雨量は1,500～2,000*mm*である。

(2) 地勢・土壌

ジャワの地勢の特色は火山島であることである。第3図に示したように，標高2,000*m*以上の山がかなりあるが，すべて火山といわれており，長い緩やかな裾野をつくっている。ジャワの耕地率が非常に高いのは雨が多く常夏の気候である

* Agronomist, Department of Farm Mechanization, Agricultural Reseach Center, Yatabe, Tsukuba, Ibaraki, JAPAN.

ことと共に，その地形と土壌によるものであろう。

中部ジャワ・東部ジャワでは一部，南に海岸平野をつくっているが，大河川の多くはジャワ海に向って流れ，北部に広い海岸平野をつくっている。その中でもJakartaを含む西部ジャワの海岸平野は最も広く，水田地帯を形成している。それと接して，CirebonからSemarangまで中部ジャの海岸平野が続く。しかし，山がせまり，規模は小さい。中部ジャワの東半分から東部ジャワにかけてはSolo河とBlantas河の沖積平野がひろがる。とくにSolo河は上流域の中部ジャワに多くの沃野をつくっている。大河川の上流域で山地の裾野には高原がひろがる。Bandungを中心とする西部ジャワの高原，中部ジャワのMagelang高原など代表的なものであるが，その基盤は火山からの噴出物に深く被われ，豊富な雨水を利用して肥沃な水田が形成され，山地の斜面高くまで棚田が発達している。中部ジャワから東部ジャワにつながる北部には石灰岩の丘陵が東西に走っている。後述するようにチーク材の植林が盛んで，雨の少ないことなどもあって，ジャワの他の地域と景観をやや異にする。

土壌は多くの種類のあることが明らかにされているが，分布の多い主なものは沖積土壌，ラトソル，レゴソル，グルムソル及び山地に多いアンドソルで，それらの分布は第4図に示すとおりである。

西部ジャワ・中部ジャワの波状地のほとんどは赤褐色のラトソルである。深いところまで風化し，物理性がよく，土壌侵食にも抵抗性をもっている。東部ジャワの波状地には黒灰色のレゴソルが多い。火山噴出物の堆積によるものが主体であるが，火山灰は比較的新しく，保水力もよく，肥沃といわれている。第4図に示した山岳・高原地帯(Mountain)にひろがっているアンドソルは日本の黒ぼく土壌にあたる。有効態燐酸は欠乏しているが，比較的に高い肥沃度をもち，水稲のほか，茶・野菜などの換金作物が栽培されている。中部ジャワ北部から東部ジャワ・マドウラの乾燥地域に分布するグルムソルは泥灰岩，石灰岩の風化堆積物を母材とし，重粘で乾燥すると固くなり，農作業には不適である。pHは高い。低地では水稲が栽培されている。

低地の河川流域は沖積あるいはコルヴィアルの堆積物から生成された沖積土壌であり，水田が形成されている。集水域の母材がグルムソルの地域の土壌は極めて重粘である。西部ジャワ北部海岸平野及びSolo河口域には排水不良のところがかなりある。

(3) 主要作物とその分布

主作物の稲は用水が整備されているところでは1年に2回以上作付できる。正確な情報を得ることができなかったが，ジャワ水田の1／2～2／5が年2回，水稲を作付していると推定されている。そのおよその分布は第5図に示すとおりである。西部ジャワの高原地帯，中部ジャワの北部海岸平野，Solo河上流域，東部ジャワのBlantas河上流域は年2作が多い。それに対し，西部ジャワの広大な北部海岸平野では1年1作のところが多く，中部ジャワから東部ジャワにひろがるグルムソル土壌の乾燥地域でも年1作である。しかし，グルムソル地域の多くでは少ない用水を利用して，トウモロコシなど畑作物が乾季に導入されている。

インドネシアでは米の自給をめざし，1964年から新しい多収品種を導入，施肥，農薬散布を行う水稲集約栽培を奨励，普及している。その集約栽培は1978年にはインドネシア全稲作付面積の約54％に拡がり，米生産量も1,760万tに達している。ジャワにおける集約栽培の普及率はインドネシア全体の平均値より高く，とくに東・中部ジャワにおいて高い。一方，病害虫(野鼠，トビイロウンカ,メイ虫等)の多発，それに伴う品種更新の必要性などが高まっている。

主要な普通畑作物は第3表に示すとおりである。このうち，キャッサバ，陸稲のほとんどは畑地作として雨季の始に播種，植付される。トウモロコシは畑地作が多いが，水稲後の乾季作として水田にも広く栽培されている。大豆，落花生，カンショはむしろ水稲後乾季作の比率の方が高い。これら水稲後乾季作の栽培は西部ジャワでは少なく，そのほとんどが中・東部ジャワで行われている。そのこともあって，中・東部ジャワでは，第3表にみられるように，畑作物栽培の比重が高い。

その他の主な作物の分布は第6図に示すとおりである。ゴムと茶の作付は西部ジャワから中部ジャワ西半分に多く，茶は山麓など傾斜地が利用されている。それに対し，サトウキビとタバコの産地は乾季のはっきりした中・東部ジャワである。サトウキビは古くから，水利用ができる肥沃な沖積地が選ばれてきており，水稲と輪作を組んでいる。タバコもサトウキビと同様な条件における作付が多いが，山岳地帯でも一部作付されている。野菜は全国で栽培されているが，主産地は交通立地条件に恵まれ，水利がよく，肥沃な土壌条件の地域である。

なお，前述したが，中・東部ジャワの北部丘陵地域を中心にチーク材が植林，産出されている。これらの植林地は耕地と隣接している。

(4) ジャワ農業の地域区分とその特色

以上述べてきたように，ジャワでは気候，土壌，作物の種類等，地域性がかなりはっきりしている。ジャワ農業の地域区分(試案)は第7図に，その特色は以下に示すとおりである。

Ⅰa：西部ジャワの北部に拡がる海岸平野。

雨季，乾季の区別がはっきりし，水利の良いところでは水稲を年2回作付しているが，なお灌排水の不良のところが多く，そこでは雨季に1作のみ水稲が作付され，乾季は休閑である。水稲地帯。

Ⅰb：中部ジャワの北部に拡がる海岸平野。

Ⅰaに比べて大河川がなく，規模が小さいため，水利の整備が進んでいる。交通立地条件のよいことも相まって，水稲の年2作に加えて，水稲後乾季作として，トウガラシ，タマネギ等の換金作物をはじめ大豆なども導入している。サトウキビの作付もある。気候，地勢，土壌など自然立地条件からはⅠaと同一区分に含まれる。

Ⅱ：西部ジャワの雨季が長く，降雨量の多い高原地帯。

水稲の作付が中心で，年2作が多い。波状地にはゴム園が多く，山麓傾斜地には茶園が開発されている。普通畑作物としては

キャッサバはかなり栽培されているが，その他の作物は少ない。Jakarta，Bandung 等の大消費地，さらには南スマトラ等を対象にした野菜作も盛んである。

Ⅲ：中部ジャワから東部ジャワにわたる広い地帯である。雨季と乾季の期間が同程度で，年間降雨量は1,500～2,000 *mm*のところが多い。用水整備が進んでおり，水に恵まれたところでは水稲の年２作あるいはサトウキビの栽培が行われ，乾季に水の不十分な地域では水稲後乾季作として，トウモロコシ，大豆をはじめ多くの種類の畑作物が栽培されている。高原や山麓は開発され，キャッサバ，トウモロコシ，大豆等が雨季作として作付されている。土地生産力が高く，土地利用の進んでいる地区が多い。

Ⅳ：中部ジャワから東部ジャワにわたる北部の乾燥地帯。土壌はグルムソルと沖積土壌が多い。水稲の作付は年１回，灌がい施設のあるところでは少ない水を利用して畑作物を水稲後乾季作として作付，とくにトウモロコシの栽培が多い。丘陵地ではチーク材の植林，産出が盛んで，地域としては混林業地帯ともいえる。

3. ジャワの大豆作

(1) 作付分布と作付方式

ジャワの大豆作付面積は約５２万*ha*，インドネシア全作付の８０％を占めている（第３表）。収量は0.8 t／*ha*と低い。第８図は県（Kubupatan）別の大豆作付面積を示したものであるが，東部ジャワと，それに接する中部ジャワの東部が主産地である。とくにJember 地区では栽培が盛んである。第８図によると中部ジャワのGrobogan県でも約５万*ha*の作付があるが，筆者の調査範囲では５万*ha*の規模の作付は確認できなかった。

ジャワの大豆はいろいろの作付方式をとっているが，主な作付順序は第９図のとおりで，水田において，水稲後乾季作として栽培する方法と普通畑で雨季に栽培する方法の二つに大別される。ジャワの水稲の主シーズンは雨季で，田植の最盛期は１２～２月である。水利の整備されている地域では２期水稲が乾季に栽培される。その田植時期は５～６月の場合が多い。以上の水稲作季との関連において，水田大豆作の作付が規制されている。

水稲後乾季作として最も多いのは③と④の作付である。③は水利の便はあるが水稲を栽培できるだけの水の余裕がない場合の作付であり，２０日間かく程度で大豆に灌水される。④は灌水をほとんど期待できない作付で，雨季末期の雨あるいは雨季に土中に貯えられた水分を利用する。③，④の作付とも乾季における干害の軽減をはかるため，大豆は水稲の収穫直後あるいは収穫直前の立毛中に播種される。グルムソルなど固い土壌を除くと不耕起条件に播種される。第１０図からわかるように，東部ジャワ大豆作の約半分は③，④の作付である。②は乾季に大豆を２期作行う作付であり，①は水稲２期作の後に大豆を導入する作付で，最近，増えているが，まだ少ない。⑤は乾季トウモロコシ作あと，⑥は乾季休閑後に，大豆を播く作付であるが，いずれも雨季はじめの雨を利用する。トウモロコシとの混作が主体であるが，その面積は多くない。

⑦は普通畑で雨季をまって大豆を播種する作付で，収穫後に大豆，トウモロコシなどをもう一度栽培する場合が多い。大豆の播種期幅は広い。⑧はキャッサバ畑に混作する作付である。⑦，⑧の作付は全地域にみられる。いずれの作付とも散播が多いが，播種棒（トガル）を用いた穴播も広がっている。穴播では畦幅４０*cm*前後をとっている場合が多い。

(2) 品種と栽培

インドネシアにおける大豆の奨励品種は第４表に示すとおりである。Orbaのような新しい品種（１９７４年登録）も生れているが，実際に栽培されているのは第１１図のように，NO．２９を中心に，在来種といわれる古い導入品種や，それから選抜したものである。品種特性として共通しているのは小粒（百粒重７～１４*g*）であることと，生育日数が短い（８０～１０５日）ことである。早生種の採用は，その作付の主体が乾季作で干害対策の必要性と関連するもので，一日も早く収穫して干害を回避するためである。このような品種特性あるいは前述した大豆の作付から推定できるように，ジャワ大豆作の主軸である乾季作の特長は早生品種による稲収穫後できるだけ早く播く早播栽培といえる。栽培のねらいは干害の軽減，回避におかれている。

第５表は生産費の内訳を示したものである。水稲やトウモロコシ，落花生の生産費と対比すると，大豆作は各種の特長をもっている。以下のとおりである。

①水稲作ではすべて自家産種子，トウモロコシ作も自家産が主であるのに対し，大豆，落花生作では種子代が高いにも拘らず約7割が購入種子である。熱帯では豆類子実の発芽力は収穫後3か月ぐらいで著しく低下し，種子としての利用が不適になることは知られている。したがって，農家では発芽力の高い新しい種子を用意する必要があるが,作付順序の面から,種子を自家産でまかなうことが難しく，多くの地域では種子を購入している。

②農薬とくに殺虫剤が利用されている。チーム専門家の調査旅行の範囲内では大豆に対する殺虫剤利用が水稲のそれを上まわるとは考えられないが，それにしても第５表の事実は大豆作において虫害が大きいことを物語るものである。第６表はジャワにおける主要害虫である。このなかでも*Ophiomyia phaseoli* は大豆作を規制する害虫として，どの地域でも恐れられている。

③水稲，トウモロコシと比べて肥料の施用が少ない。実質的にはほとんど無肥栽培である。

④畜役利用，その中心は耕うんであろうが，賃金の項の耕起，整地とも他の作物に比べて極めて少ない。グルムソルなどの重粘土壌を除いて播種前耕起は行われない。他の畑作物が耕起されるのと対照的である。

⑤除草が他の作物に比べて少ない。

以上のような大豆作の実態をもとに行った2か年の試験の結果，ジャワ大豆慣行法の個別技術について，次のようなことを明らかにできた。詳細は各専門家の報告を参照されたい。

①大豆子実の発芽力は収穫後3か月ぐらいから著しく低下，その原因は保管中の高温，高湿によることがわかった。相対的に低温の標高の高い場所に（550*m*〜1,140*m*）種子を保管すると6，8か月高い発芽力を持続できることが明らかにされた。

