OMO VALLEY FARM COOPERATION PLC
Addis Ababa
Ethiopia

OMO VALLEY FARM IRRIGATION PROJECT

Section-III: Investigation and Sectoral Studies

Volume-I: Irrigation Agronomy

May, 2015

Water Works Design and Supervision Enterprise

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Feasibility Study and Detail Design of Omo Valley Farm Irrigation Project

Irrigation Agronomy

Final Feasibility Report

May, 2015

Issue and Revision Record

Issue	Date	Originator	Checker	Approver	Description
A	March, 2015	Endale Asmare	Ato Solomon Tadesse Seid Sh.	Tilahun D. (Dr)	Draft
B	May, 2015	Endale Asmare	Ato Solomon Tadesse Seid Sh.	Tilahun D. (Dr)	Final

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ACRONYMS AND ABBREVIATIONS

ADB	-	African Development Bank
ppm.	-	Parts per Million
EC	-	Ethiopian Calendar
ETo	-	Surface Evapotranspiration
ETc	-	Crop Evapotranspiration
CWR	-	Crop Water Requirement
NIR	-	Net Irrigation Requirement
Mid	-	Medium
ha	-	hectare
l /s /ha	-	Liters per Second per Hectare
Kc	-	Crop Coefficient
ECe	-	Electrical Conductivity
K_2O	-	Potassium Oxide
P_2O_5	-	Phosphorus Pent oxide
NVRC	-	National Variety Releasing Committee
NPK	-	Nitrogen Phosphorus and Potassium
^oC	-	Degree Celsius
DAP	-	Diamonium Phosphate
Lt	-	Liter
m^2	-	Meter square
m^3	-	meter cube
masl	-	meters above sea level
Max	-	Maximum
Min	-	Minimum
mm	-	millimeter
OC	-	Organic Carbon
GTP	-	Growth and Transformation Plan
qt	-	quintal
Qt	-	Quantity
RH	-	Relative Humidity
SCS	-	Soil Conservation Service
spp.	-	Species
SNNPR	-	Southern Nation and Nationality Peoples Region
t	-	ton
t/ha	-	ton per ha
WWDSE	-	Water Works Design and Supervision Enterprise

Executive Summary

Agriculture is the main activity in the Omo Valley area. The cropping practice would be with emphasis on crops of such as maize, selected vegetables, perennials and pasture crops. In general, agriculture in the farms is characterized by mono cropping farming system only under very small scale irrigation condition. This Omo Valley Farm is located in the Southern Nation and Nationality Peoples Region (SNNPR). Historically cotton production has long been underway in Ethiopia. Large-scale commercial cotton plantations were developed in the Awash Valley and the Humera areas.

In short, the available crops resources of the Omo valley have not been properly exploited so far to meet the increasingly high demand of the area for crop production, raw material for domestic agro industries and for export market. And in cognizant of these facts, concerted efforts are being made at the moment both at national as well as regional levels to transform the prevailing subsistence production system to high value and market oriented production system and one of such efforts exerted in this line embarks on the judicious use of the available irrigation water potential found in different parts of the Omo Valley area. The productivity of soil and climatic conditions of the areas has been observed to provide high and sustained yields of cotton. In accordance with this central strategy and agreement done by The Omo Valley Farm Corporation Plc with the main objective of establishing modern cotton irrigation farm which in future could be linked to agro processing industries, attempts are being made by the Omo Valley Farm Corporation PLc in association with Water Works Design and Supervision Enterprise (WWDSE) to develop an area of 5600 ha by the Omo River.

The main objective of this project is to examine and recommend improved system of irrigated cotton production; by determining the water requirement of the cotton crop to be developed using irrigation and develop suitable crop calendar along with others input requirements. Based on this objective the detail scope of the study has been elaborated in the report. The three major procedural stages have been employed to conduct cotton irrigation agronomy study namely, pre-fieldwork, fieldwork and post-fieldwork. The field survey methodologies and data collection formats have been designed to fulfill the different but complementary objectives and targets of the Project feasibility study. In crop production there is very limited introduction of modern inputs like fertilizer, improved crop varieties, quality seed and agro-chemicals. Moreover, different natural hazards such as recurrent drought condition, land degradation due to erosion and rapid deforestation, drainage problem etc. have resulted in poor yield in surrounding area and project command. Though extensive area is not yet being used for cotton production activities due to the above reasons. During the agronomy study survey, a number of production constraints have been identified. Out of these, the important ones are being presented.

The cropping Pattern proposed is given for Omo Valley Farm irrigated production system on the basis of altitude, agro-climatic parameters and land suitability. The introduction of high yielding cotton varieties from Turky has been considered for inclusion in the planting system. Some crops like maize, haricot-bean, sesame, etc…, were considered and proposed to be included as subsidiary crops in the cropping system at Omo Valley Project Command for they may be suitable to the climate and soil of the project command. These crops are important as a break crop for soil fertility maintenance and reduction of pest and disease

build-up. The varieties of these crops should be verified for area suitability and yield performance prior to planting them out over a large area.

A good number of methods and procedures are being used for determinations of CWR. The Food and Agriculture Organization of the United Nations (FAO/ UN) has also brought out several publications dealing with various aspects of estimation of CWR including issues related to this. After the computation of Crop Water Requirement (CWR) it was found out 1202 mm/ annum, with the duty of 0.78 l/s/ha in the month of January. Irrigation scheduling aims at providing water to the plant when it needs and creating or maintaining conditions under which the plant can achieve optimum growth. For cotton, which could be planted in early May, 14 intervals of irrigation have been identified with their respective net amount of 11.6, 11.2, 16.6, 31.4, 45.5, 60.8, 69.8, 73.3, 75.3, 77.6, 78.8, 70.0, 56.8 and 44.9mm. These values were considered for the larger area occupied by clay and silt clay fraction of the soil and the full data is shown under Irrigation scheduling in Option-III. The other options I and II are shown in detail in the aforementioned section of the report respectively for Loamy sand and Sandy loam.

The yield projection for cotton and the other crops have been suggested with several recommendations such as: Introduction of high yielding varieties of cotton which are resistant to biotic and a biotic stresses and responsive to irrigation water and other production inputs for the farm.

Ensure adequate production and supply of quality cotton seed of improved varieties introduced or recommended for this area at reasonable amount.

Introduction of in-farm seed production scheme in the project command area after proper capacity building of the participating experts, with proper arrangement of priority and others.

1. Introduction

1.1 General

Historically cotton production has long been underway in Ethiopia. Large-scale commercial cotton plantations were developed in the Awash Valley and the Humera areas. The Tendaho Cotton Plantation in the lower Awash Valley was one of Ethiopia's largest cotton plantations. Rain-fed cotton also grew in Humera, Bilate, and Arba Minch.

Given its excellent growing conditions, abundance of raw materials and availability of land, Ethiopia has the potential to become a major global cotton producer. There are however, significant obstacles to the development of the industry in Ethiopia due to a distinct lack of administrative bodies to monitor and certify agricultural practices in the country and to process cotton in factories on a wide-scale commercial level. However, the development of the textile industry is a priority like what has been proposed by the Omo Valley Farm which is an important privatization initiative to attract foreign and private enterprises to develop the sector.

Agriculture is the main activity in this Omo Valley area. The cropping practice would be with emphasis on crops of such as maize, selected vegetables, perennials and pasture crops. In general, agriculture in the farms is characterized by mono cropping farming system only under very small scale irrigation condition. This Omo Valley Farm is located in the Southern Nation and Nationality Peoples Region (SNNPR). The study area is about 1000 km away from Addis Ababa along the main highway leading to Awasa**.** This area is the main lowland areas stretch to the south-west and west, mainly in South Omo and Bench Maji Administrative Zones, and with their relatively high temperatures and low rainfall they are particularly the scene of agro-pastoralism.

