ANNEX G *CASE STUDY*

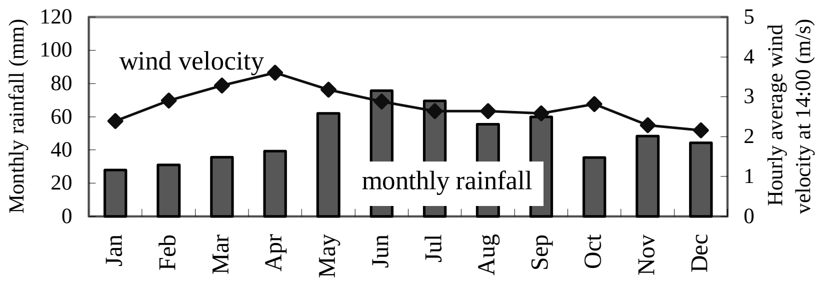
G.1 FARMLAND MANAGEMENT

G.1.1 INVESTIGATION OF WIND EROSION AND DAMAGE

(1) Position of March and April in Wind Erosion Risk

The investigation of wind erosion and damage was conducted in the case study Site-B. This area suffers strong wind in the spring season due to its widely developed plain topography. Furthermore, light sandy soils dominated by Eutric Regosol, which is easily dried and drifted by wind, is widespread in this area. According to the farming company cultivating there, this area suffers severe damage by wind or wind erosion nearly every year.

Annual Climate Condition of Malacky in Average 1981-2000



Source: Based on data provided by SHMI

In accordance with the climatic observation at Malacky Station, which is the nearest major climate observation network of the area, strong wind occurs from March to May and low rainfall usually occurs from January to April. Furthermore, the surface of the field for summer crops is stripped and loses vegetation cover due to the preparation work for seeding in April. Due to these overlapping disadvantages, April is considered to be the most risky period of wind erosion in this area.

For the purpose of understanding the actual damage by wind and wind erosion and its background conditions, the Study carried out climatic measurements on site, soil sampling and testing, field observation of cropping, vegetation coverage and crop growing condition, and an interview survey of relevant farming units.

(2) Climatic Conditions

In order to obtain climatic information on site, an automatic wind measurement gauge with climatic sensor for air temperature and relative humidity was installed on the roof of the irrigation pumping station of Dolecky (CS Dolecky: P12), which was located at the south-west corner of the target fields. The observations were carried out from March 28 to the end of April. Wind velocity and air temperatures observed are shown in Figure G.1.1.

The hourly average wind velocity at 14:00 at Dolecky was 3.07 m/s (average of measurement from March 30 to April 29), and it was a little lower than that of long term average of 1981-2000 at Malacky, which was 3.28 m/s for March and 3.61 m/s for April. A strong wind with 2-minutes continuous wind velocity of 7 m/s or more was observed during 5 days and its accumulated time was 16.8 hours. The day of wind velocity 10 m/s or more was observed only for 2 days and 12 m/s or more was not observed.

Hourly Average Wind Velocity at 14:00 (m/s)

	March	April	Remarks
Average of 1981-2000	3.28	3.61	observed at Malacky
Observed inYear 2002	3.44		observed at Dolecky average of 3/30 ~ 4/29

Source: Based on data provided by SHMI and observe by JICA Study Team

Record of Strong Wind at Dolceky during March 30 to April 29, 2002

Accumulated time ofwind velocity of	3 m/s or more	5 m/s or more	7 m/s or more	10 m/s or more	12 m/s or more
Number of days	29	24	8	2	0
Accumulated hours	228.2	81.2	16.3	0.1	0.0

Source: Observed by Study Team, 2002

The rainfall this spring, which is another important factor concerned with wind erosion, was summarized as below. The number of rainy days on March was 6 days and it was smaller than 8.4 days of the long-term average. However, monthly rainfall was 39.2 mm, which was equivalent to 110% of average and rainy days were concentrated in the second half of March. For the successive no rain days, 14-days were observed on March to April of 2002, the long-term average for this was 11.2-days.

Rainfall Condition of Spring Season in 2002

	Average of 1981-2000			Observed in year 2002		
Month	number of rainy days >=1.0mm	monthly rainfall (mm)	max daily rainfall (mm/day)	number of rainy days >=1.0mm	monthly rainfall (mm)	max daily rainfall (mm/day)
Feb	6.7	31.1	9.9	12	40.4	8.0
March	8.4	35.6	10.1	6	39.2	18.2
April	7.0	39.3	12.7	7*	28.8*	15.6*
May	8.8	44.3	12.1			

Note: * Data from April 1 to April 21

Source: Based on data provided SHMI, 2002

(3) Field Conditions

1) Soil Conditions

Soil sampling and testing to obtain water contents of soils over time was conducted in the agricultural fields in the case study site B. The seven (7) fields of which sand and loamy sand were observed as a dominant soil type were chosen for sampling based on the field observations. Ten (10) sampling sites were set up in the above fields. The location of sampling sites is shown in Figure G.1.2 as K-01 ~ K-10. The soil testing was conducted in the laboratory of SWME-ID.

Sampling	Date	Sampling for	Remarks
1st sampling	April 3, 2002	Grain size, soil moisture ratio	10 sites
2nd sampling	April 17, 18	Soil moisture ratio	10 sites
3rd sampling	April 29, 30	Soil moisture ratio	10 sites

Water contents in surface soil over time is given in Table G.1.1. At the start, at the beginning of April, water contents kept in the range of 6~13 % in weight. After a small rain on 17 April, water contents in surface soil on 14, 15 May came down to 9.4~3.2 %, step by step with rising temperature. Tunnel experiments proved that the sandy soil in this area begin to blow under the following combined conditions: water content in surface soil less than 5 % and wind velocity higher than 7 or 8 m/sec. These values of water contents suggest substantial existence of high risk potential for wind erosion.

Observations of site conditions during the soil sampling are summarized as follows:

- Extremely high ground water was not observed in any sites.
- Sand bed with yellow or yellow-brown color, which had lower clay contents and was compacted, was observed under the plow layer in most sites. At the sampling site K-4 in the field G-2, black colored plow soil was observed from the surface to 40 or 50cm depth, a yellow-brown sand layer was observed between 50 to 80cm, and a yellow sand layer was observed under 80cm.
- At the field G-2 and 4, small gravels were observed on the surface of field.

2) Field Coverage by Crops

Coverage of land surface is the most effective and realistic measure against wind erosion. A Number of spots for soil sampling and for cover-crop were measured. Percentages of effective coverage on each spot were measured by counting exposed area of land surface on the photographs taken in a vertical direction and are given in Table G.1.2. Main planted crops were rye and rape, and other crops were just after or before sowing. Growing plants of rye, rape and turf performed the effective coverage of soil surface. Turf coverage was the most effective -nearly 100 %- in growing periods but the turf production brings intermittent removal of surface soils at every selling time. Turf is put out of consideration. Cover ratios were 58-95 % for rye, 58-85 % for rape and 21-24 % for spring barley. Rye plants are characterized by cold resistance and a creeping type of growth, and they can achieve effective coverage in early spring when they grow well. Rape plants are also effective in covering the soil surface. Spring barley was just an infant seedling.

3) Field Coverage by Crops

During the survey period, significant wind drift or wind erosion was not observed due to the wet surface of the fields. However, it was expected that wind erosion could occur if rainfall did not come and the soil surface was drier.

G.1.2 SOIL SAMPLING AND TESTING IN CASE STUDY SITE

(1) Objectives of Soil Sampling and Testing

The soil sampling and testing aim to obtain data regarding soil moisture condition and water holding capacity of soils. Those components are expected to dominate the productivity in the sandy soil area in the Zahorska Lowland. At the same time, those data will be used as basic data to estimate crop water requirement and to examine an irrigation plan. The data obtained will be used for further study on assessing the potential crop productivity of fields in the succeeding study.

(2) Sampling Site and Number

Soil sampling was conducted in the agricultural fields in the Male Levare and Velke Levare Villages. Twenty-two (22) fields ranging from those covered by very poor sandy soil up to those with rich or fertile soil along the Morava River were chosen for sampling fields based on field observation. One (1) sampling site was set in each field. In addition, water retention capacity was assessed by pF-test at four (4). The location of sampling sites is shown in Figure G.1.3 as L-01 ~ L-22.

(3) Sampling and Soil Testing

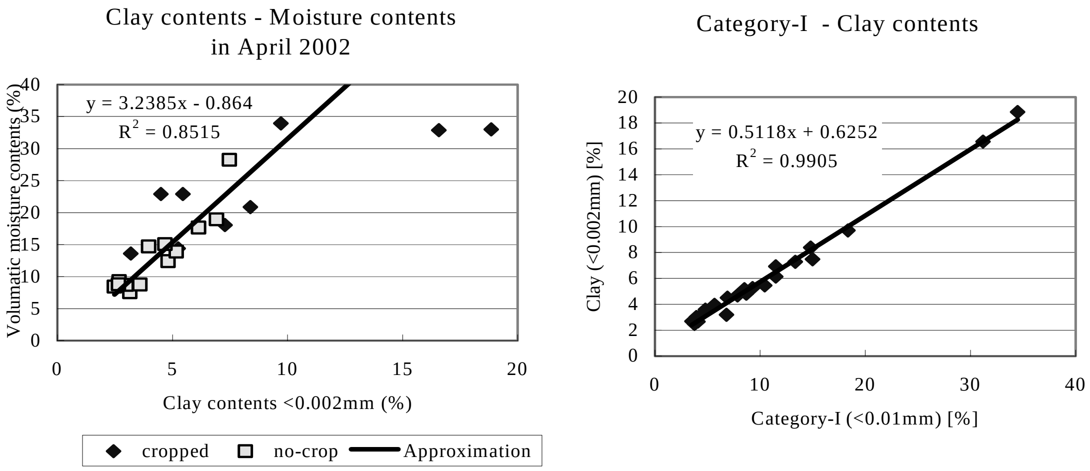
Sampling	Date	Sampling for	Remarks
1st sampling	April 4~9, 2002	Grain size, soil moisture ratio Water retention capacity (pF)	22 sites 4 sites
2nd sampling	April 7, 18	Soil moisture contents	22 sites
3rd sampling	April 29, 30	Soil moisture contents	22 sites
4th sampling	Middle of May	Soil moisture contents	
5th sampling	Middle of June	Soil moisture contents	

The soil testing was conducted in the laboratory of SWME-ID.

(4) Results of Soil Testing

The results of soil testing are shown in Table G.1.3. The results of the soil testing will be studied in parallel with information on crop growing, and they will be used for evaluating land productivity so as to provide basic information for developing the land evaluation system in the succeeding study.

According to the results, it was confirmed that there is a strong correlation between amount of fine particles and the water holding capacity, which is roughly represented by the field water contents just after precipitation, in the sandy soil area of the Zahorska Lowland, as shown below.



Relation between soil grain ditrubution and volumatic moisture contents based on the field data

(5) Soil Sampling and Testing of Sub-Soils

Soil sampling and measuring grain size distribution of sub-soil layers was conducted in Zone II area so as to obtain basic information for examining the possibility of water supply to the root zone from lower layers. In this stage, sampling was conducted and the data obtained at 72 sites. Those data are combined with the data of another 134 sites obtained by SWME-ID on November 2001, and will be used for the succeeding study. The location of sampling sites is shown in Figure. G.1.4.

G.1.3 CALCULATION OF EXPECTED YIELD INDEX

(1) Calculation of Expected Yield Index

In the Guidelines, the expected yield index is determined as the ratio of the expected grain yield under the water deficit ratio against the maximum expected grain yield. The following equation, expressing that relationship using crop evapotranspiration, was applied to calculate the expected yield index.

$(1-Ya/Ym) = Ky\ (1-ETa/ETm)$

Ya/Ym: Expected yield index

Ya: Expected grain yield under water deficit
Ym: Maximum expected grain yield
Ky: Yield response factor
ETa: Adjusted (actual) crop evapotranspiration during the growing period
ETm: Reference crop evapotranspiration for standard conditions during the growing period

Reference materials:
- FAO Irrigation and Drainage Paper No.33 “Yield Response to Water”, 1979
- FAO Irrigation and Drainage Paper No.56 “Crop Evapotranspiration - Guidelines for Computing Crop Water Requirement”, 1998

The expected yield index is calculated with the following assumptions:

- Irregular drought does not occur in the period when the crop is severely susceptible from water deficit ratio such as bud formation and flowering period.
- Irregular damage by causes other than water deficit ratio such as drainage problem, disease and insect damage, etc. does not occur.
- Neglect the significant contribution of groundwater to supply water to the root zone.

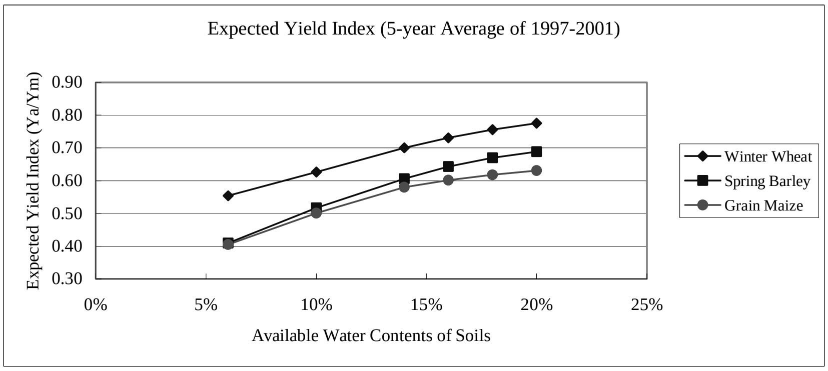
The evapotranspiration and crop water requirement are calculated by the method introduced by FAO. Necessary parameters for the above calculation are also referred to in the Irrigation and Drainage Technical Paper issued by FAO.

The expected yield index in the Case Study Site was calculated for various soil water conditions and the average value of 5 years from 1997 to 2001 was adopted finally. The climatic data and calculation results are shown in Table G.1.4, and the detail of the calculation is referred to in Table G.2.1.2.1. As mentioned above, the proportion of actual crop evapotranspiration during the growing period (ETa) and reference crop evapotranspiration for standard conditions during the growing period (ETm) is the key factor for calculation of the Index. In the calculation of the Index, the ETm is determined by whether the available water in the soil is adequate or whether the crop will not suffer from stress inducing water deficit. ETm is calculated by the equation of ETm = Kc * ETo, of which the climatic data and calculation results are shown in Table G.1.4, and the detail of the calculation is referred to in Table G.2.1.2.1. The ETa for a given crop is obtained using the available soil water index (ASI), which indicates the part of the month when available soil water is adequate for meeting full crop water requirements. A combination of ASI value, ETm and remaining available soil water provides an estimate of the mean monthly ETa. The detail of the calculation procedure is referred to in the FAO Irrigation and Drainage Paper No.33 and No.56.

The results of the calculated expected yield indexes of major crops for various soil water conditions are summarized below, and the samples of calculation are shown in Table G.1.5.

Summary of Expected Yield Index

	Available Water Contents of Soils					
	6%	10%	14%	16%	18%	20%
Winter Wheat	0.55	0.63	0.70	0.73	0.76	0.78
Spring Barley	0.41	0.52	0.61	0.64	0.67	0.69
Grain Maize	0.41	0.50	0.58	0.60	0.62	0.63



(2) Conversion of Expected Yield Index to Expected Grain Yield

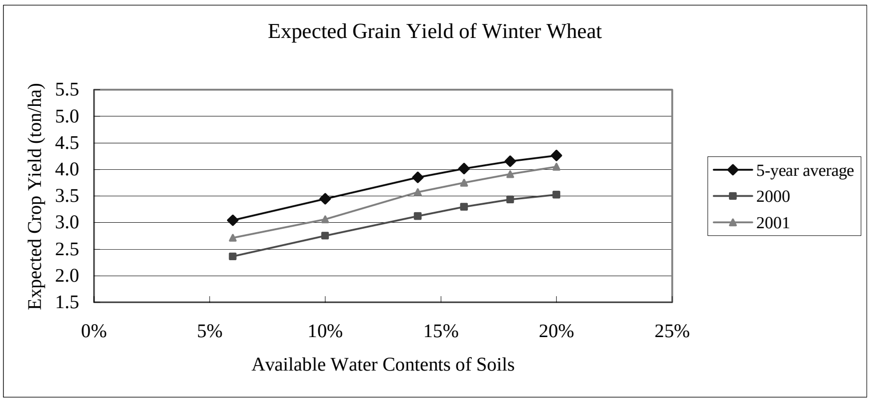
In order to convert the expected yield index to the expected grain yield, actual records of crop production and hydropedological data at certain fields, which were the fields of Garary-2 and Gajary-4, were used for setting up the maximum expected yield and to calibrate that. Gajary-2 and Gajary-4 fields are considered similar in soil conditions in accordance with grain size distribution and moisture contents in the field, and the available water contents observed at the Gajary-2 field can be adopted for Gajary-4 field. Based on the production record in the year 2001 at the Gajary-4 field, of 3.6 ton/ha as shown in the Table G.1.6, the maximum expected grain yield (Ym) is set as 5.5 ton/ha tentatively. To have further discussion on the value of the maximum expected grain yield and applicability of expected yield index, more field data has to be collected and analyzed in future.

The tentative results of the expected grain yield of winter wheat are as shown below:

Summary of Expected Grain Yield Winter Wheat
Tentative Ym = 5.5 ton/ha

(ton/ha)

	Available Water Contents of Soils					
	6%	10%	14%	16%	18%	20%
1997	3.3	3.5	3.8	3.9	4.0	4.1
1998	3.1	3.5	3.9	4.0	4.1	4.2
1999	3.7	4.4	4.9	5.1	5.3	5.5
2000	2.4	2.8	3.1	3.3	3.4	3.5
2001	2.7	3.1	3.6	3.8	3.9	4.0
5-year average	3.0	3.4	3.8	4.0	4.2	4.3



(3) Tentative Estimation of Expected Yields for Soil Units in Case Study Areas

The concept of "expected yield of crops" is proposed to represent productivity of farmland soil as a quantitative index and the calculation procedure is also elucidated as above. To complete this concept and to get reliable values of the expected yield more accurate and reliable data should be accumulated about the soil and crop yields in each field. In particular, there are only a few reliable data to define available soil water because of soil compaction. Most of the farmland has been compressed by running large heavy farming-machines, and the compacted soil-layer cannot keep its full water holding capacity. Destruction of aggregate structure due to long term cropping of cereals promotes this tendency.

Soil compaction and destruction of aggregate structure are not permanent limitation factors of soil. Soil properties should be estimated and presented in optimum condition when soil becomes free from compaction and recovers proper soil structure. Technical difficulty with pF determination in the compacted soil column is also apparent. Tentatively, holding capacity of available water is given as an assumed rough value estimated from existing data, water contents of surface soils in early spring and some of the reliable pF values of soils.

The results are given in the following tables for A and B sites in the case study areas, and the characterization of soil units used for the calculation is shown in Table G.1.6.

Trial Calculation of Expected Yield of Wheat in Soil Unit

A Site

Soil Unit	A－1	A－2	A－3	A－4	A－5
Soil Type	Fluvisols	Fluvic Phaeozems	Eutric Regosols	Eutric Regosols	Dystic Regosols
Clay Content(%)	18	8	5	3.5	2.5
Available Water	20	12	7	6	5
Expected Yield(t/ ha)	5.0	4.4	2.8	2.2	1.8

B Site

Soil Unit	B－1	B－2	B－3	B－4
Soil Type	Fluvic Phaeozems	Eutric Regosols	Eutric Regosols	Dystic Regosols
Clay Content (%)	8	5.5	4.5	3.5
Available Water	12	8	7	6
Expected Yield （t / ha）	4.4	3.0	2.4	2.2

Table G.1.1 Time Course of Water Contents during 3 April and 15 May, 2002 in Gajary Village

Site	Depth [cm]	Bulk Density [g/ cm]	3-9 April Water Content % Weight	17-18 April Water Content % Weight	29-30 April Water Content % Weight	14-15 May Water Content % Weight
K-1	0-5		12.94	11.84	8.44	9.44
	5-10	1.61		12.81	8.19	6.9
K-2	0-5		11.23	11.29	6.52	4.77
	5-10	1.66		12.2	8.3	3.56
K-3	0-5		6.02	6.9	8.33	5.09
	5-10	1.55		10.1	10.25	9.46
K-4	0-5		9.77	9.57	6.72	3.41
	5-10	1.73		9.63	8.58	9.69
K-5	0-5		12.07	9.25	8.79	9.13
	5-10	1.58		10.74	10.36	11.41
K-6	0-5		8.04	9.34	5.12	4.88
	5-10	1.74		9.67	6.52	4.15
K-7	0-5		8	9.85	5.57	7.93
	5-10	1.55		10.58	8.54	8.7
K-8	0-5		8.18	9.13	3.79	3.15
	5-10	1.5		9.65	5.73	3.24
K-9	0-5		11.81	9.25	7.56	6.75
	5-10	1.69		12.92	8.19	4.96
K-10	0-5		8.69	9.82	6.4	8.37
	5-10	1.52		10.99	7.91	3.13

Table G.1.2 Results of Land Cover Measurement in Gajary Village in 2002 Spring

Spot No.	Cover Crop	Cover Ratio (%)			
		Point A	Point B	Point C	Average
K - 2	Rye	95	94	89	92
K - 6	Rye	78	76	76	77
K - 7	Rye	85	64		74
K - 8	Oil Rape	58	69		63
K - 9	Spring Barley (seedling)	21	24	22	22
K - 10	Rye	67	78	80	75

Table G.1.3 Summary of Soil Testing and Field Observation on March-April 2002 (1/2)

General				Soil conditions from sampling results								
Area	Field name	Farming Company	Zoning	Point name	Test type	sampling depth [cm]	Grain size distribution clay [%] <0,002 mm	I.cat [%] < 0,01 mm	II.cat [%] 0,05-0,01	III.cat [%] 0,05-0,01	IV.cat [%] 0,1-2 mm	Soil type
Gajary	Gajary-1	Jakos	II	K-01	G+W	0-10	7.68	13.86	20.27	38.97	26.89	loamy-sand
				K-02	G+W	0-10	6.32	11.97	16.18	24.86	46.99	loamy-sand
	Gajary-2	Jakos	II	K-03	G+W	0-10	2.99	4.68	4.22	13.08	78.02	sand
				K-04	G+W+PF	0-10 40-45 55-60 80-85	5.76 7.41 5.43 2.36	10.78 13.44 10.01 3.18	11.70 13.92 8.55 0.90	17.96 23.01 13.94 9.73	59.56 49.63 67.50 86.19	loamy-sand loamy-sand loamy-sand sand
				K-05	G+W	0-10	8.29	15.57	18.45	36.05	29.94	loamy-sand
	Gajary-3	Jakos	II	K-06	G+W	0-10	7.21	12.66	14.91	27.75	44.68	loamy-sand
	Gajary-4	Jakos	II	K-07	G+W	0-10	6.19	11.70	12.99	20.18	55.13	loamy-sand
				K-08	G+W	0-10	7.01	13.25	11.36	17.19	58.21	loamy-sand
	Gajary-5	Jakos	II	K-09	G+W	0-10	8.08	14.53	14.25	19.85	51.38	loamy-sand
	Gajary-6	Jakos	II	K-10	G+W	0-10	5.32	9.21	11.45	34.11	45.23	sand
Levare	Levare-1	Stomfa	II	L-01	G+W	10-20	3.15	4.39	3.17	6.17	86.27	sand
	Levare-2	Stomfa	II	L-02	G+W	10-20	4.51	6.89	7.23	3.89	81.99	sand
	Levare-3	Stomfa	II	L-03	G+W	10-20	3.19	6.82	4.46	5.43	83.29	sand
	Levare-4	Stomfa	II	L-04	G+W	10-20 35-45	2.69 2.71	3.51 3.45	1.57 1.00	12.46 22.74	82.46 72.81	sand sand
	Levare-5	Stomfa	II	L-05	G+W+PF	10-20 50-60 110-120	3.00 2.25 2.62	3.93 2.99 4.46	2.69 2.17 9.76	14.27 18.77 43.51	79.11 76.08 42.27	sand sand sand
	Levare-6	Stomfa	II	L-06	G+W	10-20	2.49	3.76	1.08	18.73	76.43	sand
	Levare-7	Stomfa	II	L-07	G+W G+W	10-20 10-20	2.67 3.32	4.09 4.17	1.40 3.22	24.90 14.04	69.62 78.57	sand sand
	Levare-8	Stomfa	II	L-08	G+W G+W	10-20 30-40	3.58 2.64	4.81 4.07	3.46 2.41	8.42 6.78	83.31 86.74	sand sand
	Levare-9	Stomfa	III	L-09	G+W	10-20	6.14	11.50	6.68	12.63	69.19	loamy-sand

Table G.1.3 Summary of Soil Testing and Field Observation on March-April 2002 (2/2)

General				Soil conditions from sampling results								
Area	Field name	Farming Company	Zoning	Point name	Test type	sampling depth [cm]	Grain size distribution: clay [%] <0,002 mm	I.cat [%] < 0,01 mm	II.cat [%] 0,05-0,01	III.cat [%] 0,05-0,01	IV.cat [%] 0,1-2 mm	Soil type
Levare	Levare-10	Stomfa	II	L-10	G+W	10-20	8.39	14.79	8.99	11.99	64.23	loamy-sand
	Levare-11	Stomfa	II	L-11	G+W	10-20	7.29	13.36	10.36	17.37	58.91	loamy-sand
	Levare-12	Stomfa	II	L-12	G+W	10-20	4.82	8.69	4.16	10.19	76.96	sand
					G+W	35-45	3.82	7.26	3.83	5.74	83.18	sand
	Levare-13	Stomfa	II	L-13	G+W	10-20	5.17	8.51	4.34	11.46	75.69	sand
	Levare-14	Stomfa	III	L-14	G+W	10-20	6.92	11.48	6.34	7.18	74.99	loamy-sand
	Levare-15	Stomfa	III	L-15	G+W	10-20	5.46	10.46	7.90	7.88	73.76	loamy-sand
	Levare-16	Stomfa	III	L-16	G+W	10-20	3.97	5.67	1.75	19.92	72.67	sand
						30-40	3.16	5.37	5.58	7.42	81.63	sand
	Levare-17	Stomfa	III	L-17	G+W	10-20	7.48	15.00	18.91	8.43	57.66	loamy-sand
	Levare-18	Stomfa	III	L-18	G+W+PF	20-30	16.58	31.19	20.93	8.61	39.27	loam
						50-60	16.13	29.19	22.76	8.81	39.24	sandy-loam
						90-100	23.68	42.92	37.70	17.49	1.88	loam
	Levare-19	Stomfa	III	L-19	G+W+PF	10-20	18.85	34.48	17.27	19.49	28.77	loam
						50-60	15.98	29.32	22.07	14.61	34.00	sandy-loam
	Levare-20	Stomfa	III	L-20	G+W	10-20	4.68	7.86	4.89	6.37	80.89	sand
	Levare-21	Stomfa	II	L-21	G+W	10-20	9.71	18.37	23.54	13.26	44.84	loamy-sand
	Levare-22	Stomfa	II	L-22	G+W	10-20	5.25	9.27	7.94	10.45	72.34	sand