② 害虫の被害が大きく，とくに*Ophiomyia phaseoli*を防除しないと収量が半減することがわかった。

莢実害虫防除のための農薬を2〜3回散布した区は無散布区に比べ12〜32％増収した。

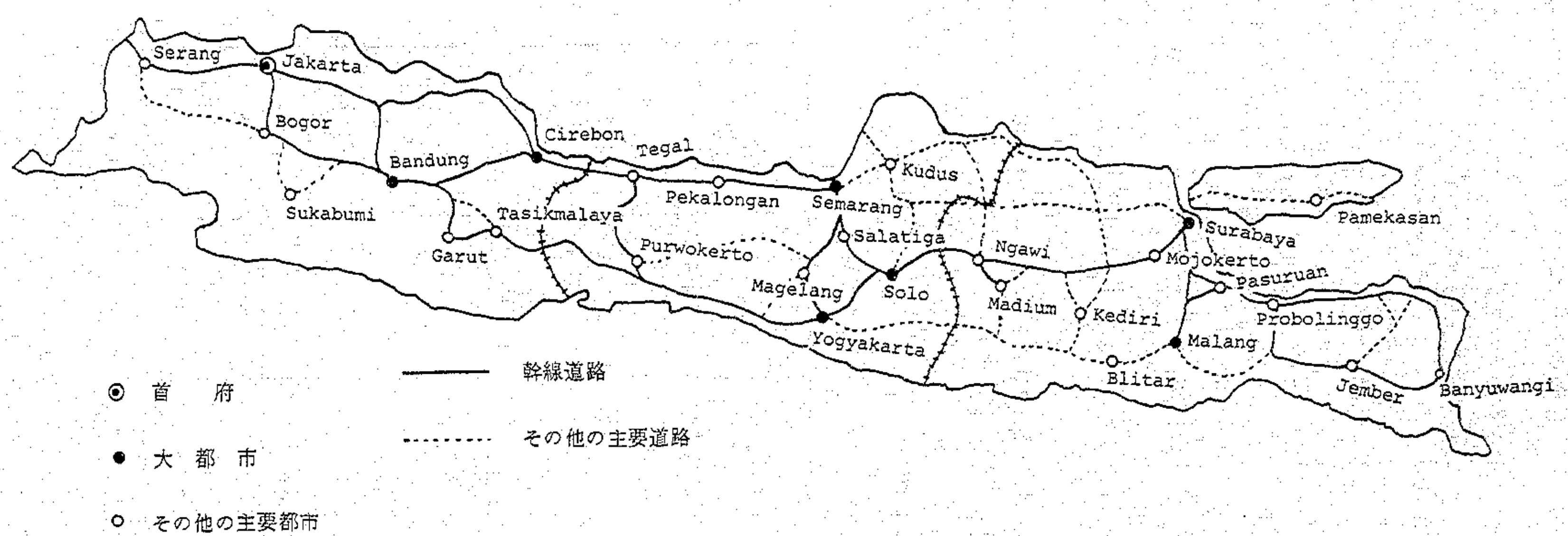
③ 化学肥料の施用により，無肥に比べ15〜29％増収した。

④ 耕うんと無耕うんの間では収量差はなかった。無耕うんの利点は稲収穫後，大豆を早播きでき，干害回避に役立つこと，また耕うんによる土壌水分の損失がなく，雨季中に貯えられた土壌水分を有効に利用できることがわかった。また，不耕起条件における灌漑，稲わらでのマルチ（stubble mulching）が *Ophiomyia phaseoli* の防除に役立つようでもある。

⑤無耕うん条件では耕うん条件に比べ，雑草の発生が著しく少なかった。

ジャワの大豆は低収ではあるが，それなりに自然条件を上手に利用，それに適応した栽培法をとってきたといえる。低収・安定の栽培法と考えてよい。

なお，インドネシアの大豆は蛋白食品として米飯食のおかずの中心となっている。いろいろの形に料理加工されるが，テンペイとターフが最も重要であり，モヤシとしての利用も多い。テンペイは塩を加えてないカビ醗酵の糸引納豆に類するもので，油であげて米飯のおかずとする。ターフは豆腐であり，日本のものより固く，油であげて食べる。



第 1 図　主要な都市と道路

第 1 表　インドネシア及びジャワの土地と人口

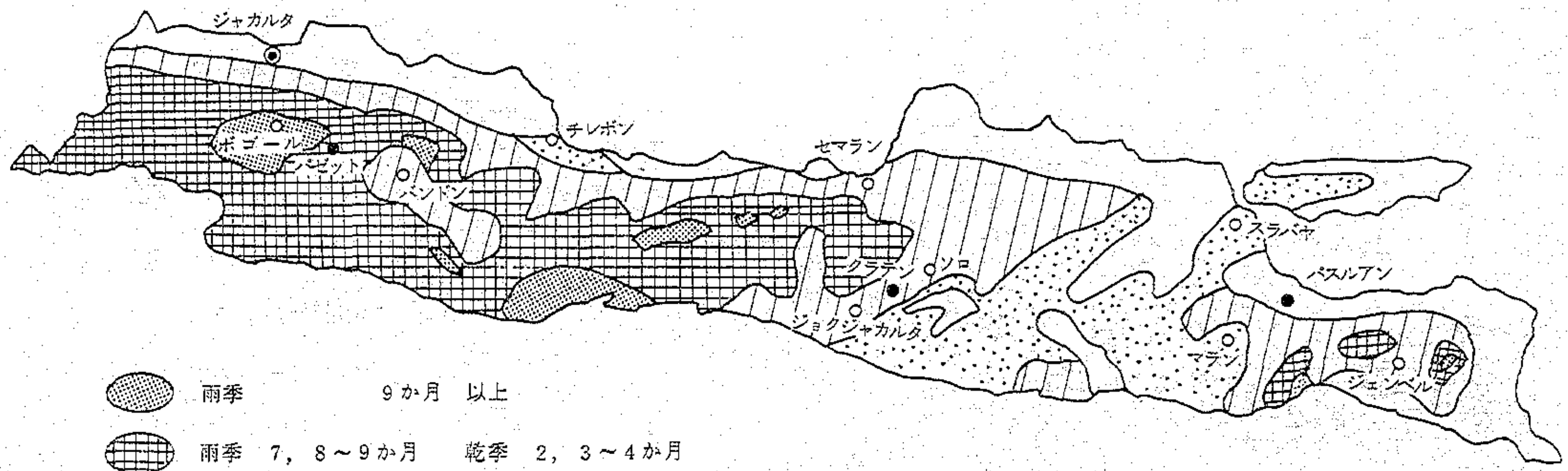
項　　　目	全インドネシア	ジ　ャ　ワ	ジャワを除くインドネシア
面　積（1,000km²）	1,904	132	1,769
人　口（1,000人）	133,916	83,753	50,163
人口密度（人／km²）	70	634	28
小農 集約耕地（1,000ha）	9,231	4,896	4,335
小農 プランテーション（1,000ha）	2,634	329	2,305
小農 焼畑・休閑等（1,000ha）	2,303	280	2,023
エステート（1,000ha）	2,226	677	1,549
全耕地面積（1,000ha）	16,394	6,182	10,212
耕 地 率（ % ）	6.1	46.8	5.8

1） Statistik Indonesia 及びJICA「インドネシアの農業概況」から引用，作成
2） 人口は1977年，土地は1973年

第 2 表　ジャワ島における月別の降水量

項　目		パスルアン（東部ジャワ）	クラテン（中部ジャワ）	パゼット（西部ジャワ）
標高（m）		5	200	1,140
月別降水量（mm）	1 月	226	270	297
	2	279	223	264
	3	213	251	357
	4	137	226	274
	5	94	98	214
	6	56	91	117
	7	25	3	83
	8	5	9	123
	9	5	14	132
	10	18	50	250
	11	61	168	337
	12	165	236	288
計		1,284	1,639	2,734
年平均気温（℃）		27.0	26.0	19.4
日最高気温の平均		31.1	31.2	—
日最低気温の平均		22.8	22.2	—

出所：畠山久尚監修　アジアの気候，1964，古今書院（東京）



雨季　　　　9か月　以上

雨季　7，8～9か月　　乾季　2，3～4か月

雨季　5～6か月　　　乾季　2，3～4か月

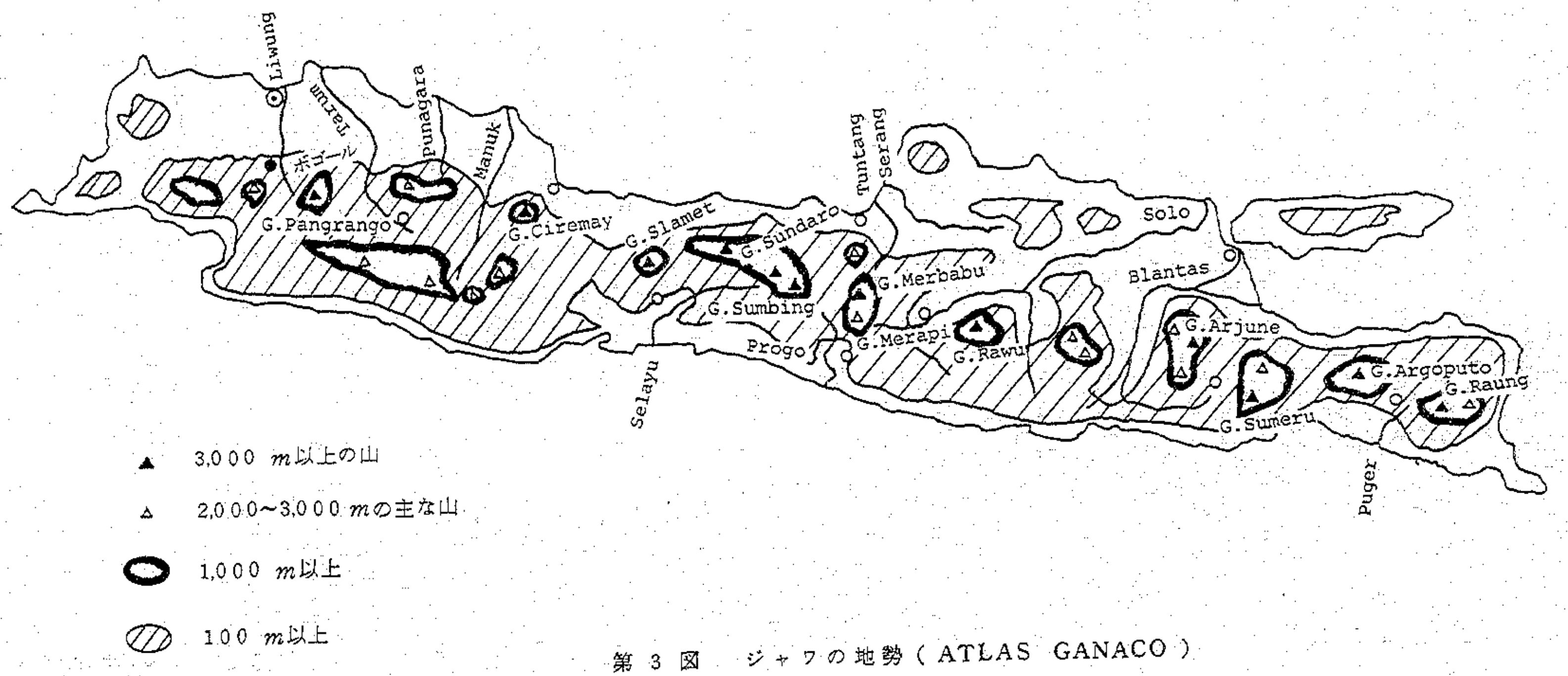
雨季　5～6か月　　　乾季5～6か月

雨季3～4か月ないし以下　　乾季5～6か月

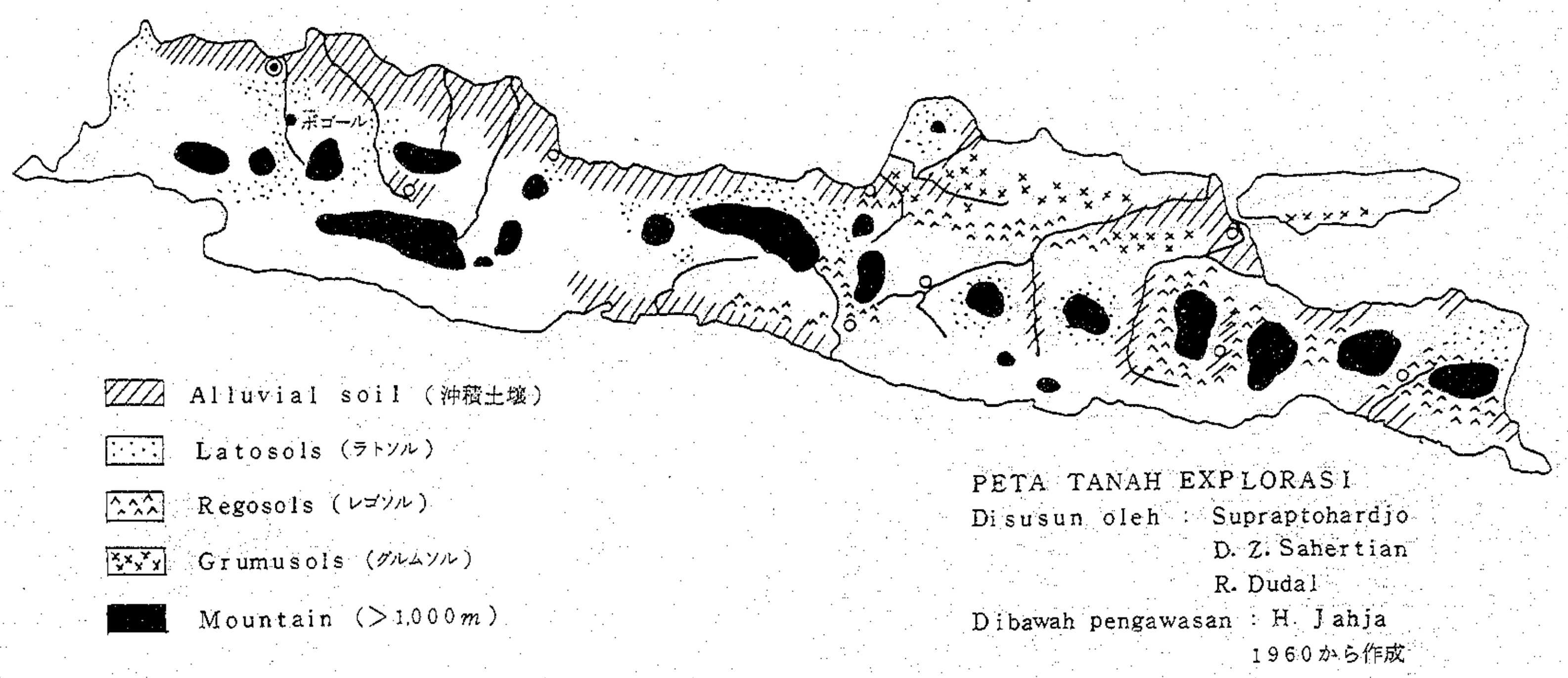
（雨季　200*mm*　rainfall／月　以上
　乾季　100*mm*　rainfall／月　以下）