In short, the available crops resources of the Omo valley have not been properly exploited so far to meet the increasingly high demand of the area for crop production, raw material for domestic agro industries and for export market. And in cognizant of these facts, concerted efforts are being made at the moment both at national as well as regional levels to transform the prevailing subsistence production system to high value and market oriented production system and one of such efforts exerted in this line embarks on the judicious use of the available irrigation water potential found in different parts of the Omo Valley area.

The productivity of soil and climatic conditions of the areas has been observed to provide high and sustained yields of cotton. The incremental development of the cotton has been a stand-still since long time in the valley. The Omo Valley Farm and the responsible professional entities in particular became too sensible for lack of sufficient supply and the increasing demand of cotton in the industry. In view of this awareness and cotton development role in the Omo Valley, the farm company has launched a large scale expansion and intended development programs since 2015. In large scale cotton development plan has also been started in 2014 with a vision of economically magnificent producer of cotton.

One of the most important initiatives taken in this connection include the implementation of a coordinated study on major rivers found in the country and development of irrigation system such as the Omo River became inevitable .

In accordance with this central strategy and agreement done by The Omo Valley Farm Corporation Plc with the main objective of establishing modern cotton irrigation farm which in future could be linked to agro processing industries, attempts are being made by the Omo Valley Farm Corporation PLc in association with Water Works Design and Supervision Enterprise (WWDSE) to develop an area of 5600 ha by the Omo River.The area proposed for the envisaged cotton crop production lies in the Omo River in the Omo Valley local area.

The idea of the feasibility report is to recommend approaches that the consultant would be taking to carry out the program formulation task. The study so preferred to serve as a means of establishing common understanding of the project between the client and the consultant. It is also an implementation plan for the various components is again a frame work for monitoring the progress of project implementation.

The main purpose of this project is that after the completion of the agronomy study, the existing and aforesaid cotton development practices will be a major branch in the study Project Command with beneficial scientific practices and necessary recommendations to satisfy the incessant cotton demand of the industry and increase foreign exchange earnings.

1.2 Objectives

1.2.1 General objectives of irrigation agronomy study:

To examine and recommend improved system of irrigated cotton production; by determining the water requirement of the cotton crop to be developed using irrigation and develop suitable crop calendar along with others input requirements;

1.2.2 Specific Objective

- To review and update previous studies concerning to the command areas;
- To evaluate the available potentials as well as the prevailing constraints and possible limitations that may block the cotton production in the areas and impede improvement in the existing farming system;
- To propose improved varieties which are adaptable, high yielding, input responsive and pest tolerant in the Command area;
- To evaluate availability of post harvest facility for lint making, fiber production and storage to fulfill the gap.

2. Scope of the Study

The scope of cotton irrigation agronomy study includes the following aspects but not limited to:-

- Review and update of previous studies pertinent to the command areas;

- The irrigation agronomy study has been studied in detail according the methodology already indicated in this report.
- A survey has already been undertaken on the existing farming systems and gap identification in the command areas;
- Cropping area characterization was considered whether it is suitable for cotton crop;
- Determination of crop water requirement has been analyzed for the crops especially for cotton through widely acceptable method;
- Establishing of the irrigation interval , frequency and irrigation duty by considering the soil, hydrology and other relevant factors;
- production potentials and constraints will be identified which may affect several technical and non-technical constraints to hinder full exploitations of the available resource;

3. Approach and Methodology

The following three major procedural stages have been employed to conduct irrigation agronomy study namely, pre-fieldwork, fieldwork and post-fieldwork. The field survey methodologies and data collection formats have been designed to fulfill the different but complementary objectives and targets of the Project feasibility study.

3.1 Pre-field Work

The pre-field work stage refers to all necessary preparatory tasks for irrigation agronomy feasibility study which mainly encompasses the collection and review of previous studies and existing documents related to the project, and preparation of data collection formats / questionnaires. For undertaking interview and hold the necessary discussions with focus group, key informants and stakeholders, checklists has also been prepared.

3.2 Field Work

The field survey work has been carried out to collect primary and secondary information regarding cotton production, productivity, management and other relevant data from the farm experts and other staff of the farm. The major tasks performed during this stage include the following, but not limited to:-

General understanding of the irrigation sites developed thereby identifying data sources and inputs;

- Problems and constraints of the existing cotton production development in the farm was identified;
- The possible project objectives were defined and assessed with respect to assuring cotton production and selection of profitable production system;

3.3 Post-Fieldwork

The post fieldwork encompasses activities such as data organization, data encoding and analysis and feasibility study report writing.

The feasibility level irrigation agronomy study report is inclusive of the analysis and interpretation of the primary data and details of organized secondary data and full write-up from the relevant sections. In this study phase the following major activities was implemented under the project feasibility study.

(a) Previous studies and existing data were updated and upgraded;

(b) Analysis of existing cotton production practices and identification of problems and constraints of the project farm with respect to: Moisture availability; cotton production practices; Important cotton diseases and pests of the project; and Availability of still improved cotton production technologies.

(c) Proposing Crop Water Requirements (CWR)

- Crop type identified is cotton most suitable farm size has already been determined for the project command.
- Reference Evapotranspiration (ETo) and Crop Water Requirement (CWR) was calculated using appropriate software.
- The climatic data have been described.
- Factors affecting crop water requirement was discussed.
- Steps to be taken to ensure the selected crop was recommended for progressive improvements.

(d) Irrigation interval, frequency and duty were determined using cropwat-8 software based on the climatic data and soil type information obtained from the respective sectoral reports i.e., hydrology and soil.

(e) The identified cotton varieties (four varieties obtained from company) suitable for the project commands: - types of potential for the project command were thoroughly studied.

(f) Determining the cropping calendar and scheduling of irrigation

- Yield estimation and projection were made and factors influencing crop yields was identified.

4. Description of the Study Area

This Omo Valley is located in the Southern Nation and Nationality Peoples Region (SNNPR). The study area is about 1000 km away from Addis Ababa along the main highway leading to Awasa**.** This area is the main lowland areas stretch to the south-west and west, mainly in South Omo and Bench Maji Administrative Zones, and with their relatively high temperatures and low rainfall they are particularly the scene of agro-pastoralism. Elsewhere there are smaller areas of more arable lowland, for instance surrounding Lakes Abaya and Chamo in the Humbo, Arba Minch Zuria and Amaro Special woredas and further south show less than 1000mm of annual precipitation in the 30-year mean 1971-2000. Those that do are lowland areas such as the Hamer rangeland (601mm) and the lowlands around Lake Abaya mentioned above (around 900mm), whilst Konso (609mm) has the lowest rainfall for an arable area.

The project command area is a relatively flat land with an average altitude of about 420 masl and land on its periphery rising gently to altitudes over 490 masl. The Omo River flows on the right of command area from north to south direction.

5. A Review of Previous Studies

5.1 Omo Gibe River Basin Integrated Development Master Plan Study.

The Omo Gibe River Basin Integrated Development Master plan Study was carried out under the auspices of the Government of Ethiopia between 1993 and 1996 with external assistance provided by African Development Bank (ADB).

As far as the agronomy study is concerned it dealt with cereal – based mixed farming system, coffee based farming system, mixed cropping enset, cereals – root – pulses farming system. The study includes a number of variations that reflect local agro-ecological conditions. Maize is by far the major cereal in both area cultivated and total production having largely displaced sorghum at medium and lower altitude. The gap between the master plan study and the Omo valley farm study is too wide such as the area, the time performed 1993 and the crop types considered. Therefore, the master plan study has no relevance for our proposed study to be considered.

5.2. Cotton Varieties Suitable for North and South Omo valley

Cotton being as one of the important industrial crop has got many agronomic and morphological characteristics that are detrimental for its fiber and seed yields. The fiber and seed yields are respectively supplied to the textile factories and oil mills.