Table G.1.4 Summary of Climatic Data and Calculated Reference Evapotranspiration

Station name : Malacky
Latitude : 48°45'
Altitude : 165 m.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Year 1997												
Tmax (°C)	-0.1	8.4	11.1	13.3	22.8	25.3	24.5	28.0	23.0	14.3	8.9	4.9
Tmin (°C)	-5.1	-1.8	-0.5	1.3	9.0	12.9	12.8	13.4	8.6	2.6	1.5	-0.1
RHmean (%)	90	77	74	64	63	68	79	71	72	75	84	87
RHmin (%)	73	50	46	39	37	43	51	41	41	47	63	72
Wind (km/d)	86	121	112	181	104	156	78	60	104	130	173	121
Cloud (10^{th})	8.80	5.60	5.20	5.30	4.30	5.60	6.00	2.90	3.30	5.40	7.30	8.70
ETo (mm/M)	9.0	17.3	42.5	72.8	107.8	124.1	112.0	114.2	79.9	41.8	17.7	9.6
Year 1998												
Tmax (°C)	5.6	10.0	8.5	16.9	21.1	24.9	25.9	27.6	19.4	14.5	4.9	0.7
Tmin (°C)	-1.7	-1.1	-0.5	6.4	9.1	13.7	14.2	14.4	10.7	7.5	-0.8	-4.3
RHmean (%)	84	75	68	66	66	70	69	64	80	83	84	87
RHmin (%)	63	47	47	44	42	47	45	39	58	64	67	71
Wind (km/d)	181	199	225	242	104	60	78	52	112	130	95	112
Cloud (10^{th})	6.50	5.70	6.20	6.40	5.10	5.10	5.30	4.30	6.60	7.50	7.40	7.10
ETo (mm/M)	9.5	27.2	48.3	79.1	103.3	113.0	119.4	105.2	64.0	34.3	15.3	6.3
Year 1999												
Tmax (°C)	2.3	3.0	11.8	16.3	21.8	23.5	26.4	24.9	23.8	15.0	6.4	3.8
Tmin (°C)	-2.4	-2.9	2.9	5.2	10.4	13.6	15.5	12.4	10.2	4.6	0.9	-2.2
RHmean (%)	88	84	72	72	69	72	70	75	79	79	86	82
RHmin (%)	73	66	51	47	45	50	47	47	47	52	70	64
Wind (km/d)	130	156	147	95	130	156	138	112	173	190	121	130
Cloud (10^{th})	6.90	7.90	5.60	5.60	4.80	5.90	4.70	5.30	4.30	4.70	6.80	6.40
ETo (mm/M)	7.0	15.4	42.3	68.4	107.1	116.6	130.1	103.8	80.7	45.5	14.2	8.2
Year 2000												
Tmax (°C)	1.0	8.0	9.6	20.0	24.2	26.4	23.1	27.4	20.2	17.7	12.0	4.0
Tmin (°C)	-5.5	-0.3	2.1	8.0	10.7	9.4	11.4	13.6	9.0	9.3	5.1	-0.2
RHmean (%)	85	78	79	64	62	57	70	70	75	77	84	88
RHmin (%)	65	56	59	40	37	29	45	42	49	56	65	75
Wind (km/d)	156	156	121	190	156	147	138	86	147	147	112	86
Cloud (10^{th})	6.40	5.90	6.60	3.40	3.70	2.30	5.90	2.80	4.80	5.30	5.60	6.40
ETo (mm/M)	10.1	18.2	37.6	93.2	129.3	152.3	116.8	116.0	74.0	41.3	16.7	7.0
Year 2001												
Tmax (°C)	3.1	7.4	11.2	14.8	24.2	22.8	27.6	28.5	18.6	18.1	6.6	-0.6
Tmin (°C)	-1.8	-1.0	3.3	4.2	10.1	11.3	15.1	15.2	10.2	8.8	0.0	-6.5
RHmean (%)	84	77	78	70	64	72	72	71	82	80	80	85
RHmin (%)	69	55	57	46	37	47	46	44	60	56	62	66
Wind (km/d)	164	147	181	164	181	181	173	164	173	173	156	138
Cloud (10^{th})	5.00	5.00	6.00	4.70	2.90	4.20	4.30	3.10	6.30	3.70	5.80	6.30
ETo (mm/M)	5.7	19.7	42.7	74.1	132.2	127.4	137.4	132.2	66.8	43.5	19.9	8.1

Table G.1.5 (1) Assessment of Expected Yield Index - Sample 1

Crop : Winter Wheat Climte Conditions : Year 2000

			1999			2000											
	description		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Monthly ETo (mm)	**(1) from Table G.1.4, Table G.2.1.2.1**		45.5	14.2	8.2	10.1	18.2	37.6	93.2	129.3	152.3	116.8	116.0	74.0	41.3	16.7	7.0
Monthly Precipitation (mm)	**(2) from Table G.1.4**		18.6	67.6	34.9	38.6	40.0	72.6	8.6	43.8	19.2	84.3	66.2	46.6	42.9	67.5	43.7
			(Eitimated by USDA-SCS method without condiering strage fuctor)														
Effective Rainfall [Pe] (mm)	**(3) caluclated by USDA-SCS shown in FAO-24 table**		13.2	34.2	22.7	24.7	25.7	45.7	8.6	35.4	17.5	62.5	50.3	33.1	29.3	35.9	25.2
		daily															
Upwaed Water Supply [Ge] (mm)	**(4) neglect**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
Kc for Single Crop Coefficient	**(5) from Table G.2.1.2.2**		0.7	0.7	0.7	0.7	0.7	0.81	1.04	1.15	0.98	0.4					
Crop Water Requirement (mm)	**(6) =Kc*ETo**		31.9	10.0	5.7	7.0	12.7	30.4	96.9	148.7	149.2	46.7					
Monthly Water Balance																	
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)	(6)		31.9	10.0	5.7	7.0	12.7	30.4	96.9	148.7	149.2	46.7					
Daily ETm [M. ETm / 30] (mm)	(7)=(1)/30		1.06	0.33	0.19	0.23	0.42	1.01	3.23	4.96	4.97	1.56					
Crop type			3	3	3	3	3	3	3	3	3	3					
Soil water depletion fraction [p]	(8) calculated by FAO-33 table		0.827	0.848	0.852	0.851	0.846	0.829	0.677	0.504	0.503	0.813	1.000	1.000			
Avairable soil water [Sa] (mm/m)	(9) from JICA Study Team	14%	140	140	140	140	140	140	140	140	140	140	140	140			
Root depth [D] (m)	(10) from JICA Study Team	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0			
Available soil water in root zone [D*Sa] (mm)	(11)=(9)*(10)		140	140	140	140	140	140	140	140	140	140	140	140			
Remaining available soil water [(1-p)Sa*D] (E	(12)=[1-(8)]*(11)*(19)/(6)		24.2	21.2	20.7	20.8	21.6	24.0	42.4	24.8	13.4	26.2	0.0	0.0			
Available soil water to crop [p*Sa*D] (mm)	(13)=(8)*(11)		115.8	118.8	119.3	119.2	118.4	116.0	97.6	115.2	126.6	113.8	140.0	140.0			
[Wb+Pe+Ge]	(14)=(21) of prior month +(3)+(4)		97.3	102.6	115.9	134.6	140.6	155.3	90.9	53.1	28.8	49.7	79.5	97.5			
[Wb+Pe+Ge] with upper limit at [p*Sa*D]+[E	(15): upper limit of value (14) is (13)+(19)/2		97.3	102.6	115.9	122.7	124.8	131.2	90.9	53.1	28.8	49.7	79.5	97.5			
We of beginning of month [Wb+Pe+Ge]	(16)=(15)		97.3	102.6	115.9	122.7	124.8	131.2	90.9	53.1	28.8	49.7					
ASI=We_beginning of month/monthly ETm	(17)=(16)/(6)		1.00	1.00	1.00	1.00	1.00	1.00	0.94	0.36	0.19	1.00					
ETa daily (mm/day)	(18)		1.062	0.332	0.190	0.235	0.425	1.015	3.031	1.769	0.960	1.558					
ETa monthly (mm/M)	(19)=(18)*30		31.9	10.0	5.7	7.0	12.7	30.4	90.9	53.1	28.8	46.7					
ET of bore land	(20) from FAO-56 table												15.0	15.0			
We of end of month [Wb+Pe+Ge-ETa]	(21)=(16)-(19)		65.4	92.6	110.1	115.6	112.0	100.8	0.0	0.0	0.0	3.0					
delta [(1-p)Sa*D]			3.0	0.6	-0.2	-0.8	-2.4	-18.4	17.7	11.3	-12.8	26.2					
We carried over		84	68.4	93.2	110.0	114.9	109.6	82.3	17.7	11.3	-12.8	29.2	64.5	82.5			
runoff of effective rainfall (mm)	as for reference: (22)=(14)-(15)	↑	0.0	0.0	0.0	11.9	15.9	24.1	0.0	0.0	0.0	0.0					
used effective rainfall (mm)	as for reference: (23)=(3)-(22)	↑	13.2	34.2	22.7	12.7	9.9	21.6	8.6	35.4	17.5	62.5					

Expected remaining soil water after Winter Wheat in average year

Yield Response

Summary of ETm	(24)=sum of (6)	**539**
Summary of ETa	(25)=sum of (19)	**317**
yield response factor Ky	(26) from FAO-33 table	**1.05**
1-Ya/Ym=Ky(1-ETa/ETm)	(27)=(26)*[1-(25)/(24)]	**0.43**
Ya/Ym	(28)=1-(27)	**0.57**

Table G.1.5 (2) Assessment of Expected Yield Index - Sample 2

Crop : Grain Maize Climte Conditions : Year 2000

description			1999 OCT	1999 NOV	1999 DEC	2000 JAN	2000 FEB	2000 MAR	2000 APR	2000 MAY	2000 JUN	2000 JUL	2000 AUG	2000 SEP	2000 OCT	2000 NOV	2000 DEC
Monthly ETo (mm)	**(1) from Table G.1.4, Table G.2.1.2.1**		45.5	14.2	8.2	10.1	18.2	37.6	93.2	129.3	152.3	116.8	116.0	74.0	41.3	16.7	7.0
Monthly Precipitation (mm)	**(2) from Table G.1.4**		18.6	67.6	34.9	38.6	40.0	72.6	8.6	43.8	19.2	84.3	66.2	46.6	42.9	67.5	43.7
			(Eitimated by USDA-SCS method without condiering strage fuctor)														
Effective Rainfall [Pe] (mm)	**(3) caluclated by USDA-SCS shown in FAO-24 table**		13.2	34.2	22.7	24.7	25.7	45.7	8.6	35.4	17.5	62.5	50.3	33.1	29.3	35.9	25.2
Upwaed Water Supply [Ge] (mm)	**(4) neglect**	daily 0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
Kc for Single Crop Coefficient	**(5) from Table G.2.1.2.2**								0.7	0.88	1.1	1.19	1.1	0.7	0.4		
Crop Water Requirement (mm)	**(6) =Kc*ETo**								65.2	113.8	167.5	139.0	131.1	53.3	16.51		
Monthly Water Balance																	
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)	(6)								65.2	113.8	167.5	139.0	131.1	53.3	16.51		
Daily ETm [M. ETm / 30] (mm)	(7)=(1)/30								2.17	3.79	5.58	4.63	4.37	1.78	0.5503		
Crop type									4	4	4	4	4	4	4		
Soil water depletion fraction [p]	(8) calculated by FAO-33 table		1.000	1.000	1.000	1.000	1.000	1.000	0.862	0.721	0.571	0.637	0.663	0.884	0.9301	1	1
Avairable soil water [Sa] (mm/m)	(9) from JICA Study Team	14%	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140
Root depth [D] (m)	(10) from JICA Study Team	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Available soil water in root zone [D*Sa] (mm)	(11)=(9)*(10)		168	168	168	168	168	168	168	168	168	168	168	168	168	168	168
Remaining available soil water [(1-p)Sa*D] (E	(12)=[1-(8)]*(11)*(19)/(6)		0.0	0.0	0.0	0.0	0.0	0.0	23.2	45.2	18.9	24.8	22.7	15.0	11.745	0	0
Available soil water to crop [p*Sa*D] (mm)	(13)=(8)*(11)		168.0	168.0	168.0	168.0	168.0	168.0	144.8	122.8	149.1	143.2	145.3	153.0	156.25	168	168
[Wb+Pe+Ge]	(14)=(21) of prior month +(3)+(4)		97.3	116.5	124.1	133.8	144.5	175.2	161.6	109.7	43.8	56.5	52.5	40.7	32.549	63.639	73.889
[Wb+Pe+Ge] with upper limit at [p*Sa*D]+[E	(15): upper limit of value (14) is (13)+(19)/2		97.3	116.5	124.1	133.8	144.5	168.0	161.6	109.7	43.8	56.5	52.5	40.7	32.549	63.639	73.889
We of beginning of month [Wb+Pe+Ge]	(16)=(15)								161.6	109.7	43.8	56.5	52.5	40.7	32.549		
ASI=We_beginning of month/monthly ETm	(17)=(16)/(6)								1.00	0.96	0.26	0.41	0.40	0.77	1		
ETa daily (mm/day)	(18)								2.175	3.657	1.461	1.884	1.749	1.358	0.5503		
ETa monthly (mm/M)	(19)=(18)*30								65.2	109.7	43.8	56.5	52.5	40.7	16.51		
ET of bore land	(20) from FAO-56 table		15.0	15.0	15.0	15.0	15.0	15.0								15	15
We of end of month [Wb+Pe+Ge-ETa]	(21)=(16)-(19)								96.4	0.0	0.0	0.0	0	0	16.039		
delta [(1-p)Sa*D]									-22.0	26.4	-5.9	2.2	7.7	3.2	11.745		
We carried over		84	82.3	101.5	109.1	118.8	129.5	153.0	74.3	26.4	-5.9	2.2	7.7	3.2	27.784	48.639	58.889
runoff of effective rainfall (mm)	as for reference: (22)=(14)-(15)	↑							0.0	0.0	0.0	0.0	0.0	0.0	0		
used effective rainfall (mm)	as for reference: (23)=(3)-(22)	↑							8.6	35.4	17.5	62.5	50.3	33.1	29.326		

Expected remaining soil water after Winter Wheat in average year

Yield Response

Summary of ETm	(24)=sum of (6)	686.41
Summary of ETa	(25)=sum of (19)	385.01
yield response factor Ky	(26) from FAO-33 table	1.25
1-Ya/Ym=Ky(1-ETa/ETm)	(27)=(26)*[1-(25)/(24)]	0.5489
Ya/Ym	(28)=1-(27)	0.4511

Table G.1.5 (3) Assessment of Expected Yield Index - Sample 3

Crop : Spring Barley Climte Conditions : Year 2000

	description		1999			2000											
			OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Monthly ETo (mm)	**(1) from Table G.1.4, Table G.2.1.2.1**		45.5	14.2	8.2	10.1	18.2	37.6	93.2	129.3	152.3	116.8	116.0	74.0	41.3	16.7	7.0
Monthly Precipitation (mm)	**(2) from Table G.1.4**		18.6	67.6	34.9	38.6	40.0	72.6	8.6	43.8	19.2	84.3	66.2	46.6	42.9	67.5	43.7
			(Eitimated by USDA-SCS method without condiering strage fuctor)														
Effective Rainfall [Pe] (mm)	**(3) caluclated by USDA-SCS shown in FAO-24 table**		13.2	34.2	22.7	24.7	25.7	45.7	8.6	35.4	17.5	62.5	50.3	33.1	29.3	35.9	25.2
		daily															
Upwaed Water Supply [Ge] (mm)	**(4) neglect**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
Kc for Single Crop Coefficient	**(5) from Table G.2.1.2.2**							1	1	1.07	1.14	0.54					
Crop Water Requirement (mm)	**(6) =Kc*ETo**							37.6	93.2	138.3	173.6	63.1					
Monthly Water Balance																	
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)	(6)							37.6	93.2	138.3	173.6	63.1					
Daily ETm [M. ETm / 30] (mm)	(7)=(1)/30							1.25	3.11	4.61	5.79	2.10					
Crop type								3	3	3	3	3					
Soil water depletion fraction [p]	(8) calculated by FAO-33 table		1.000	1.000	1.000	1.000	1.000	0.822	0.689	0.539	0.461	0.790	1.000	1.000			
Avairable soil water [Sa] (mm/m)	(9) from JICA Study Team	14%	140	140	140	140	140	140	140	140	140	140	140	140			
Root depth [D] (m)	(10) from JICA Study Team	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0			
Available soil water in root zone [D*Sa] (mm)	(11)=(9)*(10)		140	140	140	140	140	140	140	140	140	140	140	140			
Remaining available soil water [(1-p)Sa*D] (E	(12)=[1-(8)]*(11)*(19)/(6)		0.0	0.0	0.0	0.0	0.0	25.0	41.3	24.4	12.7	23.9	0.0	0.0			
Available soil water to crop [p*Sa*D] (mm)	(13)=(8)*(11)		140.0	140.0	140.0	140.0	140.0	115.0	98.7	115.6	127.3	116.1	140.0	140.0			
[Wb+Pe+Ge]	(14)=(21) of prior month +(3)+(4)		97.3	116.5	124.1	133.8	144.5	170.7	88.5	52.3	29.2	51.2	74.2	92.3			
[Wb+Pe+Ge] with upper limit at [p*Sa*D]+[E	(15): upper limit of value (14) is (13)+(19)/2		97.3	116.5	124.1	133.8	140.0	133.8	88.5	52.3	29.2	51.2	74.2	92.3			
We of beginning of month [Wb+Pe+Ge]	(16)=(15)							133.8	88.5	52.3	29.2	51.2					
ASI=We_beginning of month/monthly ETm	(17)=(16)/(6)							1.00	0.95	0.38	0.17	0.81					
ETa daily (mm/day)	(18)							1.253	2.950	1.743	0.973	1.708					
ETa monthly (mm/M)	(19)=(18)*30							37.6	88.5	52.3	29.2	51.2					
ET of bore land	(20) from FAO-56 table		15.0	15.0	15.0	15.0	15.0						15.0	15.0			
We of end of month [Wb+Pe+Ge-ETa]	(21)=(16)-(19)	54						96.2	0.0	0.0	0.0	0.0					
delta [(1-p)Sa*D]								-16.3	16.9	11.7	-11.2	23.9					
We carried over		84	82.3	101.5	109.1	118.8	125.0	79.9	16.9	11.7	-11.2	23.9	59.2	77.3			
runoff of effective rainfall (mm)	as for reference: (22)=(14)-(15)	↑						36.8	0.0	0.0	0.0	0.0					
used effective rainfall (mm)	as for reference: (23)=(3)-(22)	↑						8.8	8.6	35.4	17.5	62.5					

Expected remaining soil water after Winter Wheat in average year

Yield Response

Summary of ETm	(24)=sum of (6)	**468**
Summary of ETa	(25)=sum of (19)	**221**
yield response factor Ky	(26) from FAO-33 table	**1.15**
1-Ya/Ym=Ky(1-ETa/ETm)	(27)=(26)*[1-(25)/(24)]	**0.61**
Ya/Ym	(28)=1-(27)	**0.39**

Table G.1.6 Characterization of Soil Units in the Case Study Areas

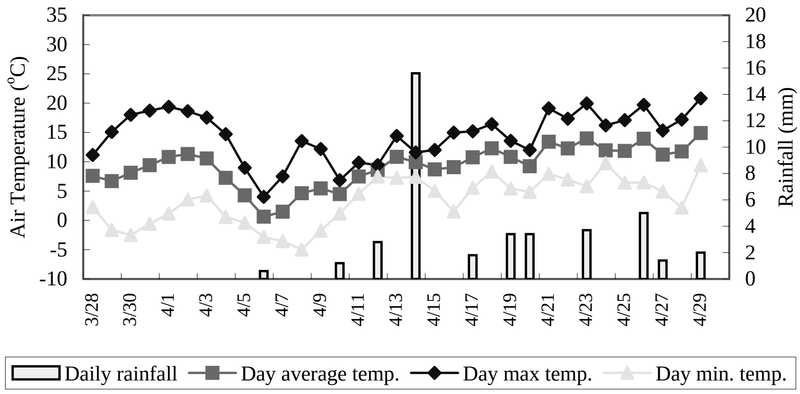
Velke Levare and Male Levare Villages (Site A)

	A - 1	A - 2	A - 3	A - 4	A - 5
Location	Flood plain of Morava	Flood plain of Rudava, Porec and Morava	Deposited area on the low terrace	Denudated area on the lowterrace	Low terrace and middle terrace
Parent Materials	River sediment	River deposit	Diluvial deposit	Diluvial deposit	Tertiary deposit and wind blown sand
Soil Type	Fluvisols	Fluvic Phaeozems (Sandy)	Eutric Regosols	Eutric Regosols	Dystric Regosols
Soil Texture (I. S.S.S.)	SL, L, CL,	LS, S	S	S	S
Area of Arable Land Natural Grassland	272ha 165ha	474ha 58ha	245ha -	173ha -	197ha 3ha
Fertility Level	High	Low to medium	Low	Very low	Extremely low
Permanent Limitation	Water logging in bottom spot and poor soil tilth	Poor holding capacity of water and nutrient	Poor holding capacity	Very poor holding capacity	Extremely poor holding capacity
Soil Samples No and Clay Content	L 18 16.6% L 19 18.9%	L 10 8.4% L 11 7.3% V 03 6.7%	L 12 4.8% V 02 4.9%	L 04 2.7% L 05 3.0%	L 06 2.5% V 01 2.4%
Field Plot No. and Grain Yield of Crops	S 10 3.60t/h (Wheat) S 14 1.76t/h (Rye) S 08 1.63t/h (Wheat) S 04 3.83t/h (Wheat)	S 32 3.23t/ha (Rye) S 22 3.67t/ha (Rye) S 34 4.36t/ha (Barey)	S 13 2.61t/ha (Wheat) S 12 0.9t/ha (Mustard)		

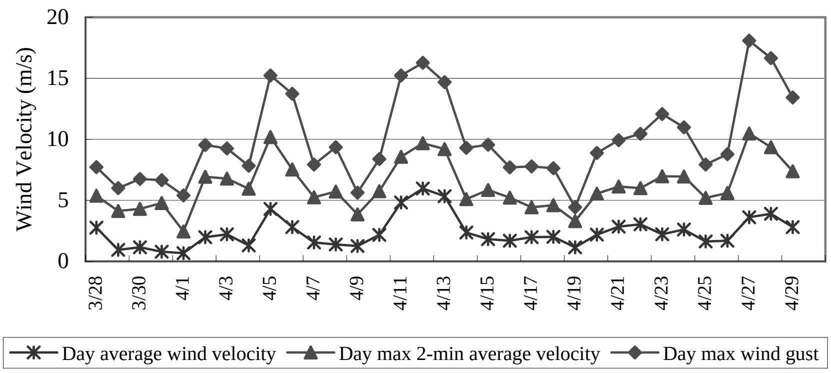
Gajary Village (Site-B)

	B - 1	B - 2	B - 3	B - 4
Location	Lowland below 150m	Low terrace	Low and Middle terraces	Low and Middle terraces
Parent Materials	River flood sediment	Diluvial deposit	Diluvial deposit and Wind blown sand	Wind blown sand and Diluvial deposit
Soil Types	FluvicPhaeozems (Sandy and Loamy)	Eutric Regosols	Eutric Regosols	Dystric Regosols
Soil Texture	L.S S.L, L,	LS, S	S	S
Area of Arable Land	81ha	127ha	103ha	54ha
Fertility Level	Medium to Low	Low	Very low	Extremely low
Permanent Limitation	Poor infiltration in spots and poor soil tilth	Poor holding capacity of water and nutrient	Very poor holding capacity of water and nutrient	Extremely poor holding capacity of water and nutrient
Soil Sample No. and Clay Content	K 09 8.0 % B 01 8.0 %	K 04 5.8 % K 10 5.3 %	G 06 4.7 %	B 02 3.8 % G 05 4.5 %
Field Plot No. and Grain Yield of Crop	J 05 4.7t/ha(Wheat) , J 03 2.3t/ha (Oat) J 04 3.6t/ha (Wheat)		J 02 2.2t/ha (Rye) J 03 2.5 t/ha (Rye)	

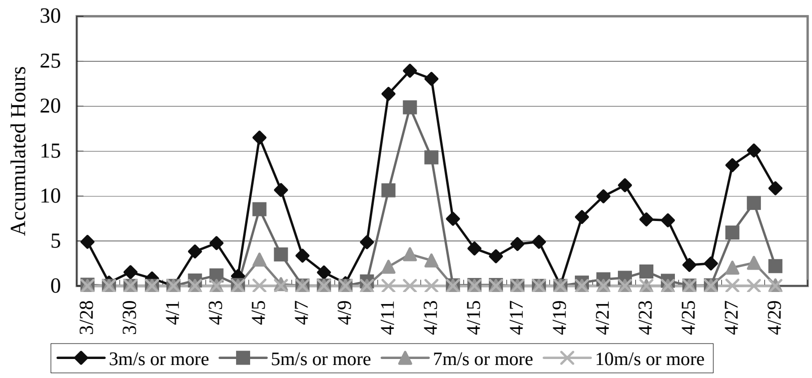
Remarks:
Location of soil samling site: refere Figure G.1.3
Location of field plot: refere Figure 3.6 in Main Report



(1) Rainfall and Tempereture of Dolceky in March to April 2002



(2) Wind Velocity of Dolceky in March to April 2002



(3) Accumlated Hours of Wind Velocity of Dolceky in March to April 2002

Source: JICA Study Team and data provided by SHMI (rainfall at Malacky)