Agro-Climatic Map（CRIA）から作成

第 2 図　降雨による地域区分



第 3 図　ジャワの地勢（ATLAS GANACO）

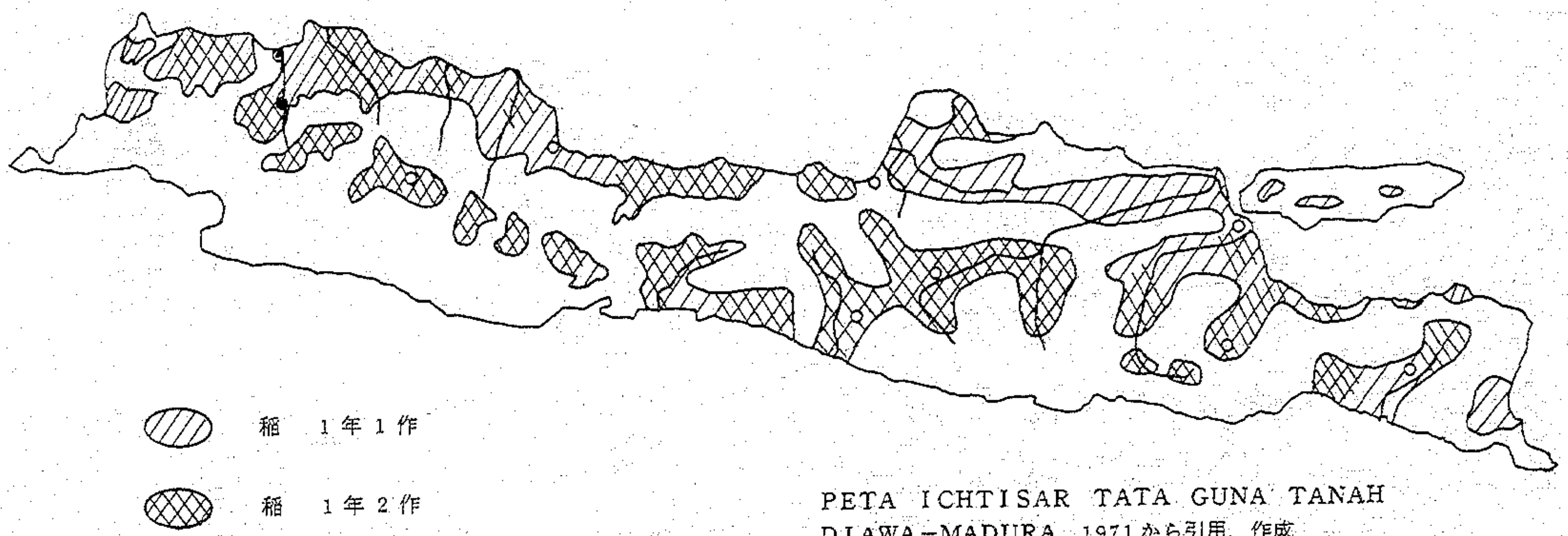


第 4 図　耕地土壌の種類と分布

第 3 表　主要作物の作付面積と収量

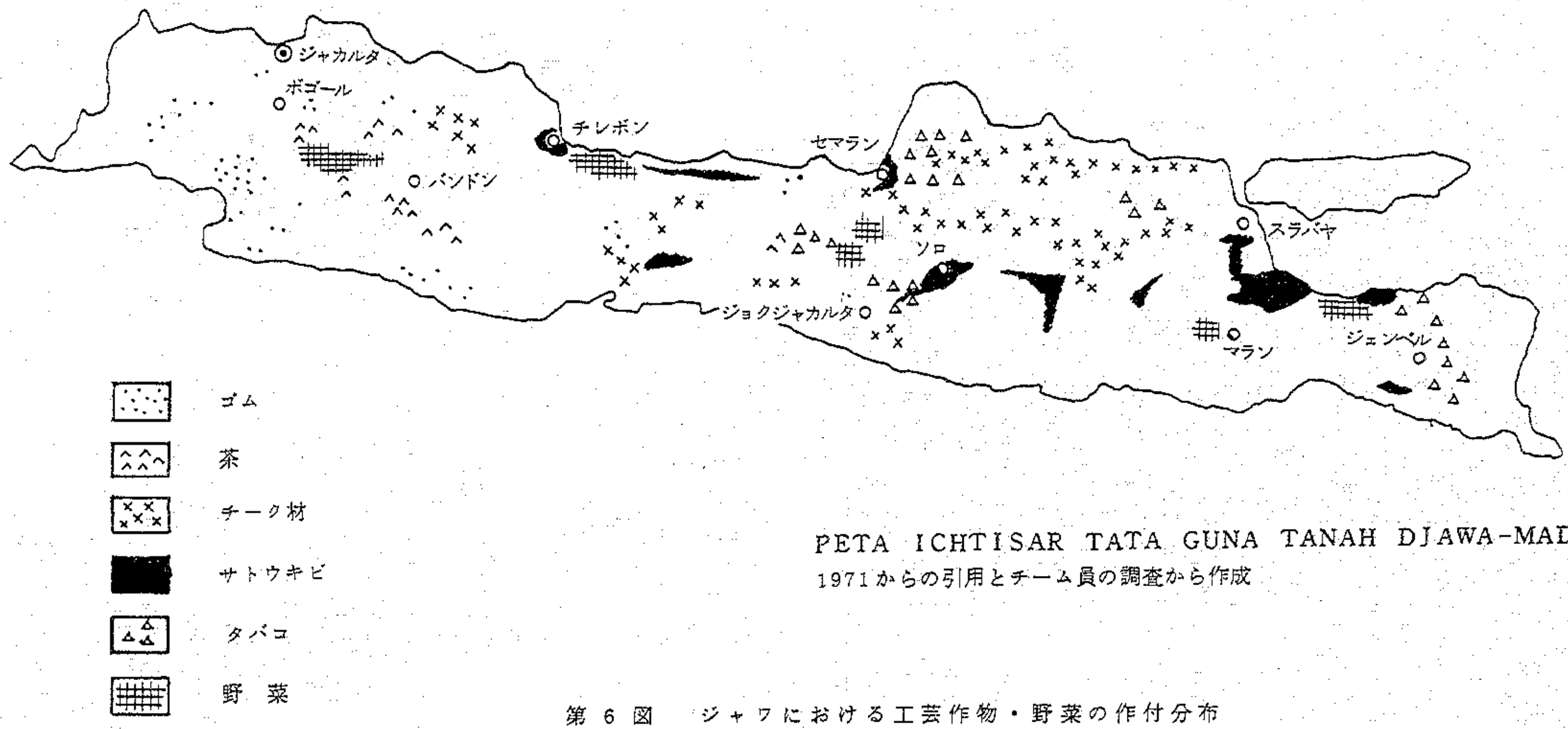
作物（牛）	インドネシア（A）	ジャワ（B）	西部ジャワ	中部ジャワ	東部ジャワ	B/A×100	ha当り収量 インドネシア	ジャワ
						%	kg/ha	kg/ha
水稲	7,202	4,133	1,596	1,282	1,255	57.4	3,028	3,236
陸稲	1,157	245	114	73	58	21.2	1,330	1,445
トウモロコシ	2,567	1,710	69	542	1,098	66.6	1,224	1,302
キャッサバ	1,364	995	204	374	417	73.0	9,200	9,100
カンショ	326	152	53	43	56	46.5	7,500	7,500
落花生	507	364	86	135	143	71.8	806	797
大豆	646	517	21	163	334	80.1	809	809
畑作物計（A）	6,567	3,983	547	1,330	2,106	−	−	−
全作物計（B）	13,769	8,116	2,143	2,612	3,361	−	−	−
A/B×100(%)	47.7	49.1	25.5	50.9	62.7			
牛（×1,000）	6,423	3,883	118	1,196	2,570	60.5	−	−
水牛（×1,000）	2,312	1,063	465	388	211	46.0	−	−

Statistik Indonesia　1978/79から引用（数値は1977年）
作物の面積は×1,000ha



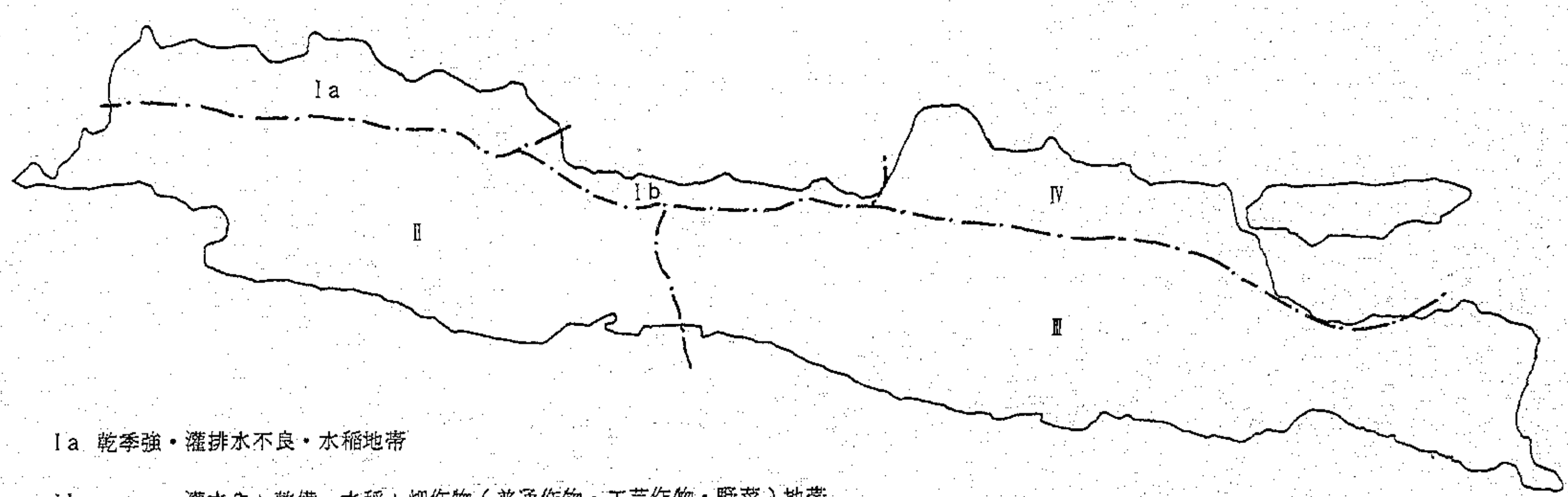
PETA ICHTISAR TATA GUNA TANAH
DJAWA－MADURA 1971から引用，作成

第5図　ジャワにおける稲の地域別作付回数



PETA ICHTISAR TATA GUNA TANAH DJAWA-MADURA
1971からの引用とチーム員の調査から作成

第 6 図　ジャワにおける工芸作物・野菜の作付分布



Ⅰa 乾季強・灌排水不良・水稲地帯

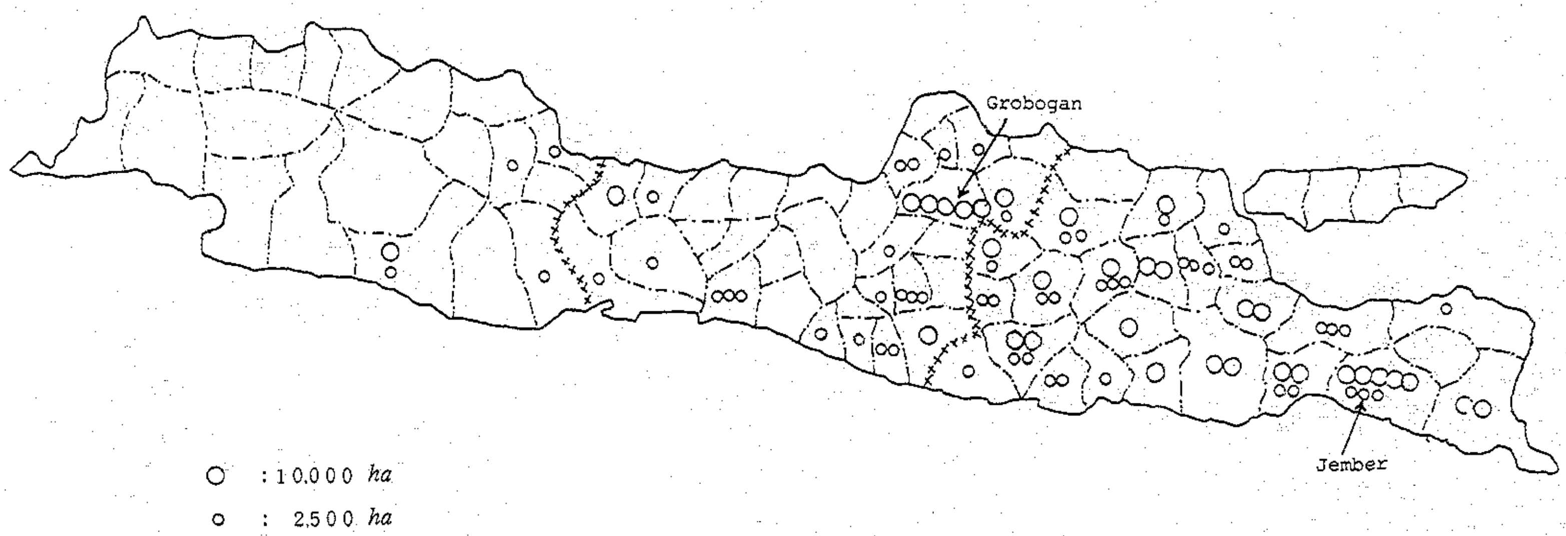
Ⅰb 〃 ・灌水やゝ整備・水稲＋畑作物（普通作物・工芸作物・野菜）地帯

Ⅱ 乾季弱・水稲地帯＋ゴム・茶

Ⅲ 乾季中・灌水整備良・水稲＋畑作物地帯

Ⅳ 乾季最強・グルムソル，水稲＋トウモロコシ・混林業地帯

第 7 図　ジャワ農業の地域区分

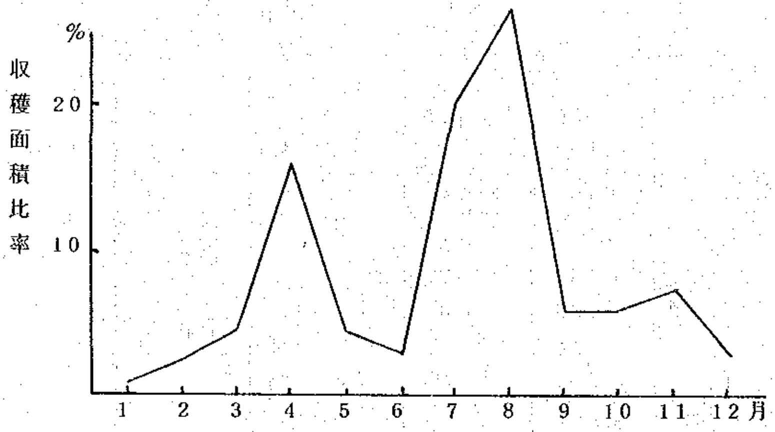


第 8 図　ジャワにおける各県（Kabupaten）別の大豆作付面積（CRIA資料）

	雨季 ←→ 乾季	大豆の 播種期	大豆の 収穫期
灌水（水田）	1. 水稲――水稲――大豆	8～10月	11～1月
	2. 水稲――大豆*――大豆**	*4～5月	7～8月
↕	3. 水稲――大豆	**8～9月	11～12月
無灌水（水田）	4. 水稲――大豆（混作）	4～5月	7～8月
↕	5. 水稲――トウモロコシ――大豆（混作）	4 月	7～8月
	6. 水稲……大豆（混作）	10～11月	12～1月
	7. 大豆……畑作物	10～11月	12～1月
（畑）	8. 大豆（キャッサバ畑に混作）	10～3月	1～5月
		10～12月	1～3月