In the following section cotton varieties that are most suitable for the North and South Omo Valley, which were released beginning from year 2007, are briefly presented for their yield performance (Table 5.1).

Table 5. 1. Cotton Varieties Suitable for North and South Omo Valley

Varieties	Year of release	Average lint yield (qt/ha)	Lint yield percentage	Average seed cotton yield (qt/ha)	Seed yield percentage
Gloria	2014	18.5	104.7	42.6	106.2
Candia	2014	18.0	117.6	40.6	100.7
Claudia	2014	17.6	118.9	38.4	116.4
STG-14	2014	16.6	126.7	38.8	117.6
Average		**17.7**	**100.0**	**40.1**	**100.0**
VBCHB-1527	2013	15.30	111.7	40.30	115.5
YD-670	2013	14.80	91.4	33.00	70.2
YD-195	2013	13.10	81.9	33.00	71.7
VBCHB-1203	2013	11.60	76.8	33.30	77.4
Average		13.7	100.0	34.9	100.0
YD-223	2011	16.2	102.7	47.0	102.2
YD-206	2011	16.0	101.5	46.0	101.5
YD-211	2011	15.1	95.8	43.0	94.9
Average		15.8	100.0	45.3	100.0
Ionia	2008	11.2	x	28.9	x
NEBAH (Stam-59A)	2007	14.3	x	33.4	x

Source: Crop Variety Register issue No. 17, 16, 15, 14, 11 and 10.

A great number of promising varieties in terms of lint and seed yield are available for Omo Valley cotton farm development. For instance, Gloria and Candia are high performing varieties in respect of lint yield as illustrated in Table 5.1. Whereas varieties of YD-223 and YD-211 are the best choices for cotton seed yield as compared to all other varieties. The rest other varieties, although they are relatively low when compared to the respective values of lint and seed yield of Gloria & Candia and YD-223 & YD-211, they have got other important agronomic characteristics like fiber length, fiber strength etc…which may surpass the high yielder varieties and may prove to be imperative for the anticipated development program.

6. Land Use Pattern and Crop Production Status of Omo Valley Farm

6.1 Land Use

The general Land use pattern of the Omo Valley Farm is shown in Table 6.1 below. The data and information in this connection were obtained from the client office in the farm site, which is about 84 percent of the command is expected to be developed by the project with the currently cultivated and planed are 2.6 and 13.4 percent respectively out of the total 5,600 ha of command land area.

Table 6. 1: Land Use Pattern of Omo Valley Farm.

Land Use Pattern	Area Coverage (Ha).	Proportion (%)
Cultivated land / Cotton	148	2.64
Cultivable land	750	13.39
Currently unutilized Land	4702	83.96
Forest Land	----	----
Grazing Land	----	----
Total	**5600**	**100**

Source:- Omo Valley Farm Office,2015.

Because of the farm nature the company land holding general practices in their occupation is large scale isolated cotton farm.

6.2 Existing Crop Production Status in the Omo Valley Farm

The status of crop production system particularly the cotton crop production in the Omo Valley Farm Project command was studied through a comprehensive questionnaire consisting of all important production parameters. The secondary data on land use patterns and crop production statistics were collected from the farm experts and director. The data on crop production was given as a total area of 148 ha of land with cotton of one improved variety called STG and also a planed area of 750 ha with other improved varieties of cotton. The yield of this variety at the moment is 24 qt/ha from the seed rate of 25 kg/ha. No animal manure or commercial fertilizer has been utilized.

The cultural practices of the farm are fully mechanized with furrow irrigation. Although cropping systems approaches like crop rotation and intercropping are new to the farm, crops like haricot-bean and other short duration crops are proposed for inclusion in the development program for soil fertility maintenance, to keep away major pest and disease problems and secure subsidiary crops yield advantage without impairing the quality and productivity of cotton crop. With regard to crop protection, chemical control is the effective system identified so far and no disease symptom was apparent and no control measure was applied.

Table 6. 2 : Type of herbicide and rate of application utilized in the farm

Names of herbicides	Types of action	Rate of application (Liter/hectare)	Total amount of herbicide used (Liter)
Nanoethyl	Pre-emergence	1.5	250
Nanotechlus	Post-emergence	2.0	200

Table 6. 3 The prevalent insect pests and diseases of the cotton farm.

Crop type	Common name	Scientific nam
Cotton	Solenopsis mealybug	*Phenacoccus solenopsis Tinsley*
	American Bollworm	*Helicoverpa armigera*
	Cotton stainer	*Dysdercus suturellus*

Table 6. 4: Chemical control measure of the insect pests

Crop	Name of insect-pest	Types of chemicals
Cotton	Boll worm	Nanosulphan
	Sucking	Nanocumphid

The existence of termitarium and termites have been observed in the command area , however no damage has been reported and no attacked cotton or other plants observed even in the adjacent Sisay Tesfaye farm.

The harvesting process of Omo valley is modern and highly mechanized. Prior to the process of harvesting, the use of harvest aid products like defoliants or boll openers can be put in use to lessen trash mix-up and preserve the quality of harvestable cotton product. Currently, the major drawback associated with mechanized harvesting is the mixing of left-over trash materials with the lint yield upon harvesting. This will be minimized by integrating manual cleaning operation, which certainly will reduce trash content mix-up before the harvested cotton bail is to be transported to the ginnery. As soon as the harvested cotton bail is clean and ready, it has to be transported to the ginnery for the follow-up ginning plant activities. Too much time should not be wasted while storing the harvest. It is also advisable that the producer and the gin should have frequent communication, prior to harvest, to ensure for the timely ginning of the seed cotton so that ginners can adjust the ginning process to preserve fiber quality.

There are well established three input storage facilities in the farm covering an area amounting to 500, 200 and 200m^2.

The clearly identified constraint of the farm are poor irrigation management, inefficient land utilization and the planting orientation of the cotton crop which caused crop loss before harvest and storage problems also contribute some loss of the product. In the project command, currently the available temporary storage facility is canvas spread over the farm area on which hips of seed cotton are temporarily placed.

6.2.1 Sisay Tesfaye Agricultural Development

Sisay Tesfaye Agricultural Development is mainly involved in cotton production near by the Omo Valley farm the altitude of the farm is 362 masl and it is totally irrigated farm. The farm was started in 2003 EC with 112 ha of cotton and some maize, banana, vegetables and mango these crops are mostly small scale and are for consumption. The current area of the farm is 243 ha and the future plan is 1200 ha. The main activity of the farm is cotton production. Excepting land preparation, all the rest activities are manual. Because of this the length of growing period is about 6 months. The source of seed is the farm itself. So far the farm yield is about 30 qt / ha in the first picking and some 8 qt /ha in the second picking. The major biological problem of the farm is white fly and boll worms, the control measure of these insect pests are chemicals namely, Talastay and Endosulfan respectively.

7. Production Constraints and Potentials

7.1. Major Production Constraints

Omo Valley Farm command is with no crop or with low cropping intensity of cotton. A lot of potential land is still left uncultivated because of lack of sufficient irrigation facilities. In commercial cotton production limited water and land area are critical for expanded modern cotton farm. Moreover, land degradation and drainage problem are the major constraints. Hence, the proposed extensive area has not yet been used for cotton production. As per the Agronomy study the following problems were identified.

7.1.1 Quality Seed

Seed is a basic input for cotton production. Even though the farm has enough seeds for planting, the quality of seed has the most profound influence on crop yields. The farm has been using cotton seeds imported from internationally known foreign company. These days it is attempting to satisfy its current requirement and is on the move to produce and make available more variety of seeds for the additional farm area it is going to be annexed. Thus, considering the quality of seeds for planting it will be a challenge for the project unless certified quality seeds are to be secured from known seed sources like the Ethiopian Institute of Agricultural Research and Regional Agricultural Research Institutes.