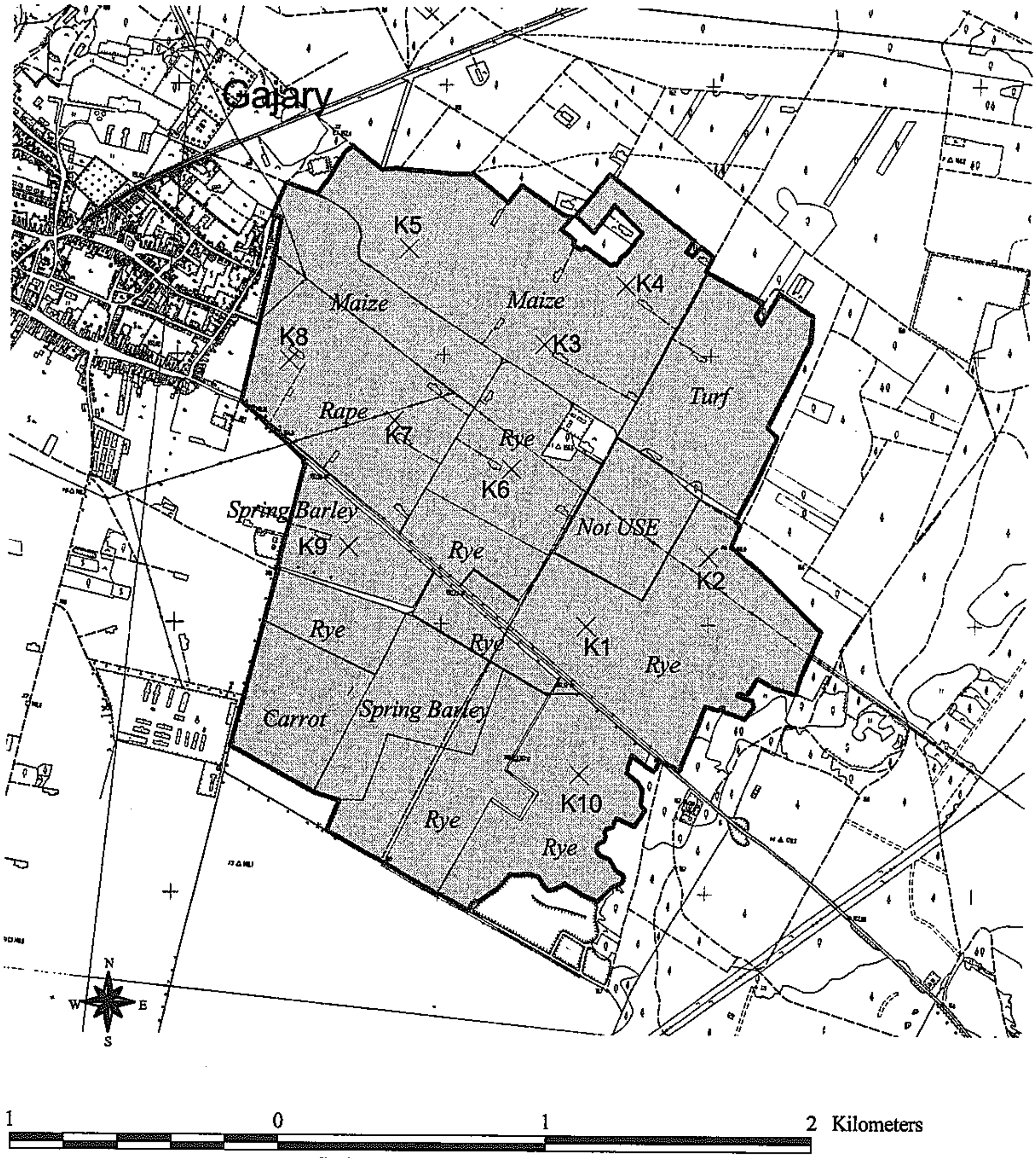


Figure G.1.2 Soil Sampling and Land Cover Measurement Point

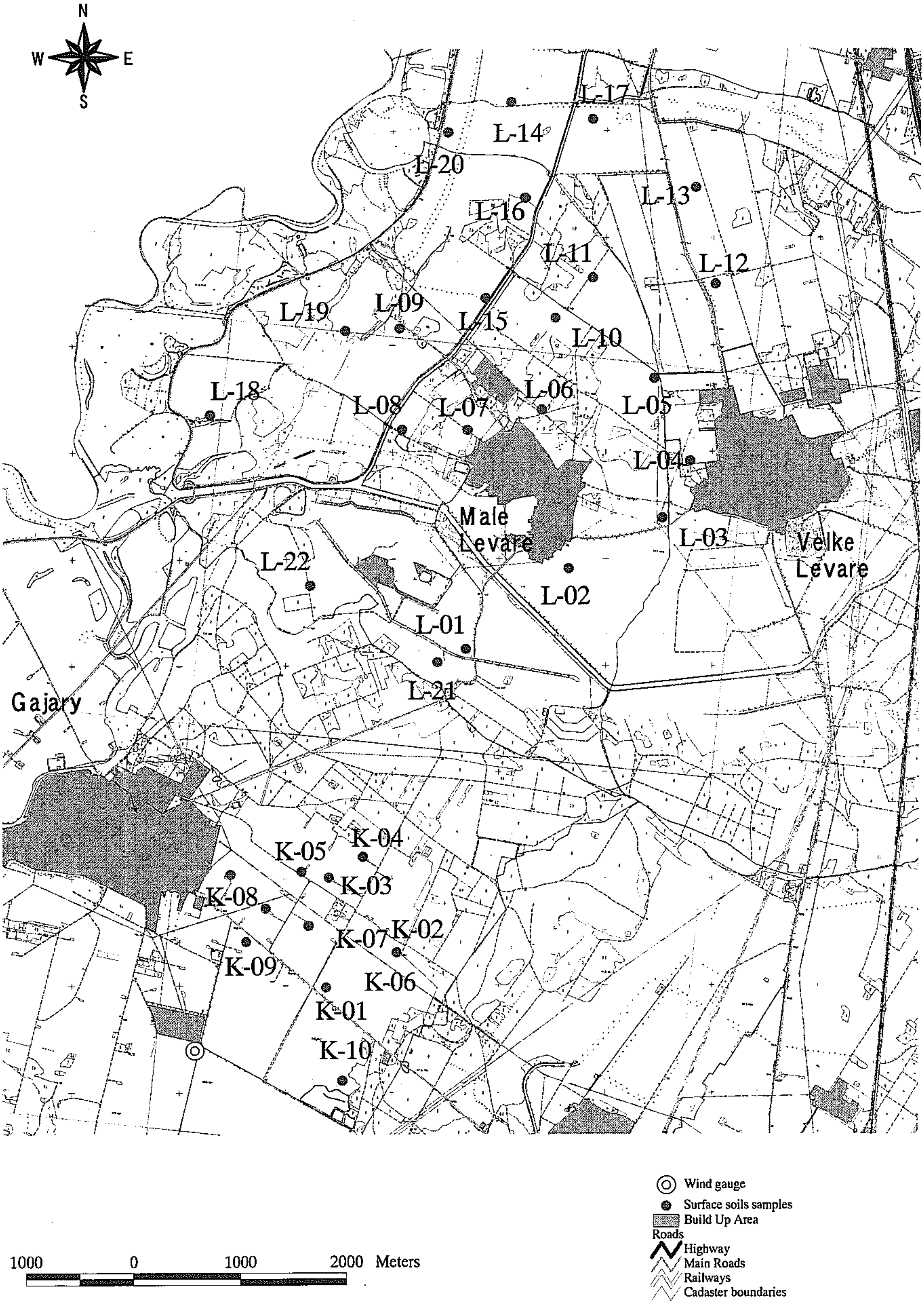


Figure G.1.3 Location Map of Soil Sampling of Surface Soils

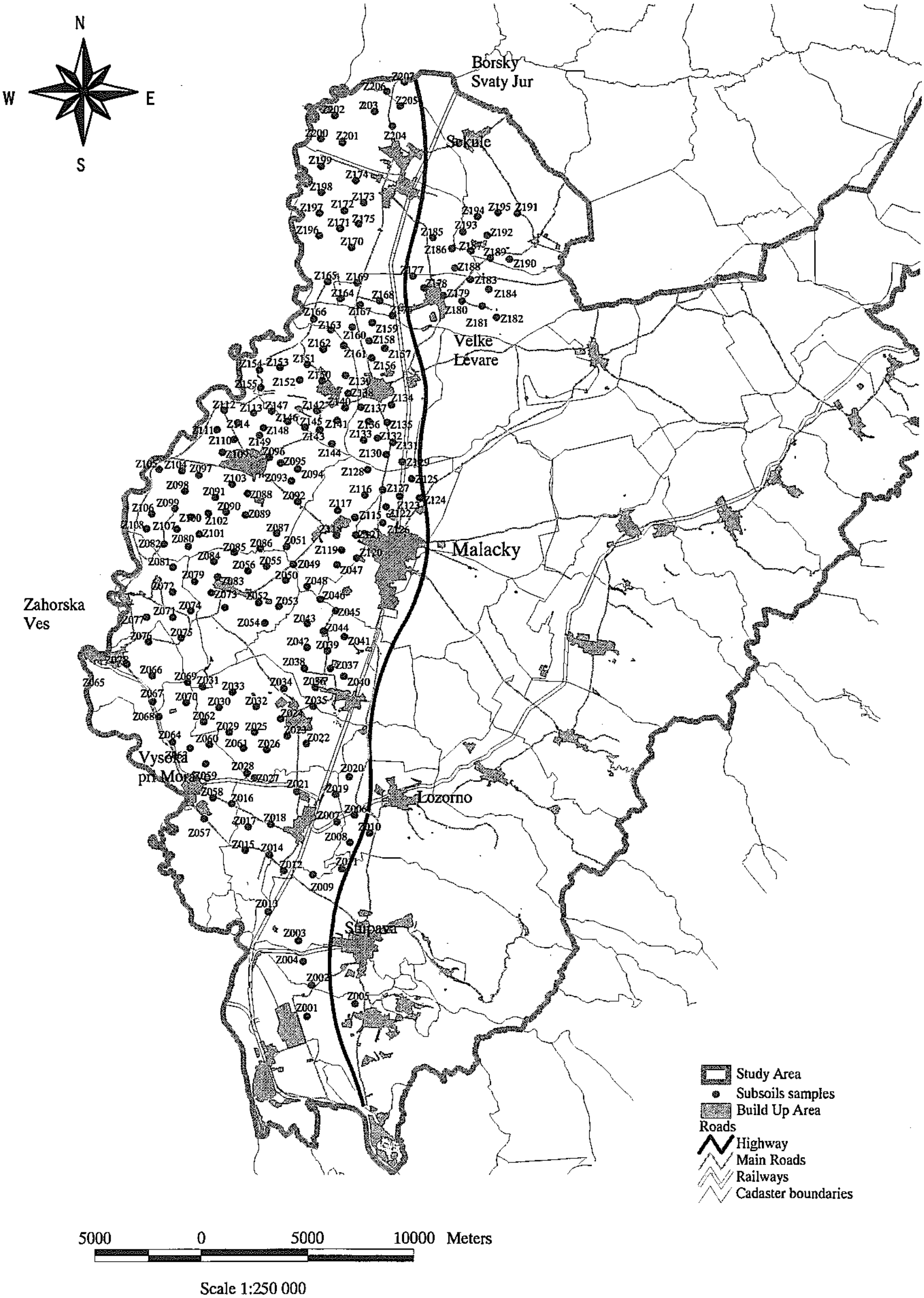


Figure G.1.4 Location Map of Soil Sampling of Subsoils

G.2 IRRIGATION AND DRAINAGE MANAGEMENT

G.2.1 IRRIGATION

G.2.1.1 FEATURES OF IRRIGATION SYSTEM IN THE CASE STUDY AREA

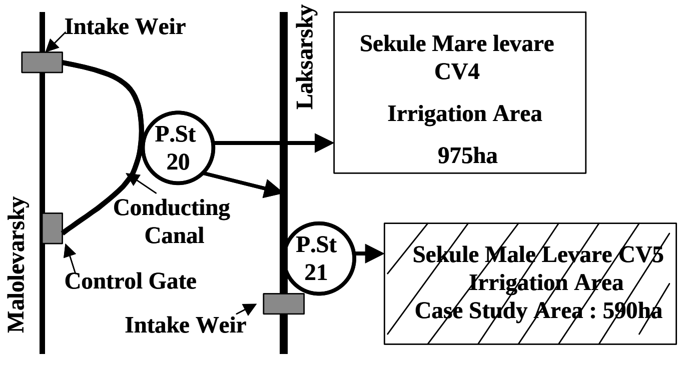
G.2.1.1.1 WATER RESOURCES AND IRRIGATION SYSTEM

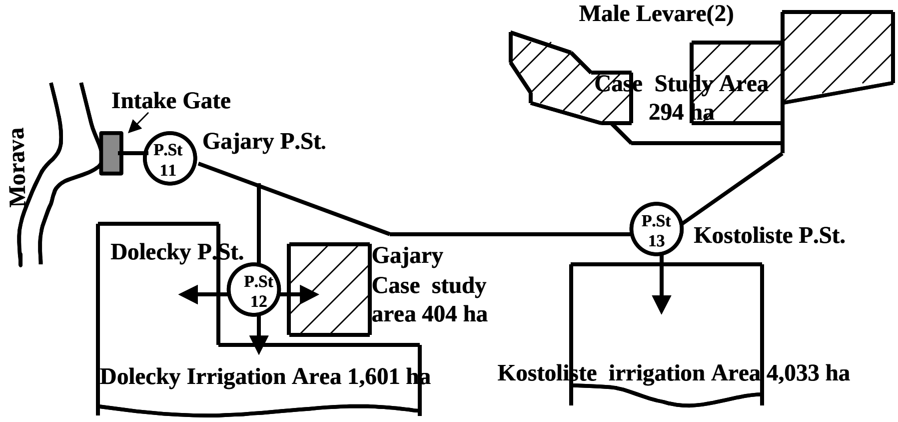
Two irrigation systems, Sekule-Male Levare and Kostoliste, are actually in use at the Male Levare sector of the case study area. The Gajary sector of the case study area falls within the jurisdiction of the Dolecky irrigation system.

(1) Sekule-Male Levare Irrigation System

The Pumping Station P-21 (CSV5) for the Sekule-Male Levare Irrigation System, which is located at the central part of the western zone of the irrigation area, takes water from the Laksarsky River. It is worth while to mention that the station was constructed without legal rights for taking water from the Laksarsky River and, thereby, the said pumping station depends on the Malolevarsky canal for a source of irrigation water.

In practice, excess water discharged from the Tomky Reservoir, an original source of water for the Laksarsky River, is used at first and deficient water, if any, is compensated for using the deviation to the Laksarsky River from the water to be conveyed between the stations of the P-20 (Sekule Male Levare CV4), which depends on the Malolevarsky canal for a source of water, and the P-21. A schematic network of water source is illustrated in the following manner.





(2) Kostoliste Irrigation System

Water for the Kostoliste Irrigation System is taken from the Morava River. Under this irrigation system, water supplied from the Gajary (P11) Pumping Station is boosted at the Kostoliste Pumping Station (P-13) to irrigate a receiving area of 4,407 ha, of which the case study area accounts for 372 ha (net irrigation area 294ha).

(3) Dolecky Irrigation System

Water for this irrigation system depends on the Morava River; water is not taken directly from the river, but similar to Kostiliste (P-13), it is boosting water at the Dolecky (P-12) Pumping Station conducted from the Gajary (P11). The total irrigable area of this system in question reaches 2,066 ha, of which 465 ha (net irrigation area 404 ha) is used for the case study area.

G.2.1.1.2 FEATURES OF IRRIGATION FACILITY

(1) Water Intake

1) Male Levare (P-21)

Water from the Laksarsky River is taken by means of intake works to the pumping station; the Laksarsky River is closed with two wooden gates and water is conveyed to the water supply tank of the pumping station once garbage materials are excluded by a screen installed at the intake. Major features of the intake works are as listed in the table below.

Intake Works (Male levare)

Gate				Intake facilities				
Span length	Height	Material	unit	length of concrete canal	Screen (Iron bar)			Crane
					Wide	Height	Bar pitch	
(m)	(m)			(m)	(m)	(m)	cm	(ton)
3.00	1.50	wooden	2	9.30	2.5	3.0	4.5	1.0

The said intake works are functioning at present, although wooden materials for the gates to close the Laksarsky River need to be replaced every 10 years or so.

2) Dolecky (P-12) and Kostoliste (P-13)

The Dolecky (P-12) and the Kostoliste (P-13) have no intake works, because they feature the dam up method. Thus, direct intake is carried out through the Gajary (P-11) – the trunk station of the relevant irrigation system -, which takes water directly from the Morava River. This intake from the Morava River does not depend on such artificial works as weirs but uses gravity. Under the circumstances, this intake relies heavily on the water level of the Morava River, but lowering of the river water has not been recorded to cause failure of the water intake in the past. The Gajary (P-11) Pumping Station is working in good order, without deterioration in its structures. A legally vested intake volume from the Morava River is 2.4 m3/s. Water between the stations is conducted through the pressured pipeline

(ϕ 1,200). Water conducted to the Dolecky (P-12) and Kostoliste (P-13) is boosted there once more to supply water to the benefiting farmlands. Major features of the intake works of Gajary are as listed in the table below.

Intake Works (Gajary)

Gate				Intake facilities					
Span length	Height	Material	unit	length of concrete	Screen (Iron bar)			Gate	
					Wide	Height	Bar pitch	Φ	unit
(m)	(m)			(m)	(m)	(m)	(cm)	(m)	
2.40	3.00	wooden	2	13.90	5.70	3.6	4.50	1.00	2

(2) Pumping Station

1) Sekule-Male Levare Irrigation System

Water to the Sekule-Male Levare irrigation system is conducted through the P-20 and P-21 pumping stations, both of which are equipped with structures evaluated at present as in category I; in particular, the P-20 , which had been evaluated as category II up to 2001, was improved in 2002 to supply irrigation water and it is upgraded to category I now. The stations have the following dimensions and capacity.

Dimension and Capacity of Pump Station

Item	No. of Pump Unit	Type/No.	Q (l/min.)	H (m)	(n/min.)	Type	Power output (KW/HP)
Sekule Male Levare P-20 Pump Station (CS V4N2 Zavod)							
Pump M1	4	300CVAV460-38/SIN	6, 800	82	985	AF1164-6	986 / 160
Pump M5	2	100CVAV460-38/SIN	800	42	1, 460	VF160I04	1,445
Pump M8	2	DE-350-LN	13, 000	5.3	730	F225M08	22
Sekule Male Levare P-21 Pump Station (CSV5 Male Levare)							
Pump M1	3	300CVAV460m32/3	7, 000	72	985	AF1066-6	130
Pump M4	2	100CVAV230-12-3	800	42	1, 460	VF160M04	11

2) Kostoliste Irrigation System

Water to the Kostoliste irrigation system is conducted through the Gajary (P-11) and the Kostoliste (P-13) pumping stations. An assessment on functioning of these pumping stations carried out by JICA has ranked both as category I. Due to the fact that irrigation water was supplied through these two stations in 2002, no salient problem relevant to the functioning of these stations has been revealed. Dimensions and capacity of the pumping stations are as follows:

Dimension and Capacity of Kostoliste Pump Station

Item	No. of Pump Unit	Type/No.	Q (l/min.)	H (m)	(n/min.)	Type	Power output (KW/HP)
Pump (Kludove)	3	150CVE-350-2 3/3-LN	3,900	75	1,480	F 280 M 04 100	100
Pump (Stredne)	4	250CVE460 38/3-LN	6,900	75	985	AF 355 L-6	200
Pump (Velke)	3	300QDV-600-65-LU-00	26,400	75	950	YF 600 M-4	630

3) Dolecky Irrigation System

Two pumping stations – Gajary (P11) and Dolecky (P12) – are operated within the Dolecky irrigation system. A technical assessment conducted by JICA Study in 2001 ranked both of these two stations as category I and it was revealed at the same time that there was no serious constraint relevant to their functioning due to proper operation in supply of irrigation water. The Gajary (P-11) is 1.6 km from the Dolecky (P-12) and irrigation water between the stations is conducted through the pressured pipeline (ϕ 1,200). Water supplied to the Dolecky (P-12) is boosted to irrigate respective farmlands. Dimensions and capacity of the Gajary (P11) and the Dolecky (P-12) Pumping Station are as follows:

Dimension and Capacity of Pump Station

Item	No. of Pump	Type/No.	Q	H	(n/min.)	Type	Power output
	Unit		(l/min.)	(m)			(KW/HP)
Gajary Pump Station P-11 (CS Gajary)							
Pump (kalove)	6	FLYGT 5350.260	24, 000	35	-	-	200
Dolecky Pump Station P12 (CS Dolecky)							
Pump (Kludove)	4	125CVE30519/3LN	1,800	72	1, 475	F 250 MO 4	55
Pump (Kludove)	6	50CVE460-38/3LN00F/2	6,000	72	985	ZK 355 M 6	160

(3) Pipeline

1) Sekule- Male Levare Irrigation System

The pipeline for the Sekule-Male Levare irrigation system is features a reticulated pipeline system which benefits a gross area of 759 ha (net area 590 ha) in total. The diameter of pipelines ranges from ϕ 125 mm to ϕ 500 mm. In so far as functioning of these pipelines, a water conveyance test carried out in 2001 relevant to trunk pipelines, revealed that 80% of the pipelines in question had served in good order. It is reported that pipes were damaged at two points and these points have since been repaired.

2) Kostoliste Irrigation System

The pipeline for the Kostoliste irrigation system forms an arborescent pipeline system which benefits a gross area of 372 ha (net area 294 ha). The diameter of pipelines fluctuates between ϕ 150mm and ϕ 500 mm. Inservice s.o.r, is responsible for operation and maintenance of these pipelines. It is revealed that the pipelines located at the western part of the sector to benefit an area of 80 ha have not been checked for more than 10 years and their functioning needs to be tested accordingly.

3) Dolecky Irrigation System

The pipeline for the Dolecky irrigation system consists of an arborescence pipeline system which benefits a gross area of 465 ha (net area 404 ha) in total. The diameter of pipelines ranges from ϕ 125 mm to ϕ 500 mm and these pipelines form a network. Regarding the functioning of these pipelines, it is considered to be in good order due to the fact that irrigation is actually carried out at the northern and southern parts of the sector and water is adequately conveyed owing to proper maintenance tasks done by Inservice s.r.o. It is necessary to confirm the function of pipeline through water flow tests where irrigation has not been practiced for a long time.

(4) Hydrant and Other Related Structures

Hydrants for water supply are installed every 2 – 7 ha, equipped with control valves and air valves for water management and maintenance of facilities. In so far as maintenance of hydrants is concerned, those which are installed where irrigation is carried out, no constraint on their use is known, meanwhile those which have been left for years without operation have some problems such as growth of weeds within the maintenance box, damage in structure, etc. It is reported that 5 - 10% of the facilities within the Sekule-Male Levare irrigation system are damaged and this percentage has risen to 20% within the Kostoliste irrigation system. Furthermore, it is also revealed that some of control valves are beyond a man's strength to turn because of rust in some parts. In the light of this, it is advised that arrangement, repair and test operation are indispensable in advance of re-using the irrigation system which has been left without operation for a long time. Although it seems that maintenance for this irrigation system is more adequately done than that for the Sekule-Male Levare irrigation system supported by a higher irrigation ratio, a conveyance test for the pipelines which have been left without operation for a long time should be carried out.

G.2.1.1.3 FACT FINDING ON IRRIGATION SYSTEM

(1) Irrigated Area

An average irrigated area of the Case Study Area from 2000 to 2002 is 19 ha at the Gajary sector and 48 ha at the Male Levare sector. The irrigation is carried out for vegetable such as carrot, onion and parsley in Gajary sector and asparagus in Male Levare sector.

(2) Irrigation Method

Traditionally, pumping irrigation has been carried out aiming at large-scale farmlands in which cereals and sunflower are planted. In such farmlands, reel hose sprinkler has been employed to suit large-scale lots, representing about 85% of sprinklers owned by farmers. Nevertheless, underground drip irrigation on a small scale is introduced at Male Levare sector.

(3) Maintenance and Management.

Irrigation facilities including pump to hydrant in the field are owned by the SWME-PD (State), so that they carry out operation and maintenance for the facilities. However, operation, maintenance and repair for irrigation facilities are entrusted to a private company on a contract basis. Farmers manage sprinklers in the field after delivery of water from the hydrant. Presently, a water users association does not exist among farmers and the SWME-PD, including private companies. Five pumping stations are related to the Case-Study Area. But two (2) private companies manage those main facilities. The relationship between each pumping station and the private company is shown in the following table.

Maintenance company and Irrigation Area

Item	Sekule Male Levare Cv4	Sekule Male Levare Cv5	Gajary	Kostoliste CV	Dolecky CV
Maintenance company	HMU(Halas)	HML(Halas)	In-service	In-service	In-service
Irrigation area	Irrigation system of Sekule Male Levare CV5	Male Levare (1)	Irrigation system of Kostoliste & Dolechy	Male levare (2)	Gajary
		(ha)		(ha)	(ha)
		593		293	396

G.2.1.1.4 GROUNDWATER CONTROL AREA

(1) Location

The groundwater control area is located on flatter lower plains along the Rudava River, in the southern part of Male Levare sector. In this area, irrigation water is taken from the drainage canal (tributary of Rudava river) to supply, in turn, the underdrains; in such an area the ground water level is controlled by relief wells of underdrains and groundwater irrigation is carried out experimentally to cover a control area of 102 ha.

(2) Features of Facilities

1) Underdrains

In view of controlling drainage and groundwater, water catchment pipes with diameter of 5 cm are laid every 20 – 25 m and water conveyed to these pipes is collected through a collecting pipe that discharges into drainage canals.

2) Water Intake Works

In order to supplement irrigation water, a weir was constructed to divert water from the drainage canal (190032). Water intake volume at the weir is from 100 l/s to 150 l/s at maximum. Water taken from the weir is conveyed through catchment pipes of underdrains, which aims to prevent the raising of groundwater level.

3) Operation and Maintenance Task

These farmlands are administrated by agricultural entrepreneurs who are also responsible for operation and maintenance of irrigation works. Groundwater level is controlled by the installation of a manhole equipped with a flap gate at the confluence of catchment pipes and inflow and by the installation of a gate valve at the outlet box of collecting pipes. The benefiting crop of asparagus is cultivated in 56ha; ground water level is maintained 0.8 – 1.0 m below the ground level and water to supplement irrigation is estimated at 2 – 4 mm/day. SWME-ID is providing technical assistance in such fields as operation and maintenance of underedrains, balancing of groundwater, supplement of irrigation water, productivity of crops, etc because this field falls within the target fields of their research.

G.2.1.2 IRRIGATION PLAN

G.2.1.2.1 BASIC INVESTIGATIONS FOR IRRIGATION PLAN

(1) Meteorological Data

Such meteorological data as rainfall, air temperature, humidity, wind speed and radiation that are indispensable for estimation of intake volume for irrigation system are available at the Malacky Meteorological Station, which is located within the city of Malacky and is the nearest (4 – 7 km) station from the case study area.

(2) Soil Survey

In order to contribute to basic information for developing an irrigation development plan (irrigation water volume, sprinkling intensity, etc.) of the case study area, an investigation into soil characteristic (soil gravity and soil moisture, relation between pF and moisture) test was conducted as summarized in the table below.

Soil Hydraulic Coefficients

Area	Depth	Bulk density	Capillary suction capacity(24 hr saturation)	Maximum capillary capacity(24 hr suction)	Retention water capacity (24 hr suction)	Wilting Point	Average water capacity (field capacity - wilting point)	Point of decreased availability (wilting point +60% of available water charge)
	(cm)	(% obj)	(% obj)	(% obj)	(% obj)	(% obj)	(% obj)	(% obj)
Kostoliste k-4	40-45	1.88	29.44	23.44	21.51	7.46	14.05	15.89
	80-85	1.71	29.90	20.65	18.51	4.71	13.80	12.99
Vel.levare L-18	30-40	1.52	38.91	31.62	19.27	5.17	14.10	19.63
	50-60	1.78	29.43	19.82	17.59	2.69	14.90	11.63

(Survey : 8/2002: SWME-ID)

In order to plan the irrigation method and appropriate irrigation intensity, an intake rate test was conducted and is summarized in the table below.

Intake Rate in the Case Study Area

Item	Time passed (0bservation time)	Integrated Infiltration	Intake rate (I) (Infiltration rate)	Basic intake rate
	(mm)	(mm)	(mm/hr)	(mm/hr)
Gajary	41;09	90	128	141
Vel.Levare	49;00	90	117	128

(Survey : 8/2002: SWME-ID)

G.2.1.2.2 WATER BALANCE BETWEEN CROP WATER REQUIREMENT AND SOIL MOISTURE

The crop water requirement is calculated by applying the data for evapotranspiration depending on climate conditions, cropping period and crop coefficient. This calculation follows the sequence to be explained hereinafter.

(1) Reference crop Evapotranspiration (ETo)

Of various formulas regarding calculation of the reference crop evapotranspiration (ETo), the FAO Penman-Monteith Method (FAO Table 56) which is based on four meteorological data (air temperature, humidity, wind speed and radiation) is employed for this study. where, the year of 1993 registered the ETo of an average year, and the year of 2000 represented the Etc of a drought year (corresponding to return period of 1/10). The effective rainfall, on the other hand, is set as 0 in the case that daily rainfall records are below 5 mm and is estimated in compliance with FAO Paper 25 in the case that daily rainfall exceeds 5 mm.

Effective rainfall (ER) and The reference crop evapotranspiration (ETo)

Item		Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
			mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
Average year of rainfall	E.R	1993	15.2	24.9	25.1	9.0	36.8	54.5	80.1	71.2	23.1	35.9	21.0	32.4	429.3
	ETo	1993	10.8	16.9	37.0	75.8	121.4	121.1	123.2	109.6	70.2	41.8	17.7	9.6	755.1
Droughty year of rainfall	ER	2000	24.65	25.75	45.66	8.6	35.38	17.48	62.47	50.29	33.05	29.33	35.86	25.25	393.8
	ETo	2000	10.1	18.2	37.6	93.2	129.3	152.3	116.8	116.0	74.0	41.3	16.7	7.0	812.3

(2) Cropping Period and Crop Coefficient (Kc)

Crops and cropping period are based on the research to be carried out in the case study area. The crop coefficient, meanwhile, is calculated referring to FAO's Table 56: Single crop coefficient (kc). The result of the said calculation is as per the Table G.2.1.2.2 and is summarized in the table below.

Kc for Single Crop Coefficient and cropping period

Item	Cropping period												
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
Winter Wheat	0.7	0.7	0.7	0.7	0.7	0.81	1.04	1.15	0.98	0.4			
Spring Barley						1.00	1.00	1.07	1.14	0.54			
Grain maize							0.70	0.88	1.10	1.19	1.13	0.72	0.4
Carrot						0.70	0.72	0.91	1.05	1.05	1.00		
Onion							0.77	1.02	1.05	1.03	0.86		
Radish						0.70	0.88						
Potato							0.50	0.59	1.03	1.15	0.95		
Green Beans							0.50	0.63	1.02	1.02			
Soybeans							0.40	0.65	1.15	1.08	0.54		
Sunflower							0.35	0.45	0.10	1.15	1.17	0.48	
Rapeseed	0.35	0.35	0.35	0.35	0.35	0.35	0.60	1.11	0.60				
Alfalfa (1)							0.70	1.11					
Alfalfa (2)									0.50	1.18	0.83		
Alfalfa (3)											0.40	0.96	1.04
Apples						0.47	0.63	0.83	0.95	0.95	0.95	0.82	

(3) Effective Depth of Roots Group Layer

In order to estimate the effective soil moisture of the case study area, an investigation was made with regard to an effective depth of roots group layer for rye, maize and sunflower. The effective depth of roots group layer for these three crops relies on the said investigation, while that for vegetables and pasture refers to interview surveys with local farmers as well as to the Table 56 of FAO. The result of the estimation is shown as follows;

Effective Rooting Depth

Crop	Root depth (m)	Reference	Crop	Root depth (m)	Reference
Winter Wheat	1.0	From JICA Study team	Asparagus	1.0	from FAO-56 table
Spring Barley	1.0	From JICA Study team	Sunflower	1.0	From JICA Study team
Grain maize	1.2	From JICA Study team	Soybeans	0.6	from FAO-56 table
Carrot	0.5	from FAO-56 table	Rapeseed	1.0	from FAO-56 table
Potato	0.5	from FAO-56 table	Alfalfa	1.0	from FAO-56 table

(4) Water Balance between the Crop Evapotranspiration (ETc) and Soil Moisture

Bearing the conditions mentioned before in mind, the water balance between crop evapotranspiration (ETc) and soil moisture (including effective rainfall) is calculated as given in the Table G.2.1.2.3. The summary of this calculation is shown in the following table.