第９図　ジャワにおける大豆作に関わる作付順序

注：大豆（混作）は混作が多いことを示し，混作作物としては
　　トウモロコシが主である。



第１０図　東部ジャワにおける大豆の月別収穫面積の比率

熱研センター「インドネシアの豆類に関する生産および
研究事情調査報告書」から引用，作成

第 4 表　インドネシアにおける大豆奨励品種

品種名	来歴	生育日数	種皮色	百粒重	収量性
				g	kg/ha
No. 16	台湾より導入	95	黒	7.5	1,200
No. 27	No. 16の系統選抜	100	黒	9.5	1,200
No. 29	No. 17（Botan）の系統選抜	105	黄～黄緑	7.0	2,000
Ringgit	No. 27×在来種	85	黄	9.0	1,500
Davros	在来種の系統選抜	85	黄	12.0	1,200
TK 5	IRRIより導入	80	黄	12.5	1,500
Taichung	〃	80	黄	10.0	1,500
Orba	Davros×Shakti	85	黄	12.5	2,000
Americana		100	黄	14.0	2,000

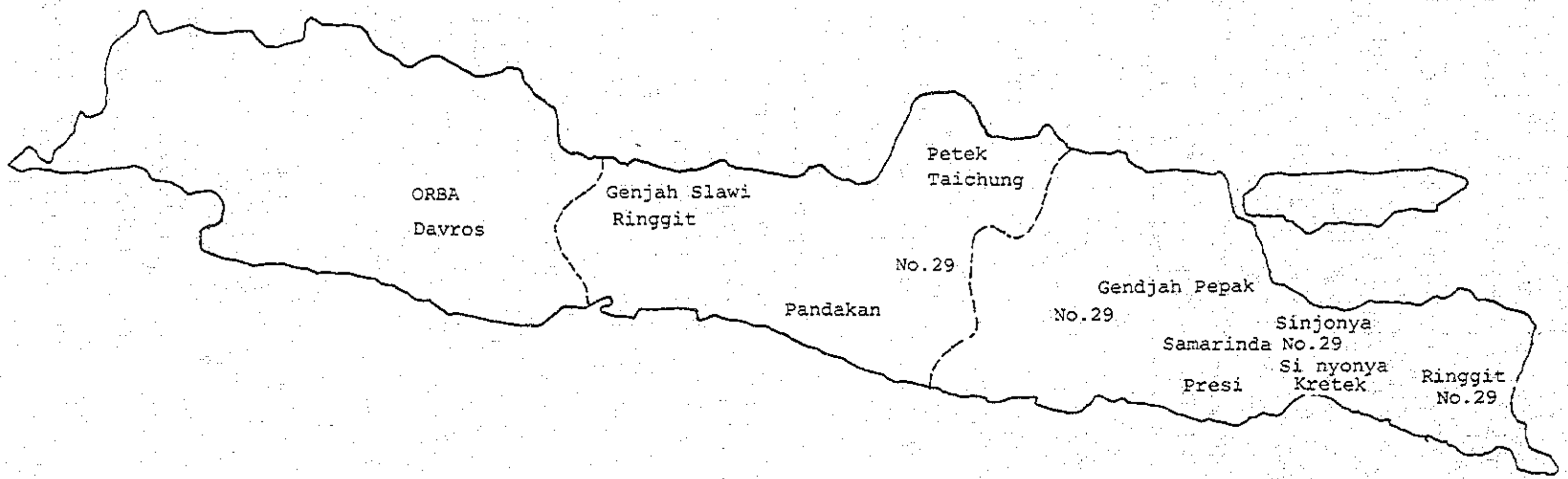
CRIA 資料

第 5 表　普通作物のha当り収入と生産費（1974/75）

（単位 Rp/ha）

項目		大豆	落花生	トウモロコシ	水稲
収量（kg）		730	770	1,223	3,746
収入		80,663	145,092	44,958	152,192
生産費（全体）		18,468	29,746	16,526	34,807
生産費の内訳	種子（自家産）	1,543	2,919	701	1,827
	（購入）	3,507	7,055	436	
	農薬（殺虫剤）	699	69	62	655
	（その他）	18	6	4	
	肥料（化学肥料）	810	566	2,143	5,263
	（堆肥・その他）	275	757	1,014	
	畜役（借料）	467	2,285	1,293	3,494
	（自家用）	225	569	817	
	灌がい	394	268	204	789
	賃金（溝ほり）	1,837	3,101	1,973	19,153
	（耕起・整地）	643	2,216	1,267	
	（播種）	1,778	2,056	1,085	
	（除草）	990	2,329	1,564	
	（収穫）	2,670	3,583	1,589	
	（その他）	861	473	363	
	その他	1,751	1,492	2,011	3,626

ESCAP Regional Co-operation in Food and Agriculture Development of CGPRT Crops, 1978から引用



第 11 図　主なる大豆品種の地域分布

第 6 表　インドネシアにおける大豆の主要害虫*

種　　類	日　本　名
Ophiomyia phaseoli Tryon	マメモグリバエ
Phaedonia inclusa Stal	ハムシの1種
Etiella zinkenella Treitschke	シロイチモジマダラメイガ
Asphondylia sp.	ダイズサヤタマバエの1種
Nezara viridula Linne	ミナミアオカメムシ
Riptortus linearis Fabricius	タイワンヘリカメムシ
Plusia chalcites Esper	ウワバの1種
Spodoptera litura Fabricius	ハスモンヨトウ
Hedylepta indicata Fabricius	ミスジノメイガ
Melanagromyza sojae Zehntner	ダイズクキモグリバエ

＊：岡田斉夫専門家による

2. THE CULTIVATION METHOD OF SOYBEAN PLANTED AFTER LOWLAND RICE

Kanenori Nakayama*, Sarlan Abdulrachman**, Suprapto Sunadi**, Adisarwanto*** and Muneo Okada****

ABSTRACT

Some experiments on the cultivation method of soybean planted after lowland rice were carried out by comparing traditional and intensive methods.

Difference in yield was not found with or without tillage. Broadcast seeding was inferior to dibbled seeding with regular spacing in a ratio of number of plants harvested to number of seeds. Injury caused by *Ophiomyia phaseoli* (Tryon) and shortage of water in the soil were limiting factors for increasing yield. Fertilization and insecticide application to control pod insect increased yields remarkably.

INTRODUCTION

Around 77 percent of the total harvested area of soybean in Indonesia (650,000 ha, 1978) is concentrated in East and Central Java (1). About 75 percent of the soybean in these districts is cultivated in the dry season after lowland rice. Most soybean here is planted without tillage, without fertilizer or pesticide. Though some seeding is by dibbling with a regular spacing, most soybean is still by broadcasting. Consequently, the average yield of soybean is only 0.7 to 0.8 t/ha (2, 5 and 6).

At present, the introduction of intensive cultivation with tillage, fertilizers and pesticides has encouraged the improvement of the traditional method as above.

This study was conducted to clarify the character and value of traditional method and to find effective method of improvement by comparing traditional and intensive methods.

Four experiments were carried out at Muara and Mojosari substations from 1979 to 1980. The purposes of these experiments are as follows:

EXP. 1 Effect of seeding, fertilization and insecticide application to control pod insect.

EXP. 2 Effect of tillage, seeding, fertilization and insecticide application to control pod insect.

EXP. 3 Effect of tillage, seeding, fertilization and insecticide application to control pod insect and *O. phaseoli*.

EXP. 4 Effect of tillage, irrigation and weeding.

(EXP. 1)

MATERIALS AND METHODS

Two soybean varieties, ORBA and No.29 were sown after rice cropping in a lowland field at Muara substation on 21 July, 1979.

The treatments were as follows:

(1) No fertilization + Broadcast seeding

(2) Fertilization + Dibbled seeding

(3) Fertilization + Dibbled seeding + Insecticide application to control pod insect.

A split-plot design with three replications was applied. The treatments were put in the main plot, and the varieties in the subplot. The size of the subplot was 8.8 x 8.8 meters.

The field was ploughed to a depth of 10 to 15 cm using a hand tractor, and 500 kg/ha of lime was applied. After land preparation, for treatment (1) about 5,000 seeds per 100 m^2 were broadcasted, and covered with 3 t/ha airdried rice straw. In treatment (2) and (3), seed was dibbled at a spacing of 40 x 20 cm with four to five seeds per hole, and three weeks after seeding, the plants were thinned out to two per hill. Fertilizers in treatments (2) and (3) were 20 kg/ha N + 60 kg/ha P_2O_5 + 60 kg/ha K_2O (urea, triple superphosphate and potassium chloride respectively). Azodrin was sprayed twice (one and two weeks after seeding) for all plots to control *O. phaseoli*. Kalphos was used four times (August 30, September 9 and 25, and October 1) for treatment (3) to control pod insect.

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RESULTS

Emergence was good, because it rained just before seeding time and plots were irrigated twice after seeding. Injury caused by *O. phaseoli* was slight. The plants were irrigated twice during a dry period from August 14 to September 3. Consequently, plants grew favorably.

Growth survey (Table 1)

There was no clear difference among treatment (1), (2) and (3) for both varieties in flowering time and maturing time. Flowering and maturing time of the three treatments for ORBA were on August 25 and October 18 respectively (a growth duration of 89 days), and on September 8 and October 29 for No.29 (a growth duration of 100 days).

It was observed on August 18 (about one month after seeding) that in both varieties, the length of the main stem were in treatment (2) = (3) > (1), and the inferiority of treatment (1) to (2) and (3) continued until harvesting. The main stem length of treatment (3) was higher than that of treatment (2) from September 15, and this continued as growth progressed.

Table 1. Length of main stem as affected by fertilizer, seeding method and insecticide. (Exp. 1, 1979)

Variety		ORBA			No. 29		
Treatment*		(1) No. F B.S	(2) F D.S	(3) F D.S, In	(1) No. F B.S	(2) F D.S	(3) F D.S, In
		cm	cm	cm	cm	cm	cm
Aug.	18	14.5	17.4	18.1	18.8	24.5	24.4
Sep.	1	19.5	23.2	24.1	24.1	28.8	29.0
Sep.	15	29.6	32.1	36.1	44.6	52.4	56.2
Sep.	29	36.7	37.9	40.3	57.8	64.4	71.5
Oct.	15	37.6	38.7	42.6	65.4	71.3	79.3

* : (1) No F, B.S : No feritilization, Broadcast seeding
(2) F, D.S : Fertilization, Dibbled seeding
(3) F, D.S, In : Fertilization, Dibbled seeding, Insecticide application to control pod insect.

Yield survey (Table 2)

The number of plants per 100 m^2 at harvesting was the about same for all treatments of No.29, while for ORBA, treatment (1) > (2) = (3). The yield of ORBA was higher than that of No.29 for all treatments. The yields were in the order of treatment (3) > (2) > (1) for both varieties with highly significant differences, that is, for ORBA the yield of treatment (2) was 115% and of treatment (3) 148% greater than that of treatment (1), for No.29 treatment (2) yielded 122% and treatment (3) 162% more grain than treatment (1). The one hundred grain weight showed a trend in the order of treatment (3) > (2) > (1) for both varieties. The number of cleaned grains per plant showed the same pattern as the yield for both varieties.

Table 2. Yield as affected by fertilizer, seeding method and insecticide. (Exp. 1, 1979).

Variety		ORBA			No. 29		
Treatment*		(1) No F B.S	(2) F D.S	(3) F D.S,In	(1) No F B.S	(2) F D.S	(3) F D.S, In
No. of plant at harvest time	Plant/ 100 m^2	3,450	2,426	2,466	2,330	2,260	2,254
Yield	kg/100 m^2	11.27	13.00	16.67	9.17	11.20	14.83
Wt.of 100 grain	g	13.0	13.2	13.3	6.4	6.5	6.8
No. of cleaned ** grains per plant		25.1	40.6	50.8	61.5	76.2	96.8

* : as for Table 1.
** : No. of cleaned grains per plant = $\frac{\text{Yield}}{\text{No. of plants x Wt. of 100 grains}} \times 100$

(EXP. 2)

MATERIALS AND METHODS

Soybean variety ORBA was sown after rice cropping in a lowland field at Muara substation on 31 July, 1980.