7.1. 2 Fertilizers

Fertility of the soil in the project area is good; however this will not be maintained long enough to support the production of cotton sustainably with the optimum and potential yield that should be obtained. Currently, the project command farm does not apply any fertilizer for cotton development. It is a recently established one and human interference in the growing of any one crop is too minimal. The management in charge for the development is young and gradually growing, although it is weak in respect of communication link and exchange of information with other relevant development partners.

7.1. 3 Agro- Chemicals

During the survey the presence of high incidence of insect-pests and diseases was noticeable. Currently, the Omo Valley Farm has got sufficient amount of agro-chemicals for the limited land it is cultivating. Upon further development of the farm area and increased activities, the problems of weeds, insect-pests and diseases could be more pronounced. Hence, this may call for the introduction of a variety of more additional chemicals to safe guard crop enemies.

7.1. 4 Natural Hazards

The major natural hazards are erratic behavior of rainfall, drought and flood. In the project command there is variation in rainfall pattern from year to year. The farm meteorological station is very young and has a few years of records to estimate water requirement for the cotton crop. Moreover, one cannot tell or predict the rainfall since the met-station is very far from the actual farm area. However, with scientific approach and analysis it became possible

to estimate the water requirement of the crop with records of climatic parameters of the project command extrapolated from the near-by met-station, i.e., Erborae met station. Its elevation is 700masl and has agro-ecological similarity in respect of temperature, humidity, sunshine hours etc.... Hence, it is relatively better and preferable than the other stations to closely predict the rainfall pattern of the project command.

The erratic rainfall behavior of the project command as shown in section 8, Table 8.1 of the report indicate that supplementary irrigation is crucially important for sustained production and productivity of the crop and farm land respectively.

7.1. 5 Under-Developed Cum–Demonstration Plots

The Omo valley Farm has just started identifying the problems of the farm and collect solutions from the research results obtained from centers such as Melkawerer. The existing cum-demonstration plots, which are relatively young and under developed, were established to verify and apply research results of cotton found elsewhere in the country over a large area of the farm. But it still requires further strengthening with respect to experts and communication link with other research and development partners.

7. 2 . Productions potentials

Omo Valley Farm project command has fairly high potential farm land that can be exploited through comprehensive integrated cotton production development program, well developed infrastructure etc. The existing farm is on small area of the project command and has yet to develop further through proper utilization of water and land resources and solving the major production constraints. The major potential areas requiring intervention are as mentioned below:

- There is a good scope of development of cotton production under irrigated production system by exploiting the existing irrigation potential and utilizing the water available in the Omo River. There is already indication of enhanced productivity per unit area by using the small scale irrigation.
- Proper soil and water conservation measures and the introduction of proper drainage is also an important aspect.
- The Omo Valley farm has already introduced improved varieties and agro chemicals along with the adoption of improved package of production practices and soil fertility conservation.

To improve the productivity of the farm, and to exploit the potential of the latest technologies and other inputs, the cum–demonstration has to be made very strong, and the need based capacity building at all stages including the specialized experts are essential.

8. Proposed Cropping Pattern, Crop Calendar, CWR and Irrigation Schedule.

8.1. Cropping Pattern and Crop Calendar

The cropping Pattern proposed is given in the following Tables for Omo Valley Farm irrigated production system on the basis of altitude, agro-climatic parameters and land suitability. The introduction of high yielding cotton varieties from Turky has been considered for inclusion in the planting system. Some crops like maize, haricot-bean, sesame, etc…, were considered and proposed to be included as subsidiary crops in the cropping system at Omo Valley Project Command for they may be suitable to the climate and soil of the project command. These crops are important as a break crop for soil fertility maintenance and reduction of pest and disease build-up. The varieties of these crops should be verified for area suitability and yield performance prior to planting them out over a large area.

Table 8. 1: Cropping patterns for Omo Valley Farm irrigation project during wet season.

No	Crop / Variety	Area (ha)	Area, /%/	L .G. P /day/	Growing period/ day/		
					Planting	Harvesting	
1	Cotton /STG / CANDIA	5208	93	150	05/05	01/10	
	Fixed Cropping Area						
1	Vegetables	56	1	95	15/06	17/09	
2	Fruit	56	1	365	26/06	25/06	
3	Forage	56	1	365	26/06	25/06	
4	Observation plot	224	4	150	10/06	06/11	
	Total	**5,600**	**100**				

Table 8. 2 : Cropping patterns for Omo Valley Farm- irrigation project during dry season.

No	Crop / Variety	Area (ha)	Area, /%/	L .G. P /day/	Growing period/ day/		
					Planting	Harvesting	
1	Cotton /STG & CANDIA	2856	50	150	20/10	18/03	
2	Maize	672	12	125	30/10	26/02	
3	Wheat	560	10	130	30/10	05/03	
4	Soya bean	280	5	85	30/10	22/01	
5	Mung bean	280	5	110	05/11	22/02	
6	Haricot bean	280	5	110	25/10	11/02	
7	Sesame	280	5	95	01/11	03/02	
	Fixed Cropping Area						
1	Vegetable	56	1	95	01/11	03/02	
2	Forage	56	1	365	26/06	25/06	
3	Fruit	56	1	365	26/06	25/06	
4	Observation plot	224	4	150	20/10	18/03	
	Total	**5600**	**100**				

8.2. Crop Water Requirement

8.2.1. General

The computation of Crop Water Requirement (CWR) constitutes / contains an important component of irrigation Projects for planning planting systems. A good number of methods and procedures are available for determinations of CWR. The Food and Agriculture Organization of the United Nations (FAO/ UN) has also brought out several publications dealing with various aspects of estimation of CWR including issues related to this.

8.2.2. Procedure for Computation of CWR

As recommended in FAO Publications three steps are involved in the calculation of the crop water requirement.

8.2.3. Reference Evapotranspiration, ETo

The crop water requirement (CWR) is a dependent function of the meteorological parameters and Reference Evapotranspiration (ETo) (A return of moisture to the air from plants and soils) which presents the effect of the meteorological factors. The following meteorological factors are taken into account for computation of ETo by modified Penman Method (FAO I & D paper No.24) and Penman Montieth Approach (FAO I & D Paper No.46):

- Temperature
- Relative humidity
- Wind Velocity
- Sunshine Hours

The details of the above climatological parameters are given in this report.

8.2.4 Selection of Values for Crop Coefficient

The Crop Coefficient (Kc) denotes the effect of crop on its water requirement. This is represented by the relationship between ETo and Crop Evapotranspiration. ET crop as ETc = Kc * ETo. The values of Crop Coefficient vary from one to the other crop, its stage of growth, growing season and prevailing season and water conditions. The next step comprises the selection of suitable values for the Crop Coefficient. Kc is the experimentally derived crop coefficient that is presented to relate ETo to crop Evapotranspiration ETcrop = ETc = Kc*ETo. For the given plant/crop types and planting/cropping patterns, the corresponding Kc values are selected from FAO's publications and other literatures available on the subject and the monthly ETc for the respective plants/crops is computed from Cropwat 8 software of FAO.

8.2.5 Determination of CWR and Net Water Requirement (NIR)

Determination of CWR and NIR entails the evaluation of temporal and spatial variability of climate. This also calls for the assessment of the effect of soil water availability as well as plantation and irrigation practices.

The three steps outlined above will be able to give the CWR during its crop growth period at monthly interval. The requirement so computed would be under field conditions. Therefore, the water losses in the irrigation system have to be incorporated to arrive at the CWR at the head of the irrigation system. If irrigation efficiency is considered as 70% (this is according the Cropwat soft ware 8 recommendation), the total monthly CWR for the individual plant categories and crops, for the seasons and the total water need i.e., NIR would be more than double. Monthly and Seasonal / Decadal (10 days interval) Net Irrigation Requirement (NIR) has been presented in Table 8.4 for the proposed cropping pattern.