Water Balance during Cutivation Priod

Item	Average year(1993)												
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
Winter Wheat	92.5	112.2	134.3	127.0	132.2	113.8	44.0	-58.8	-64.2	30.9			
Spring Barley						103.3	36.6	-56.6	-83.6	13.6			
Grain maize							30.4	-39.6	-78.8	-66.5	-52.7	-27.4	19.2
Carrot						65.6	3.5	-70.2	-72.7	-49.2	-2.3		
Potato							25.8	-9.1	-70.3	-61.6	1.4		
Asparagus						63.8	26.7	-48.2	-60.6	-36.9	-29.7	-23.2	20.5
Sunflower							73.6	55.7	-29.1	-61.6	-54.9	6.3	
Soybeans							70.5	28.4	-56.4	-52.9	31.5		
Alfalfa							2.8	-95.1	-6.1	-65.3	3.2	-41.1	6.8
Rapeseed	113.8	138.5	144.0	131.2	138.6	131.5	81.9	-16.0	-18.2				
	Drought year (2000)												
Winter Wheat	66.2	90.4	107.3	124.9	132.2	133.6	27.7	-85.6	-131.8	15.7			
Spring Barley						121.0	30.4	-72.5	-156.1	-0.6			
Grain maize							48.9	-29.5	-150.0	-76.5	-80.8	-20.2	12.8
Carrot						86.0	-9.5	-82.3	-142.4	-60.2	-27.5		
Potato							20.7	-20.2	-139.4	-71.9	-23.6		
Asparagus						94.6	46.4	-37.2	-127.2	-48.5	-56.5	-15.8	14.1
Sunflower							80.2	57.4	-100.2	-71.9	-85.5	15.3	
Soybeans							65.9	17.2	-140.4	-63.7	8.3		
Alfalfa							21.3	-86.9	-58.7	-75.4	-21.1	-37.9	0.6
Rapeseed	89.7	118.9	138.7	140.9	139.0	151.8	71.0	-37.1	-73.9				

The above calculation implies that, in the light of the water balance, most crops face a deficiency in water requirement and require irrigation accordingly. The deficiency in crop water requirement is closely related to the decrease in crop production, although it varies crop by crop. Irrigation of cereals brings about less benefit compared with the necessary investment; it is reported that a considerable benefit is expected in production of cereals without the use of irrigation.Oleaginous crops are likely to benefit more from irrigation than cereals. Vegetables, on the other hand, are heavily dependent on irrigation and considerabe benefits owing to intensive farming with irrigation can be expected.

G.2.1.2.3 IRRIGATION WATER REQUIREMENT

(1) Irrigation Efficiency

In calculating irrigation water requirement to supplement deficiency in crop water requirement it is a precondition to take into account the losses of water in conveyance between intake point and benefitinge farmlands. Referring to the irrigation works (pipelines) and the irrigation method (sprinkling) of the case study area, the irrigation efficiency is estimated at Ea = 0.85, which is explained in the following table:

Irrigation Efficiency

Irrigation Method	Application efficiency	Rate of Conveyance loss	Irrigation efficiency
Sprinkler and drip irrigation	90%	5%	85%

(2) Gross Water Requirement

The unit water requirement per ha obtained in the section G.2.1.2.2 above is multiplied by the irrigation efficiency (0.85) to obtain the crop water requirement. In this calculation, it is worth while to point out that unit water requirement for the years with average rainfall is based on the mean rainfall for the years 1993 and 1998, meanwhile that for the years with drought (with return period of 1/10) is based on the data of the year 2000. Monthly and yearly crop water requirement (unit: ha) for respective crops is estimated in the table below.

Gross Irrigation Water Requirement

E: Irrigation Efficiency: 0.85

	Average year (1993,1998)							Total	
Item	APR	MAY	JUN	JUL	AUG	SEP	OCT	(mm)	(m3/ha)
Winter Wheat	0	70.1	61.1	0.0	0.0	0.0	0	131.3	1,313
Spring Barley	0	77.8	83.1	5.0	0.0	0.0	0	165.9	1,659
Grain maize	0	44.6	77.6	89.8	85.0	16.1	0	313.2	3,132
Carrot	0	67.7	70.8	69.8	26.9	0.0	0	235.2	2,352
Potato	0	7.8	68.0	84.1	23.5	0.0	0	183.4	1,834
Asparagus	0	57.6	57.0	55.5	58.5	13.7	0	242.3	2,423
Sunflower	0	0.0	33.9	84.1	88.8	0.0	0	206.8	2,068
Soybeans	0	0.0	49.9	74.1	0.0	0.0	0	124.0	1,240
Rapeseed	0	9.4	10.7	0.0	0.0	0.0	0	20.1	201
Alfalfa	0	107.6	3.6	79.8	22.5	24.2	0	237.6	2,376
Droughty year: 2000									
Item	APR	MAY	JUN	JUL	AUG	SEP	OCT	(mm)	(m3/ha)
Winter Wheat	0.0	100.7	155.1	0.0	0.0	0.0	0.0	255.8	2,558
Spring Barley	0.0	85.3	183.6	0.7	0.0	0.0	0.0	269.6	2,696
Grain maize	0.0	34.7	176.5	90.0	95.1	23.8	0.0	420.0	4,200
Carrot	11.2	96.8	167.5	70.8	32.4	0.0	0.0	378.7	3,787
Potato	0.0	23.8	164.0	84.6	27.8	0.0	0.0	300.1	3,001
Asparagus	0.0	43.8	149.6	57.1	66.5	18.6	0.0	335.5	3,355
Sunflower	0.0	0.0	117.9	84.6	100.6	0.0	0.0	303.1	3,031
Soybeans	0.0	0.0	33.4	85.9	0.0	0.0	0.0	119.3	1,193
Rapeseed	0.0	43.6	86.9	0.0	0.0	0.0	0.0	130.6	1,306
Alfalfa	0.0	102.2	69.1	88.7	24.8	44.6	0.0	329.4	3,294

G.2.1.2.4 ON-FARM IRRIGATION SYSTEM

(1) Basic Intake Rate and Constraint on Irrigation Method

The basic intake rate within the case study area amounts to a considerable value ranging from 120 mm/hr. to 150 mm/hr. Due to the fact that soils in the area are represented by sandy loam, an appropriate irrigation method would be by sprinkling or by drip. Referring to the value of the basic intake rate, it is supposed that the spray irrigation intensity should not constitute a constraint on employment of irrigation equipment; the majority of irrigation equipment can be used for the case study area.

(2) Unit Water Requirement and Irrigation Interval

The unit water requirement, which varies according to available soil moisture and the effective depth of roots group layer of crops, is in the range of 50 – 70 mm/application for cereals and 25 – 30 mm/application for vegetables, on the assumption that the irrigation interval is between 10 days to 15 days. Nevertheless, in view of making better utilization of effective rainfall, it is a prerequisite that irrigation water should be supplied with some allowance given to the capacity of available soil moisture. It is thus suggested that the unit water requirement should be set at 30 mm for wheat, sunflower and maize and 20 mm for vegetables. This means that the irrigation interval is likely to be closer than in the case where water requirement is estimated by no other factors except the capacity of available soil moisture. An amount for each irrigation, irrigation interval and area of daily irrigation for the designed water requirement are summarized in the following table. In practice, irrigation in the field is carried out with consideration of soil moisture condition (pF level), weather forecast and related factors.

Irrigation Volume and Interval days

Item	Total Available Moisture	Max ETc	Requested Irrigation interval days from the soil moisture	Irrigation water volume of one time and Irrigation interval days		Field Application	Gross irrigation requirement	Gross irrigation requirement	Capacity of hydrant	Irrigation hour/ha	Peak irrigation priod	
											Hour	Area
Crop	(mm)	(mm/day)	Irrigation Interval day	(mm/day)	(days)	(Ea)	(mm/ha)	(m3/ha)	(l/sec)	(hr/ha)	hr	ha
Winter Wheat	74.9	4.7	16.1	30	6.5	0.9	33	333	15	6.2	16	2.6
Spring Barley	75.6	4.6	16.4	30	6.5	0.9	33	333	15	6.2	16	2.6
Grain maize	102.7	4.9	21.0	30	6.1	0.9	33	333	15	6.2	16	2.6
Carrot	31.6	4.3	7.3	20	4.6	0.9	22	222	10	6.2	16	2.6
Potato	22.0	4.7	4.7	20	4.2	0.9	22	222	10	6.2	16	2.6
Asparagus	67.9	3.9	17.4	30	7.7	0.9	33	333	15	6.2	16	2.6
Sunflower	73.9	4.7	15.6	30	6.4	0.9	33	333	15	6.2	16	2.6
Soybeans	53.4	4.6	11.5	30	6.5	0.9	33	333	15	6.2	16	2.6
Rapeseed	77.1	4.5	17.2	30	6.7	0.9	33	333	15	6.2	16	2.6
Alfalfa (1)	107.3	4.9	22.1	30	6.2	0.9	33	333	15	6.2	16	2.6

(3) Irrigation Time

The irrigation time is calculated multiplying the unit water requirement by the spray irrigation intensity; in the case of the unit water requirement and irrigable area per hour for the reel-hose type sprinkler, which has the spray irrigation capacity of 15 l/sec., it can be obtained as given in the table below. For instance, when hydrant discharge is 15 l/sec. and irrigation time per day is limited to 8 hours (AM9:00 – PM17:00), the irrigable area shall be 1.3 ha. The irrigable area in June shall be 2.6 ha when the peak irrigation time is assumed to be 16 hours. In the case of vegetable cultivation, irrigable area in a normal period (8 hours) shall be 1.3 ha when the amount of water in each irrigation time is 20 mm and with hydrant discharge of 10 l/sec while 2.6 ha shall be irrigated at peak period with irrigation time of 16 hours.

(4) Rotation Irrigation and Irrigation Block

Irrigable areas of each case study area (Male Levare, Kostoliste, Gajary) are ranging within 600 ha～300 ha. Based on the quantity of water supply by hydrant (15-20 l/sec) and size of pipe and pipeline system, the irrigable area is divided into 7 irrigation blocks in Male Levare, 3 blocks in Kostoliste and 4 blocks in Gajary. That is, each irrigation area is divided into irrigation blocks with a scale of 50 to 70 ha. Rotation irrigation systems of 7 days interval for cereal crops and 4 days for vegetables will be employed based upon the designed amount of irrigation water per application. In this case, 3～5 hydrants will cover 7～9ha/day according to the rotation schedule to reach every part of the area. The number of rotation blocks and hydrants are standardized as shown in the table below.

Relation between Hydrant Discharge, Irrigation Hour, and Irrigation Area

Irrigation hour	Irrigation hour														
	8hr			14hr			16hr			22hr			24hr		
Hydrant discharge (l/sec)	(mm) 10 (ha)	(mm) 20 (ha)	(mm) 30 (ha)	(mm) 10 (ha)	(mm) 20 (ha)	(mm) 30 (ha)	(mm) 10 (ha)	(mm) 20 (ha)	(mm) 30 (ha)	(mm) 10 (ha)	(mm) 20 (ha)	(mm) 30 (ha)	(mm) 10 (ha)	(mm) 20 (ha)	(mm) 30 (ha)
10.0	2.6	1.3	0.9	4.5	2.3	1.5	5.2	2.6	1.7	7.1	3.6	2.4	7.8	3.9	2.6
12.5	3.2	1.6	1.1	5.7	2.8	1.9	6.5	3.2	2.2	8.9	4.5	3.0	9.7	4.9	3.2
15.0	3.9	1.9	1.3	6.8	3.4	2.3	7.8	3.9	2.6	10.7	5.3	3.6	11.7	5.8	3.9
20.0	5.2	2.6	1.7	9.1	4.5	3.0	10.4	5.2	3.5	14.3	7.1	4.8	15.6	7.8	5.2

It also should be remembered that the irrigation rotation is established taking the diameter of conveyance pipe into account; in short, the discharge-duration between pipe velocity and conveyance discharge recommended is shown in the table below.

Number of Sprinkler and Pipe Velocity

Discharge of sprinkler	10 l/sec							15 l/sec						
Pipe diameter (m)	0.125	0.150	0.200	0.250	0.300	0.400	0.500	0.125	0.150	0.200	0.250	0.300	0.400	0.500
Area of pipe (m^2)	0.012	0.018	0.031	0.049	0.071	0.126	0.196	0.012	0.018	0.031	0.049	0.071	0.126	0.196
Number of sprinkler	1	2	5	7	11	20	35	1	2	3	5	7	13	24
Pipe velocity (m/sec)	0.815	1.132	1.592	1.426	1.556	1.592	1.7825	1.2223	1.698	1.432	1.528	1.485	1.552	1.833

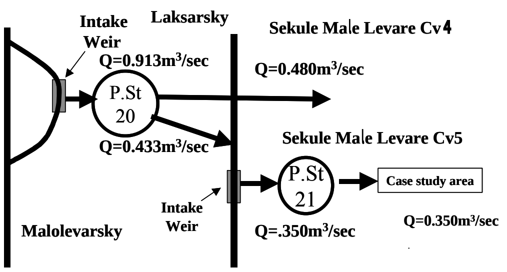
G.2.1.2.5 ESTABLISHMENT OF IRRIGABLE AREA

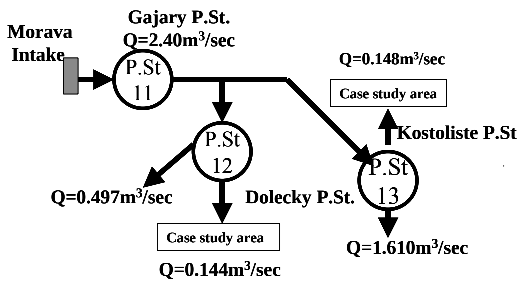
(1) Available Water for Irrigation

Irrigation water to supply the case study area is taken from the Morava River, which has enough flow to satisfy the irrigation water requirement of the area in question. This fact suggests that the availability of irrigation water is not limited by source of water but by conveyance capacity and operation time of pump. On condition that existing pumps should be used and that the operation time of pumps in July (maximum water requirement throughout the year) should be set as 16 hours (one of three pumps shall remain out of operation for use in times of emergency) for an average year and as 24 hours for a drought year, the available irrigation water to be conveyed to three pumping stations (Sekule Male Levare CV5, Kostoliste Cs and Dolecky Cs) is estimated as given in the table below.

Irrigation Area and Amount of Water Resource

Item	Sekule Male Levare Cv5	Kostoliste	Dolecky	Total
Irrigation area (ha)	590	294	404	1,288
Amount of water	m^3/sec	m^3/sec	m^3/sec	m^3/sec
Average year	0.233	0.098	0.096	0.427
Droughty area	0.350	0.148	0.144	0.642





(2) Irrigation for Crops

As it is stated in the foregoing paragraph, irrigation is needed for most crops to maintain suitable soil moisture to grow. However, only 20% of agricultural land is irrigated at present. The crops to be irrigated are vegetables, asparagus, potato, wheat, sunflower and others. Irrigation is absolutely needed throughout the cultivation period for vegetables and asparagus in order to produce acceptable quantity and quality. On the other hand, cereal crops such as wheat and maize can be grown and produced without a sharp drop of production even under some degree of water stress condition. Drought damage might lower the quality of wheat, maize and other crops but it still can be diverted to livestock feed. Likewise, alfalfa can be grown in accordance with water supply regardless of growing time. Accordingly, vegetables, soybean and asparagus are ranked as the first priority group to be irrigated. Then, sunflower, maize and wheat will be the next priority crops for irrigation. The cultivated area of these crops will be estimated based on the volume of available irrigation water and the assessment of irrigation effect in relation to soil and cultivated land.

(3) Irrigable Area according to Scenarios

The irrigable area in the case study area is estimated to be 856 ha fromcomponents obtained from the study on quantity of unit water requirement, available irrigation water volume and recommended crops to be cultivated based on the soil characteristic. An irrigation farm which aims to raise productivity of crops with a consistent supply of irrigation water entails investment in operation and maintenance of pumps and pipelines (including provision of spare parts), electric system, on-farm irrigation system (sprinkler), etc. Actually, approximately 67 ha of lands are irrigated within the case study area. With reference to the development of irrigation farming in the case study area, three scenarios with different irrigable area and investment level have been evaluated in relation to their impact on productivity of crops. An irrigable area for respective scenarios is established as explained below:

Scenario A (856 ha): aims at maximum use of available water for irrigation.

Scenario B (403 ha): intends to focus irrigation water on crops which produce higher benefits with irrigation (like vegetables).

Scenario C (185 ha): seeks to upgrade moderately prevailing irrigation to vegetables.

The irrigable area, target crops and irrigation water requirement for the three scenarios mentioned above are as follows:

Summary of Irrigation Area of Scenario A,B,C

Item	Scenario A			Scenario B			Scenario C		
	Irrigation area (ha)	No irrigation area (ha)	total (ha)	Irrigation area (ha)	No irrigation area (ha)	total (ha)	Irrigation area (ha)	No irrigation area (ha)	Total (ha)
Mala Levare (1)	403	186	589	121	469	589	51	538	589
Mala Levare (2)	236	59	295	174	121	295	69	226	295
Gajary	217	187	404	108	296	404	65	339	404
Total	856	432	1,288	403	885	1,288	185	1,103	1,288
Wheat	46	79	125	0	173	173	0	145	145
Spring barley	135	10	144	88	0	88		17	17
Grain maize	208	53	261	0	164	164	0	176	176
Vegetable	204	0	204	145	0	145	101	0	101
Potato	0	0	0	0	0	0	0	0	0
Asparagus	49	0	49	49	0	49	49	0	49
Sunflower	74	0	74	86	0	86	0	0	0
Soybeans	18	0	18	0	32	32	0	0	0
Alfalfa	122	84	206	35	158	193	35	260	295
Rapeseed	0	28	28	0	41	41	0	58	58
Rye	0	0	0	0	33	33	0	163	163
Apple	0	34	34	0	34	34	0	34	34
Meadow	0	146	146	0	251	251	0	251	251
Total	856	432	1,288	403	885	1,288	185	1,103	1,288

Namely, the irrigable area of scenario A is 856 ha, 403 ha in scenario B and 185 ha in scenario C, respectively.

The irrigation volume of water of each scenario is calculated as shown in the table below.

Water Volume for Irrigation in Scenario A,B,C

Item	Scenario A				Scenario B				Scenario C			
	Average Year (1993,1998)											
	Male Levare-1	Male Levare-2	Gajary	Total	Male Levare-1	Male Levare-2	Gajary	Total	Male Levare-1	Male Levare-2	Gajary	Total
	m^3/year	m^3/year	m^3/year	m^3/year	m^3/year	m^3/year	m^3/year	m^3/year	m^3/year	m^3/year	m^3/year	m^3/year
Wheat	11,157	47,033	0	58,190	0	0	0	0	0	0	0	0
Spring Barley	120,566	30,418	72,727	223,711	71,621	31,801	42,032	145,454	0	0	0	0
Grain maize	435,839	21,400	193,126	650,365	0	0	0	0	0	0	0	0
Vegetable	188,164	197,572	94,082	479,818	119,955	150,531	70,562	341,047	119,955	47,041	70,562	237,557
Potato	0	0	0	0	0	0	0	0	0	0	0	0
Asparagus	0	118,716	0	118,716	0	118,716	0	118,716	0	118,716	0	118,716
Sunflower	35,157	68,247	49,634	153,038	54,460	86,170	36,881	177,511	0	0	0	0
Soybeans	0	10,124	12,397	22,521	0	0	0	0	0	0	0	0
Alfalfa	204,321	2,376	83,154	289,851	0	0	83,154	83,154	0	0	81,903	81,903
Total	995,204	495,887	505,120	1,999,211	246,035	387,218	232,629	865,882	119,955	165,757	152,464	438,176

G.2.1.2.6 IRRIGATION METHOD BY CROP

The target crops under irrigation in the case study area are vegetables, cereals, oleaginous crops, pasture, etc. At present, irrigation water is provided mainly to vegetables (asparagus, carrot) by means of reel hose rotary sprinkler. With due consideration of the prevailing water supply system to farmlands as well as diversification and technological progress in the area of irrigation equipment, an appropriate irrigation system by crop is proposed as explained hereinafter.

(1) Irrigation to Cereals and Oleaginous Crops

Due to the fact that cereals and oleaginous crops are cultivated in large-scale lots and the farming system among these crops is similar, the same type of sprinkler can be applied. Generally speaking, sprinkler equipment available for irrigation systems are represented by: reel hose sprinkler, center pivot, lateral move and side-wheel sprinkler ; in so far as the case study area (including Zahorska lowland) is concerned, the reel hose sprinkler is recommended, because water conveyance pipelines and hydrants are already installed within the area and the equipment is more economical than others from the viewpoint of the size of lands to benefit; the center pivot is suited to large-scale lots extracting water from ground sources or diverted from farm ponds and the lateral move type is more costly than reel hose sprinkler in terms of necessary attachments. The type of reel hose sprinkler is selected by referring to the hydraulic conditions of hydrants: 650 – 1,200 l/min. of discharge and 5 – 8 kg/cm^2 of pressure; a variety of types are available from different manufacturers, but the one recommended is the 300-meter-length of reel hose. The irrigation efficiency of this type of reel hose sprinkler fluctuates according to wind condition; when strong wind prevails, the spraying width of irrigation water becomes narrower and, thus, traveling interval of the equipment should be adjusted taking account of this effect .

(2) Irrigation to Vegetables

It is desirable that the irrigation to vegetables should be provided not by the sprinkler with high pressure but by the one with medium or low pressure, because the plant body of vegetables is smaller and more fragile than cereals. Irrigation to root crops like carrot and onion may be provided by replacing the sprinkler nozzle of reel hose from high pressure type to medium pressure type with the discharge in the range of 650 – 1,200 l/min. and the pressure in the range of 5 – 8 kg/cm^2. For this purpose, the hydrant should be equipped with a device (valve) to lower the pressure. On the other hand, it should be remembered that the sprinkler with lower pressure is disadvantageous in terms of smaller spraying diameter that makes irrigation time longer.

Due to the fragile plant body, irrigation to leaf crops should be provided by the sprinkler with low pressure; it is advisable that the attachment of the sprinkler should be replaced by an arm spray sprinkler type. Regarding other irrigation methods to vegetables, a permanent sprinkler (solid set) system may be specified that irrigates fields by laying lateral pipes and dispensing with medium and low pressure sprinklers, or drip irrigation (pipes may be laid on the ground or underground), and perforated pipe irrigation. All of these methods are more costly than the reel hose type because they entail a number of on-farm equipment like pipeline network, sprinkler, drip pipe, etc. Nevertheless, the said methods make it possible to carry out on-farm irrigation control more economically – the focal factor for upgrading the quality of vegetables; simultaneous fertilization and application of pesticide and herbicide may be achieved and multi-purpose irrigation may be realized.

(3) Preparation of Irrigation Facilities

The previous considerations lead to the suggestion that the most appropriate irrigation method for cereals, maize and sunflower should be reel hose type sprinklers, from the viewpoint of the location of existing hydrants and adaptability of sprinklers. It is worth while to point out that farmers in the case study area have no experience of cultivating vegetables except for asparagus. Although the irrigation equipment actually employed by farmers in the area is limited to reel hose type, a variety of irrigation equipment may be introduced to the area in parallel with the progress of vegetables cultivation. It is important to decide on the employment of new irrigation equipment with due consideration to the balance between investment cost and expected benefits (farm-gate price and quality of crops). As an initial step to proceed with the development of a new irrigation system, it is recommended that a reel hose type sprinkler attached with medium size sprinkler and arm spray sprinkler is employed. An estimated number of reel hose sprinklers for respective scenario is as given below:

Number of Sprinkler of Each Case Study Area (Scenario A:Max-case)

Item	Male levare-1		Male levare-2		Gajary		Total
	Vegetable	Cereal	Vegetable	Cereal	Vegetable	Cereal	
Irrigation area	80	323	133	103	40	177	856
Irrigation area 1 set/day	2.6	2.6	2.6	2.6	2.6	2.6	-
Hydrant discharge	Number of Sprinkler						
0.010	8	-	13	-	4	-	25
0.015	-	18	-	6	-	10	34

Vegetable : Irrigation Interval : 4days

(4) Water Use and Farmer Council

In the case of extension of irrigated agriculture and increase of frequency in water use being realized, irrigation with rotation will be needed. On the other hand, use of hydrants within one rotation block will bring a limitation of 3 – 5 units at a time even on the day which is possible to irrigate. Consequently, it is necessary to organize a council among farmers who have connected pumps or rotation. Namely, for irrigation with rotation, it is important for farmers to cooperate with each other to keep a calendar irrigation. It is desirable to accelerate union formation under the guidance of SWME-PD in order to achieve smooth irrigation.

G.2.1.2.7 IRRIGATION COST

(1) Irrigation and Repair Cost

As described in G.2.1.2.6, it has been proposed that on-farm irrigation facilities shall be reel hose for cultivation of cereals and sunflower and reel hose attached with arm type sprinkler for vegetables. Irrigation cost consists of installation cost of sprinkler to receive water from hydrant, labor cost of operator during supply of irrigation water, depreciation cost and operation/ maintenance cost of sprinkler, etc. On the other hand, the following costs are taken into account in pricing water charge.

- Basic price: 2.0 SKK/m^3 (Payable from farmers to the State)
- Electricity cost: 0.35 SKK/m^3 (Payable from farmers to the State)
- Operation/maintenance cost: 0.5 SKK/m^3 (Payable from farmers to the maintenance company)

Water charge is calculated in accordance with the volume of water to be supplied, and the water requirement is variable by crop. The irrigation cost then is proportional to the volume of water to be supplied. Farmers benefit from the State subsidy of 70% of the sum of irrigation cost from sprinkler and water charge. The irrigation cost for each crop is given in the Table G.2.1.2.17 and is summarized in the table below:

Irrigation Cost

Item	unite	Wheat	Spring Barley	Grain maize	Sunflower	Soybeans	Alfalfa	Asparagus	Vegetable
	Average Year								
Water Requirement	(m3/year)	1,313	1,659	3,132	2,068	1,240	2,376	2,423	2,352
Irrigation cost	sk/ha	2,744	3,056	4,382	3,424	2,679	3,701	3,743	5,216
Item	Droughty Year (2000)								
Water Requirement	(m3/year)	2,558	2,696	4,200	3,031	1,193	3,294	3,355	3,787
Irrigation cost	sk/ha	3,865	3,990	5,343	4,291	2,637	4,528	4,583	6,508

(The irrigation cost contains the work expense ,equipment cost and water cost)

As for remaining costs relevant to the irrigation system (not chargeable to farmers), the following costs are paid by the State to the maintenance company.

- Administration cost of irrigation facilities: 190 SKK/ha
- Operation cost: 0.35 SKK/m^3

The services for repair and administration of main structures represented by pump and pipe are undertaken by SWME-PD at their expense, with the expansion of irrigable area in the case study area, it is proposed to strengthen related facilities and the cost required for this is estimated as shown in the Table G.2.1.2.19-20, with its summary as follows:

Repair Cost for Irrigation Facilities of Case Study Area

Irrigation system	unit	Male Levare (1)	Male Levare (2) (Kostoliste)	Gajary (Dolecky)	Gajary (P.St 11)	Total
Irrigation area	(ha)	590	294	404	-	1,288
Total repair cost	(Sk)	3,476,000	758,756	1,264,500	1,221,630	6,720,886
Unit repair cost	(Sk/ha)	5,892	2,581	3,130	1,460	-

(2) Assessment Study of Irrigation Cost

Economic correlation between amount of water use and maintenance cost is studied and suggested as follows.