The treatments were as follows:

Main plot : (1) No fertilization
(2) Fertilization
(3) Fertilization + Insecticide application to control pod insect

Subplot : (i) No tillage + Broadcast seeding
(ii) No tillage + Dibbled seeding
(iii) Tillage + Dibbled seeding

A split-plot design with three replications was applied. Treatment (1), (2) and (3) were put in the main plot and treatment (i), (ii) and (iii) in the subplot. The size of the subplot was 3.2 x 4 meters.

Fertilizers in treatment (2) and (3) were 40 kg/ha N + 60 kg/ha P_2O_5 + 50 kg/ha K_2O, using urea, triple superphosphate and potassium chloride respectively. Azodrin was sprayed twice (one and two weeks after seeding) to control *O. phaseoli* for all plots, Kalphos was used twice (September 16 and October 15) to control pod insect for treatment (3). Seeding was conducted without tillage after rice harvest for treatment (i) and (ii), and with tillage to a depth of 10 to 15 cm using a hoe for treatment (iii). About 4,200 seeds per 100 m^2 were broadcasted for treatment (i), and covered with 2 t/ha air-dried rice straw during one week after seeding. Seed was dibbled for treatment (ii) and (iii), at a spacing of 40 x 15 cm with two to three seeds per hole. The seeding rate of treatment (ii) and (iii) differed little from that of treatment (i).

RESULTS

Emergence was good, because it rained just before and after seeding time, but the plants seeded by broadcasting were not uniform. Injury by *O. phaseoli* was slight. The plants were not irrigated during the growing season as the rain was plentiful. The soybeans of all plots were harvested on November 1.

Number of plants at harvesting (Table 3)

The number of dibble-seeded plants at harvesting was about same in tilled and untilled, and also fertilized and unfertilized plots. The number of broadcast-seeded plants in untilled plots (i) was less than dibble-seeded plants in tilled (iii) and untilled (ii) plots. Fertilization reduced the number of plants in untilled broadcast-seeding plot (i).

Table 3. Number of plants per plot at harvesting as affected by fertilizer, insecticide, tillage and seeding method (Exp. 2, 1980)

Main plot / Subplot	(1) No F	(2) F	(3) F, In
(i) No T, B.S	312	257	284
(ii) No T, D.S	340	378	390
(iii) T, D.S	389	372	370

Note; (1) No F : No fertilization
(2) F : Fertilization
(3) F, In : Fertilization & Insecticide application
(i) No T, B.S : No tillage, Broadcast seeding
(ii) No T, D.S : No tillage, Dibbled seeding
(iii) T, D.S : Tillage, Dibbled seeding

Yield survey (Table 4)

The yields were in the order of treatment (3) > (2) > (1), that is, the yield of treatment (3) was 145% and of treatment (2) 129% greater than that of treatment (1). Tillage did not affect the yield of dibble-seeded plants. With fertilizers and without tillage, dibble-seeded plants produced higher yields than broadcast-seeds, but without fertilizer and without tillage there was no difference. The main stem length was in the order of treatment (3) = (2) > (1). With dibbled seeding, the one hundred grain weight of no tillage treatment was higher than that of tillages. The number of cleaned grains per plant showed pattern as the yield.

Table 4. Yield and yield components as affected by fertilizer, insecticide, tillage and seeding method (Exp. 2, 1980).

Treatment *		No F (1)			F (2)			F, In (3)		
		(i) No T B.S	(ii) No T D.S	(iii) T D.S	(i) No T B.S	(ii) No T D.S	(iii) T D.S	(i) No T B.S	(ii) No T D.S	(iii) T D.S
Yield	kg/ha	645	653	663	705	927	927	816	1.051	988
Main stem length.	cm	34.2	32.6	32.3	34.7	40.2	37.7	36.3	36.0	38.0
Wt. of 100 grain.	g	13.3	13.8	13.0	13.3	13.6	13.1	13.5	13.6	12.4
No of cleaned grains per plant		19.9	17.8	16.8	26.4	23.1	24.4	27.3	25.4	27.6

* : as for Table 3.

(EXP. 3)

MATERIALS AND METHODS

Soybean variety ORBA was sown after rice cropping in a lowland field at Mojosari substation on 3 May, 1980.

The treatments were as follows:

Main plot : (1) No tillage + Broadcast seeding
(2) No tillage + Dibbled seeding
(3) Tillage + Dibbled seeding

Subplot : (i) No fertilization
(ii) No fertilization + Azodrin application to control *O. phaseoli*
(iii) Fertilization + Azodrin application to control *O. phaseoli*
(iv) Fertilization + Azodrin application to control *O. phaseoli* + Kalphos application to control pod insect.

A split-plot design with three replications was applied. Treatment (1), (2) and (3) were put in the main plot, and treatment (i), (ii), (iii) and (iv) in the subplot. The size of the subplot was 5.6 x 5 meters.

Seeding was conducted without tillage after rice harvest for treatment (1) and (2), and with tillage to a depth of 10 to 15 cm using a hoe for treatment (3). For treatment (1), seeds were broadcasted at 479 gm per 100 m^2, and were not covered. Seed was dibbled for treatment (2) and (3) at a spacing of 40 x 15 cm *with two seeds per hole. The seeding rate of treat*ment (1) was 110% of treatment (2) and (3). Fertilizers in treatment (iii) and (iv) were 40 kg/ha N + 60 kg/ha P_2O_5 + 50 kg/ha K_2O using urea, triple superphosphate and potassium chloride respectively. Azodrin was sprayed twice (one and two weeks after seeding) to control *O. phaseoli* for treatment (ii), (iii) and (iv). Kalphos was used twice (June 8 and July 2) to control pod insect for treatment (iv).

RESULTS

Emergence was good, because irrigation was given just after seeding and there was 20.4 mm of rainfall the day after seeding. After that, the weather was dry and there was only 2.6 mm before harvest time, and so the plants were irrigated six times at ten to sixteen day intervals from May 18 to July 20.

Disease sympton such a virus were found in all plots from about one month after seeding, so the growth of the soybean was not good. The disease could not be identified despite diagnostic tests on the harvested soybean seed. Harvesting of all plots was on August 9.

Survey of insect-damaged plants (Table 5)

Thirty soybean plants from each treatment were collected at random on May 17, and the number of plants damaged by the beanfly, *O. phaseoli* and *Melanagromyza sojae* was counted. The number of damaged plants in Azodrin treated plot (ii), (iii) and (iv) was between seven and zero, and the average percentage of damaged plants was 7.4%. No difference among treatment (ii), (iii) and (iv) was found, not any interaction with tillage or seeding methods. The number of damaged plants in plot (i) untreated by Azodrin was between twenty-two and fourteen, and the average percentage of damaged plants was 56.7%. The percentage of plants damaged in the tilled plot (3) was greater than that in the untilled plots (1) and (2). The average ratio of plants over all plants damaged by *O. phaseoli* to *M. sojae* was 54 : 17.

Forty-five soybean plants from each treatment were collected on July 16, and the number of pods damaged by pod insect was counted. The percentage of pods damaged by *Pyralid Moth* in plots untreated with Kalphos (i), (ii) and (iii) was between 37.1% and 23.2%, and was not affected by tillage or seeding methods. The percentage of damaged pods ranged between 2.8% and 2.1% in the plots treated with Kalphos (iv). Some *plants were damaged by fly, the percentage of damaged* pods being from 4.0% to 0.3% for treatment (i), (ii) and (iii), and 0.6% to 0.4% for treatment (iv).

Growth survey (Table 6)

In tilled plots (3), soybean emerged one day later, and grew three to four days later than in untilled plot (1) and (2). Flowering in plots (i) untreated with Azodrin was one to two days later than in treated plot (ii), (iii) and (iv).

Fertilization, Azodrin application and lack of tillage was effective for increasing main stem length from twenty days after seeding to harvesting. From two weeks after flowering, the main stem of Kalphos-treated plants was longer than that of untreated plants. No difference in main stem length between broadcast seeding and dibbled seeding was found. The plant/seed (number) ratio was higher in untilled plots with dibbled seeding (2), and lower without tillage and with broadcast seeding (1), the ratio was not affected by fertilizer or insecticide application.

Table 5. Plants damaged by *O. phaseoli* and *M. sojae* (Exp. 3, 1980)

Treatment *		No. of plants damaged by** *O. phaseoli*	*M. sojae*	No. of pods damaged by No. of pods***	*P. Moth*	Fly
(1) No T B.S	(i) No F,	14	0	68.1	17.7	1.3
	(ii) No F, Azo	0	0	59.1	21.9	0.2
	(iii) F, Azo	0	0	63.9	16.2	0.7
	(iv) F, Azo & Kal	4	0	80.8	2.3	0.5
(2) No T D.S	(i) No F,	8	7	44.6	10.5	0.5
	(ii) No F, Azo	0	1	37.3	12.0	0.5
	(iii) F, Azo	3	0	47.3	11.8	0.4
	(iv) F, Azo & Kal	0	0	62.8	0.9	0.3
(3) T, D.S	(i) No F,	15	7	29.3	6.8	0.4
	(ii) No F, Azo	2	0	40.2	9.8	1.6
	(iii) F, Azo	2	1	51.8	13.2	0.6
	(iv) F, Azo & Kal	6	1	48.3	1.0	0.2

* : (1) No T, B.S : No tillage, Brodcast seeding
(2) No T, D.S : No tillage, Dibbled seeding
(3) T, D.S : Tillage, Dibbled seeding
(i) No F, : No fertilization
(ii) No F, Azo : No fertilization, Azodrin application to control *O. phaseoli*
(iii) F, Azo : Fertilization, Azodrin application to control *O. phaseoli*
(iv) F, Azo & Kal : Fertilization, Azodrin application to control *O. phaseoli* and Kalphos application to control pod insect.

** : 30 plants/plot were used.
*** : 45 plants/plot were used.

Table 6. Growth as affected by fertilizer, insecticide, tillage and seeding method (Exp. 3, 1980).

Treatment *		Flowering time	Main stem length: 20 days after seeding	Flowering time	2 weeks after flowering	Harvesting time	No. of plants at harvesting
			cm	cm	cm	cm	plant/ha x 1,000
(1) No T B.S	(i) No F	June 4	19.5	26.8	34.2	35.3	277
	(ii) No F, Azo	June 3	21.6	29.5	36.6	39.1	268
	(iii) F, Azo	June 3	23.4	29.3	36.0	38.8	236
	(iv) A, Azo & Kal	June 3	23.9	30.3	44.0	45.0	264
(2) No T D.S	(i) No F	June 4	18.0	25.6	34.1	36.6	290
	(ii) No F, Azo	June 3	20.6	28.6	34.7	36.1	287
	(iii) F, Azo	June 3	21.2	29.6	41.5	42.9	258
	(iv) F, Azo & Kal	June 3	21.6	30.3	42.4	45.1	270
(3) T, D.S	(i) No F	June 8	13.7	19.7	24.4	26.3	268
	(ii) No F, Azo	June 6	16.6	23.8	30.3	31.8	261
	(iii) F, Azo	June 6	18.4	25.0	34.6	36.2	254
	(iv) F, Azo & Kal	June 6	18.8	26.0	36.2	37.8	254

* : as for Table 5.

Yield survey (Table 7)

Tillage (3) resulted in significant lower yields and air-dried plant weight than untilled plot (1) and (2) as did fertilizer and insecticide application (iv) > (iii) > (ii) > (i), the number of cleaned grains per plant showed the same pattern. Tillaged and seeding method did not affected the ratio of grain weight to air-dried plant weight, but fertilizer and insecticide application did [(iv) > (iii) = (ii) > (i)]. For the one hundred grain weight (iv) ⩾ (iii) > (ii) = (i).

Table 7. Yield and yield components as affected by fertilizer, insecticide, tillage and seeding method (Exp. 3, 1980).

Treatment *			Wt. of ** plants	Wt. of ** grains	Yield	Wt. of grains / Wt. of plants x 100	Wt. of 100 grain	Wt. of cleaned grains per plant
			g/plot	g/plot	kg/ha	%	g	
(1) No T B.S	(i)	No F	1,930	497	249	25.8	13.0	6.9
	(ii)	No F, Azo	2,200	1,103	552	50.1	12.7	16.2
	(iii)	F, Azo	2,330	1,230	615	52.8	13.8	18.9
	(iv)	F, Azo & Kal	3,060	1,753	877	57.3	14.3	23.3
(2) No T D.S	(i)	No F	1,730	510	255	29.5	14.0	6.3
	(ii)	No F, Azo	2,330	1,082	541	46.4	13.7	13.8
	(iii)	F, Azo	2,730	1,272	636	46.6	14.0	17.6
	(iv)	F, Azo & Kal	2,860	1,567	784	54.8	14.0	20.8
(3) T, D.S	(i)	No F	1,200	297	149	24.8	13.0	4.3
	(ii)	No F, Azo	1,600	807	404	50.4	13.0	11.9
	(iii)	F, Azo	2,000	958	479	47.9	13.8	13.7
	(iv)	F, Azo & Kal	2,530	1,238	619	48.9	14.0	17.4

* : as for Table 5
** : air-dried weight

(EXP. 4)

MATERIALS AND METHODS

Soybean variety No.29 was sown after rice cropping in a lowland field at Mojosari substation on 30 July, 1980.

The treatments were as follows:

Main plot : (1) Irrigation
(2) No irrigation

Subplot : (i) No tillage + Weeding
(ii) No tillage + No Weeding
(iii) Tillage + Weeding
(iv) Tillage + No Weeding

A split-plot design with three replications was applied. Treatment (1) and (2) were put in the main plot and treatment (i), (ii), (iii) and (iv) in the subplot. The size of the subplot was 6 x 5 meters.