8.2.6 Crop Wise CWR and NIR Requirement

As indicated earlier Crop Water Requirement has been estimated using the climatic parameters namely, temperature, rainfall, relative humidity, wind speed, and sunshine hours. Effective rainfall has also been considered in computation. FAO I & D Paper No.56 (Soft-ware Cropwat 8) has been employed in determination of CWR/NIR. Details of the monthly Kc value, ETo, ETc, CWR and NIR as against to the proposed percentage of cropping intensity also be determined.

NIR of any crops vary with respect to many factors associated with climatologically phenomena and planting and cropping intensity assigned to the crop in that particular period. In particular the assignment of cropping intensity again varies from crop to crop depending on the importance and multiple values of the crop to be considered in the Omo Valley Farm Command.

8.2.7 Crops

A cropping intensity of the total area has been assigned for the proposed cropping pattern. The pattern includes the growing of Cotton crop dominantly along with selected crops of Maize, Haricot-bean, Vegetables, Fruits and forages. The assignment of cropping intensity to each crop was based on the discussion held with the Omo Valley Farm agronomist and director of the company from the Omo Valley command. In this agro-ecological zone, main emphasis on cropping intensity assignment was given to value annual and perennial crops. Monthly and Seasonal / Decadal Net Irrigation Requirement (NIR) has been presented as follows for the proposed cropping pattern.

Table 8. 3 : Climatic data, ETo and other parameters of the command area.

MONTHLY ETO PENMAN-MONTEITH DATA

Country: Ethiopia Station: Omo Valley Farm
Altitude: 420 m. Latitude: 5.22 °N Longitude: 36.25 °E

Month	Min Temp °C	Max Temp °C	Humidity kPa	Wind m/s	Sun hours	Rad MJ/m?/day	ETo mm/day
January	16.7	37.1	1.4	1.9	9.2	21.9	6.2
February	17.3	36.8	1.5	2.1	9.2	23.0	6.6
March	17.5	36.4	1.6	2.3	7.0	20.3	6.5
April	17.4	35.0	1.9	1.8	8.7	22.8	5.9
May	17.1	34.3	2.0	1.7	8.4	21.5	5.4
June	17.5	33.7	1.9	1.9	8.4	20.9	5.4
July	17.0	34.1	1.5	1.9	7.9	20.4	5.7
August	17.2	34.2	1.3	1.9	7.7	20.8	5.9
September	18.0	35.6	1.8	1.9	8.7	22.8	6.1
October	18.1	35.7	1.9	1.9	8.9	22.6	6.0
November	17.4	35.9	1.8	1.9	8.6	21.2	5.6
December	17.3	35.4	1.7	1.8	9.2	21.5	5.6
Average	17.4	35.3	1.7	1.9	8.5	21.6	5.91

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MONTHLY RAIN DATA
File: C:\Documents and Settings\All Users\Application Data\CROPWAT\data\rain\FinalMOVFrain.CRM)

Station: Final OMO Valley

Eff. rain method: USDA Soil Conservation Service formula:
Peff = Pmon * (125 - 0.2 * Pmon) / 125 for Pmon <= 250 mm
Peff = 125 + 0.1 * Pmon for Pmon > 250 mm

	Mean Monthly Rain-fall (mm)	
	80% Dependable	**80% Dependable & Effective**
Months	**Monthly**	**Monthly**
January	26.6	11.2
February	22.6	12.4
March	54.1	28.0
April	98.6	57.9
May	70.3	35.6
June	37.8	18.2
July	21.5	6.4
August	17.9	6.6
September	23.0	10.1
October	54.9	27.5
November	48.7	27.4
December	26.3	12.9
Total	**502.4**	**254.2**

CROP WATER REQUIREMENTS

ETo station: Final Modi Omo Valley Crop: COTTON
Rain station: Final OMO Valley Planting date: 05/05

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
May	1	Init	0.35	1.95	11.7	12.6	1.2
May	2	Init	0.35	1.90	19.0	19.2	0.0
May	3	Deve	0.41	2.20	24.2	16.0	8.2
Jun	1	Deve	0.62	3.38	33.8	11.5	22.2
Jun	2	Deve	0.84	4.56	45.6	7.9	37.7
Jun	3	Deve	1.06	5.84	58.4	9.2	49.1
Jul	1	Mid	1.22	6.80	68.0	11.5	56.5
Jul	2	Mid	1.22	6.94	69.4	12.5	56.9
Jul	3	Mid	1.22	7.05	77.6	11.6	66.0
Aug	1	Mid	1.22	7.16	71.6	10.3	61.4
Aug	2	Late	1.22	7.23	72.3	9.4	62.8
Aug	3	Late	1.10	6.63	72.9	9.2	63.7
Sep	1	Late	0.96	5.85	58.5	9.0	49.5
Sep	2	Late	0.83	5.10	51.0	8.7	42.2
Sep	3	Late	0.70	4.25	42.5	8.4	34.1
Oct	1	Late	0.63	3.78	3.8	0.7	3.8
					780.3	167.9	615.5

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CROP WATER REQUIREMENTS

ETo station: Final Modi Omo Valley Crop: Haricot-beans
Rain station: Final OMO Valley Planting date: 25/10

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Oct	3	Init	0.40	2.37	16.6	7.0	11.0
Nov	1	Init	0.40	2.34	23.4	19.4	4.0
Nov	2	Deve	0.47	2.72	27.2	25.2	2.0
Nov	3	Deve	0.72	4.13	41.3	20.2	21.1
Dec	1	Deve	0.98	5.56	55.6	13.4	42.2
Dec	2	Mid	1.17	6.56	65.6	9.3	56.3
Dec	3	Mid	1.18	6.83	75.1	8.2	66.9
Jan	1	Mid	1.18	7.05	70.5	6.9	63.6
Jan	2	Mid	1.18	7.27	72.7	5.1	67.6
Jan	3	Late	1.01	6.41	70.6	6.6	64.0
Feb	1	Late	0.58	3.78	37.8	7.9	30.0
Feb	2	Late	0.35	2.36	2.4	0.9	2.4
					558.7	130.1	431.0

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CROP WATER REQUIREMENTS

ETo station: Final Modi Omo Valley Crop: Mung-beans
Rain station: Final OMO Valley Planting date: 05/11

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Nov	1	Init	0.40	2.34	14.0	11.6	4.3
Nov	2	Init	0.40	2.30	23.0	25.2	0.0
Nov	3	Deve	0.45	2.60	26.0	20.2	5.8
Dec	1	Deve	0.70	3.96	39.6	13.4	26.2
Dec	2	Deve	0.96	5.38	53.8	9.3	44.5
Dec	3	Mid	1.16	6.76	74.4	8.2	66.2
Jan	1	Mid	1.18	7.07	70.7	6.9	63.8
Jan	2	Mid	1.18	7.29	72.9	5.1	67.8
Jan	3	Mid	1.18	7.51	82.6	6.6	76.1
Feb	1	Late	1.03	6.75	67.5	7.9	59.6
Feb	2	Late	0.62	4.18	41.8	8.7	33.0
Feb	3	Late	0.37	2.47	4.9	2.9	4.9
					571.3	126.1	452.2

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CROP WATER REQUIREMENTS

ETo station: Final Modi Omo Valle Crop: Maize (Grain)
Rain station: Final OMO Valley Planting date: 30/10