1) Income and Expenditure of The Maintenance Company

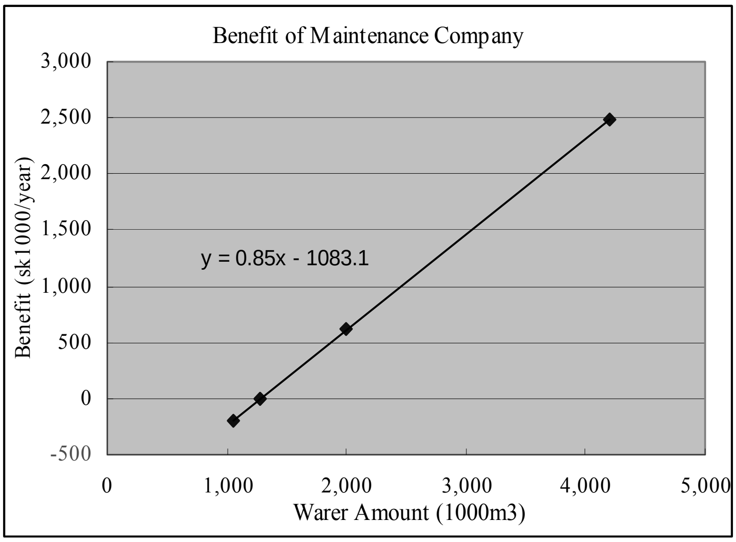
190.00 SKK per hectare of administration cost of the irrigation facilities paid from the State to the Company is an item of expenditure actually spent and pure income of the Company is shown as follows;

Operation and Maintenance Cost (from farmer):	0.35 SKK/m3
Operation cost (from State):	0.50 SKK/m3
Total	0.85 SKK/m3

On the other hand expenditures necessary for maintaining the Company can be estimated from survey in the field as shown below;

Labor Cost (annual):	809,968.00 (SKK/year)
Running Cost	174,690.00 (SKK/year)
Managing Cost:	98,465.80 (SKK/year)
Total	1,083,123.80(SKK/year)

As shown in the figure, the benefit to the Company will increase in proportion to the amount of water use and the break-even point is about 1.2 million cubic meters of water. As shown in the following figure, the amount of the water use changes according to the water use per ha and ratios of the irrigated area at the break-even point are 25% when unit water of 800 cubic meter per ha, that is equivalent to present value is used, and 22% when it increases up to 900 cubic meter.



Correlation of Water Amount and Irrigation Area in In-Servis: 6,473 ha

Case	A	B	C	D	E	F
Water Amount(1,000 m3)	1,050.0	1,280.0	1,278.0	2,000.0	4,200.0	6,400.0
Irrigation Area (ha)	1,500.0	1,600.0	1,420.0	2,000.0	3,000.0	4,000.0
Water Use per ha	700.0	800.0	900.0	1,000.0	1,400.0	1,600.0
Ratio of Irrigated Area(%)	23.2%	24.7%	21.9%	30.9%	46.3%	61.8%

2) Water Price

The whole cost necessary for irrigation consists of the fixed cost and the fluctuating cost; the former consists of cost of the maintenance company and maintenance cost of the irrigation facilities and the latter is electric cost imposed in proportion to water use.

i) Fixed Cost (in In-Service) : 5,614,223.80 SKK/year

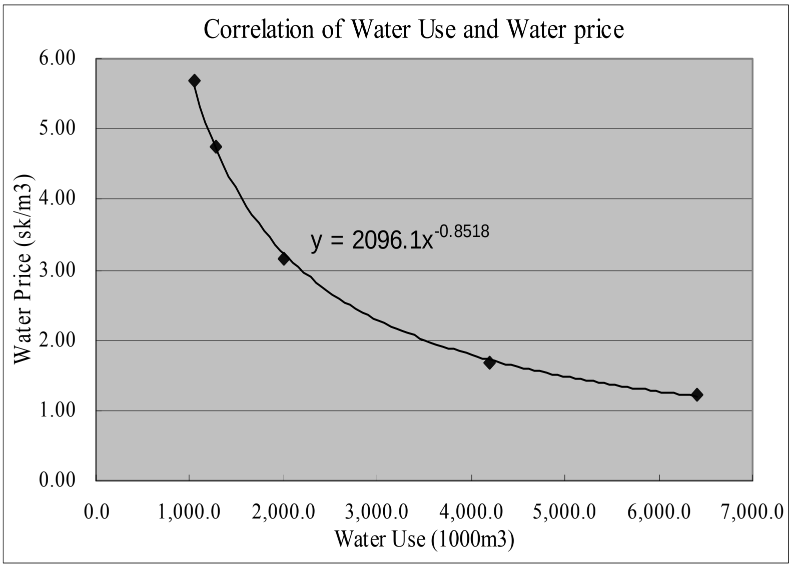
a. Maintenance Cost of Irrigation Facilities (700.00 SKK/ha x 6,743.0ha = 4,531,000.00 SKK)

b. Cost of Maintenance Company (In-Service: 1,083,123.80 SKK/year)

ii) Fluctuating Cost (Electric cost: 0.35 SKK/m^3)

On the other hand, current irrigation unit costs are shown as follows;

(A) Farmer's Portion: 2.85 SKK/m3
(B) State's Portion: 0.35 SKK/m3 (Operation cost)
(C) State's Portion: 190.00 SKK/ha (Administration cost of irrigation facilities)



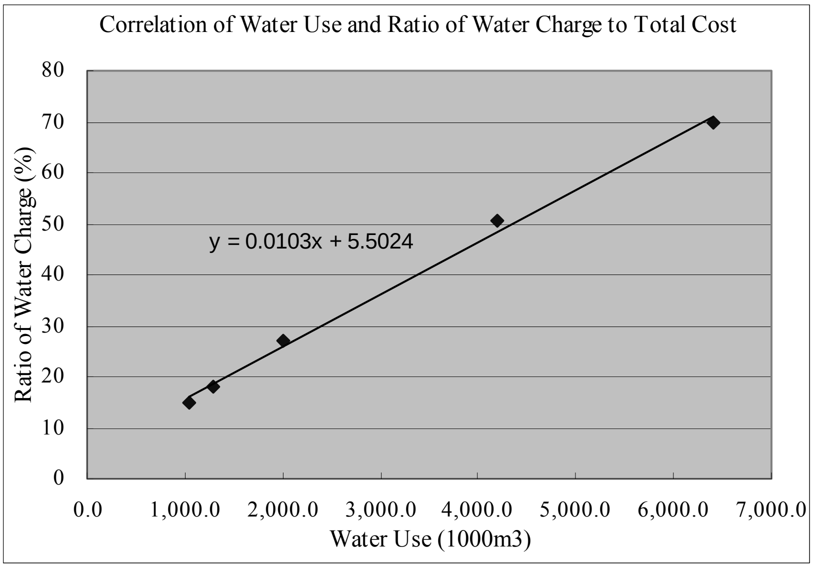
Cost (C) can be converted into around 0.30 SKK/m^3 by judging from the actual values of 0.25 to 0.40 SKK/m^3 in the past eight years. And accordingly, current irrigation unit cost shall be estimated to be 3.50 SKK/m^3 in all, which is equivalent to the break-even point of irrigation cost.

As shown in the upper figure, a correlation between water use and water price is expressed as an exponential function and a water price becomes cheaper rapidly as amount of water use increases. The amount of the water use at break-even point 3.50 SKK/m^3 is about 1,800,000 cubic meters and if there is a water use beyond this amount, it is possible to maintain the present water charge system at least. And if more water is used for irrigation, the water price will become cheaper, and when the ratio of irrigation is about 60%, it will be around 1.00 SKK/m^3.

3）Burden Rate of Water Users

Water users pay 30% of the following irrigation expenses, and the remaining 70 % is a governmental subsidy.

Basic price:	2.00 SKK/m^3
Operation and Maintenance Cost:	0.50 SKK/m^3
Electric Cost:	0.35 SKK/m^3
Total	2.85 SKK/m^3



Correlation between amount of water use and burden ratio of the water users to all irrigation costs is shown in the right figure. In the case where there is a small amount of irrigation water like the present condition, the burden ratio of the users is under 20% and the ratio of the subsidy is over 80%. The user's burden ratio also increases as water use increases, and the rate of the subsidy decreases conversely and it will be around 30% when the ratio of irrigation reaches around 60%.

4）Water Price in the Case Study Area

By applying the above-mentioned ideas to the Case Study Area, water prices for each scenarios can be calculated as shown in the following table. The water price of Scenario C, where amount of water use is the lowest within the three scenarios, is 3.25 SKK/m^3 and it is lower than the break-even point.

Water Price and Ratio of Water Charge in Case Study Site A

	Scenario A	Scenario B	Scenario C
Water Volume (1,000 m^3)	1,999	866	438
Fixed Cost	1,114,651	1,114,651	1,114,651
1) Maintenance Company	215,851	215,851	215,851
2) Expenses of State	898,800	898,800	898,800
Electric cost (100%)	699,650	303,100	153,300
Total Cost	1,814,301	1,417,751	1,267,951
Water Price (SKK/m^3)	0.91	1.64	2.89
Water Charge (Paid by farmer)	1,709,145	740,430	374,490
Ratio of Water Charge	94%	52%	30%

5）Summary

It is realized that the present subsidy or charge system in irrigation is maintained in situations such as: (1) amount of water use per hectare is rather low, (2) ratio of irrigation is considerably low, (3) consequently administration of the maintenance companies are barely maintained in the condition of lower water use, and (4) bigger costs to maintain the irrigation facilities are not needed due to low usage of the facilities. With expansion of irrigation, water price will become cheaper sharply and the rate of a governmental subsidy will become lower simultaneously. It is presumed that the current charge system would be unsuitable and need to be reviewed at some stage in the future.

G.2.1.2.8 OPERATION AND MAINTENANCE PLAN

(1) Project Implementation

Irrigation facilities are the property of SWME-ID, which are in charge of operation and maintenance of these works. In the light of this background, the recovery of the project shall be the responsibility of SWME-PD. On-farm irrigation facilities like sprinklers shall be prepared by farmers.

(2) Operation and Maintenance

1) Irrigation

A private company, which is entrusted by SWME-ID with the task in question, shall remain the responsible body for operation and maintenance of pumps and pipelines, meanwhile farmers shall take charge of on-farm irrigation works. In the case of some farmers making use of the same pump, it is essential that a water users' council should be established to make decisions on the distribution of irrigation water, prioritization for use of irrigation works, introduction of rotation for irrigation, etc.

2) Maintenance Cost

The maintenance and repair works for irrigation and drainage systems shall be undertaken on the basis of contracting. And, the operation and maintenance of pipelines including their minor repairs shall be in the charge of a private company, which is entrusted this task by SWME-ID on the basis of annual contracts; other repair tasks not in the annual contract shall be paid for on the basis of contracting for each task. Construction materials and equipment shall be procured by contractors, thus the cost relevant to these materials and equipment shall be estimated as depreciation cost.

Table G.2.1.2.1 (1) EVAPOTRANSPIRATION (ETo) PENMAN-MONTEITH CALCULATIONS (1993)

Give :	Station name :		Malacky				
	Data :		Year 1993				
	Latitude :		48.27	48.45	0.85	rad	
	Altitude :		165	m.			

Parameters :	Short Wave Rad		a_s =	0.25	b_s =	0.50		
	Albedo		alpha =	0.23				
	Long Wave Rad		a =	0.90	b =	0.10		
			al =	0.34	bl =	-0.139		
	Instrument height			wind	temp	Cropheight		AeroT Cff
	AerDyn Resistance	$r_a * U_z$ =	276	10.00	1.90	0.12		673
			Grass	Alfalfa				
	Canopy resistance	r_c =	70	86		12		

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Tmax (^oC)	5.5	3.0	8.8	16.5	25.1	24.5	25.5	26.5	21.2	15.7	5.0	5.8
Tmin (^oC)	-3.6	-6.6	-1.5	3.9	9.6	11.5	11.6	11.8	9.5	5.4	-2.0	-1.4
RHmean (%)	79	84	77	66	67	71	72	71	77	82	84	85
RHmin (%)	54	55	50	40	37	43	42	41	49	55	63	64
Wind (km/d)	121	130	138	173	147	138	156	95	112	138	112	121
Sunhours (h/d)												
Cloud (10^{th})	5.30	5.30	5.60	5.30	4.20	5.50	6.00	4.10	4.80	6.20	8.10	9.10
ET fao (mm/d)	0.35	0.60	1.19	2.53	3.92	4.04	3.98	3.54	2.34	1.26	0.56	0.31
ET fao (mm/M)	10.8	16.9	37.0	75.8	121.4	121.1	123.2	109.6	70.2	39.0	16.7	9.7
Avg Temp	0.95	-1.80	3.65	10.20	17.35	18.00	18.55	19.15	15.35	10.55	1.50	2.20
n/N	54%	54%	52%	54%	63%	53%	50%	64%	57%	48%	29%	14%
U_z (m/s)	1.40	1.50	1.60	2.00	1.70	1.60	1.80	1.10	1.30	1.60	1.30	1.40
U_2 (m/s)	1.05	1.12	1.20	1.50	1.27	1.20	1.35	0.82	0.97	1.20	0.97	1.05
Ea(Tmax)	0.90	0.76	1.13	1.88	3.19	3.07	3.26	3.46	2.52	1.78	0.87	0.92
Ea(Tmin)	0.47	0.37	0.55	0.81	1.20	1.36	1.37	1.38	1.19	0.90	0.53	0.55
Ea(Tx)-Ea(Tn)	0.69	0.57	0.84	1.34	2.19	2.22	2.31	2.42	1.85	1.34	0.70	0.74
Edew	0.49	0.42	0.57	0.75	1.16	1.34	1.39	1.40	1.24	0.98	0.55	0.59
RH(max-min)	79%	84%	77%	66%	67%	71%	72%	71%	77%	82%	84%	85%
Dlt(ETx-ETn)	0.05	0.04	0.06	0.09	0.14	0.14	0.14	0.15	0.12	0.09	0.05	0.05
P-atm.	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4
lambda	2.50	2.51	2.49	2.48	2.46	2.46	2.46	2.46	2.46	2.48	2.50	2.50
gamma	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.06
rc	70	70	70	70	70	70	70	70	70	70	70	70
ra	197	184	172	138	162	172	153	251	212	172	212	197
gamma*	0.09	0.09	0.09	0.10	0.09	0.09	0.10	0.08	0.09	0.09	0.09	0.09
dl/dl+gm*	0.36	0.32	0.39	0.47	0.59	0.60	0.60	0.64	0.57	0.49	0.37	0.37
gm/dl+gm*	0.47	0.50	0.43	0.35	0.29	0.29	0.28	0.28	0.32	0.36	0.48	0.46
Aeroterm	0.32	0.27	0.46	0.99	1.16	0.93	1.07	0.73	0.59	0.50	0.22	0.24
Month	1	2	3	4	5	6	7	8	9	10	11	12
dayno	15	46	76	107	137	168	198	229	259	290	320	351
soldeclin	-0.370	-0.230	-0.033	0.179	0.334	0.408	0.372	0.233	0.036	-0.176	-0.336	-0.408
xx	-0.271	-0.171	-0.025	0.133	0.245	0.297	0.272	0.173	0.027	-0.131	-0.247	-0.297
yy	0.618	0.646	0.663	0.653	0.627	0.609	0.618	0.645	0.663	0.653	0.626	0.609
omega	1.12	1.30	1.53	1.78	1.97	2.08	2.03	1.84	1.61	1.37	1.17	1.06
dr	1.03	1.02	1.01	0.99	0.98	0.97	0.97	0.98	0.99	1.01	1.02	1.03
Ra	9.81	15.38	23.66	32.61	38.92	41.81	40.23	34.51	26.31	17.45	11.08	8.39
N	8.53	9.95	11.71	13.57	15.07	15.89	15.48	14.07	12.31	10.45	8.91	8.11
Rns	3.9	6.1	9.3	13.0	16.9	16.5	15.5	15.1	10.8	6.6	3.4	2.1
f(n/N)	0.58	0.58	0.57	0.58	0.67	0.57	0.55	0.68	0.61	0.53	0.36	0.22
sigma(Tx_Tn)	27.71	26.62	28.83	31.68	35.05	35.32	35.60	35.91	34.03	31.81	27.91	28.20
emissivity	0.24	0.25	0.24	0.22	0.19	0.18	0.18	0.18	0.19	0.20	0.24	0.23
Rbo	6.72	6.64	6.77	6.95	6.64	6.32	6.26	6.28	6.28	6.43	6.59	6.57
LWR	3.92	3.87	3.85	4.05	4.44	3.63	3.45	4.26	3.86	3.43	2.36	1.46
Rn (Rns-Rl)	0.00	2.26	5.44	8.94	12.49	12.87	12.04	10.89	6.98	3.16	0.99	0.59
G	-0.18	-0.39	0.76	0.92	1.00	0.09	0.08	0.08	-0.53	-0.67	-1.27	0.10
Rn-G	0.17	2.64	4.68	8.02	11.49	12.78	11.96	10.81	7.51	3.83	2.26	0.49
Rad Term	0.00	0.29	0.85	1.71	2.99	3.13	2.93	2.82	1.62	0.63	0.15	0.09
Rad Term(-G)	0.02	0.33	0.73	1.53	2.75	3.10	2.91	2.80	1.75	0.76	0.33	0.07
ETcomb	0.32	0.55	1.31	2.70	4.16	4.06	3.99	3.56	2.22	1.12	0.37	0.33
	-7.8%	-8.8%	9.1%	6.5%	5.8%	0.5%	0.5%	0.6%	-5.6%	-11.8%	-50.3%	4.5%
ET (-G)	0.35	0.60	1.19	2.53	3.92	4.04	3.98	3.54	2.34	1.26	0.56	0.31
Crop height (m)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adjusment factor for Kc_mid&end	-0.05	-0.06	-0.04	0.00	0.00	-0.02	-0.01	-0.02	-0.04	-0.05	-0.08	-0.08

Table G.2.1.2.1 (2) EVAPOTRANSPIRATION (ETo) PENMAN-MONTEITH CALCULATIONS (1998)

Give :	Station name :		Malacky				
	Data :		Year 1998				
	Latitude :		48.27	48.45	0.85	rad	
	Altitude :		165	m.			

Parameters :	Short Wave Rad		a_s =	0.25	b_s =	0.50		
	Albedo		alpha =	0.23				
	Long Wave Rad		a =	0.90	b =	0.10		
			al =	0.34	bl =	-0.139		
	Instrument height			wind	temp	Cropheight		AeroT Cff
	AerDyn Resistance	$r_a * U_z$ =	276	10.00	1.90	0.12		673
			Grass	Alfalfa				
	Canopy resistance	r_c =	70	86		12		

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Tmax (^oC)	5.6	10.0	8.5	16.9	21.1	24.9	25.9	27.6	19.4	14.5	4.9	0.7
Tmin (^oC)	-1.7	-1.1	-0.5	6.4	9.1	13.7	14.2	14.4	10.7	7.5	-0.8	-4.3
RHmean (%)	84	75	68	66	66	70	69	64	80	83	84	87
RHmin (%)	63	47	47	44	42	47	45	39	58	64	67	71
Wind (km/d)	181	199	225	242	104	60	78	52	112	130	95	112
Sunhours (h/d)												
Cloud (10^{th})	6.50	5.70	6.20	6.40	5.10	5.10	5.30	4.30	6.60	7.50	7.40	7.10
ET fao (mm/d)	0.31	0.97	1.56	2.64	3.33	3.77	3.85	3.39	2.13	1.11	0.51	0.20
ET fao (mm/M)	9.5	27.2	48.3	79.1	103.3	113.0	119.4	105.2	64.0	34.3	15.3	6.3
Avg Temp	1.95	4.45	4.00	11.65	15.10	19.30	20.05	21.00	15.05	11.00	2.05	-1.80
n/N	45%	52%	48%	46%	55%	55%	54%	62%	44%	35%	36%	39%
U_z (m/s)	2.10	2.30	2.60	2.80	1.20	0.70	0.90	0.60	1.30	1.50	1.10	1.30
U_2 (m/s)	1.57	1.72	1.94	2.09	0.90	0.52	0.67	0.45	0.97	1.12	0.82	0.97
Ea(Tmax)	0.91	1.23	1.11	1.93	2.50	3.15	3.34	3.69	2.25	1.65	0.87	0.64
Ea(Tmin)	0.54	0.56	0.59	0.96	1.16	1.57	1.62	1.64	1.29	1.04	0.58	0.44
Ea(Tx)-Ea(Tn)	0.72	0.90	0.85	1.44	1.83	2.36	2.48	2.67	1.77	1.34	0.72	0.54
Edew	0.57	0.58	0.52	0.85	1.04	1.47	1.51	1.45	1.31	1.06	0.58	0.46
RH(max-min)	84%	75%	68%	66%	66%	70%	69%	64%	80%	83%	84%	87%
Dlt(ETx-ETn)	0.05	0.06	0.06	0.09	0.12	0.14	0.15	0.16	0.11	0.09	0.05	0.04
P-atm.	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4
lambda	2.50	2.49	2.49	2.47	2.47	2.46	2.45	2.45	2.47	2.48	2.50	2.51
gamma	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.06
rc	70	70	70	70	70	70	70	70	70	70	70	70
ra	131	120	106	98	230	394	306	459	212	184	251	212
gamma*	0.10	0.10	0.11	0.11	0.09	0.08	0.08	0.08	0.09	0.09	0.08	0.09
dl/dl+gm*	0.34	0.38	0.35	0.46	0.58	0.65	0.65	0.68	0.56	0.50	0.38	0.32
gm/dl+gm*	0.43	0.40	0.39	0.32	0.33	0.30	0.28	0.28	0.33	0.37	0.48	0.51
Aeroterm	0.34	0.70	0.80	1.26	0.72	0.43	0.57	0.46	0.46	0.37	0.18	0.14
Month	1	2	3	4	5	6	7	8	9	10	11	12
dayno	15	46	76	107	137	168	198	229	259	290	320	351
soldeclin	-0.370	-0.230	-0.033	0.179	0.334	0.408	0.372	0.233	0.036	-0.176	-0.336	-0.408
xx	-0.271	-0.171	-0.025	0.133	0.245	0.297	0.272	0.173	0.027	-0.131	-0.247	-0.297
yy	0.618	0.646	0.663	0.653	0.627	0.609	0.618	0.645	0.663	0.653	0.626	0.609
omega	1.12	1.30	1.53	1.78	1.97	2.08	2.03	1.84	1.61	1.37	1.17	1.06
dr	1.03	1.02	1.01	0.99	0.98	0.97	0.97	0.98	0.99	1.01	1.02	1.03
Ra	9.81	15.38	23.66	32.61	38.92	41.81	40.23	34.51	26.31	17.45	11.08	8.39
N	8.53	9.95	11.71	13.57	15.07	15.89	15.48	14.07	12.31	10.45	8.91	8.11
Rns	3.6	6.0	8.9	12.1	15.7	16.8	16.0	14.9	9.5	5.7	3.7	2.9
f(n/N)	0.51	0.56	0.53	0.51	0.59	0.59	0.58	0.66	0.50	0.42	0.42	0.45
sigma(Tx_Tn)	28.10	29.17	28.96	32.31	33.92	35.93	36.30	36.80	33.86	31.98	28.13	26.58
emissivity	0.24	0.23	0.24	0.21	0.20	0.17	0.17	0.17	0.18	0.20	0.23	0.25
Rbo	6.59	6.82	6.92	6.84	6.70	6.16	6.14	6.33	6.11	6.29	6.57	6.52
LWR	3.34	3.85	3.69	3.52	3.97	3.64	3.58	4.17	3.04	2.62	2.79	2.95
Rn (Rns-Rl)	0.25	2.16	5.24	8.53	11.69	13.18	12.45	10.70	6.48	3.09	0.88	-0.08
G	0.53	0.35	-0.06	1.07	0.48	0.59	0.11	0.13	-0.83	-0.57	-1.25	-0.54
Rn-G	-0.27	1.81	5.30	7.46	11.21	12.59	12.35	10.57	7.32	3.66	2.13	0.46
Rad Term	0.03	0.33	0.75	1.58	2.73	3.50	3.31	2.97	1.48	0.62	0.13	-0.01
Rad Term(-G)	-0.04	0.27	0.75	1.38	2.62	3.34	3.28	2.93	1.67	0.73	0.33	0.06
ETcomb	0.38	1.02	1.55	2.83	3.45	3.92	3.88	3.43	1.94	0.99	0.32	0.13
	19.0%	5.2%	-0.6%	7.0%	3.3%	4.0%	0.7%	1.1%	-9.8%	-11.5%	-60.7%	-51.2%
ET (-G)	0.31	0.97	1.56	2.64	3.33	3.77	3.85	3.39	2.13	1.11	0.51	0.20
Crop height (m)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adjusment factor for Kc_mid&end	-0.06	-0.01	-0.01	0.01	-0.02	-0.05	-0.04	-0.03	-0.07	-0.08	-0.10	-0.10

Table G.2.1.2.1 (3) EVAPOTRANSPIRATION (ETo) PENMAN-MONTEITH CALCULATIONS (2000)

Give :	Station name :	Malacky				
	Data :	Year 2000				
	Latitude :	48.27	48.45	0.85	rad	
	Altitude :	165	m.			

Parameters :	Short Wave Rad		a_s =	0.25	b_s =	0.50		
	Albedo		alpha =	0.23				
	Long Wave Rad		a =	0.90	b =	0.10		
			al =	0.34	bl =	-0.139		
	Instrument height			wind	temp	Cropheight		AeroT Cff
	AerDyn Resistance	$r_a * U_z$ =	276	10.00	1.90	0.12		673
			Grass	Alfalfa				
	Canopy resistance	r_c =	70	86		12		

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Tmax (^oC)	1.0	8.0	9.6	20.0	24.2	26.4	23.1	27.4	20.2	17.7	12.0	4.0
Tmin (^oC)	-5.5	-0.3	2.1	8.0	10.7	9.4	11.4	13.6	9.0	9.3	5.1	-0.2
RHmean (%)	85	78	79	64	62	57	70	70	75	77	84	88
RHmin (%)	65	56	59	40	37	29	45	42	49	56	65	75
Wind (km/d)	156	156	121	190	156	147	138	86	147	147	112	86
Sunhours (h/d)												
Cloud (10^{th})	6.40	5.90	6.60	3.40	3.70	2.30	5.90	2.80	4.80	5.30	5.60	6.40
ET fao (mm/d)	0.32	0.65	1.21	3.11	4.17	5.08	3.77	3.74	2.47	1.33	0.56	0.23
ET fao (mm/M)	10.1	18.2	37.6	93.2	129.3	152.3	116.8	116.0	74.0	41.3	16.7	7.0
Avg Temp	-2.25	3.85	5.85	14.00	17.45	17.90	17.25	20.50	14.60	13.50	8.55	1.90
n/N	46%	51%	44%	71%	68%	79%	51%	76%	57%	54%	52%	46%
U_z (m/s)	1.80	1.80	1.40	2.20	1.80	1.70	1.60	1.00	1.70	1.70	1.30	1.00
U_2 (m/s)	1.35	1.35	1.05	1.65	1.35	1.27	1.20	0.75	1.27	1.27	0.97	0.75
Ea(Tmax)	0.66	1.07	1.20	2.34	3.02	3.44	2.83	3.65	2.37	2.03	1.40	0.81
Ea(Tmin)	0.41	0.60	0.71	1.07	1.29	1.18	1.35	1.56	1.15	1.17	0.88	0.60
Ea(Tx)-Ea(Tn)	0.53	0.84	0.95	1.71	2.15	2.31	2.09	2.60	1.76	1.60	1.14	0.71
Edew	0.43	0.60	0.70	0.94	1.12	1.00	1.28	1.53	1.16	1.14	0.91	0.61
RH(max-min)	85%	78%	79%	64%	62%	57%	70%	70%	75%	77%	84%	88%
Dlt(ETx-ETn)	0.04	0.06	0.07	0.11	0.13	0.14	0.13	0.16	0.11	0.10	0.08	0.05
P-atm.	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4
lambda	2.51	2.49	2.49	2.47	2.46	2.46	2.46	2.45	2.47	2.47	2.48	2.50
gamma	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06
rc	70	70	70	70	70	70	70	70	70	70	70	70
ra	153	153	197	125	153	162	172	276	162	162	212	276
gamma*	0.09	0.09	0.09	0.10	0.10	0.09	0.09	0.08	0.09	0.09	0.09	0.08
dl/dl+gm*	0.29	0.38	0.43	0.52	0.58	0.60	0.58	0.66	0.54	0.52	0.47	0.38
gm/dl+gm*	0.49	0.43	0.42	0.31	0.29	0.28	0.30	0.27	0.32	0.33	0.40	0.49
Aeroterm	0.23	0.44	0.36	1.23	1.24	1.44	0.89	0.68	0.76	0.61	0.29	0.12
Month	1	2	3	4	5	6	7	8	9	10	11	12
dayno	15	46	76	107	137	168	198	229	259	290	320	351
soldeclin	-0.370	-0.230	-0.033	0.179	0.334	0.408	0.372	0.233	0.036	-0.176	-0.336	-0.408
xx	-0.271	-0.171	-0.025	0.133	0.245	0.297	0.272	0.173	0.027	-0.131	-0.247	-0.297
yy	0.618	0.646	0.663	0.653	0.627	0.609	0.618	0.645	0.663	0.653	0.626	0.609
omega	1.12	1.30	1.53	1.78	1.97	2.08	2.03	1.84	1.61	1.37	1.17	1.06
dr	1.03	1.02	1.01	0.99	0.98	0.97	0.97	0.98	0.99	1.01	1.02	1.03
Ra	9.81	15.38	23.66	32.61	38.92	41.81	40.23	34.51	26.31	17.45	11.08	8.39
N	8.53	9.95	11.71	13.57	15.07	15.89	15.48	14.07	12.31	10.45	8.91	8.11
Rns	3.6	6.0	8.6	15.2	17.7	20.7	15.6	16.7	10.8	7.0	4.4	3.1
f(n/N)	0.51	0.55	0.50	0.74	0.71	0.81	0.55	0.78	0.61	0.58	0.57	0.51
sigma(Tx_Tn)	26.42	28.89	29.73	33.41	35.06	35.35	34.94	36.56	33.67	33.13	30.89	28.06
emissivity	0.25	0.23	0.22	0.21	0.19	0.20	0.18	0.17	0.19	0.19	0.21	0.23
Rbo	6.57	6.70	6.62	6.84	6.75	7.09	6.38	6.13	6.39	6.33	6.40	6.48
LWR	3.38	3.72	3.29	5.06	4.82	5.73	3.54	4.82	3.93	3.69	3.64	3.34
Rn (Rns-Rl)	0.24	2.23	5.27	10.13	12.86	14.96	12.02	11.92	6.91	3.26	0.71	-0.24
G	-0.58	0.85	0.28	1.14	0.48	0.06	-0.09	0.46	-0.83	-0.15	-0.69	-0.93
Rn-G	0.82	1.37	4.99	8.99	12.38	14.89	12.12	11.46	7.73	3.42	1.40	0.69
Rad Term	0.03	0.34	0.90	2.12	3.05	3.65	2.86	3.19	1.52	0.69	0.13	-0.04
Rad Term(-G)	0.10	0.21	0.86	1.88	2.93	3.64	2.88	3.07	1.71	0.73	0.27	0.11
ETcomb	0.26	0.78	1.26	3.35	4.28	5.09	3.75	3.86	2.28	1.30	0.42	0.08
	-26.6%	16.8%	3.8%	7.1%	2.7%	0.3%	-0.6%	3.1%	-8.0%	-2.5%	-31.0%	-174.1%
ET (-G)	0.32	0.65	1.21	3.11	4.17	5.08	3.77	3.74	2.47	1.33	0.56	0.23
Crop height (m)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adjusment factor for Kc_mid&end	-0.08	-0.05	-0.07	0.00	0.00	0.02	-0.02	-0.03	-0.03	-0.05	-0.09	-0.12