Seeding was without tillage after rice harvest in treatment (i) and (ii), but with hoe-tillage to a depth of 10 to 15 cm for treatment (iii) and (iv). Seed was diblled in all plots at a spacing of 40 x 10 cm with two seed per hole. Treatment (1) was irrigated during the growing period (see results). Azodrin was applied a week after seeding. To prevent weed injury, treatment (i) and (iii) were weeded on August 20 (twenty-six days after seeding), treatments (ii) and (iv) were not weeded at all. Fertilizers were applied to all plots (40 kg/ha N + 60 kg/ha P_2O_5 + 50 kg/ha K_2O using urea, triple superphosphate and potassium chloride respectively).

RESULTS

Emergence was good and injury caused by *O. phaseoli* was slight, because of the irrigation and Azodrin application after seeding. The weather was dry for about eighty days from seeding until the middle of October. The maximum and minimum temperatures during the growing period were 36.2 and 18.1°C respectively. Treatment (1) was irrigated just after seeding and six other times (August 10, 21, 30, September 7, 18 and 25). The amounts of air-dried weed on August 20 were 715 g/m^2 for treatment (1) and 418 g/m^2 for treatment (2). The dominant weed was *Echinocloa colonum*, and other major weeds were *Cynodon dactylon*, *Cyperus rotundus* and rice plant (occurrence by falling seed of preceding rice).

Differences in flowering time among the plots were not clear, but treatment (1) matured on October 27, and treatment (2) on October 29.

Growth survey (Table 8)

Twenty days after seeding, the main stem length in irrigated plots (1) was higher than that in unirrigated (2), difference between the two treatments was increased with growth. Tillage and weeding increased length of main stem after flowering. The number of plants of harvest time was in the order of plot unirrigated (2) > irrigated (1), and weeding (i) > no weeding (ii) without tillage.

Table 8. Growth as affected by irrigation, tillage and weeding (Exp. 4, 1980)

Treatment *			Main stem length				No. of plants at harvesting
			20 days after seeding	Flowering time	2 weeks after flowering	Harvesting time	
			cm	cm	cm	cm	plant/ha x 1,000
	(i)	No T, W	16.6	48.1	79.0	85.9	288
(1)	(ii)	No T, No W	15.5	45.2	73.9	79.8	223
Irrigated	(iii)	T, W	14.6	50.9	87.5	92.8	268
	(iv)	T, No W	16.1	56.3	84.4	89.7	254
	(i)	No T, W	13.7	35.6	50.8	51.6	306
(2)	(ii)	No T, No W	14.4	33.8	43.4	46.8	265
Unirrigated	(iii)	T, W	13.1	38.3	57.0	58.0	281
	(iv)	T, No W	13.1	37.5	53.2	54.4	290

* (i) No T, W : No tillage, Weeding
(ii) No T, No W : No tillage, No weeding
(iii) T, W : Tillage, Weeding
(iv) T, No W : Tillage, No weeding

Yield survey (Table 9)

The yield of irrigated (1) was 727% of unirrigated plots (2). Weeding increased yield, but had not clear in irrigated plots with tillage. Air-dried plant weight and number of cleaned grains per plant showed the same pattern as yields. The one hundred grain weight of irrigated plots (1) was higher than unirrigated (2), and was not affected by tillage or weeding.

Table 9. Yield and yield components as affected by irrigation, tillage and weeding (Exp. 4, 1980).

Treatment *			Wt. of ** plants	Wt. of ** grains	Yield	$\frac{\text{Wt. of grains}}{\text{Wt. of plants}} \times 100$	Wt. of 100 grain	No. of cleaned grains per plant
			$g/8m^2$	$g/8m^2$	kg/ha	%	g	
	(i)	No T, W	3,170	978	1,223	30.9	6.3	67.4
(1)	(ii)	No T, No W	2,400	467	584	19.5	6.7	39.1
Irrigated	(iii)	T, W	3,100	813	1,016	26.2	6.5	58.3
	(iv)	T, No W	2,970	837	1,046	28.2	6.7	61.5
	(i)	No T, W	800	137	171	17.1	5.7	9.8
(2)	(ii)	No T, No W	470	57	71	12.1	5.2	5.2
Unirrigated	(iii)	T, W	830	145	181	17.5	5.2	12.4
	(iv)	T, No W	630	87	109	13.8	5.3	7.1

* : as for Table 8
** : air-dried weight

DISCUSSION

Most soybean cultivated after lowland rice is sown in the dry season without tillage, fertilizers or pesticides, and though some dibbled seeding with regular spacing is applied, broadcast seeding is still common. At present, the introduction of intensive cultivation with tillage, fertilizers and pesticides is encouraging the improvement of traditional method.

This study is conducted to clarify the character and value of traditional method and to find effective means of improvement by comparing it with intensive cultivation.

Four experiments were carried out, from which, information on the effects and problems of individual working of tillage, fertilization and pesticide application was obtained. We will consider these effects and problems from a practical point of view.

1. Effect of tillage (Table 10)

In Exp.2, the one hundred grain weight of tilled plots was lower than that of untilled plots, and yield and other yield components were affected by tillage. Exp.3 showed that emergence and flowering was delayed by tillage, and the main stem length, the number of cleaned grains per plant and yield were lower with tillage. Yields and main stem length in tilled plots were higher than these in untilled plots in Exp.4. The reason for this discrepancy among the three experiments is not clear. Two of the authors carried out an other experiment to compare the effect of tillage on corn, no difference in yield between tillage and no tillage was found for planting in the wet season, but yield with tillage was less than without tillage for planting in the dry season. One reason for this was lower soil moisture content in the dry season in tilled plots (unpublished). Tillage encouraged more weeds, especially gramineous grass (e.g. *Echinocloa colonum*) (3). Furthermore we must consider that in Exp.3, tilled plots increased more *O. phaseoli* than untilled. One reason that soybean is planted without tillage after paddy rice will be restricted by time of farming as necessity for early seeding to use soil moisture. In view of the results above, we doubt the advisability of tillage. Effect of tillage must be study from all the aspect of farming system on main soil types.

2. Effect of dibbled seeding with regular spacing (Table 10)

Exp.2 showed no difference in yield between dibbled and broadcast seeding without fertilization, while with fertilization the yield from dibbled seeding was higher than that of broadcast seeding.

This difference in yield between the two kinds of seeding was caused by differences of plant number at harvest time : the ratio of the number of plants harvested to the number of seeds for dibbled seeding was higher than that of broadcast seeding. The ratio of the number of harvested to seeds for dibbled seeding was higher than broadcast seeding in Exp.3, but yields were about the same. We can not say something on other about the effect of dibbled seeding from the results, but we can indicated that broadcast seeding has a lower ratio of plant number to seed number, and so has a risk of decreased yield The seeding rate of broadcast seeding must be increase ten to thirty percent to dibbled seeding to keep the same ratio of plant number to seed number.

Table 10. Effect of tillage and dibbled seeding on the growth and yield of soybean.

No. of experiment	Variety	Yield		Yield index		No. of plants at harvest time		Main stem length		100 grain weight		No. of cleaned grains per plant	
		No T	T	No T	T	No T	T	No T	T	No T	T	No T	T
		Effect of tillage											
		kg/ha	kg/ha	%	%	x1,000/ha	x1,000/ha	cm	cm	g	g		
Exp. 2	ORBA	877	859	100	98	289	295	36.3	36.0	(13.7	12.8)**	22.1	22.9
Exp. 3	ORBA	(554	413)**	100	75	276	259	(40.2	33.0)**	13.9	13.5	14.6	11.8
Exp. 4	No.29	(904	1.031)**	100	114	256	261	(82.9	91.3)**	6.5	6.6	53.3	59.9
		Effect of seeding											
		B.S	D.S	B.S	D.S	B.S	D.S	B.S	D.S	B.S	D.S	B.S	D.S
Exp. 2	ORBA	722	877	100	121	(222	289)**	35.1	36.3	13.4	13.7	24.5	22.1
Exp. 3	ORBA	573	554	100	97	261	276	39.6	40.2	13.5	13.9	16.3	14.6

Note; No T : No tillage T : Tillage B.S : Broadcast seeding D.S : Dibbled seeding
*) Significant at 5% level **) Significant at 1% level

3. Effect of fertilization (Table 11)

Fertilization increased yields in Exp.1 by 15% for ORBA and 22% for No.29. The main stem length and number of cleaned grains per plant were also increased by fertilization.

There was no significant difference in yield between fertilization and no fertilization in Exp.2, but increased yields. Fertilization increased yields by 16%, main stem length and one hundred grain weight in Exp.3. The above results show fertilization increased yields by increasing the number of grains resulted in higher plant weights, an increase in one hundred grain weight will increase the yield too.

Many fertilizing experiments on soybean have been conducted in Indonesia, but no stable results have been obtained (5).

Fertilizers were applied 20 kg/ha N + 60 kg/ha P_2O_5 + 60 kg/ha K_2O for Exp.1 and 40 kg/ha N + 60 kg/ha P_2O_5 + 50 kg/ha K_2O for Exp.2, 3 and 4. And, fertilizer was applied in side part of plants in tilled plots and also side part of plants by use tugul in untilled plots.

Study on the optimum quantity and ratio of fertilizers and fertilizing methods should be conducted on the main soil types.

Table 11. Effect of fertilizer application on the growth and yield of soybean.

No. of experiment	Variety	Yield		Yield index		No. of plants at harvest time		Main stem length		100 grain weight		No. of cleaned grains per plant	
		No F	F	No F	F	No F	F	No F	F	No F	F	No F	F
		kg/ha	kg/ha	%	%	x1,000/ha	x1,000/ha	cm	cm	g	g		
Exp. 1	ORBA	(1,127	1,300)**	100	115	(345	243)**	37.6	38.7	13.0	13.2	25.1	40.6
Exp. 1	No.29	(917	1,120)**	100	122	233	226	(65.4	71.3)**	6.4	6.5	61.5	76.2
Exp. 2	ORBA	654	952	100	129	271	262	33.0	37.5	13.4	13.3	18.2	24.6
Exp. 3	ORBA	(499	577)*	100	116	(272	249)**	(35.7	39.3)*	(13.1	13.9)**	14.0	16.7

Note; No F : No fertilizer application F : Fertilizer application
*) Significant at 5% level **) Significant at 1% level

4. Effect on insecticide application to control pod insect (Table 12)

Insecticide application increased yields by 28% for ORBA and 32% for No.29 in Exp.1, and also 32% in Exp.3 and 12% in Exp.2. Main stem length and number of cleaned grains per plant were increased by application of insecticide, and the one hundred grain weight also increased in Exp.1 and Exp.3. The number of cleaned grains per plant increased with application of insecticide in all experiments.

The results show injury on soybean caused by pod insect is remarkable. According to the survey in Exp.3, the percentage of the damaged pods caused by *Pyralid Moth* without insecticide was between 37.1% and 23.2%.

Kalphos was used in the experiments, and applied four times for Exp.1, twice for Exp.2 and Exp.3. Judging by the above results, study on the screening of insecticide, application time and number of application must be progress related to study on the seasonal prevalence of pod insect.

5. Effect of insecticide application to control *O. phaseoli* (Table 12)

The results of Exp.3 showed that average percentage of injurious plant caused by *O. phaseoli* and *M. sojae* was 56.7% without insecticide and 7.4% with insecticide. The difference in yields between with and without insecticide was remarkable. Similar results to above were found in our other experiment (4), namely, "Studies on the Seasonal Prevalence, Damage and Control of the Beanfly, *Ophiomyia phaseoli* (Tryon) as a Pest of Soybean". Results of these experiments point out that control of *O. phaseoli* is very important in soybean cultivation.

Table 12. Effect of insecticide application on the growth and yield of soybean.

No. of experiment	Variety	Yield		Yield index		No. of plants at harvest time		Main stem length		100 grain weight		No. of cleaned grains per plant	
		No In	In	No In	In	No In	In	No In	In	No In	In	No In	In
		Effect of insecticide (Kalphos) application to control pod insect											
		kg/ha	kg/ha	%	%	x1,000/ha	x1,000/ha	cm	cm	g	g		
Exp. 1	ORBA	(1,300	1,667**)	100	128	243	247	(38.7	42.6*)	13.2	13.3	40.6	50.8
Exp. 1	No.29	(1,120	1,438**)	100	132	226	225	(71.3	79.3*)	6.5	6.8	76.2	96.8
Exp. 2	ORBA	853	952	100	112	262	272	37.5	36.8	13.3	13.2	24.6	26.8
Exp. 3	ORBA	(577	760**)	100	132	(249	262*)	(39.3	42.6**)	13.9	14.1	16.7	20.5
		Effect of insecticide (Azodrin) application to control *O. phaseoli*											
Exp. 3	ORBA	(218	499**)	100	229	278	272	(32.7	35.7*)	13.3	13.1	5.8	14.0

Note; No In : No insecticide application In : Insecticide application
*) Significant at 5% level **) Significant at 1% level

6. Effect of irrigation (Table 13)

The yield for unirrigated plots was only 133 kg/ha as compare with 967 kg/ha for irrigated plots in Exp.4. The main stem length, number of cleaned grains per plant and one hundred grain weight in unirrigated were also remarkably inferior to those of irrigated plots.

Examining the results of four experiments, the yields of soybean at Mojosari were lower than those at Muara be caused of lower numbers of clean grains per plant. The reason for this difference in yield between Mojosari and Muara must be related to soil fertility and other factors, but we assume that the difference of soil moisture content is important reason. Deficiency of soil moisture caused falling flowers and pods, and also undeveloped grains. Irrigation was conducted seven times at about ten days interval in Exp.4. And, judging from the above results, studies on irrigation time and interval must be progress related to soil types.

The effect of weeding was found to be remarkable in Exp.4. We discuss the weeding problem in other report (3).

Table 13. Effect of irrigation and weeding on the growth and yield of soybean.