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Oct	3	Init	0.30	1.78	3.6	2.0	3.6
Nov	1	Init	0.30	1.75	17.5	19.4	0.0
Nov	2	Deve	0.31	1.77	17.7	25.2	0.0
Nov	3	Deve	0.50	2.87	28.7	20.2	8.5
Dec	1	Deve	0.77	4.38	43.8	13.4	30.4
Dec	2	Deve	1.04	5.86	58.6	9.3	49.3
Dec	3	Mid	1.24	7.19	79.1	8.2	70.9
Jan	1	Mid	1.25	7.47	74.7	6.9	67.9
Jan	2	Mid	1.25	7.71	77.1	5.1	71.9
Jan	3	Mid	1.25	7.94	87.3	6.6	80.8
Feb	1	Late	1.11	7.29	72.9	7.9	65.0
Feb	2	Late	0.81	5.48	54.8	8.7	46.1
Feb	3	Late	0.54	3.63	29.0	11.7	17.3
Mar	1	Late	0.38	2.51	7.5	4.5	0.0
					652.4	149.1	511.6

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CROP WATER REQUIREMENTS

ETo station: Final Modi Omo Valley Crop: Small Vegetables
Rain station: Final OMO Valley Planting date: 15/06

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Jun	2	Init	0.70	3.80	22.8	4.8	18.8
Jun	3	Init	0.70	3.85	38.5	9.2	29.3
Jul	1	Deve	0.73	4.06	40.6	11.5	29.0
Jul	2	Deve	0.84	4.77	47.7	12.5	35.1
Jul	3	Deve	0.97	5.58	61.4	11.6	49.8
Aug	1	Mid	1.06	6.21	62.1	10.3	51.9
Aug	2	Mid	1.07	6.33	63.3	9.4	53.9
Aug	3	Mid	1.07	6.40	70.4	9.2	61.2
Sep	1	Late	1.04	6.32	63.2	9.0	54.2
Sep	2	Late	0.99	6.05	42.3	6.1	33.6
					512.2	93.6	416.7

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CROP WATER REQUIREMENTS

ETo station: Final Modi Omo Valley Crop: CITRUS
Rain station: Final OMO Valley Planting date: 26/06

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Jun	3	Init	0.73	4.03	20.1	4.6	15.5
Jul	1	Init	0.70	3.91	39.1	11.5	27.6
Jul	2	Init	0.70	3.97	39.7	12.5	27.2
Jul	3	Init	0.70	4.03	44.4	11.6	32.8
Aug	1	Init	0.70	4.10	41.0	10.3	30.7
Aug	2	Init	0.70	4.16	41.6	9.4	32.2
Aug	3	Deve	0.70	4.20	46.3	9.2	37.1
Sep	1	Deve	0.70	4.25	42.5	9.0	33.5
Sep	2	Deve	0.70	4.30	43.0	8.7	34.3
Sep	3	Deve	0.70	4.27	42.7	8.4	34.3
Oct	1	Deve	0.70	4.25	42.5	6.8	35.7
Oct	2	Deve	0.70	4.22	42.2	5.8	36.4
Oct	3	Deve	0.70	4.17	45.9	11.1	34.8
Nov	1	Deve	0.71	4.12	41.2	19.4	21.8
Nov	2	Deve	0.71	4.07	40.7	25.2	15.5
Nov	3	Mid	0.71	4.04	40.4	20.2	20.1
Dec	1	Mid	0.71	4.00	40.0	13.4	26.6
Dec	2	Mid	0.71	3.97	39.7	9.3	30.4
Dec	3	Mid	0.71	4.10	45.2	8.2	36.9
Jan	1	Mid	0.71	4.24	42.4	6.9	35.5
Jan	2	Mid	0.71	4.37	43.7	5.1	38.6
Jan	3	Mid	0.71	4.50	49.5	6.6	43.0
Feb	1	Mid	0.71	4.63	46.3	7.9	38.5
Feb	2	Mid	0.71	4.76	47.6	8.7	38.9
Feb	3	Mid	0.71	4.72	37.7	11.7	26.0
Mar	1	Mid	0.71	4.67	46.7	15.0	31.7
Mar	2	Mid	0.71	4.62	46.2	17.8	28.4
Mar	3	Late	0.73	4.60	50.6	20.1	30.5
Apr	1	Late	0.73	4.47	44.7	23.5	21.1
Apr	2	Late	0.73	4.31	43.1	26.5	16.6
Apr	3	Late	0.73	4.19	41.9	23.9	18.0
May	1	Late	0.73	4.08	40.8	21.0	19.8
May	2	Late	0.73	3.96	39.6	19.2	20.4

May	3	Late	0.73	3.97	43.6	16.0	27.6
Jun	1	Late	0.73	3.97	39.7	11.5	28.1
Jun	2	Late	0.73	3.97	39.7	7.9	31.8
Jun	3	Late	0.73	4.03	20.1	4.6	15.5
					1542.1	468.6	1073.5

CROP WATER REQUIREMENTS
ETo station: Final Modi Omo Valley Crop: Forage perennial
Rain station: Final OMO Valley Planting date: 26/06

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Jun	3	Init	0.87	4.76	23.8	4.6	19.2
Jul	1	Init	0.85	4.75	47.5	11.5	36.0
Jul	2	Init	0.85	4.82	48.2	12.5	35.7
Jul	3	Init	0.85	4.90	53.9	11.6	42.3
Aug	1	Init	0.85	4.98	49.8	10.3	39.5
Aug	2	Init	0.85	5.05	50.5	9.4	41.1
Aug	3	Init	0.85	5.10	56.1	9.2	46.9
Sep	1	Init	0.85	5.16	51.6	9.0	42.6
Sep	2	Init	0.85	5.21	52.1	8.7	43.4
Sep	3	Init	0.85	5.17	51.7	8.4	43.3
Oct	1	Init	0.85	5.13	51.3	6.8	44.6
Oct	2	Init	0.85	5.10	51.0	5.8	45.2
Oct	3	Init	0.85	5.03	55.3	11.1	44.3
Nov	1	Init	0.85	4.96	49.6	19.4	30.2
Nov	2	Deve	0.86	4.94	49.4	25.2	24.2
Nov	3	Deve	0.88	5.01	50.1	20.2	29.9
Dec	1	Deve	0.90	5.09	50.9	13.4	37.5
Dec	2	Deve	0.92	5.16	51.6	9.3	42.3
Dec	3	Deve	0.94	5.46	60.0	8.2	51.8
Jan	1	Deve	0.96	5.76	57.6	6.9	50.8
Jan	2	Mid	0.97	6.01	60.1	5.1	55.0
Jan	3	Mid	0.97	6.19	68.1	6.6	61.6
Feb	1	Mid	0.97	6.37	63.7	7.9	55.9
Feb	2	Mid	0.97	6.55	65.5	8.7	56.8
Feb	3	Mid	0.97	6.49	51.9	11.7	40.2
Mar	1	Mid	0.97	6.42	64.2	15.0	49.2
Mar	2	Mid	0.97	6.35	63.5	17.8	45.8
Mar	3	Mid	0.97	6.14	67.6	20.1	47.5
Apr	1	Mid	0.97	5.93	59.3	23.5	35.8
Apr	2	Mid	0.97	5.72	57.2	26.5	30.7
Apr	3	Mid	0.97	5.57	55.7	23.9	31.8
May	1	Mid	0.97	5.42	54.2	21.0	33.1
May	2	Late	0.96	5.20	52.0	19.2	32.8
May	3	Late	0.93	5.06	55.7	16.0	39.7
Jun	1	Late	0.91	4.93	49.3	11.5	37.7
Jun	2	Late	0.88	4.79	47.9	7.9	40.0
Jun	3	Late	0.87	4.76	23.8	4.6	19.2
					1972.1	468.6	1503.5

CROP WATER REQUIREMENTS

ETo station: Final Modi Omo Valle Crop: COTTON / Observation
Rain station: Final OMO Valley Planting date: 05/05