Table G.2.1.2.2 (1) Crop Coefficient (Climte Conditions : Year 1992-1993)															
Item	1992			1993											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Monthly ETo (mm)	39.3	14.1	7.0	10.8	16.9	37.0	75.8	121.4	121.1	123.2	109.6	70.2	41.8	17.7	9.6
Monthly Precipitation (mm)	53.6	53.4	55.0	23.1	38.1	36.3	11.3	46.9	71.8	111.6	99.4	31.0	54.6	31.7	81.8
Effective Rainfall [Pe] (mm)	35.2	29.6	27.0	15.2	24.9	25.1	9.0	36.8	54.5	80.1	71.2	23.1	35.9	21.0	32.4
Winter Wheat															
Kc for Single Crop Coefficient	0.7	0.7	0.7	0.7	0.7	0.81	1.04	1.15	0.98	0.4					
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)	27.5	9.9	4.9	7.6	11.8	29.9	78.8	139.6	118.7	49.3					
Daily ETm [M. ETm / 30] (mm)	0.92	0.33	0.16	0.25	0.39	1.00	2.63	4.65	3.96	1.64					
Crop type	3	3	3	3	3	3	3	3	3	3					
Soil water depletion fraction [p]	0.831	0.848	0.853	0.851	0.847	0.829	0.737	0.535	0.604	0.810					
Spring Barley															
Kc for Single Crop Coefficient						1.00	1.00	1.07	1.14	0.54					
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)						37.0	75.8	129.9	138.1	66.5					
Daily ETm [M. ETm / 30] (mm)						1.23	2.53	4.33	4.60	2.22					
Crop type						3	3	3	3	3					
Soil water depletion fraction [p]						0.822	0.747	0.567	0.540	0.778					
Grain maize															
Kc for Single Crop Coefficient							0.70	0.88	1.10	1.19	1.13	0.72	0.4		
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)							53.0	106.8	133.2	146.6	123.9	50.6	16.7		
Daily ETm [M. ETm / 30] (mm)							1.77	3.56	4.44	4.89	4.13	1.69	0.56		
Crop type							4	4	4	4	4	4	4		
Soil water depletion fraction [p]							0.884	0.744	0.656	0.611	0.687	0.887	0.930		
Carrot															
Kc for Single Crop Coefficient						0.70	0.72	0.91	1.05	1.05	1.00				
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)						25.9	54.6	110.5	127.2	129.4	109.6				
Daily ETm [M. ETm / 30] (mm)						0.86	1.82	3.68	4.24	4.31	3.65				
Crop type	(estimated)					2	2	2	2	2	2				
Soil water depletion fraction [p]						0.700	0.679	0.507	0.457	0.452	0.510				
Onion															
Kc for Single Crop Coefficient							0.77	1.02	1.05	1.03	0.86				
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)							58.3	123.8	127.2	126.9	94.3				
Daily ETm [M. ETm / 30] (mm)							1.94	4.13	4.24	4.23	3.14				
Crop type							1	1	1	1	1				
Soil water depletion fraction [p]							0.501	0.344	0.338	0.338	0.414				
Radish															
Kc for Single Crop Coefficient						0.70	0.88								
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)						25.9	66.7								
Daily ETm [M. ETm / 30] (mm)						0.86	2.22								
Crop type	(estimated)					2	2								
Soil water depletion fraction [p]						0.700	0.653								
Potato															
Kc for Single Crop Coefficient							0.50	0.59	1.03	1.15	0.95				
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)							37.9	71.6	124.8	141.7	104.1				
Daily ETm [M. ETm / 30] (mm)							1.26	2.39	4.16	4.72	3.47				
Crop type							1	1	1	1	1				
Soil water depletion fraction [p]							0.510	0.471	0.342	0.314	0.390				
Green Beans															
Kc for Single Crop Coefficient							0.50	0.63	1.02	1.02					
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)							37.9	76.5	123.5	125.7					
Daily ETm [M. ETm / 30] (mm)							1.26	2.55	4.12	4.19					
Crop type							3	3	3	3					
Soil water depletion fraction [p]							0.821	0.745	0.588	0.581					
Soybeans															
Kc for Single Crop Coefficient							0.40	0.65	1.15	1.08	0.54				
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)							30.3	78.9	139.3	133.1	59.2				
Daily ETm [M. ETm / 30] (mm)							1.01	2.63	4.64	4.44	1.97				
Crop type							4	4	4	4	4				
Soil water depletion fraction [p]							0.913	0.828	0.636	0.656	0.876				
Sunflower															
Kc for Single Crop Coefficient							0.35	0.45	0.10	1.15	1.17	0.48			
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)							26.5	54.6	12.1	141.7	128.3	33.7			
Daily ETm [M. ETm / 30] (mm)							0.88	1.82	0.40	4.72	4.28	1.12			
Crop type							3	3	3	3	3	3			
Soil water depletion fraction [p]							0.832	0.805	0.846	0.528	0.572	0.825			
Rapeseed															
Kc for Single Crop Coefficient	0.35	0.35	0.35	0.35	0.35	0.35	0.60	1.11	0.60						
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)	13.7	4.9	2.5	3.8	5.9	12.9	45.5	134.7	72.7						
Daily ETm [M. ETm / 30] (mm)	0.46	0.16	0.08	0.13	0.20	0.43	1.52	4.49	2.42						
Crop type	3	3	3	3	3	3	3	3	3		(estimated)				
Soil water depletion fraction [p]	0.845	0.853	0.856	0.854	0.852	0.845	0.814	0.551	0.758						

Table G.2.1.2.2 (1) Crop Coefficient (Climte Conditions : Year 1992-1993)

Alfalfa (1)															
Kc for Single Crop Coefficient							0.70	1.11							
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)							53.0	134.7							
Daily ETm [M. ETm / 30] (mm)							1.77	4.49							
Crop type							3	3							
Soil water depletion fraction [p]							0.807	0.551							
Alfalfa (2)															
Kc for Single Crop Coefficient									0.50	1.18	0.83				
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)									60.6	145.4	91.0				
Daily ETm [M. ETm / 30] (mm)									2.02	4.85	3.03				
Crop type									3	3	3				
Soil water depletion fraction [p]									0.798	0.515	0.697				
Alfalfa (3)															
Kc for Single Crop Coefficient											0.40	0.96	1.04		
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)											43.8	67.4	43.5		
Daily ETm [M. ETm / 30] (mm)											1.46	2.25	1.45		
Crop type											3	3	3		
Soil water depletion fraction [p]											0.816	0.775	0.816		
Asparagus															
Kc for Single Crop Coefficient						0.50	0.61	0.92	0.95	0.95	0.92	0.66	0.37		
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)						18.5	46.2	111.7	115.1	117.1	100.9	46.4	15.5		
Daily ETm [M. ETm / 30] (mm)						0.62	1.54	3.72	3.84	3.90	3.36	1.55	0.52		
Crop type	(estimated)					2	2	2	2	2	2	2	2		
Soil water depletion fraction [p]						0.705	0.685	0.503	0.491	0.485	0.539	0.685	0.708		
Apples															
Kc for Single Crop Coefficient						0.47	0.63	0.83	0.95	0.95	0.95	0.82			
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)						17.4	47.7	100.7	115.1	117.1	104.1	57.6			
Daily ETm [M. ETm / 30] (mm)						0.58	1.59	3.36	3.84	3.90	3.47	1.92			
Crop type	(estimated)					3	3	3	3	3	3	3			
Soil water depletion fraction [p]						0.841	0.812	0.664	0.616	0.610	0.653	0.802			

Table G.2.1.2.2 (2) Crop Coefficient (Climte Conditions : Year 1997-1998)

Item	1997			1998											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Monthly ETo (mm)	41.8	17.7	9.6	9.5	27.2	48.3	79.1	103.3	113.0	119.4	105.2	64.0	34.3	15.3	6.3
Monthly Precipitation (mm)	17.6	80.5	37.3	21.4	4.0	25.3	51.6	26.2	98.4	74.4	33.5	148.8	121.3	27.8	23.7
Effective Rainfall [Pe] (mm)	12.3	39.6	24.3	14.0	4.0	18.1	36.4	21.1	71.1	55.9	27.0	82.6	54.6	18.4	15.4
Winter Wheat															
Kc for Single Crop Coefficient	0.7	0.7	0.7	0.7	0.7	0.81	1.04	1.15	0.98	0.4					
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)	29.2	12.4	6.7	6.7	19.0	39.1	82.3	118.8	110.7	47.8					
Daily ETm [M. ETm / 30] (mm)	0.97	0.41	0.22	0.22	0.63	1.30	2.74	3.96	3.69	1.59					
Crop type	3	3	3	3	3	3	3	3	3	3					
Soil water depletion fraction [p]	0.830	0.846	0.852	0.852	0.840	0.820	0.726	0.604	0.631	0.812					
Spring Barley															
Kc for Single Crop Coefficient						1.00	1.00	1.07	1.14	0.54					
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)						48.3	79.1	110.6	128.8	64.5					
Daily ETm [M. ETm / 30] (mm)						1.61	2.64	3.69	4.29	2.15					
Crop type						3	3	3	3	3					
Soil water depletion fraction [p]						0.811	0.736	0.631	0.571	0.785					
Grain maize															
Kc for Single Crop Coefficient							0.70	0.88	1.10	1.19	1.13	0.72	0.4		
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)							55.4	90.9	124.3	142.1	118.9	46.1	13.7		
Daily ETm [M. ETm / 30] (mm)							1.85	3.03	4.14	4.74	3.96	1.54	0.46		
Crop type							4	4	4	4	4	4	4		
Soil water depletion fraction [p]							0.881	0.797	0.686	0.626	0.704	0.893	0.934		
Carrot															
Kc for Single Crop Coefficient						0.70	0.72	0.91	1.05	1.05	1.00				
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)						33.8	56.9	94.0	118.6	125.4	105.2				
Daily ETm [M. ETm / 30] (mm)						1.13	1.90	3.13	3.95	4.18	3.51				
Crop type	(estimated)					2	2	2	2	2	2				
Soil water depletion fraction [p]						0.694	0.677	0.562	0.480	0.462	0.524				
Onion															
Kc for Single Crop Coefficient							0.77	1.02	1.05	1.03	0.86				
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)							60.9	105.4	118.6	123.0	90.5				
Daily ETm [M. ETm / 30] (mm)							2.03	3.51	3.95	4.10	3.02				
Crop type							1	1	1	1	1				
Soil water depletion fraction [p]							0.498	0.386	0.353	0.345	0.424				
Radish															
Kc for Single Crop Coefficient						0.70	0.88								
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)						33.8	69.6								
Daily ETm [M. ETm / 30] (mm)						1.13	2.32								
Crop type	(estimated)					2	2								
Soil water depletion fraction [p]						0.694	0.643								
Potato															
Kc for Single Crop Coefficient							0.50	0.59	1.03	1.15	0.95				
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)							39.5	61.0	116.4	137.3	99.9				
Daily ETm [M. ETm / 30] (mm)							1.32	2.03	3.88	4.58	3.33				
Crop type							1	1	1	1	1				
Soil water depletion fraction [p]							0.509	0.498	0.359	0.321	0.400				
Green Beans															
Kc for Single Crop Coefficient							0.50	0.63	1.02	1.02					
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)							39.5	65.1	115.2	121.8					
Daily ETm [M. ETm / 30] (mm)							1.32	2.17	3.84	4.06					
Crop type							3	3	3	3					
Soil water depletion fraction [p]							0.820	0.783	0.616	0.594					
Soybeans															
Kc for Single Crop Coefficient							0.40	0.65	1.15	1.08	0.54				
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)							31.6	67.2	129.9	129.0	56.8				
Daily ETm [M. ETm / 30] (mm)							1.05	2.24	4.33	4.30	1.89				
Crop type							4	4	4	4	4				
Soil water depletion fraction [p]							0.911	0.857	0.667	0.670	0.879				
Sunflower															
Kc for Single Crop Coefficient							0.35	0.45	0.10	1.15	1.17	0.48			
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)							27.7	46.5	11.3	137.3	123.1	30.7			
Daily ETm [M. ETm / 30] (mm)							0.92	1.55	0.38	4.58	4.10	1.02			
Crop type							3	3	3	3	3	3			
Soil water depletion fraction [p]							0.831	0.813	0.847	0.542	0.590	0.828			
Rapeseed															
Kc for Single Crop Coefficient	0.35	0.35	0.35	0.35	0.35	0.35	0.60	1.11	0.60						
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)	14.6	6.2	3.4	3.3	9.5	16.9	47.5	114.7	67.8						
Daily ETm [M. ETm / 30] (mm)	0.49	0.21	0.11	0.11	0.32	0.56	1.58	3.82	2.26						
Crop type	3	3	3	3	3	3	3	3	3		(estimated)				
Soil water depletion fraction [p]	0.844	0.852	0.855	0.855	0.849	0.842	0.812	0.618	0.774						

Table G.2.1.2.2 (2) Crop Coefficient (Climte Conditions : Year 1997-1998)

Alfalfa (1)															
Kc for Single Crop Coefficient							0.70	1.11							
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)							55.4	114.7							
Daily ETm [M. ETm / 30] (mm)							1.85	3.82							
Crop type							3	3							
Soil water depletion fraction [p]							0.804	0.618							
Alfalfa (2)															
Kc for Single Crop Coefficient									0.50	1.18	0.83				
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)									56.5	140.9	87.3				
Daily ETm [M. ETm / 30] (mm)									1.88	4.70	2.91				
Crop type									3	3	3				
Soil water depletion fraction [p]									0.803	0.530	0.709				
Alfalfa (3)															
Kc for Single Crop Coefficient											0.40	0.96	1.04		
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)											42.1	61.4	35.7		
Daily ETm [M. ETm / 30] (mm)											1.40	2.05	1.19		
Crop type											3	3	3		
Soil water depletion fraction [p]											0.817	0.795	0.824		
Asparagus															
Kc for Single Crop Coefficient						0.50	0.61	0.92	0.95	0.95	0.92	0.66	0.37		
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)						24.1	48.2	95.1	107.3	113.4	96.8	42.2	12.7		
Daily ETm [M. ETm / 30] (mm)						0.80	1.61	3.17	3.58	3.78	3.23	1.41	0.42		
Crop type	(estimated)					2	2	2	2	2	2	2	2		
Soil water depletion fraction [p]						0.701	0.684	0.558	0.517	0.497	0.552	0.688	0.710		
Apples															
Kc for Single Crop Coefficient						0.47	0.63	0.83	0.95	0.95	0.95	0.82			
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)						22.7	49.8	85.8	107.3	113.4	99.9	52.5			
Daily ETm [M. ETm / 30] (mm)						0.76	1.66	2.86	3.58	3.78	3.33	1.75			
Crop type	(estimated)					3	3	3	3	3	3	3			
Soil water depletion fraction [p]						0.836	0.810	0.714	0.642	0.622	0.667	0.807			

Table G.2.1.2.2 (3) Crop Coefficient (Climte Conditions : Year 1999-2000)

Item	1998			1999											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Monthly ETo (mm)	34.3	15.3	6.3	7.0	15.4	42.3	68.4	107.1	116.6	130.1	103.8	80.7	45.5	14.2	8.2
Monthly Precipitation (mm)	121.3	27.8	23.7	19.7	59.4	32.2	78.2	57.3	163.9	119.0	62.4	50.5	18.6	67.6	34.9
Effective Rainfall [Pe] (mm)	54.6	18.4	15.4	12.8	32.2	22.7	52.8	43.0	111.2	86.3	46.4	35.8	13.2	34.2	22.7
Winter Wheat															
Kc for Single Crop Coefficient	0.7	0.7	0.7	0.7	0.7	0.81	1.04	1.15	0.98	0.4					
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)	24.0	10.7	4.4	4.9	10.8	34.3	71.1	123.1	114.3	52.0					
Daily ETm [M. ETm / 30] (mm)	0.80	0.36	0.15	0.16	0.36	1.14	2.37	4.10	3.81	1.73					
Crop type	3	3	3	3	3	3	3	3	3	3					
Soil water depletion fraction [p]	0.835	0.848	0.854	0.853	0.848	0.825	0.763	0.590	0.619	0.808					
Spring Barley															
Kc for Single Crop Coefficient						1.00	1.00	1.07	1.14	0.54					
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)						42.3	68.4	114.6	133.0	70.2					
Daily ETm [M. ETm / 30] (mm)						1.41	2.28	3.82	4.43	2.34					
Crop type						3	3	3	3	3					
Soil water depletion fraction [p]						0.817	0.772	0.618	0.557	0.766					
Grain maize															
Kc for Single Crop Coefficient							0.70	0.88	1.10	1.19	1.13	0.72	0.4		
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)							47.9	94.2	128.3	154.8	117.3	58.1	18.2		
Daily ETm [M. ETm / 30] (mm)							1.60	3.14	4.28	5.16	3.91	1.94	0.61		
Crop type							4	4	4	4	4	4	4		
Soil water depletion fraction [p]							0.890	0.786	0.672	0.592	0.709	0.877	0.928		
Carrot															
Kc for Single Crop Coefficient						0.70	0.72	0.91	1.05	1.05	1.00				
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)						29.6	49.2	97.4	122.5	136.6	103.8				
Daily ETm [M. ETm / 30] (mm)						0.99	1.64	3.25	4.08	4.55	3.46				
Crop type	(estimated)					2	2	2	2	2	2				
Soil water depletion fraction [p]						0.697	0.683	0.550	0.469	0.434	0.529				
Onion															
Kc for Single Crop Coefficient							0.77	1.02	1.05	1.03	0.86				
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)							52.7	109.2	122.5	134.0	89.3				
Daily ETm [M. ETm / 30] (mm)							1.76	3.64	4.08	4.47	2.98				
Crop type							1	1	1	1	1				
Soil water depletion fraction [p]							0.503	0.377	0.346	0.327	0.427				
Radish															
Kc for Single Crop Coefficient						0.70	0.88								
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)						29.6	60.2								
Daily ETm [M. ETm / 30] (mm)						0.99	2.01								
Crop type	(estimated)					2	2								
Soil water depletion fraction [p]						0.697	0.674								
Potato															
Kc for Single Crop Coefficient							0.50	0.59	1.03	1.15	0.95				
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)							34.2	63.2	120.1	149.6	98.6				
Daily ETm [M. ETm / 30] (mm)							1.14	2.11	4.00	4.99	3.29				
Crop type							1	1	1	1	1				
Soil water depletion fraction [p]							0.512	0.492	0.350	0.301	0.403				
Green Beans															
Kc for Single Crop Coefficient							0.50	0.63	1.02	1.02					
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)							34.2	67.5	119.0	132.7					
Daily ETm [M. ETm / 30] (mm)							1.14	2.25	3.97	4.42					
Crop type							3	3	3	3					
Soil water depletion fraction [p]							0.825	0.775	0.603	0.558					
Soybeans															
Kc for Single Crop Coefficient							0.40	0.65	1.15	1.08	0.54				
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)							27.4	69.6	134.1	140.5	56.1				
Daily ETm [M. ETm / 30] (mm)							0.91	2.32	4.47	4.68	1.87				
Crop type							4	4	4	4	4				
Soil water depletion fraction [p]							0.916	0.851	0.653	0.632	0.880				
Sunflower															
Kc for Single Crop Coefficient							0.35	0.45	0.10	1.15	1.17	0.48			
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)							23.9	48.2	11.7	149.6	121.5	38.7			
Daily ETm [M. ETm / 30] (mm)							0.80	1.61	0.39	4.99	4.05	1.29			
Crop type							3	3	3	3	3	3			
Soil water depletion fraction [p]							0.835	0.811	0.847	0.501	0.595	0.821			
Rapeseed															
Kc for Single Crop Coefficient	0.35	0.35	0.35	0.35	0.35	0.35	0.60	1.11	0.60						

Table G.2.1.2.2 (3) Crop Coefficient (Climte Conditions : Year 1999-2000)

Alfalfa (1)															
Kc for Single Crop Coefficient							0.70	1.11							
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)							47.9	118.9							
Daily ETm [M. ETm / 30] (mm)							1.60	3.96							
Crop type							3	3							
Soil water depletion fraction [p]							0.812	0.604							
Alfalfa (2)															
Kc for Single Crop Coefficient									0.50	1.18	0.83				
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)									58.3	153.5	86.2				
Daily ETm [M. ETm / 30] (mm)									1.94	5.12	2.87				
Crop type									3	3	3				
Soil water depletion fraction [p]									0.802	0.494	0.713				
Alfalfa (3)															
Kc for Single Crop Coefficient											0.40	0.96	1.04		
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)											41.5	77.4	47.3		
Daily ETm [M. ETm / 30] (mm)											1.38	2.58	1.58		
Crop type											3	3	3		
Soil water depletion fraction [p]											0.818	0.742	0.812		
Asparagus															
Kc for Single Crop Coefficient						0.50	0.61	0.92	0.95	0.95	0.92	0.66	0.37		
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)						21.2	41.7	98.5	110.8	123.6	95.5	53.2	16.8		
Daily ETm [M. ETm / 30] (mm)						0.71	1.39	3.28	3.69	4.12	3.18	1.77	0.56		
Crop type	(estimated)					2	2	2	2	2	2	2	2		
Soil water depletion fraction [p]						0.703	0.688	0.547	0.506	0.466	0.557	0.680	0.707		
Apples															
Kc for Single Crop Coefficient						0.47	0.63	0.83	0.95	0.95	0.95	0.82			
Monthly ETm (=Etcrop) [Kc*M. ETo] (mm)						19.9	43.1	88.9	110.8	123.6	98.6	66.1			
Daily ETm [M. ETm / 30] (mm)						0.66	1.44	2.96	3.69	4.12	3.29	2.20			
Crop type	(estimated)					3	3	3	3	3	3	3			
Soil water depletion fraction [p]						0.839	0.816	0.704	0.631	0.588	0.671	0.780			

Table G.2.1.2.3 (1) Unit Crop Water Requirement (Climate Conditions : Average 1992-1993)

Crop :Winter wheat																	
Item	Description	1992			1993												Total (Oct-Jul)
		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
(1)Monthly Water Balance																	
Monthly ETo (mm)	(1)	39.3	14.1	7.0	10.8	16.9	37.0	75.8	121.4	121.1	123.2	109.6	70.2	41.8	17.7	9.6	566.6
Monthly precipitation (mm)	(2)	53.6	53.4	55.0	23.1	38.1	36.3	11.3	46.9	71.8	111.6	99.4	31.0	54.6	31.7	81.8	501.1
Effective rainfall (Pe)(mm)	(3)calculated by FAO-24 table	35.2	29.6	27.0	15.2	24.9	25.1	9.0	36.8	54.5	80.1	71.2	23.1	35.9	21.0	32.4	337.4
Upward water supply (Ge)(mm)	(4)estimation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kc for single crop coefficient	(5)from FAO-56 table	0.70	0.70	0.70	0.70	0.70	0.81	1.04	1.15	0.98	0.40						
Crop water requirement ETc(mm)	(6)=(1)*(5)	27.5	9.9	4.9	7.6	11.8	29.9	78.8	139.6	118.7	49.3						478.0
Daily ETc (M.ET c/30)(mm)	(7)=(6)/30	0.92	0.33	0.16	0.25	0.39	1.00	2.63	4.65	3.96	1.64						
Soil water depletion fraction [p]	(8)calculated by FAO-33 table	0.835	0.848	0.853	0.851	0.847	0.829	0.737	0.535	0.604	0.810						
Available soil water [Sa](mm/m)	(9) from JICA study team (14%)	140	140	140	140	140	140	140	140	140	140						
Root Depth [D](m)	(10) from JICA study team	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0						
Available soil water in root zone [D*Sa](mm)	(11)=(9)*(10)	140	140	140	140	140	140	140	140	140	140						
Remaining available soil water [(1-p)Sa*D](mm)	(12)=((1-(8)*(11))	23.1	21.3	20.6	20.9	21.4	23.9	36.8	65.1	55.4	26.6						
Available soil water to crop [p*Sa*D](mm)	(13)=(9)*(11)	116.9	118.7	119.4	119.1	118.6	116.1	103.2	74.9	84.6	113.4						
We of begiming of month [Wb+Pe+Ge]	(14)=(be.mon.(17)+(2)+(3))	120.0	122.1	139.2	134.6	144.0	143.7	122.8	80.8	54.5	80.1						
Rate of Cultivated period of month	(15)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0						
We of end of month [Wb+Pe+Ge-ETc]	(16)=(14)-(6)*(15)	92.5	112.2	134.3	127.0	132.2	113.8	44.0	-58.8	-64.2	30.9						
We carried over: (Wb)(mm)	(17)=(16)<=(13) 84.8	92.5	112.2	119.4	119.1	118.6	113.8	44.0	0.0	0.0	30.9						
Runoff of effective rainfall (mm)	(18)	0.0	0.0	14.9	7.9	13.6	0.0	0.0	0.0	0.0	0.0						
(2) Irrigation water requirement																	
Necessary irrigation water requirement (mm)	(19)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58.8	64.2	0.0						123.0
Net irrigation water requirement (m^3/ha)	(20)	0	0	0	0	0	0	0	588	642	0						1,230
Gross irrigation water requirement (m^3/ha)	(21)=(20)*(1/0.65)	0	0	0	0	0	0	0	905	988	0						1,893
Crop :Spring Barley																	
Item	Description	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
(1)Monthly Water Balance																	
Kc for single crop coefficient	(5)from FAO-56 table						1.00	1.00	1.07	1.14	0.54						
Crop water requirement ETc(mm)	(6)=(1)*(5)						37.0	75.8	129.9	138.1	66.5						447.2
Daily ETc (M.ET c/30)(mm)	(7)=(6)/30						1.23	2.53	4.33	4.60	2.22						
Soil water depletion fraction [p]	(8)calculated by FAO-33 table						0.822	0.747	0.567	0.540	0.778						
Available soil water [Sa](mm/m)	(9) from JICA study team (14%)						140	140	140	140	140						
Root Depth [D](m)	(10) from JICA study team						1.0	1.0	1.0	1.0	1.0						
Available soil water in root zone [D*Sa](mm)	(11)=(9)*(10)						140	140	140	140	140						
Remaining available soil water [(1-p)Sa*D](mm)	(12)=((1-(8)*(11))						24.9	35.4	60.6	64.4	31.1						
Available soil water to crop [p*Sa*D](mm)	(13)=(9)*(11)						115.1	104.6	79.4	75.6	108.9						
We of beginning of month [Wb+Pe+Ge]	(14)=(be.mon.(17)+(2)+(3))						140.3	112.3	73.3	54.5	80.1						
Rate of Cultivated period of month	(15)						1.0	1.0	1.0	1.0	1.0						
We of end of month [Wb+Pe+Ge-ETc]	(16)=(14)-(6)*(15)						103.3	36.6	-56.6	-83.6	13.6						
We carried over: (Wb)(mm)	(17)=(16)<=(13)					115.1	103.3	36.6	0.0	0.0	13.6						
Runoff of effective rainfall (mm)	(18)						0.0	0.0	0.0	0.0	0.0						0.0
(2) Irrigation water requirement																	
Necessary irrigation water requirement (mm)	(19)						0.0	0.0	56.6	83.6	0.0						140.2
Net irrigation water requirement (m^3/ha)	(20)						0	0	566	836	0						1,402
Gross irrigation water requirement (m^3/ha)	(21)=(20)*(1/0.65)						0	0	870	1,286	0						2,156