No. of experiment	Variety	Yield		Yield index		No. of plants at harvest time		Main stem length		100 grain weight		No. of cleaned grains per plant	
		No I	I	No I	I	No I	I	No I	I	No I	I	No I	I
		Effect of irrigation											
		kg/ha	kg/ha	%	%	x1,000/ha	x1,000/ha	cm	cm	g	g		
Exp. 4	No.29	(133	967**)	100	727	(286	258**)	(52.7	87.1**)	5.4	6.6	8.6	56.6
		Effect of weeding											
		No W	W	No W	W	No W	W	No W	W	No W	W	No W	W
Exp. 4	No.29	(815	1,120**)	100	137	(239	278**)	84.8	89.4	6.7	6.4	50.3	62.9

Note; No I : No irrigated I : Irrigated
No W : No weeding W : Weeding
*) : Significant at 5% level **) : Significant at 1% level

SUMMARY

Some experiments on soybean cultivation were conducted covering soybean planted in the dry season after paddy rice in Java. The object was to clarify the character and value of traditional method and to find effective method of improvement by comparing it with intensive cultivation.

The experiments were carried out at Muara and Mojosari substations in 1979 and 1980.

The results were as follows :

1. Differences in yield was not found with and without tillage. Broadcast seeding was inferior to dibbled seeding with regular spacing in the ratio of number of plants harvested to number of seeds.
2. The effect of fertilization on yield was remarkable, increasing yields by between 15% and 29%.
3. The effect of insecticide application to control pod insect was also remarkable, increasing yields by between 12% to 32%.
4. Injury caused by *Ophiomyia phaseoli* (Tryon) and the shortage of water in the soil were limiting factors for increasing yields.

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摘　　　　要

水稲後作大豆の栽培法

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ジャワの大豆作の約７５％は水稲後乾季作である。その多くは不耕起，無施肥，無農薬である。播種は播種棒を用いた条（穴）播もあるが，散播が多い。品種は生育期間８０～１０５日の早生種が作付され，収量は*ha*当り0.7ｔと低い。この伝統的な栽培の改善策として，耕起，施肥，農薬散布，条播など集約技術の導入がすすめられている。

本研究は伝統的栽培法と集約改善技術を比較することによって，伝統的栽培法のもつ意義を探るとともに，有効な改善技術の資料を得ようとするものである。

研究はムアラ（西部ジャワ）とモジャサリ（東部ジャワ）の試験地において，大豆品種ＯＲＢＡおよびNo. 29を用い，２か年（１９７９～８０年）にわたり，以下の４つの試験によって行った。

試験１：条播・施肥・農薬散布（莢実害虫防除）の効果
試験２：耕起・条播・施肥・農薬散布（莢実害虫防除）の効果
試験３：耕起・条播・施肥・農薬散布（莢実害虫・幼苗害虫防除）の効果
試験４：耕起・灌がい・除草の効果

得られた結果を実用的見地から考察，要約すると，以下のとおりである。

1. 耕起の効果

生育・収量についてみると，試験３では耕起区が不耕起区に優り，試験４では逆に不耕起が優り，試験２では両者の差はみられなかった。試験３，４において調査した雑草量（別論文で報告）は耕起区で多く，*O. phaseoli*（幼苗害虫）の大豆への飛来，付着数も耕起区で多い傾向を示した。

水稲後大豆作において不耕起が慣行となっている原因として，干害回避のための早播の必要性に基づく農作業の制約があげられるが，前記の結果のように，不耕起は雑草発生の抑制，*O. phaseoli* の飛来，付着の抑制などにも効果を示した。

2. 条播の効果

条播における栽植様式は畦幅４０*cm*，株間１５*cm*，１株２～３粒を基準とした。生育，収量についてみると，試験２の不耕起・施肥条件において，条播は散播に優る傾向を示したが，その違いは成苗歩合の違いに基づくものであった。条播に比べ散播の播種量を増やした試験３では条播，散播の収量差はなかった。条播と同じ成苗数を確保するためには散播の播種量を条播のそれに比べ１０～３０％増す必要のあることがわかった。

3. 施肥の効果

窒素，燐酸，加里の*ha*当り施用量は，試験１ではそれぞれ20,60,60*kg*,試験2,3では40,60,60*kg*，耕起条件では条側肥，不耕起ではトガルを用いた条側肥とした。無肥に対する施肥区の増収効果は，試験１のＯＲＢＡでは15％，No.29では22％，試験２では29％，試験３では16％であった。その増収の主効果は個体の生長量の増大をとおした粒数の増加に基づくもので，百粒重の増大も試験３では認められた。

4. 莢実害虫防除のための農薬散布効果

農薬としてはイソキサチオン乳剤を用い，試験１では開花後に４回，試験２，３では同じく２回散布した。無散布区に対する散布区の増収効果は，試験１のＯＲＢＡでは２８％，No. ２９では３２％，試験２では１２％，試験３では３２％で，その効果は個体当り精粒数の増大によるのが主であった。

5. 幼苗害虫防除のための農薬散布効果

試験３の調査では，幼苗害虫の*O. phaseoli*の平均飛来付着率は無散布区の５6.7％に対し農薬散布区は7.4％であり，その収量も両区の間に大きい差がみられた。

〔*O. phaseoli*は大豆作を規制している要因の一つといわれているため，本研究とは別に「大豆害虫*O. phaseoli*の発生消長，被害と防除に関する研究」を実施したが，本試験と同様な被害と農薬散布効果を認めた。〕

6. 灌がいの効果

試験４の調査において，*ha*当り収量は，灌がい区の９６７*kg*に対し無灌がい区は僅か１３３*kg*で，乾季大豆作では水が制限因子になっていることがわかった。

7. 除草の効果

試験４の調査において，無除草区に対し除草区の収量比は１３７％で，高い除草効果が認められた。

8. 総　括

以上の結果から，乾季大豆作で収量を高めるためには，土壌水分の利用，補給と*O. phaseoli* の防除が前提であり，施肥，莢実害虫防除のための農薬散布も効果的といえる。散播は成苗歩合確保の面から条播より播種量をやゝ多くする必要がある。また，不耕起と耕起の間では収量差はなかったが，各種の障害防止の面で不耕起の効果が認められた。

3. STUDIES ON THE GERMINATION OF SOYBEAN SEEDS

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ABSTRACT

Experiments were conducted to elucidate the effects of internal and external factors related to the germination of soybean seeds.

Changes of the seed viability as affected by the place of production and storage were investigated with the seeds stored in 3 substations of CRIFC, namely Pacet, Kuningan and Muara (Bogor). The maximum and the minimum temperature in the storeroom were 27-19, 29-23 and 32-26 C, respectively. It was clarified that the seed longevity was influenced by the place of storage and the varietal difference in the seed longevity was recognized.

For practical use, the limit of seed storage was supposed to be 4 months in Bogor, 6 months in Kuningan for 3 varieties tested. In Pacet, it was 8 months for Orba and No. 945 and 10 months or more for No. 29. Effect of the place of production on the seedling vigor was recognized.

Factors influencing the seedling emergence were investigated. The relative placement of fertilizer to avoid the salt injury was at least 5 cm below the seed level and 2 cm aside the seed.

INFLUENCE OF STORAGE CONDITIONS ON THE SEED LONGEVITY

INTRODUCTION

Rapid decrease of the seed longevity is one of the serious problems in soybean cultivation in Indonesia. In the tropics, the seed viability of soybeans deteriorates rapidly within several months. The maintenance of soybean seed quality during storage in these hot and humid environments has been recognized as a limiting factor in soybean production (2).

In farmer's fields, it was often observed uneven growth of soybean plants with a number of missing hills. Aside from the damage due to insect and disease, it seems that there exist many problems related to the germination of soybean seeds which are supposed to be a cause of the uneven growth of soybean plants in farmer's fields.

The problems related to the germination of soybean seeds should be studied from two sides; the problem of the seed itself and the effect of factors influencing the germination of the seed. The former is the problem of the seed quality which is known to be influenced by several factors, of which temperature and relative humidity during seed storage are the principal external factors that affect the seed longevity (1). The latter is the problem of environmental factors which affect the process of the seedling emergence.

Several experiments were carried out to investigate the seed longevity under different storage conditions and the effect of factors affecting the germination of soybean seeds. The main purpose was to find out practical and economical way for storing soybean seeds in the tropics.

MATERIALS AND METHODS

Experiment 1 : The effects of temperature and relative humidity on the seed longevity of soybeans

In order to investigate the effect of temperature during the storage period, soybean seeds were stored under different storage conditions, namely in refrigerator and in the storeroom of Plant Nutrition Subdivision of CRIFC, Bogor and Pacet substation. Soybean varieties used were Orba and Ijo. After 5 months, the seeds were sown in vats and grown for 10 days in greenhouse. The growth of the seedlings was investigated. One hundred seeds were used for germination test for each treatment.

To investigate the effect of relative humidity on the seed longevity, soybean seeds were stored under 3 levels of relative humidity. Saturated salt solutions of chemicals were used to attain different relative humidity levels using closed containers. The theoretical values of the relative humidity in equilibrium with potassium chloride, sodium chloride and potassium carbonate at 30 C are 85, 76 and 44 % , respectively. Seeds were stored for 5 months and germination percentage of the seeds was investigated. Soybean varieties, Orba, Americana and No. 29 were tested.

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Experiment 2 : Storage condition and seed longevity of soybeans

From the results of Experiment 1, it was supposed that the seed viability could be kept well if stored in cool place like Pacet in sealed condition to minimize the change in moisture content. In Indonesia, to store soybean seeds in cold facilities is practically impossible in present circumstance. The second-best way to keep the seed viability longer may be to store seeds in the place with high altitude.

In order to study the limit of the storage period, experiments were carried out. Three soybean varieties, Orba, No. 945 and No. 29 were grown in 3 substations of CRIFC, i.e. Pacet, Kuningan and Muara (Bogor). The seeds produced in each substation were distributed respectively to the three substations for the storage experiment. The seeds stored in the storeroom of each substation were brought to Bogor every 2 months for the investigation.

The germination percentage was determined by the percentage of germinated seeds in petri dishes after 2 days. For the seedling vigor test, seeds were sown in Neubauer pots, grown in greenhouse without fertilizer application and the dry matter weight of the top was measured 10 days after sowing.

The altitude and the maximum-minimum temperature in the storeroom were as follows : Pacet; 1100 m, 27-19 C, Kuningan; 550 m, 29-23 C, Bogor; 260 m, 32-26 C.

RESULTS AND DISCUSSION

Experiment 1.

It is known that the seed viability disappears quickly in the tropics and the main cause of the short seed longevity is supposed to be high temperature and high relative humidity. Preliminary experiments were conducted to investigate the effects of temperature and relative himidity during the storage period on the seed longevity of soybeans.

Temperature: The maximum and minimum temperature in refrigerator and in the storerooms of Bogor and Pacet were 10-5, 32-26 and 27-19 C, respectively. As the seeds were kept in sealed plastic bags, the changes in the moisture content of the seeds were not recognized.

The influence of storage condition on plant growth was clearly observed as shown in Table 1. Orba stored in Bogor showed very poor growth compared with those stored in refrigerator and Pacet. Germination percentage of the seeds stored in Bogor was 40 %, while that stored in refrigerator and Pacet was 90 and 80 % respectively. The varietal difference was apparently observed. In case of Ijo, a small sized seed, the difference in the initial growth among treatments was smaller than that found in case of Orba. The germination percentage was 100 % for the seeds stored in refrigerator and Pacet and 80 % for that in Bogor. The initial growth of Bogor seeds was slightly inferior to the others.

Relative himidity: Effects of relative himidity on the germination percentage are presented in Table 2. It was recognized that the germination percentage was kept higher when stored under low relative himidity. The seeds lost viability entirely at 85 % and at 75 % the germination percentage was very low. At 44 % relative himidity, the varietal difference was clearly observed. The germination percentage of Orba and Americana decreased to 51 and 63 % respectively, while that of No. 29 was 97 %.

Table 1. Effect of storage condition on the initial growth of soybeans

Variety		ORBA			IJO		
Place		Pacet	Bogor	Refrigerator	Pacet	Bogor	Refrigerator
Dry matter	Top	110	64	121	75	70	86
Weight (mg)	Root	32	19	35	23	15	19
Length	Top	10.8	9.3	12.3	12.3	11.3	12.3
(cm)	Root	20.6	15.6	19.1	16.0	11.6	16.2

Table 2. Effect of relative humidity on germination percentage and moisture content of soybean seeds.

(%)

Relative humidity	Germination percentage			Moisture content of seeds		
	Orba	Americana	No. 29	Orba	Americana	No. 29
85 %	0	0	0	21.7	21.3	23.4
76 %	18	11	32	15.6	14.7	14.9
44 %	51	63	97	7.7	6.9	8.0

The sum of the percent relative humidity plus the temperature in degrees Fahrenheit should not exceed 100 for safe storage. For safe storage from 1 to 3 years, this combined total may be as high as 120 as long as the temperature contributes no more than half the total (1). In this experiment, the lowest value of this combined total was 130 at 44 % relative humidity and the contribution of the temperature exceeded half the total. However, for safe storage of No. 29 for half year, the combined total of 130 proved to be sufficient.

Ravalo et al (2) reported that one of the most important factors affecting the rapid loss of germination in storage is the moisture content of the seeds. It is not only essential to have low initial seed moisture contents, but even more important is the requirement to maintain the low initial moisture content of the seeds throughout the storage periods. The results obtained in these experiment suggested also that the high temperature and humidity environments caused the rapid loss of seed longevity.

Experiment 2.

Experiments were carried out to know how long the seed viability is maintained if stored in the place with high altitude.

Figure 1 gives the germination percentage of the seeds stored in each place with different altitude. The data show that the germination percentage was influenced by the place of production and storage and the varietal difference were also recognized. The changes in the moisture content of the seeds were negligibly small throughout the storage period in every places as they were stored in a tin can. Therefore, the temperature in the store-room is considered as the main cause of the differences found in the germination percentage and the seedling vigor.

The germination percentage of the seeds stored in Pacet was kept higher compared with those stored in Kuningan and Bogor. They showed different declining tendency due to variety. That of No. 29 produced in Bogor and Kuningan was especially high, more than 90 % even after 10 months, while that produced in Pacet was slightly lower being 80 % at 6 months. Changes in the germination percentage of Orba and No. 945 stored in Pacet showed gradual decrease. The germination percentage of Orba and No. 945 decreased to 50 - 60 % after 8 months. The germination percentage of No. 29 stored in Kuningan and Bogor was more than 95 % at 2 months, however it showed rapid decrease from 4 months on. In contrast to the seeds stored in Pacet, all the seeds stored in Bogor showed rapid decrease in germination percentage after 4 months and they decreased to almost zero at 8 months.