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
May	1	Init	0.35	1.95	11.7	12.6	1.2
May	2	Init	0.35	1.90	19.0	19.2	0.0
May	3	Deve	0.41	2.20	24.2	16.0	8.2
Jun	1	Deve	0.62	3.38	33.8	11.5	22.2
Jun	2	Deve	0.84	4.56	45.6	7.9	37.7
Jun	3	Deve	1.06	5.84	58.4	9.2	49.1
Jul	1	Mid	1.22	6.80	68.0	11.5	56.5
Jul	2	Mid	1.22	6.94	69.4	12.5	56.9
Jul	3	Mid	1.22	7.05	77.6	11.6	66.0
Aug	1	Mid	1.22	7.16	71.6	10.3	61.4
Aug	2	Late	1.22	7.23	72.3	9.4	62.8
Aug	3	Late	1.10	6.63	72.9	9.2	63.7
Sep	1	Late	0.96	5.85	58.5	9.0	49.5
Sep	2	Late	0.83	5.10	51.0	8.7	42.2
Sep	3	Late	0.70	4.25	42.5	8.4	34.1
Oct	1	Late	0.63	3.78	3.8	0.7	3.8
					780.3	167.9	615.5

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CROP WATER REQUIREMENTS
ETo station: Final Modi Omo Valley Crop: Wheat
Rain station: Final OMO Valley Planting date: 30/10

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Oct	3	Init	0.30	1.78	3.6	2.0	3.6
Nov	1	Init	0.30	1.75	17.5	19.4	0.0
Nov	2	Init	0.30	1.73	17.3	25.2	0.0
Nov	3	Deve	0.31	1.76	17.6	20.2	0.0
Dec	1	Deve	0.52	2.96	29.6	13.4	16.2
Dec	2	Deve	0.82	4.60	46.0	9.3	36.7
Dec	3	Mid	1.11	6.47	71.2	8.2	63.0
Jan	1	Mid	1.19	7.14	71.4	6.9	64.5
Jan	2	Mid	1.19	7.36	73.6	5.1	68.5
Jan	3	Mid	1.19	7.58	83.4	6.6	76.8
Feb	1	Late	1.16	7.61	76.1	7.9	68.2
Feb	2	Late	0.91	6.12	61.2	8.7	52.5
Feb	3	Late	0.64	4.28	34.2	11.7	22.5
Mar	1	Late	0.40	2.67	21.3	12.0	6.4
					624.1	156.6	478.8

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CROP WATER REQUIREMENTS
ETo station: Final Modi Omo Valle Crop: Sesame
Rain station: Final OMO Valley Planting date: 01/11

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Nov	1	Init	0.40	2.34	23.4	19.4	4.0
Nov	2	Init	0.40	2.30	23.0	25.2	0.0
Nov	3	Deve	0.43	2.48	24.8	20.2	4.6
Dec	1	Deve	0.63	3.59	35.9	13.4	22.5
Dec	2	Deve	0.86	4.82	48.2	9.3	38.9
Dec	3	Mid	1.09	6.33	69.7	8.2	61.4
Jan	1	Mid	1.18	7.09	70.9	6.9	64.0
Jan	2	Mid	1.18	7.31	73.1	5.1	68.0
Jan	3	Mid	1.18	7.53	82.8	6.6	76.3
Feb	1	Mid	1.18	7.75	77.5	7.9	69.6
Feb	2	Late	1.12	7.55	75.5	8.7	66.8
Feb	3	Late	0.93	6.20	49.6	11.7	37.9
Mar	1	Late	0.73	4.84	48.4	15.0	33.4
					702.8	157.6	547.3

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CROP WATER REQUIREMENTS

ETo station: Final Modi Omo Valle Crop: COTTON /STG / CANDIA
Rain station: Final OMO Valley Planting date: 20/10

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Oct	2	Init	0.35	2.10	2.1	0.6	2.1
Oct	3	Init	0.35	2.07	22.8	11.1	11.7
Nov	1	Deve	0.36	2.08	20.8	19.4	1.4
Nov	2	Deve	0.52	2.97	29.7	25.2	4.6
Nov	3	Deve	0.74	4.22	42.2	20.2	22.0
Dec	1	Deve	0.96	5.44	54.4	13.4	41.0
Dec	2	Mid	1.18	6.61	66.1	9.3	56.8
Dec	3	Mid	1.24	7.20	79.2	8.2	70.9
Jan	1	Mid	1.24	7.43	74.3	6.9	67.4
Jan	2	Mid	1.24	7.66	76.6	5.1	71.5
Jan	3	Mid	1.24	7.89	86.8	6.6	80.3
Feb	1	Late	1.18	7.74	77.4	7.9	69.5
Feb	2	Late	1.05	7.07	70.7	8.7	62.0
Feb	3	Late	0.93	6.21	49.7	11.7	38.0
Mar	1	Late	0.81	5.37	53.7	15.0	38.7
Mar	2	Late	0.69	4.54	36.3	14.2	18.5
					842.8	183.5	656.4

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SCHEME SUPPLY

ETo station: Final Modi Omo Valley Cropping pattern: OVF Scheme
Rain station: Final OMO Valley

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation deficit												
1. COTTON /STG & CANDIA	0.0	0.0	0.0	0.0	9.5	111.0	183.1	191.8	129.8	3.9	0.0	0.0
2. Small Vegetables	0.0	0.0	0.0	0.0	0.0	48.1	114.6	168.5	88.8	0.0	0.0	0.0
3. CITRUS 70% ca bare	111.9	98.4	86.9	56.4	68.5	75.9	87.6	99.9	100.9	104.0	53.2	89.2
4. Forage perennial	165.6	151.1	140.6	96.7	104.5	97.1	114.0	127.5	129.2	134.0	84.2	130.6
5. COTTON	0.0	0.0	0.0	0.0	0.0	23.1	93.3	196.5	198.4	148.3	14.2	0.0
6. COTTON/STG & CANDIA	220.4	170.2	57.3	0.0	0.0	0.0	0.0	0.0	0.0	13.8	28.2	169.7
7. MAIZE (Grain)	220.8	128.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	8.5	150.7
8. Wheat	210.0	143.3	6.4	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0	116.0
9. Soybean	114.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	48.8	176.6
10. Mung beans	97.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.1	136.7	207.4
11. Haricot beans	85.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.6	167.7	191.1
12. Sesame	208.2	174.3	33.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.5	122.8
13. Small Vegetables	184.5	15.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.3	145.5
14. COTTON	220.4	170.2	57.3	0.0	0.0	0.0	0.0	0.0	0.0	13.8	28.2	169.7
Net scheme irr.req.												
in mm/day	6.6	5.3	1.3	0.1	0.3	3.5	5.7	6.1	4.4	0.7	0.7	4.8
in mm/month	206.0	147.4	39.8	1.5	10.5	106.3	177.1	190.2	131.8	20.4	22.2	148.9
in l/s/h	0.77	0.61	0.15	0.01	0.04	0.41	0.66	0.71	0.51	0.08	0.09	0.56
Irrigated area (% of total area)	99.0	94.0	88.0	2.0	95.0	100.0	100.0	100.0	100.0	180.0	88.0	99.0
Irr.req. for actual area (l/s/h)	**0.78**	**0.65**	**0.17**	**0.30**	**0.04**	**0.41**	**0.66**	**0.71**	**0.51**	**0.04**	**0.10**	**0.56**

1202 mm/ annum, with the duty of 0.78 l/s/ha in the month of January.

8. 3. Irrigation Scheduling

Irrigation scheduling aims at providing water to the plant when it needs and creating or maintaining conditions under which the plant can achieve optimum growth. The cotton plant and the situation in the farm are the best indicators of the water needs of the plant. The actual irrigation in the Omo Valley Farm is carried out according to the irrigation schedule worked out on the basis of crop development stage, prevailing climatic condition and water management practices. Irrigation schedule was worked out using crop-wat 8.0 software. In the process of working out the irrigation schedule, agronomic parameters of the crops (planting date and root depth) together with the three major types of soil categories identified in the Project Command i.e., Clay & Silt-clay, Sandy loam and Loamy sand were considered. Moreover, to depict soil affinity to moisture, Percent of Total Available soil Moisture, the difference between Field Capacity (FC) & Permanent Wilting Point (PWP), Maximum rain infiltration rate and Initial soil moisture Depletion were considered. The following calculation procedures and formula were employed to determine the irrigation interval and water requirement stages of the crops.