Table G.2.1.2.3 (2) Unit Crop Water Requirement (Climate Conditions : Average 1992-1993)

Crop :Sunflower

Item	Description	1992			1993												Total
		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	(Apr-Sep)
(1)Monthly Water Balance																	
Monthly ETo (mm)	(1)	39.3	14.1	7.0	10.8	16.9	37.0	75.8	121.4	121.1	123.2	109.6	70.2	41.8	17.7	9.6	621.4
Monthly precipitation (mm)	(2)	53.6	53.4	55.0	23.1	38.1	36.3	11.3	46.9	71.8	111.6	99.4	31.0	54.6	31.7	81.8	372.0
Effective rainfall (Pe)(mm)	(3)calculated by FAO-24 table	35.2	29.6	27.0	15.2	24.9	25.1	9.0	36.8	54.5	80.1	71.2	23.1	35.9	21.0	32.4	274.7
Upward water supply (Ge)(mm)	(4)estimation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kc for single crop coefficient	(5)from FAO-56 table							0.35	0.45	1.15	1.15	1.15	0.48				
Crop water requirement ETc(mm)	(6)=(1)*(5)							26.5	54.6	139.3	141.7	126.1	33.7				521.9
Daily ETc (M.ET c/30)(mm)	(7)=(6)/30							0.88	1.82	4.64	4.72	4.20	1.12				
Soil water depletion fraction[p]	(8)calculated by FAO-33 table							0.832	0.805	0.846	0.528	0.572	0.825				
Available soil water [Sa](mm/m)	(9) from JICA study team (14%)							140	140	140	140	140	140				
Root Depth [D](m)	(10) from JICA study team							1.0	1.0	1.0	1.0	1.0	1.0				
Available soil water in root zone [D*Sa](mm)	(11)=(9)*(10)							140	140	140	140	140	140				
Remaining available soil water [(1-p)Sa*D](mm	(12)=((1-(8)*(11))							23.5	27.3	21.5	66.1	59.9	24.4				
Available soil water to crop [p*Sa*D](mm)	(13)=(9)*(11)							116.5	112.7	118.5	73.9	80.1	115.6				
We of beginning of month [Wb+Pe+Ge]	(14)=(be.mon.(17)+(2)+(3))							82.3	110.3	110.2	80.1	71.2	23.1				
Rate of Cultivated period of month	(15)							0.3	1.0	1.0	1.0	1.0	0.5				
We of end of month [Wb+Pe+Ge-ETc]	(16)=(14)-(6)*(15)							73.6	55.7	-29.1	-61.6	-54.9	6.3				
We carried over: (Wb)(mm)	(17)=(16)<=(13)						73.3	73.6	55.7	0.0	0.0	0.0	6.3				
Runoff of effective rainfall (mm)	(18)							0.0	0.0	0.0	0.0	0.0	0.0				0.0
(2) Irrigation water requirement																	
Necessary irrigation water requirement (mm)	(19)							0.0	0.0	29.1	61.6	54.9	0.0				145.6
Net irrigation water requirement (m^3/ha)	(20)							0	0	291	616	549	0				1,456
Gross irrigation water requirement (m^3/ha)	(21)=(20)*(1/0.65)							0	0	448	947	845	0				2,240

Crop :Grain Maize

Item	Description	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
(1)Monthly Water Balance																	
Kc for single crop coefficient	(5)from FAO-56 table							0.70	0.88	1.10	1.19	1.13	0.72	0.40			
Crop water requirement ETc(mm)	(6)=(1)*(5)							53.0	106.8	133.2	146.6	123.9	50.6	16.7			630.9
Daily ETc (M.ET c/30)(mm)	(7)=(6)/30							1.77	3.56	4.44	4.89	4.13	1.69	0.56			
Soil water depletion fraction [p]	(8)calculated by FAO-33 table							0.884	0.744	0.656	0.611	0.687	0.887	0.930			
Available soil water [Sa](mm/m)	(9) from JICA study team (14%)							140	140	140	140	140	140	140			
Root Depth [D](m)	(10) from JICA study team							1.2	1.2	1.2	1.2	1.2	1.2	1.2			
Available soil water in root zone [D*Sa](mm)	(11)=(9)*(10)							168	168	168	168	168	168	168			
Remaining available soil water [(1-p)Sa*D](mm	(12)=((1-(8)*(11))							19.5	43.0	57.8	65.3	52.6	19.0	11.8			
Available soil water to crop [p*Sa*D](mm)	(13)=(9)*(11)							148.5	125.0	110.2	102.7	115.4	149.0	156.2			
We of beginning of month [Wb+Pe+Ge]	(14)=(be.mon.(17)+(2)+(3))							83.5	67.2	54.5	80.1	71.2	23.1	35.9			
Rate of Cultivated period of month	(15)							1.0	1.0	1.0	1.0	1.0	1.0	1.0			
We of end of month [Wb+Pe+Ge-ETc]	(16)=(14)-(6)*(15)							30.4	-39.6	-78.8	-66.5	-52.7	-27.4	19.2			
We carried over: (Wb)(mm)	(17)=(16)<=(13)						74.4	30.4	0.0	0.0	0.0	0.0	0.0	19.2			
Runoff of effective rainfall (mm)	(18)							0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0
(2) Irrigation water requirement																	
Necessary irrigation water requirement (mm)	(19)							0.0	39.6	78.8	66.5	52.7	27.4	0.0			265
Net irrigation water requirement (m^3/ha)	(20)							0	396	788	665	527	274	0			2,650
Gross irrigation water requirement (m^3/ha)	(21)=(20)*(1/0.65)							0	610	1,212	1,023	811	422	0			4,077

Table G.2.1.2.3 (3) Unit Crop Water Requirement (Climate Conditions : Average 1992-1993)

Crop :Carrot

Item	Description	1992 OCT	1992 NOV	1992 DEC	1993 JAN	1993 FEB	1993 MAR	1993 APR	1993 MAY	1993 JUN	1993 JUL	1993 AUG	1993 SEP	1993 OCT	1993 NOV	1993 DEC	Total (Mar-Aug)
(1)Monthly Water Balance																	
Monthly ETo (mm)	(1)	39.3	14.1	7.0	10.8	16.9	37.0	75.8	121.4	121.1	123.2	109.6	70.2	41.8	17.7	9.6	588.1
Monthly precipitation (mm)	(2)	53.6	53.4	55.0	23.1	38.1	36.3	11.3	46.9	71.8	111.6	99.4	31.0	54.6	31.7	81.8	377.3
Effective rainfall (mm) (Pe)	(3)calculated by FAO-24 table	35.2	29.6	27.0	15.2	24.9	25.1	9.0	36.8	54.5	80.1	71.2	23.1	35.9	21.0	32.4	276.7
Upward water supply	(4)estimation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kc for single crop coefficient	(5)from FAO-56 table						0.70	0.72	0.91	1.05	1.05	1.00					
Crop water requirement ETc(mm)	(6)=(1)*(5)						25.9	54.6	110.5	127.2	129.4	109.6					557.1
Daily ETc (M.ET c/30)(mm)	(7)=(6)/30						0.86	1.82	3.68	4.24	4.31	3.65					
Soil water depletion fraction [p]	(8)calculated by FAO-33 table						0.700	0.679	0.507	0.457	0.452	0.510					
Available soil water [Sa](mm/m)	(9) from JICA study team (14%)						140	140	140	140	140	140					
Root Depth [D](m)	(10) from FAO-56 table						0.5	0.5	0.5	0.5	0.5	0.5					
Available soil water in root zone [D*Sa](mm)	(11)=(9)*(10)						70	70	70	70	70	70					
Remaining available soil water [(1-p)Sa*D](mm)	(12)=((1-(8)*(11))						21.0	22.5	34.5	38.0	38.4	34.3					
Available soil water to crop [p*Sa*D](mm)	(13)=(9)*(11)						49.0	47.5	35.5	32.0	31.6	35.7					
We of beginning of month [Wb+Pe+Ge]	(14)=(be.mon.(17)+(2)+(3))						74.1	58.0	40.2	54.5	80.1	71.2					
Rate of Cultivated period of month	(15)						0.33	1.00	1.00	1.00	1.00	0.67					
We of end of month [Wb+Pe+Ge-ETc]	(16)=(14)-(6)*(15)						65.6	3.5	-70.2	-72.7	-49.2	-2.3					
We carried over: (Wb)(mm)	(17)=(16)<=(13)					49.0	49.0	3.5	0.0	0.0	0.0	0.0					
Runoff of effective rainfall (mm)	(18)						16.6	0.0	0.0	0.0	0.0	0.0					16.6
(2) Irrigation water requirement																	
Necessary irrigation water requirement (mm)	(19)						0.0	0.0	70.2	72.7	49.2	2.3					194.4
Net irrigation water requirement (m^3/ha)	(20)						0	0	702	727	492	23					1,944
Gross irrigation water requirement (m^3/ha)	(21)=(20)*(1/0.65)						0	0	1,080	1,118	758	35					2,992

Crop :Potato

Item	Description	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
(1)Monthly Water Balance																	
Kc for single crop coefficient	(5)from FAO-56 table							0.50	0.59	1.03	1.15	0.95					
Crop water requirement ETc(mm)	(6)=(1)*(5)							37.9	71.6	124.8	141.7	104.1					480.1
Daily ETc (M.ET c/30)(mm)	(7)=(6)/30							1.26	2.39	4.16	4.72	3.47					
Soil water depletion fraction [p]	(8)calculated by FAO-33 table							0.510	0.471	0.342	0.314	0.390					
Available soil water [Sa](mm/m)	(9) from JICA study team (14%)							140	140	140	140	140					
Root Depth [D](m)	(10) from FAO-56 table							0.5	0.5	0.5	0.5	0.5					
Available soil water in root zone [D*Sa](mm)	(11)=(9)*(10)							70	70	70	70	70					
Remaining available soil water [(1-p)Sa*D](mm)	(12)=((1-(8)*(11))							34.3	37.0	46.1	48.0	42.7					
Available soil water to crop [p*Sa*D](mm)	(13)=(9)*(11)							35.7	33.0	23.9	22.0	27.3					
We of end of month [Wb+Pe+Ge]	(14)=(be.mon.(17)+(2)+(3))							44.7	62.5	54.5	80.1	71.2					
Rate of Cultivated period of month	(15)							0.50	1.00	1.00	1.00	0.67					
We of end of month [Wb+Pe+Ge-ETc]	(16)=(14)-(6)*(15)							25.8	-9.1	-70.3	-61.6	1.4					
We carried over: (Wb)(mm)	(17)=(16)<=(13)						35.7	25.8	0.0	0.0	0.0	1.4					
Runoff of effective rainfall (mm)	(18)							0.0	0.0	0.0	0.0	0.0					0.0
(2) Irrigation water requirement																	
Necessary irrigation water requirement (mm)	(19)							0.0	9.1	70.3	61.6	0.0					140.9
Net irrigation water requirement (m^3/ha)	(20)							0	91	703	616	0					1,409
Gross irrigation water requirement (m^3/ha)	(21)=(20)*(1/0.65)							0	139	1,081	947	0					2,168

Table G.2.1.2.3 (4) Unit Crop Water Requirement (Climate Conditions : Average 1992-1993)

Crop :Asparagus

Item	Description	1992 OCT	1992 NOV	1992 DEC	1993 JAN	1993 FEB	1993 MAR	1993 APR	1993 MAY	1993 JUN	1993 JUL	1993 AUG	1993 SEP	1993 OCT	1993 NOV	1993 DEC	Total (Mar-oct)
(1)Monthly Water Balance																	
Monthly ETo (mm)	(1)	39.3	14.1	7.0	10.8	16.9	37.0	75.8	121.4	121.1	123.2	109.6	70.2	41.8	17.7	9.6	700.1
Monthly precipitation (mm)	(2)	53.6	53.4	55.0	23.1	38.1	36.3	11.3	46.9	71.8	111.6	99.4	31.0	54.6	31.7	81.8	462.9
Effective rainfall (mm) (Pe)	(3)calculated by FAO-24 table	35.2	29.6	27.0	15.2	24.9	25.1	9.0	36.8	54.5	80.1	71.2	23.1	35.9	21.0	32.4	335.8
Upward water supply	(4)estimation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kc for single crop coefficient	(5)from FAO-56 table						0.50	0.61	0.92	0.95	0.95	0.92	0.66	0.37			
Crop water requirement ETc(mm)	(6)=(1)*(5)						18.5	46.2	111.7	115.1	117.1	100.9	46.4	15.5			571.2
Daily ETc (M.ET c/30)(mm)	(7)=(6)/30						0.62	1.54	3.72	3.84	3.90	3.36	1.55	0.52			
Soil water depletion fraction [p]	(8)calculated by FAO-33 table						0.705	0.685	0.503	0.491	0.485	0.539	0.685	0.708			
Available soil water [Sa](mm/m)	(9) from JICA study team (14%)						140	140	140	140	140	140	140	140			
Root Depth [D](m)	(10) from FAO-56 table						1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0			
Available soil water in root zone [D*Sa](mm)	(11)=(9)*(10)						140	140	140	140	140	140	140	140			
Remaining available soil water [(1-p)Sa*D](mm)	(12)=((1-(8)*(11))						41.2	44.1	69.6	71.2	72.1	64.6	44.1	40.9			
Available soil water to crop [p*Sa*D](mm)	(13)=(9)*(11)						98.8	95.9	70.4	68.8	67.9	75.4	95.9	99.1			
We of beginning of month [Wb+Pe+Ge]	(14)=(be.mon.(17)+(2)+(3))						82.3	72.9	63.4	54.5	80.1	71.2	23.1	35.9			
Rate of Cultivated period of month	(15)						1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00			
We of end of month [Wb+Pe+Ge-ETc]	(16)=(14)-(6)*(15)						63.8	26.7	-48.2	-60.6	-36.9	-29.7	-23.2	20.5			
We carried over: (Wb)(mm)	(17)=(16)<=(13)					57.2	63.8	26.7	0.0	0.0	0.0	0.0	0.0	20.5			
Runoff of effective rainfall (mm)	(18)						0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0
(2) Irrigation water requirement																	
Necessary irrigation water requirement (mm)	(19)						0.0	0.0	48.2	60.6	36.9	29.7	23.2	0.0			198.7
Net irrigation water requirement (m^3/ha)	(20)						0	0	482	606	369	297	232	0			1,987
Gross irrigation water requirement (m^3/ha)	(21)=(20)*(1/0.65)						0	0	742	932	568	457	357	0			3,056

Crop :Rapeseed

Item	Description	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
(1)Monthly Water Balance																	
Kc for single crop coefficient	(5)from FAO-56 table	0.35	0.35	0.35	0.35	0.35	0.35	0.60	1.11	0.60							
Crop water requirement ETc(mm)	(6)=(1)*(5)	13.7	4.9	2.5	3.8	5.9	12.9	45.5	134.7	72.7							296.6
Daily ETc (M.ET c/30)(mm)	(7)=(6)/30	0.46	0.16	0.08	0.13	0.20	0.43	1.52	4.49	2.42							
Soil water depletion fraction [p]	(8)calculated by FAO-33 table	0.845	0.853	0.856	0.854	0.852	0.845	0.814	0.551	0.758							
Available soil water [Sa](mm/m)	(9) from JICA study team (14%)	140	140	140	140	140	140	140	140	140							
Root Depth [D](m)	(10) from FAO-56 table	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0							
Available soil water in root zone [D*Sa](mm)	(11)=(9)*(10)	140	140	140	140	140	140	140	140	140							
Remaining available soil water [(1-p)Sa*D](mm)	(12)=((1-(8)*(11))	21.7	20.5	20.2	20.4	20.7	21.6	26.0	62.9	33.9							
Available soil water to crop [p*Sa*D](mm)	(13)=(9)*(11)	118.3	119.5	119.8	119.6	119.3	118.4	114.0	77.1	106.1							
We of end of month [Wb+Pe+Ge]	(14)=(be.mon.(17)+(2)+(3))	127.6	143.4	146.5	134.9	144.5	144.5	127.4	118.7	54.5							
Rate of Cultivated period of month	(15)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
We of end of month [Wb+Pe+Ge-ETc]	(16)=(14)-(6)*(15)	113.8	138.5	144.0	131.2	138.6	131.5	81.9	-16.0	-18.2							
We carried over: (Wb)(mm)	(17)=(16)<=(13) 92.4	113.8	119.5	119.8	119.6	119.3	118.4	81.9	0.0	0.0							
Runoff of effective rainfall (mm)	(18)	0.0	19.0	24.2	11.6	19.3	13.2	0.0	0.0	0.0							87.2
(2) Irrigation water requirement																	
Necessary irrigation water requirement (mm)	(19)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0	18.2							34.2
Net irrigation water requirement (m^3/ha)	(20)	0	0	0	0	0	0	0	160	182							342.2
Gross irrigation water requirement (m^3/ha)	(21)=(20)*(1/0.65)	0	0	0	0	0	0	0	247	280							526

Table G.2.1.2.3 (5) Unit Crop Water Requirement (Climate Conditions : Average 1992-1993)

Crop :Alfalfa

Item	Description	1992 OCT	1992 NOV	1992 DEC	1993 JAN	1993 FEB	1993 MAR	1993 APR	1993 MAY	1993 JUN	1993 JUL	1993 AUG	1993 SEP	1993 OCT	1993 NOV	1993 DEC	Total (Apr-Oct)
(1)Monthly Water Balance																	
Monthly ETo (mm)	(1)	39.3	14.1	7.0	10.8	16.9	37.0	75.8	121.4	121.1	123.2	109.6	70.2	41.8	17.7	9.6	663.1
Monthly precipitation (mm)	(2)	53.6	53.4	55.0	23.1	38.1	36.3	11.3	46.9	71.8	111.6	99.4	31.0	54.6	31.7	81.8	426.6
Effective rainfall (mm) (Pe)	(3)calculated by FAO-24 table	35.2	29.6	27.0	15.2	24.9	25.1	9.0	36.8	54.5	80.1	71.2	23.1	35.9	21.0	32.4	310.6
Upward water supply	(4)estimation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kc for single crop coefficient	(5)from FAO-56 table							0.70	1.11	0.50	1.18	0.62	0.96	1.04			
Crop water requirement ETc(mm)	(6)=(1)*(5)							53.0	134.7	60.6	145.4	68.0	67.4	43.5			572.6
Daily ETc (M.ET c/30)(mm)	(7)=(6)/30							1.77	4.49	2.02	4.85	2.27	2.25	1.45			
Soil water depletion fraction [p]	(8)calculated by FAO-33 table							0.807	0.511	0.798	0.515	0.752	0.775	0.816			
Available soil water [Sa](mm/m)	(9) from JICA study team (14%)							140	140	140	140	140	140	140			
Root Depth [D](m)	(10) from FAO-56 table							1.0	1.0	1.0	1.0	1.0	1.0	1.0			
Available soil water in root zone [D*Sa](mm)	(11)=(9)*(10)							140	140	140	140	140	140	140			
Remaining available soil water [(1-p)Sa*D](mm)	(12)=((1-(8)*(11))							27.0	68.5	28.3	67.9	34.7	31.5	25.8			
Available soil water to crop [p*Sa*D](mm)	(13)=(9)*(11)							113.0	71.5	111.7	72.1	105.3	108.5	114.2			
We of beginning of month [Wb+Pe+Ge]	(14)=(be.mon.(17)+(2)+(3))							55.9	39.6	54.5	80.1	71.2	26.3	35.9			
Rate of Cultivated period of month	(15)							1.00	1.00	1.00	1.00	1.00	1.00	0.67			
We of end of month [Wb+Pe+Ge-ETc]	(16)=(14)-(6)*(15)							2.8	-95.1	-6.1	-65.3	3.2	-41.1	6.8			
We carried over: (Wb)(mm)	(17)=(16)<=(13)						46.8	2.8	0.0	0.0	0.0	3.2	0.0	6.8			
Runoff of effective rainfall (mm)	(18)							0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0
(2) Irrigation water requirement																	
Necessary irrigation water requirement (mm)	(19)							0.0	95.1	6.1	65.3	0.0	41.1	0.0			207.6
Net irrigation water requirement (m^3/ha)	(20)							0	951	61	653	0	411	0			2,076
Gross irrigation water requirement (m^3/ha)	(21)=(20)*(1/0.65)							0	1,464	93	1,004	0	632	0			3,194

Crop :Soybeans

Item	Description	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
(1)Monthly Water Balance																	
Kc for single crop coefficient	(5)from FAO-56 table							0.40	0.65	1.15	1.08	0.54					
Crop water requirement ETc(mm)	(6)=(1)*(5)							30.3	78.9	139.3	133.1	59.2					440.8
Daily ETc (M.ET c/30)(mm)	(7)=(6)/30							1.01	2.63	4.64	4.44	1.97					
Soil water depletion fraction [p]	(8)calculated by FAO-33 table							0.913	0.828	0.636	0.656	0.876					
Available soil water [Sa](mm/m)	(9) from JICA study team (14%)							140	140	140	140	140					
Root Depth [D](m)	(10) from FAO-56 table							0.6	0.6	0.6	0.6	0.6					
Available soil water in root zone [D*Sa](mm)	(11)=(9)*(10)							84	84	84	84	84					
Remaining available soil water [(1-p)Sa*D](mm)	(12)=((1-(8)*(11))							7.3	14.5	30.6	28.9	10.4					
Available soil water to crop [p*Sa*D](mm)	(13)=(9)*(11)							76.7	69.5	53.4	55.1	73.6					
We of end of month [Wb+Pe+Ge]	(14)=(be.mon.(17)+(2)+(3))							85.7	107.3	82.9	80.1	71.2					
Rate of Cultivated period of month	(15)							0.50	1.00	1.00	1.00	0.67					
We of end of month [Wb+Pe+Ge-ETc]	(16)=(14)-(6)*(15)							70.5	28.4	-56.4	-52.9	31.5					
We carried over: (Wb)(mm)	(17)=(16)<=(13)						76.7	70.5	28.4	0.0	0.0	31.5					
Runoff of effective rainfall (mm)	(18)							0.0	0.0	0.0	0.0	0.0					0.0
(2) Irrigation water requirement																	
Necessary irrigation water requirement (mm)	(19)							0.0	0.0	56.4	52.9	0.0					109.3
Net irrigation water requirement (m^3/ha)	(20)							0	0	564	529	0					1,093
Gross irrigation water requirement (m^3/ha)	(21)=(20)*(1/0.65)							0	0	868	814	0					1,682

Table G.2.1.2.3 (6) Unit Crop Water Requirement (Climate Conditions : Average 1997-1998)

Crop :Winter wheat																	
Item	Description	1997			1998												Total (Oct-Jul)
		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
(1)Monthly Water Balance																	
Monthly ETo (mm)	(1)	41.8	17.7	9.6	9.5	27.2	48.3	79.1	103.3	113.0	119.4	105.2	64.0	34.3	15.3	6.3	568.8
Monthly precipitation (mm)	(2)	17.6	80.5	37.3	21.4	4.0	25.3	51.6	26.2	98.4	74.4	33.5	148.8	121.3	27.8	23.7	436.7
Effective rainfall (Pe)(mm)	(3)calculated by FAO-24 table	12.3	39.6	24.3	14.0	4.0	18.1	36.4	21.1	71.1	55.9	27.0	82.6	54.6	18.4	15.4	296.7
Upward water supply (Ge)(mm)	(4)estimation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kc for single crop coefficient	(5)from FAO-56 table	0.70	0.70	0.70	0.70	0.70	0.81	1.04	1.15	0.98	0.40						
Crop water requirement ETc(mm)	(6)=(1)*(5)	29.2	12.4	6.7	6.7	19.0	39.1	82.3	118.8	110.7	47.8						472.7
Daily ETc (M.ET c/30)(mm)	(7)=(6)/30	0.97	0.41	0.22	0.22	0.63	1.30	2.74	3.96	3.69	1.59						
Soil water depletion fraction [p]	(8)calculated by FAO-33 table	0.830	0.846	0.852	0.852	0.840	0.820	0.726	0.604	0.631	0.812						
Available soil water [Sa](mm/m)	(9) from JICA study team (14%)	140	140	140	140	140	140	140	140	140	140						
Root Depth [D](m)	(10) from JICA study team	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0						
Available soil water in root zone [D*Sa](mm)	(11)=(9)*(10)	140	140	140	140	140	140	140	140	140	140						
Remaining available soil water [(1-p)Sa*D](mm)	(12)=((1-(8)*(11))	23.8	21.6	20.8	20.8	22.5	25.2	38.4	55.5	51.7	26.3						
Available soil water to crop [p*Sa*D](mm)	(13)=(9)*(11)	116.2	118.4	119.2	119.2	117.5	114.8	101.6	84.5	88.3	113.7						
We of beginning of month [Wb+Pe+Ge]	(14)=(be.mon.(17)+(2)+(3))	97.1	107.5	119.3	126.6	123.2	122.3	119.6	58.4	71.1	55.9						
Rate of Cultivated period of month	(15)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0						
We of end of month [Wb+Pe+Ge-ETc]	(16)=(14)-(6)*(15)	67.9	95.1	112.6	119.9	104.2	83.2	37.4	-60.4	-39.7	8.2						
We carried over: (Wb)(mm)	(17)=(16)<=(13) 84.8	67.9	95.1	112.6	119.2	104.2	83.2	37.4	0.0	0.0	8.2						
Runoff of effective rainfall (mm)	(18)	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0						
(2) Irrigation water requirement																	
Necessary irrigation water requirement (mm)	(19)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.4	39.7	0.0						100.1
Net irrigation water requirement (m^3/ha)	(20)	0	0	0	0	0	0	0	604	397	0						1,001
Gross irrigation water requirement (m^3/ha)	(21)=(20)*(1/0.65)	0	0	0	0	0	0	0	929	610	0						1,539

Crop :Spring Barley																	
Item	Description	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
(1)Monthly Water Balance																	
Kc for single crop coefficient	(5)from FAO-56 table						1.00	1.00	1.07	1.14	0.54						
Crop water requirement ETc(mm)	(6)=(1)*(5)						48.3	79.1	110.6	128.8	64.5						431.2
Daily ETc (M.ET c/30)(mm)	(7)=(6)/30						1.61	2.64	3.69	4.29	2.15						
Soil water depletion fraction [p]	(8)calculated by FAO-33 table						0.811	0.736	0.631	0.571	0.785						
Available soil water [Sa](mm/m)	(9) from JICA study team (14%)						140	140	140	140	140						
Root Depth [D](m)	(10) from JICA study team						1.0	1.0	1.0	1.0	1.0						
Available soil water in root zone [D*Sa](mm)	(11)=(9)*(10)						140	140	140	140	140						
Remaining available soil water [(1-p)Sa*D](mm)	(12)=((1-(8)*(11))						26.4	36.9	51.6	60.1	30.1						
Available soil water to crop [p*Sa*D](mm)	(13)=(9)*(11)						113.6	103.1	88.4	79.9	109.9						
We of beginning of month [Wb+Pe+Ge]	(14)=(be.mon.(17)+(2)+(3))						104.8	92.9	34.9	71.1	55.9						
Rate of Cultivated period of month	(15)						1.0	1.0	1.0	1.0	1.0						
We of end of month [Wb+Pe+Ge-ETc]	(16)=(14)-(6)*(15)						56.5	13.8	-75.7	-57.7	-8.5						
We carried over: (Wb)(mm)	(17)=(16)<=(13)					86.6	56.5	13.8	0.0	0.0	0.0						
Runoff of effective rainfall (mm)	(18)						0.0	0.0	0.0	0.0	0.0						0.0
(2) Irrigation water requirement																	
Necessary irrigation water requirement (mm)	(19)						0.0	0.0	75.7	57.7	8.5						142.0
Net irrigation water requirement (m^3/ha)	(20)						0	0	757	577	85						1,420
Gross irrigation water requirement (m^3/ha)	(21)=(20)*(1/0.65)						0	0	1,165	888	131						2,184