The seedling vigor is defined as the potential for rapid uniform germination and fast seedling growth under general field conditions (1). In this experiment, the seedling vigor is expressed as the dry matter weight of the seedlings taken 10 days after sowing. The seeds stored in Pacet, Kuningan and Bogor were sampled five times at intervals of 2 months. It is hard to compare the seasonal changes as the climatic conditions were not quite the same at each testing time. We can compare its difference among the place of production and storage at each testing time.

The seedling vigor as expressed by the dry matter weight of the top 10 days after sowing is shown in Table 3. The seedling vigor of Orba was, on the whole, in the order of Kuningan > Pacet > Bogor, the difference between Pacet and Kuningan was small compared with that between Bogor and Kuningan or Pacet. In case of No. 945, it was in the order of Pacet > Kuningan > Bogor. The influence of production place on the seedling vigor was not recognized for No. 29.

Table 3. Effect of the place of production and storage on the seedling vigor of soybean

(mg/plant)

Variety	Storage period (month)	Place of production and storage							
		P-P	K-P	B-P	P-K	B-K	P-B	K-B	B-B
Orba	2	113	119	96	98	129	111	113	83
	4	101	98	75	89	75	88	108	73
	6	92	99	65					
	8	108	112	85	111	82			
	10	98	137	64					
No.945	2	122	107	103	137	103	127	108	99
	4	122	98	91	85	70	103	96	68
	6	112	104	103					
	8	115	106	89					
	10	118	112	65					
No.29	2	67	73	64	66	72	65	69	62
	4	55	64	57	51	48	50	50	51
	6	50	53	51					
	8	61	62	66	47	54			
	10	83	87	54					

P : Pacet, K : Kuningan, B : Bogor

From the results mentioned above, it is supposed that cool climate region is suitable for better seed production of Orba and No. 945, while in case of No. 29 the place of seed production does not influence the seedling vigor.

The germination percentage should be 60 % or more for practical use, that means, of 5 seeds dibbled to a hole one can satisfy with 3 seedlings emergence. Roughly speaking, the limit of storage period of soybean seeds for practical use is summarized as follows; 4 months in Bogor for all varieties, 6 months in Kuningan for all varieties and 8 months for Orba and No. 945 and 10 months or more for No. 29 in Pacet.

FACTORS INFLUENCING THE SEEDLING EMERGENCE OF SOYBEANS

INTRODUCTION

The seedling emergence is influenced by environmental conditions. Under field condition, the moisture content of the soil is of primary importance. In Indonesia, they never practice plowing for soybean cultivation. The method of seed sowing is either broadcasting or dibbling depending on the moisture content of the soil. If it is wet enough or surface water still remaining, soybean seeds are broadcasted. If it is dry, seeds are dibbled.

The relationship between soil moisture content and seedling emergence was investigated using latosol soil.

Another problem that affect seedling emergence is the salt injury. As long as the field is not plowed, the method of fertilizer application is limited to broadcasting or application to the same hole or close to the hole of seeding. Salt injury sometimes occurs. Experiments were carried out to investigate the degree of salt injury caused by fertilizer application and to find out the optimum placement to avoid the salt injury.

MATERIALS, METHODS AND RESULTS

Influence of soil moisture content; The moisture content of the soil was adjusted from 30 to 100 % of the maximum water holding capacity at intervals of 10 %. As shown in Table 3, the speeds of the seedling emergence was influenced by the moisture content of the soil. The best germination was found in a moisture content of 60 % to the maximum water holding capacity. Below 40 %, seeds did not germinate due to the lack of water. Above 70 %, the higher the moisture content the lower the germination percent due to the overhumidity and lack of air. The time course of water imbibition was investigated. When the soil moisture content was kept at 60 % of the maximum water holding capacity, the moisture content of the seeds (fresh weight basis) was 47 % after 12 hours and 53 % after 24 hours while at 40 % soil moisture content it was 27 % after 24 hours. Soybean seed bigins to germinate at a moisture content of 50 % (fresh weight basis), being higher than corn (31 %) and rice (26.5 %) (3). At a moisture content of 60 % to the maximum water holding capacity, the seeds could absorb enough water for germination within a day.

Table 4. Effect of soil moisture content on the germination of soybean seed

Germination percentage (%)

Days	Moisture content of the soil (% of maximum water holding capacity)							
	100	90	80	70	60	50	40	30
2	9	22	41	50	45	14	0	0
3	14	48	67	83	95	17	0	0
4	20	58	78	86	98	50	0	0

Salt injury; The influence of fertilizer placement on the seedling emergency was investigated. The treatment in the experiment was a combination of 3 levels of fertilizer and 3 levels of its placement. Urea and TSP were applied at the rate of 0, 0.2 and 0.5 g N and P_2O_5 each per pot. The placement of fertilizer was 0, 2 and 5 cm below the seed placement.

Fertilizer application at a rate of 40 kg/ha with a plant spacing of 20 hills/m^2 is equal to 0.2 g/hill.

Germination did not occur when fertilizers were applied at the same level (0 cm) as the seeds. When applied 2 cm below the seed level at the rate of 0.2 g

N and P_2O_5 per pot, the plant height was very low and the root development stopped at the fertilizer level. The dry matter weight of the top was 225 mg per plant. In case of 0.5 g application, the root did not develop. When urea and TSP were applied 5 cm below the seed placement, the plant height was the same as no fertilizer, however the root development was limited to 0 - 5 cm below the seed level and the dry matter weight of 0.2 and 0.5 treatments were 335 and 270 mg per plant, respectively.

In this experiment, urea and TSP were applied at the same time and it is not clear which is the main cause of the salt injury. Urea or TSP was applied at the rate of 0.1, 0.2, 0.4, 0.6 and 1.0 g as N or P_2O_5 per 100 g soil, 1 cm below the seed level. In case of urea treatments, germination did not occur at all in every treatments. In case of TSP, seedling emergence was observed in all treatments, but the growth of the seedlings of 0.4 to 1.0 g P_2O_5 was inferior to the control.

In another experiment, where urea was mixed well with soil, germination was observed up to the rate of 0.25 g N/100 g soil. However, in 0.25 g N plot the development of the lateral roots was very poor, in 0.1 g N plot the growth of the root was the same as the control.

The seedling emergence did not occur at P_2O_5 level higher than 0.5 g.

In the experiments mentioned above, fertilizer was applied at the same level or below the seed placement. In order to investigate the effect of urea application in relation to horizontal placement, an experiment was conducted using latosol soil.

Urea was applied at the center of Neubauer pots at the rate of 1.0 g N/pot and soybean seeds were sown 1, 2 and 5 cm aside the urea spot. The results were as follows.

When sown at 1 cm aside the urea spot, the seeds did not germinate at all, at 2 cm the root development was only slightly inferior and at 5 cm the growth of the seedlings was the same as no urea treatment.

The salt injury caused by urea is well known. It is caused by the toxic action of biuret contained as an impurity in urea or by ammonia gas evolved from urea. In these experiments, the reagent chemicals of urea was used, so the cause of the salt injury is considered due to ammonia gas.

From the results mentioned above, the relative placement of fertilizer to avoid the salt injury should be at least 5 cm below the seeds level and 2 cm aside the seeds.

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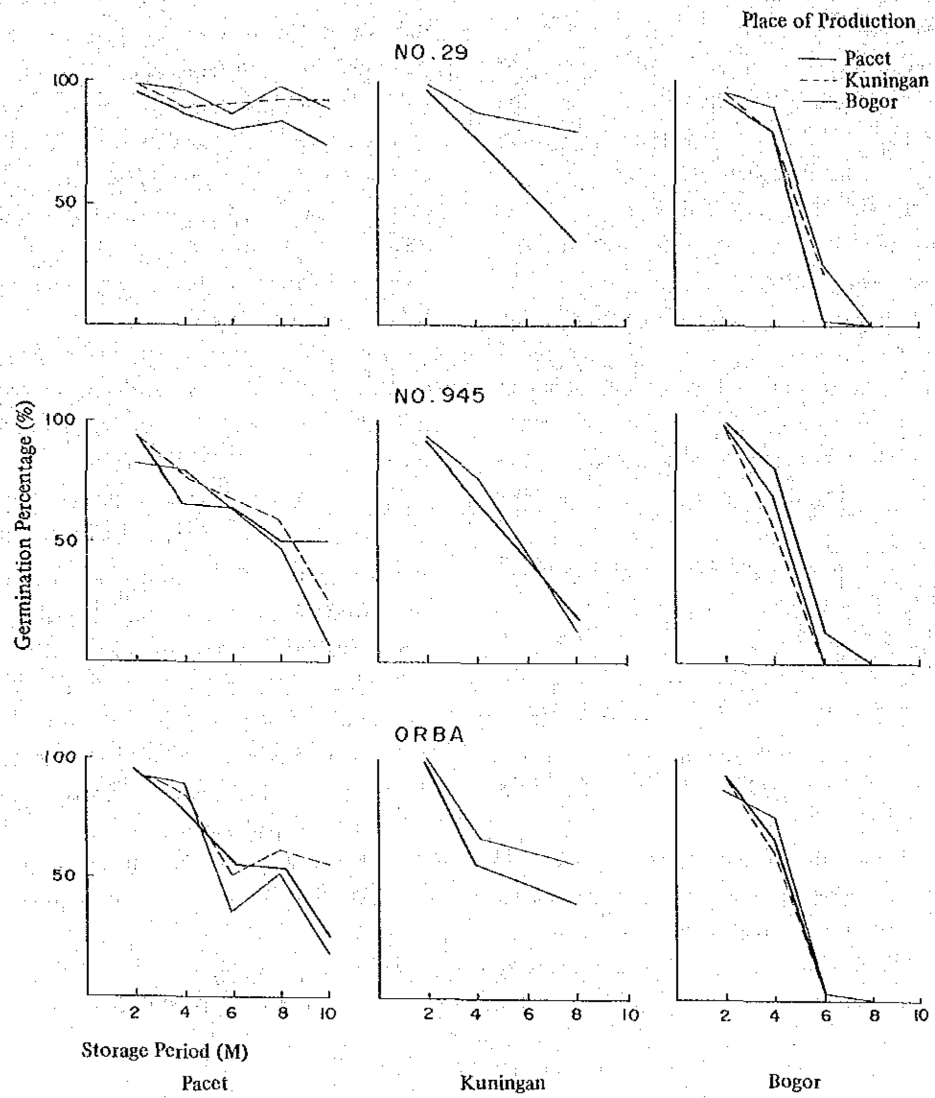

Fig. 1 Effect of the place of production and storage on the germination percentage of soybean seeds.

摘　　　要

大豆種子の発芽

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熱帯では，大豆種子の発芽率が収穫後急速に低下し，大豆栽培上，大きな問題の一つである。大豆圃場をみると，発芽，苗立ちが悪く，欠株が非常に多い。その一因として，種子の発芽力の低下が指摘される。

大豆の発芽を巡る二，三の問題について検討した。

1. 大豆種子の発芽に及ぼす貯蔵期間中の温度，湿度の影響

一般に種子の発芽力は，貯蔵期間中の温度，湿度により影響されることが知られている。インドネシア産大豆について，温度，湿度が発芽率に及ぼす影響を調べた。

粒径を異にする大豆二品種を冷蔵庫，パチェット試験地（標高1，１００ｍ，貯蔵室内の最高―最低温度２７―１９℃）およびボゴール中央農研（２６０ｍ，３２―２６℃）の三ケ所に５ケ月間貯蔵後，播種し，ガラス室内で１０日間栽培した。種子の発芽率は，温度による影響が顕著にみられ，また，品種間差も明らかに認められた。パチェット試験地に貯蔵された種子の発芽率は，冷蔵庫貯蔵種子とほぼ同程度であった，しかし，ボゴール貯蔵種子の発芽力は著しく低下した。

貯蔵容器中の湿度を変えて５ケ月間貯蔵後，発芽の様子を調べた結果，低湿度に貯蔵された種子の発芽率は高く保たれ，品種による差も認められ，小粒種（No．２９）の発芽率低下は認められなかった。

2. 種子の貯蔵地と貯蔵期間

以上の結果から，大豆種子を標高の高い冷涼な場所に貯蔵することにより，発芽率の低下をある程度防ぐことが可能であると予想された。そこで，標高を異にする三ケ所の試験地で大豆を栽培し，得られた種子をそれぞれ三ケ所の試験地に貯蔵し，２ケ月毎に発芽試験を行い，種子の長期間貯蔵の可能性について検討した。粒径を異にする大豆三品種（Orba，No．945，No．29）を供試した。試験は，パチェット試験地，クニンガン試験地（標高５５０ｍ，貯蔵室内温度２９～２３℃）およびボゴール中央農研で実施した。

大豆種子の発芽率の推移は，貯蔵場所，品種による差が明らかに認められた。種子として使用可能な貯蔵期間の限界は，ボゴールでは三品種とも４ケ月間，クニンガンでは三品種とも６ケ月間であった。一方，パチェットでは，大・中粒種（Orba，No．945）では８ケ月間，小粒種（No．２９）では１０ケ月以上であった。

大豆の発芽勢の推移に対する生産地の影響もわずかにみられ，パチェット産のOrba，№945の発芽勢は，ボゴール産に優る傾向がみられた。しかし，№29の発芽勢の産地間による差はみられなかった。

3. 濃度障害

種子の発芽に関与する外的要因の一つとして，肥料による濃度障害が問題となる。現行の不耕起，穴播き栽培法を前提として，現在使用されている尿素，ＴＳＰを用いて検討した。尿素による発芽の阻害は，ＴＳＰにくらべ顕著に認められた。肥料を種子の側方２㎝，下方５㎝以上に施用することにより，濃度障害を回避することができる。