Table G.2.1.2.3 (7) Unit Crop Water Requirement (Climate Conditions : Average 1997-1998)

Crop :Sunflower

Item	Description	1997 OCT	1997 NOV	1997 DEC	1998 JAN	1998 FEB	1998 MAR	1998 APR	1998 MAY	1998 JUN	1998 JUL	1998 AUG	1998 SEP	1998 OCT	1998 NOV	1998 DEC	Total (Apr-Sep)
(1)Monthly Water Balance																	
Monthly ETo (mm)	(1)	41.8	17.7	9.6	9.5	27.2	48.3	79.1	103.3	113.0	119.4	105.2	64.0	34.3	15.3	6.3	584.0
Monthly precipitation (mm)	(2)	17.6	80.5	37.3	21.4	4.0	25.3	51.6	26.2	98.4	74.4	33.5	148.8	121.3	27.8	23.7	432.9
Effective rainfall (Pe)(mm)	(3)calculated by FAO-24 table	12.3	39.6	24.3	14.0	4.0	18.1	36.4	21.1	71.1	55.9	27.0	82.6	54.6	18.4	15.4	294.1
Upward water supply (Ge)(mm)	(4)estimation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kc for single crop coefficient	(5)from FAO-56 table							0.35	0.45	1.15	1.15	1.17	0.48				
Crop water requirement ETc(mm)	(6)=(1)*(5)							27.7	46.5	129.9	137.3	123.1	30.7				495.2
Daily ETc (M.ET c/30)(mm)	(7)=(6)/30							0.92	1.55	4.33	4.58	4.10	1.02				
Soil water depletion fraction[p]	(8)calculated by FAO-33 table							0.831	0.813	0.847	0.542	0.590	0.828				
Available soil water [Sa](mm/m)	(9) from JICA study team (14%)							140	140	140	140	140	140				
Root Depth [D](m)	(10) from JICA study team							1.0	1.0	1.0	1.0	1.0	1.0				
Available soil water in root zone [D*Sa](mm)	(11)=(9)*(10)							140	140	140	140	140	140				
Remaining available soil water [(1-p)Sa*D](mm)	(12)=((1-(8)*(11))							23.6	26.2	21.4	64.1	57.4	24.0				
Available soil water to crop [p*Sa*D](mm)	(13)=(9)*(11)							116.4	113.8	118.6	75.9	82.6	116.0				
We of beginning of month [Wb+Pe+Ge]	(14)=(be.mon.(17)+(2)+(3))							65.0	76.9	101.5	55.9	27.0	82.6				
Rate of Cultivated period of month	(15)							0.3	1.0	1.0	1.0	1.0	0.5				
We of end of month [Wb+Pe+Ge-ETc]	(16)=(14)-(6)*(15)							55.8	30.4	-28.5	-81.4	-96.1	67.2				
We carried over: (Wb)(mm)	(17)=(16)<=(13)						28.6	55.8	30.4	0.0	0.0	0.0	67.2				
Runoff of effective rainfall (mm)	(18)							0.0	0.0	0.0	0.0	0.0	0.0				0.0
(2) Irrigation water requirement																	
Necessary irrigation water requirement (mm)	(19)							0.0	0.0	28.5	81.4	96.1	0.0				205.9
Net irrigation water requirement (m^3/ha)	(20)							0	0	285	814	961	0				2,059
Gross irrigation water requirement (m^3/ha)	(21)=(20)*(1/0.65)							0	0	438	1,252	1,478	0				3,167

Crop :Grain Maize

Item	Description	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
(1)Monthly Water Balance																	
Kc for single crop coefficient	(5)from FAO-56 table							0.70	0.88	1.10	1.19	1.13	0.72	0.4			
Crop water requirement ETc(mm)	(6)=(1)*(5)							55.4	90.9	124.3	142.1	118.9	46.1	13.7			591.3
Daily ETc (M.ET c/30)(mm)	(7)=(6)/30							1.85	3.03	4.14	4.74	3.96	1.54	0.46			
Soil water depletion fraction [p]	(8)calculated by FAO-33 table							0.881	0.797	0.686	0.626	0.704	0.893	0.934			
Available soil water [Sa](mm/m)	(9) from JICA study team (14%)							140	140	140	140	140	140	140			
Root Depth [D](m)	(10) from JICA study team							1.2	1.2	1.2	1.2	1.2	1.2	1.2			
Available soil water in root zone [D*Sa](mm)	(11)=(9)*(10)							168	168	168	168	168	168	168			
Remaining available soil water [(1-p)Sa*D](mm)	(12)=((1-(8)*(11))							20.0	34.1	52.8	62.8	49.8	18.0	11.2			
Available soil water to crop [p*Sa*D](mm)	(13)=(9)*(11)							148.0	133.9	115.2	105.2	118.2	150.0	156.8			
We of beginning of month [Wb+Pe+Ge]	(14)=(be.mon.(17)+(2)+(3))							88.9	54.6	71.1	55.9	27.0	82.6	91.1			
Rate of Cultivated period of month	(15)							1.0	1.0	1.0	1.0	1.0	1.0	1.0			
We of end of month [Wb+Pe+Ge-ETc]	(16)=(14)-(6)*(15)							33.6	-36.3	-53.2	-86.1	-91.8	36.5	77.4			
We carried over: (Wb)(mm)	(17)=(16)<=(13)						52.5	33.6	0.0	0.0	0.0	0.0	36.5	77.4			
Runoff of effective rainfall (mm)	(18)							0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0
(2) Irrigation water requirement																	
Necessary irrigation water requirement (mm)	(19)							0.0	36.3	53.2	86.1	91.8	0.0	0.0			268
Net irrigation water requirement (m^3/ha)	(20)							0	363	532	861	918	0	0			2,675
Gross irrigation water requirement (m^3/ha)	(21)=(20)*(1/0.65)							0	558	819	1,325	1,413	0	0			4,115

Table G.2.1.2.3 (8) Unit Crop Water Requirement (Climate Conditions : Average 1997-1998)

Crop :Carrot

Item	Description	1997 OCT	1997 NOV	1997 DEC	1998 JAN	1998 FEB	1998 MAR	1998 APR	1998 MAY	1998 JUN	1998 JUL	1998 AUG	1998 SEP	1998 OCT	1998 NOV	1998 DEC	Total (Mar-Aug)
(1)Monthly Water Balance																	
Monthly ETo (mm)	(1)	41.8	17.7	9.6	9.5	27.2	48.3	79.1	103.3	113.0	119.4	105.2	64.0	34.3	15.3	6.3	568.3
Monthly precipitation (mm)	(2)	17.6	80.5	37.3	21.4	4.0	25.3	51.6	26.2	98.4	74.4	33.5	148.8	121.3	27.8	23.7	309.4
Effective rainfall (mm) (Pe)	(3)calculated by FAO-24 table	12.3	39.6	24.3	14.0	4.0	18.1	36.4	21.1	71.1	55.9	27.0	82.6	54.6	18.4	15.4	229.6
Upward water supply	(4)estimation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kc for single crop coefficient	(5)from FAO-56 table						0.70	0.72	0.91	1.05	1.05	1.00					
Crop water requirement ETc(mm)	(6)=(1)*(5)						33.8	56.9	94.0	118.6	125.4	105.2					534.0
Daily ETc (M.ET c/30)(mm)	(7)=(6)/30						1.13	1.90	3.13	3.95	4.18	3.51					
Soil water depletion fraction [p]	(8)calculated by FAO-33 table						0.694	0.677	0.562	0.480	0.462	0.524					
Available soil water [Sa](mm/m)	(9) from JICA study team (14%)						140	140	140	140	140	140					
Root Depth [D](m)	(10) from FAO-56 table						0.5	0.5	0.5	0.5	0.5	0.5					
Available soil water in root zone [D*Sa](mm)	(11)=(9)*(10)						70	70	70	70	70	70					
Remaining available soil water [(1-p)Sa*D](mm)	(12)=((1-(8)*(11))						21.4	22.6	30.7	36.4	37.7	33.3					
Available soil water to crop [p*Sa*D](mm)	(13)=(9)*(11)						48.6	47.4	39.3	33.6	32.3	36.7					
We of beginning of month [Wb+Pe+Ge]	(14)=(be.mon.(17)+(2)+(3))						95.0	85.0	49.1	71.1	55.9	27.0					
Rate of Cultivated period of month	(15)						0.33	1.00	1.00	1.00	1.00	0.67					
We of end of month [Wb+Pe+Ge-ETc]	(16)=(14)-(6)*(15)						83.8	28.0	-44.9	-47.6	-69.4	-43.5					
We carried over: (Wb)(mm)	(17)=(16)<=(13)					76.8	48.6	28.0	0.0	0.0	0.0	0.0					
Runoff of effective rainfall (mm)	(18)						35.2	0.0	0.0	0.0	0.0	0.0					35.2
(2) Irrigation water requirement																	
Necessary irrigation water requirement (mm)	(19)						0.0	0.0	44.9	47.6	69.4	43.5					205.4
Net irrigation water requirement (m^3/ha)	(20)						0	0	449	476	694	435					2,054
Gross irrigation water requirement (m^3/ha)	(21)=(20)*(1/0.65)						0	0	691	732	1,068	669					3,160

Crop :Potato

Item	Description	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
(1)Monthly Water Balance																	
Kc for single crop coefficient	(5)from FAO-56 table							0.50	0.59	1.03	1.15	0.95					
Crop water requirement ETc(mm)	(6)=(1)*(5)							39.5	61.0	116.4	137.3	99.9					454.1
Daily ETc (M.ET c/30)(mm)	(7)=(6)/30							1.32	2.03	3.88	4.58	3.33					
Soil water depletion fraction [p]	(8)calculated by FAO-33 table							0.509	0.498	0.359	0.321	0.400					
Available soil water [Sa](mm/m)	(9) from JICA study team (14%)							140	140	140	140	140					
Root Depth [D](m)	(10) from FAO-56 table							0.5	0.5	0.5	0.5	0.5					
Available soil water in root zone [D*Sa](mm)	(11)=(9)*(10)							70	70	70	70	70					
Remaining available soil water [(1-p)Sa*D](mm)	(12)=((1-(8)*(11))							34.4	35.2	44.9	47.5	42.0					
Available soil water to crop [p*Sa*D](mm)	(13)=(9)*(11)							35.6	34.8	25.1	22.5	28.0					
We of end of month [Wb+Pe+Ge]	(14)=(be.mon.(17)+(2)+(3))							72.0	56.7	71.1	55.9	27.0					
Rate of Cultivated period of month	(15)							0.50	1.00	1.00	1.00	0.67					
We of end of month [Wb+Pe+Ge-ETc]	(16)=(14)-(6)*(15)							52.2	-4.2	-45.3	-81.4	-39.9					
We carried over: (Wb)(mm)	(17)=(16)<=(13)						35.6	35.6	0.0	0.0	0.0	0.0					
Runoff of effective rainfall (mm)	(18)							16.6	0.0	0.0	0.0	0.0					16.6
(2) Irrigation water requirement																	
Necessary irrigation water requirement (mm)	(19)							0.0	4.2	45.3	81.4	39.9					170.8
Net irrigation water requirement (m^3/ha)	(20)							0	42	453	814	399					1,708
Gross irrigation water requirement (m^3/ha)	(21)=(20)*(1/0.65)							0	65	697	1,252	614					2,628

Table G.2.1.2.3 (9) Unit Crop Water Requirement (Climate Conditions : Average 1997-1998)

Crop :Asparagus

Item	Description	1997 OCT	1997 NOV	1997 DEC	1998 JAN	1998 FEB	1998 MAR	1998 APR	1998 MAY	1998 JUN	1998 JUL	1998 AUG	1998 SEP	1998 OCT	1998 NOV	1998 DEC	Total (Mar-oct)
(1)Monthly Water Balance																	
Monthly ETo (mm)	(1)	41.8	17.7	9.6	9.5	27.2	48.3	79.1	103.3	113.0	119.4	105.2	64.0	34.3	15.3	6.3	666.5
Monthly precipitation (mm)	(2)	17.6	80.5	37.3	21.4	4.0	25.3	51.6	26.2	98.4	74.4	33.5	148.8	121.3	27.8	23.7	579.5
Effective rainfall (mm) (Pe)	(3)calculated by FAO-24 table	12.3	39.6	24.3	14.0	4.0	18.1	36.4	21.1	71.1	55.9	27.0	82.6	54.6	18.4	15.4	366.8
Upward water supply	(4)estimation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kc for single crop coefficient	(5)from FAO-56 table						0.50	0.61	0.92	0.95	0.95	0.92	0.66	0.37			
Crop water requirement ETc(mm)	(6)=(1)*(5)						24.1	48.2	95.1	107.3	113.4	96.8	42.2	12.7			539.9
Daily ETc (M.ET c/30)(mm)	(7)=(6)/30						0.80	1.61	3.17	3.58	3.78	3.23	1.41	0.42			
Soil water depletion fraction [p]	(8)calculated by FAO-33 table						0.701	0.684	0.558	0.517	0.497	0.552	0.688	0.710			
Available soil water [Sa](mm/m)	(9) from JICA study team (14%)						140	140	140	140	140	140	140	140			
Root Depth [D](m)	(10) from FAO-56 table						1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0			
Available soil water in root zone [D*Sa](mm)	(11)=(9)*(10)						140	140	140	140	140	140	140	140			
Remaining available soil water [(1-p)Sa*D](mm)	(12)=((1-(8)*(11))						41.8	44.3	61.9	67.6	70.4	62.7	43.7	40.6			
Available soil water to crop [p*Sa*D](mm)	(13)=(9)*(11)						98.2	95.7	78.1	72.4	69.6	77.3	96.3	99.4			
We of beginning of month [Wb+Pe+Ge]	(14)=(be.mon.(17)+(2)+(3))						60.4	72.7	45.5	71.1	55.9	27.0	82.6	94.9			
Rate of Cultivated period of month	(15)						1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00			
We of end of month [Wb+Pe+Ge-ETc]	(16)=(14)-(6)*(15)						36.3	24.4	-49.6	-36.3	-57.5	-69.8	40.4	82.2			
We carried over: (Wb)(mm)	(17)=(16)<=(13)					42.3	36.3	24.4	0.0	0.0	0.0	-0.0	40.4	82.2			
Runoff of effective rainfall (mm)	(18)						0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0
(2) Irrigation water requirement																	
Necessary irrigation water requirement (mm)	(19)						0.0	0.0	49.6	36.3	57.5	69.8	0.0	0.0			213.1
Net irrigation water requirement (m^3/ha)	(20)						0	0	496	363	575	698	0	0			2,131
Gross irrigation water requirement (m^3/ha)	(21)=(20)*(1/0.65)						0	0	762	558	884	1,073	0	0			3,278

Crop :Rapeseed

Item	Description	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
(1)Monthly Water Balance																	
Kc for single crop coefficient	(5)from FAO-56 table	0.35	0.35	0.35	0.35	0.35	0.35	0.60	1.11	0.60							
Crop water requirement ETc(mm)	(6)=(1)*(5)	14.6	6.2	3.4	3.3	9.5	16.9	47.5	114.7	67.8							283.9
Daily ETc (M.ET c/30)(mm)	(7)=(6)/30	0.49	0.21	0.11	0.11	0.32	0.56	1.58	3.82	2.26							
Soil water depletion fraction [p]	(8)calculated by FAO-33 table	0.844	0.852	0.855	0.855	0.849	0.842	0.812	0.618	0.774							
Available soil water [Sa](mm/m)	(9) from JICA study team (14%)	140	140	140	140	140	140	140	140	140							
Root Depth [D](m)	(10) from FAO-56 table	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0							
Available soil water in root zone [D*Sa](mm)	(11)=(9)*(10)	140	140	140	140	140	140	140	140	140							
Remaining available soil water [(1-p)Sa*D](mm)	(12)=((1-(8)*(11))	21.9	20.7	20.3	20.3	21.2	22.2	26.3	53.5	31.6							
Available soil water to crop [p*Sa*D](mm)	(13)=(9)*(11)	118.1	119.3	119.7	119.7	118.8	117.8	113.7	86.5	108.4							
We of end of month [Wb+Pe+Ge]	(14)=(be.mon.(17)+(2)+(3))	104.7	129.7	143.5	133.6	123.7	132.3	151.8	125.4	81.8							
Rate of Cultivated period of month	(15)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
We of end of month [Wb+Pe+Ge-ETc]	(16)=(14)-(6)*(15)	90.1	123.5	140.2	130.3	114.2	115.4	104.3	10.7	14.0							
We carried over: (Wb)(mm)	(17)=(16)<=(13) 92.4	90.1	119.3	119.7	119.7	114.2	115.4	104.3	10.7	14.0							
Runoff of effective rainfall (mm)	(18)	0.0	4.2	20.5	10.6	0.0	0.0	0.0	0.0	0.0							35.4
(2) Irrigation water requirement																	
Necessary irrigation water requirement (mm)	(19)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0							0.0
Net irrigation water requirement (m^3/ha)	(20)	0	0	0	0	0	0	0	0	0							0.0
Gross irrigation water requirement (m^3/ha)	(21)=(20)*(1/0.65)	0	0	0	0	0	0	0	0	0							0

Table G.2.1.2.3 (10) Unit Crop Water Requirement (Climate Conditions : Average 1997-1998)

Crop :Alfalfa

Item	Description	1997 OCT	1997 NOV	1997 DEC	1998 JAN	1998 FEB	1998 MAR	1998 APR	1998 MAY	1998 JUN	1998 JUL	1998 AUG	1998 SEP	1998 OCT	1998 NOV	1998 DEC	Total (Apr-Oct)
(1)Monthly Water Balance																	
Monthly ETo (mm)	(1)	41.8	17.7	9.6	9.5	27.2	48.3	79.1	103.3	113.0	119.4	105.2	64.0	34.3	15.3	6.3	618.3
Monthly precipitation (mm)	(2)	17.6	80.5	37.3	21.4	4.0	25.3	51.6	26.2	98.4	74.4	33.5	148.8	121.3	27.8	23.7	554.2
Effective rainfall (mm) (Pe)	(3)calculated by FAO-24 table	12.3	39.6	24.3	14.0	4.0	18.1	36.4	21.1	71.1	55.9	27.0	82.6	54.6	18.4	15.4	348.6
Upward water supply	(4)estimation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kc for single crop coefficient	(5)from FAO-56 table							0.70	1.11	0.50	1.18	0.62	0.96	1.04			
Crop water requirement ETc(mm)	(6)=(1)*(5)							55.4	114.7	56.5	140.9	65.2	61.4	35.7			529.8
Daily ETc (M.ET c/30)(mm)	(7)=(6)/30							1.85	3.82	1.88	4.70	2.17	2.05	1.19			
Soil water depletion fraction [p]	(8)calculated by FAO-33 table							0.804	0.618	0.803	0.530	0.763	0.795	0.824			
Available soil water [Sa](mm/m)	(9) from JICA study team (14%)							140	140	140	140	140	140	140			
Root Depth [D](m)	(10) from FAO-56 table							1.0	1.0	1.0	1.0	1.0	1.0	1.0			
Available soil water in root zone [D*Sa](mm)	(11)=(9)*(10)							140	140	140	140	140	140	140			
Remaining available soil water [(1-p)Sa*D](mm)	(12)=((1-(8)*(11))							27.4	53.5	27.5	65.7	33.2	28.7	24.7			
Available soil water to crop [p*Sa*D](mm)	(13)=(9)*(11)							112.6	86.5	112.5	74.3	106.8	111.3	115.3			
We of beginning of month [Wb+Pe+Ge]	(14)=(be.mon.(17)+(2)+(3))							61.3	27.0	71.1	70.5	27.0	82.6	75.7			
Rate of Cultivated period of month	(15)							1.00	1.00	1.00	1.00	1.00	1.00	0.67			
We of end of month [Wb+Pe+Ge-ETc]	(16)=(14)-(6)*(15)							6.0	-87.7	14.6	-70.4	-38.2	21.2	51.8			
We carried over: (Wb)(mm)	(17)=(16)<=(13)						24.9	6.0	0.0	14.6	0.0	0.0	21.2	51.8			
Runoff of effective rainfall (mm)	(18)							0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0
(2) Irrigation water requirement																	
Necessary irrigation water requirement (mm)	(19)							0.0	87.7	0.0	70.4	38.2	0.0	0.0			196.3
Net irrigation water requirement (m^3/ha)	(20)							0	877	0	704	382	0	0			1,963
Gross irrigation water requirement (m^3/ha)	(21)=(20)*(1/0.65)							0	1,349	0	1,083	588	0	0			3,019

Crop :Soybeans

Item	Description	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
(1)Monthly Water Balance																	
Kc for single crop coefficient	(5)from FAO-56 table							0.40	0.65	1.15	1.08	0.54					
Crop water requirement ETc(mm)	(6)=(1)*(5)							31.6	67.2	129.9	129.0	56.8					414.5
Daily ETc (M.ET c/30)(mm)	(7)=(6)/30							1.05	2.24	4.33	4.30	1.89					
Soil water depletion fraction [p]	(8)calculated by FAO-33 table							0.911	0.857	0.667	0.670	0.879					
Available soil water [Sa](mm/m)	(9) from JICA study team (14%)							140	140	140	140	140					
Root Depth [D](m)	(10) from FAO-56 table							0.6	0.6	0.6	0.6	0.6					
Available soil water in root zone [D*Sa](mm)	(11)=(9)*(10)							84	84	84	84	84					
Remaining available soil water [(1-p)Sa*D](mm)	(12)=((1-(8)*(11))							7.5	12.0	28.0	27.7	10.2					
Available soil water to crop [p*Sa*D](mm)	(13)=(9)*(11)							76.5	72.0	56.0	56.3	73.8					
We of end of month [Wb+Pe+Ge]	(14)=(be.mon.(17)+(2)+(3))							112.9	97.6	101.5	55.9	27.0					
Rate of Cultivated period of month	(15)							0.50	1.00	1.00	1.00	0.67					
We of end of month [Wb+Pe+Ge-ETc]	(16)=(14)-(6)*(15)							97.1	30.4	-28.4	-73.0	-11.0					
We carried over: (Wb)(mm)	(17)=(16)<=(13)						76.5	76.5	30.4	0.0	0.0	0.0					
Runoff of effective rainfall (mm)	(18)							20.6	0.0	0.0	0.0	0.0					20.6
(2) Irrigation water requirement																	
Necessary irrigation water requirement (mm)	(19)							0.0	0.0	28.4	73.0	11.0					112.5
Net irrigation water requirement (m^3/ha)	(20)							0	0	284	730	110					1,125
Gross irrigation water requirement (m^3/ha)	(21)=(20)*(1/0.65)							0	0	437	1,123	170					1,730

Table G.2.1.2.3 (11) Unit Crop Water Requirement (Climate Conditions : Droughty 1999-2000)

Crop :Winter wheat																	
Item	Description	1999			2000												Total (Oct-Jul)
		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
(1)Monthly Water Balance																	
Monthly ETo (mm)	(1)	45.5	14.2	8.2	10.1	18.2	37.6	93.2	129.3	152.3	116.8	116.0	74.0	41.3	16.7	7.0	625.4
Monthly precipitation (mm)	(2)	18.6	67.6	34.9	38.6	40.0	72.6	8.6	43.8	19.2	84.3	66.2	46.6	42.9	67.5	43.7	428.2
Effective rainfall (Pe)(mm)	(3)calculated by FAO-24 table	13.2	34.2	22.7	24.7	25.7	45.7	8.6	35.4	17.5	62.5	50.3	33.1	29.3	35.9	25.2	290.0
Upward water supply (Ge)(mm)	(4)estimation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kc for single crop coefficient	(5)from FAO-56 table	0.7	0.7	0.7	0.7	0.7	0.81	1.04	1.15	0.98	0.4						
Crop water requirement ETc(mm)	(6)=(1)*(5)	31.9	10.0	5.7	7.0	12.7	30.4	96.9	148.7	149.2	46.7						539.3
Daily ETc (M.ET c/30)(mm)	(7)=(6)/30	1.06	0.33	0.19	0.23	0.42	1.01	3.23	4.96	4.97	1.56						
Soil water depletion fraction [p]	(8)calculated by FAO-33 table	0.827	0.848	0.852	0.851	0.846	0.829	0.677	0.504	0.503	0.813						
Available soil water [Sa](mm/m)	(9) from JICA study team (14%)	140	140	140	140	140	140	140	140	140	140						
Root Depth [D](m)	(10) from JICA study team	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0						
Available soil water in root zone [D*Sa](mm)	(11)=(9)*(10)	140	140	140	140	140	140	140	140	140	140						
Remaining available soil water [(1-p)Sa*D](mm)	(12)=((1-(8)*(11))	24.2	21.2	20.7	20.8	21.6	24.0	45.2	69.4	69.6	26.2						
Available soil water to crop [p*Sa*D](mm)	(13)=(9)*(11)	115.8	118.8	119.3	119.2	118.4	116.0	94.8	70.6	70.4	113.8						
We of beginning of month [Wb+Pe+Ge]	(14)=(be.mon.(17)+(2)+(3))	98.0	100.3	113.0	132.0	144.9	164.1	124.6	63.1	17.5	62.5						
Rate of Cultivated period of month	(15)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0						
We of end of month [Wb+Pe+Ge-ETc]	(16)=(14)-(6)*(15)	66.2	90.4	107.3	124.9	132.2	133.6	27.7	-85.6	-131.8	15.7						
We carried over: (Wb)(mm)	(17)=(16)<=(13) 84.8	66.2	90.4	107.3	119.2	118.4	116.0	27.7	0.0	0.0	15.7						
Runoff of effective rainfall (mm)	(18)	0.0	0.0	0.0	5.7	13.8	17.6	0.0	0.0	0.0	0.0						
(2) Irrigation water requirement																	
Necessary irrigation water requirement (mm)	(19)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	85.6	131.8	0.0						217.4
Net irrigation water requirement (m^3/ha)	(20)	0	0	0	0	0	0	0	856	1,318	0						2,174
Gross irrigation water requirement (m^3/ha)	(21)=(20)*(1/0.65)	0	0	0	0	0	0	0	1,317	2,027	0						3,344

Crop :Spring Barley																	
Item	Description	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
(1)Monthly Water Balance																	
Kc for single crop coefficient	(5)from FAO-56 table						1.00	1.00	1.07	1.14	0.54						
Crop water requirement ETc(mm)	(6)=(1)*(5)						37.6	93.2	138.3	173.6	63.1						505.8
Daily ETc (M.ET c/30)(mm)	(7)=(6)/30						1.25	3.11	4.61	5.79	2.10						
Soil water depletion fraction [p]	(8)calculated by FAO-33 table						0.822	0.689	0.539	0.461	0.790						
Available soil water [Sa](mm/m)	(9) from JICA study team (14%)						140	140	140	140	140						
Root Depth [D](m)	(10) from JICA study team						1.0	1.0	1.0	1.0	1.0						
Available soil water in root zone [D*Sa](mm)	(11)=(9)*(10)						140	140	140	140	140						
Remaining available soil water [(1-p)Sa*D](mm)	(12)=((1-(8)*(11))						25.0	43.5	64.6	75.5	29.4						
Available soil water to crop [p*Sa*D](mm)	(13)=(9)*(11)						115.0	96.5	75.4	64.5	110.6						
We of beginning of month [Wb+Pe+Ge]	(14)=(be.mon.(17)+(2)+(3))						158.6	123.6	65.8	17.5	62.5						
Rate of Cultivated period of month	(15)						1.0	1.0	1.0	1.0	1.0						
We of end of month [Wb+Pe+Ge-ETc]	(16)=(14)-(6)*(15)						121.0	30.4	-72.5	-156.1	-0.6						
We carried over: (Wb)(mm)	(17)=(16)<=(13)					113.0	115.0	30.4	0.0	0.0	0.0						
Runoff of effective rainfall (mm)	(18)						6.0	0.0	0.0	0.0	0.0						6.0
(2) Irrigation water requirement																	
Necessary irrigation water requirement (mm)	(19)						0.0	0.0	72.5	156.1	0.6						229.3
Net irrigation water requirement (m^3/ha)	(20)						0	0	725	1,561	6						2,293
Gross irrigation water requirement (m^3/ha)	(21)=(20)*(1/0.65)						0	0	1,116	2,402	9						3,527