Irrigation Scheduling = DxPxAWC/Peak NIR (mm)

D = Root Depth (m)

P = Management allowable depletion (%)

AWC = (FC-PWP) (mm/m)

8.3.1 Soil Physical Characteristics

8.3.1.1 Soil Texture

In the study area Omo Valley Farm, textures vary reasonably on the surface. Almost every possible texture can be found somewhere in the area: Most of the soils are, however, predominantly medium textured: typically sandy loams, sandy clay loams, silty clay. Texture has been used as the main criterion in classifying the soils of the study area.

8.3.1.2 Effective Soil Depth

Generally soils of the area are deep, extending to at least two meter depth. Effective depth is unlikely to be a major limitation to development of the area, for irrigated cotton production, except the type of the canal to be used.

8.3.1.3 Bulk Density

With the exceptions of the 0-24 cm sample (bulk density ranges between 1.47 to 1.91 g/cm3 for all types of texture) and the 90 – 100 cm sample (1.75 g/cm3 for sandy loam) all measured bulk density values were less than 1.91 g /cm3, and about 75% of the samples had values of less than 1.84 g/cm3. These are generally medium results indicate that no major problems of root penetration or of soil aeration and drainage are likely in the study area.

8.3.2 Irrigation Depths and Intervals

The period between two irrigation events on a given field is called irrigation interval. Intervals have to be determined prior to every irrigation turn. Irrigation interval is dependent on growth stages of the crop and soil type. The relationship between the crop and the soil is expressed in terms of soil moisture depletion level. Studies indicated that during vegetative, and yield formation periods, the depletion level, is about 65 %. The procedure utilized to estimate the irrigation interval of the Omo Valley Farm command has been worked out using the cropwat-8 software based on the soils data analysis obtained from the soli survey study sector considering the three major textural classes as Clay & Silt-clay (Heavy), Sandy loam (medium) and Loamy sand (Light) and the 80% dependable effective rainfall obtained from hydrology sectoral report.

Option I

CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: COTTON Planting date: 05/05
Rain station: Modified OVRF Soil: Loamy sand Harvest date: 28/09

Yield red.: 7.6 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
14 May	10	Init	0.0	1.00	100	42	9.6	0.0	0.0	13.6	0.16
24 May	20	Init	0.0	1.00	100	36	10.9	0.0	0.0	15.6	0.18
3 Jun	30	Dev	3.9	1.00	100	42	15.8	0.0	0.0	22.6	0.26
13 Jun	40	Dev	2.9	1.00	100	62	28.1	0.0	0.0	40.2	0.47
23 Jun	50	Dev	2.3	0.91	99	78	41.4	0.0	0.0	59.1	0.68
3 Jul	60	Dev	1.5	0.64	94	85	51.6	0.0	0.0	73.8	0.85
13 Jul	70	Mid	0.8	0.40	87	90	56.6	0.0	0.0	80.8	0.94
23 Jul	80	Mid	0.9	0.35	85	92	57.3	0.0	0.0	81.9	0.95
2 Aug	90	Mid	0.0	0.30	83	93	58.1	0.0	0.0	83.0	0.96
12 Aug	100	Mid	0.0	0.28	83	93	58.3	0.0	0.0	83.4	0.96
22 Aug	110	End	0.0	0.29	83	94	58.4	0.0	0.0	83.5	0.97
1 Sep	120	End	0.0	0.37	90	93	58.4	0.0	0.0	83.4	0.97
11 Sep	130	End	0.0	0.97	100	88	54.8	0.0	0.0	78.3	0.91
21 Sep	140	End	0.0	1.00	100	74	46.2	0.0	0.0	66.0	0.76
28 Sep	End	End	0.0	1.00	100	32					

Totals:

Total gross irrigation	865.1 mm	Total rainfall	70.2 mm
Total net irrigation	605.6 mm	Effective rainfall	60.8 mm
Total irrigation losses	0.0 mm	Total rain loss	9.4 mm

Actual water use by crop	686.3 mm	Moist deficit at harvest	19.9 mm
Potential water use by crop	753.4 mm	Actual irrigation requirement	692.6 mm

Efficiency irrigation schedule	100.0 %	Efficiency rain	86.6 %
Deficiency irrigation schedule	8.9 %		

Yield reductions:

Stagelabel	A	B	C	D	Season
Reductions in ETc	0.0	2.5	14.0	8.4	8.9 %
Yield response factor	0.20	0.50	0.50	0.25	0.85
Yield reduction	0.0	1.2	7.0	2.1	7.6 %
Cumulative yield reduction	0.0	1.2	8.2	10.1	%

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CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: Mung bean Planting date: 05/11
Rain station: Modified OVRF Soil: Loamy sand Harvest date: 22/02

Yield red.: 31.3 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
14 Nov	10	Init	0.0	0.90	96	61	12.7	0.0	0.0	18.2	0.21
24 Nov	20	Init	0.0	0.94	99	57	15.4	0.0	0.0	22.1	0.26
4 Dec	30	Dev	0.0	0.72	94	69	22.8	0.0	0.0	32.6	0.38
14 Dec	40	Dev	0.0	0.44	81	82	31.9	0.0	0.0	45.6	0.53
24 Dec	50	Dev	0.0	0.32	72	87	39.2	0.0	0.0	56.0	0.65
3 Jan	60	Mid	1.9	0.23	65	91	40.9	0.0	0.0	58.4	0.68
13 Jan	70	Mid	1.8	0.21	63	92	41.3	0.0	0.0	59.0	0.68
23 Jan	80	Mid	1.9	0.20	62	92	41.6	0.0	0.0	59.4	0.69
2 Feb	90	Mid	0.0	0.12	61	95	42.9	0.0	0.0	61.3	0.71
12 Feb	100	End	0.0	0.18	70	93	41.9	0.0	0.0	59.9	0.69
22 Feb	End	End	0.0	0.74	55	74					

Totals:

Total gross irrigation	472.4 mm	Total rainfall	53.9 mm
Total net irrigation	330.7 mm	Effective rainfall	50.0 mm
Total irrigation losses	0.0 mm	Total rain loss	3.9 mm
Actual water use by crop	413.9 mm	Moist deficit at harvest	33.2 mm
Potential water use by crop	568.8 mm	Actual irrigation requirement	518.9 mm
Efficiency irrigation schedule	100.0 %	Efficiency rain	92.7 %
Deficiency irrigation schedule	27.2 %		

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	2.4	19.8	37.4	19.9	27.2	%
Yield response factor	0.20	0.60	1.00	0.20	1.15	
Yield reduction	0.5	11.9	37.4	4.0	31.3	%
Cumulative yield reduction	0.5	12.3	45.1	47.3		%

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CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: Soybean Planting date: 05/11
Rain station: Modified OVRF Soil: Loamy sand Harvest date: 28/01

Yield red.: 14.8 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
14 Nov	10	Init	0.0	1.00	100	52	13.8	0.0	0.0	19.7	0.23
24 Nov	20	Dev	0.0	1.00	100	58	22.2	0.0	0.0	31.7	0.37
4 Dec	30	Dev	0.0	0.64	94	83	41.3	0.0	0.0	59.0	0.68
14 Dec	40	Mid	0.0	0.27	78	93	46.4	0.0	0.0	66.2	0.77
24 Dec	50	Mid	0.0	0.24	76	94	46.8	0.0	0.0	66.9	0.77
3 Jan	60	Mid	1.9	0.26	73	93	46.7	0.0	0.0	66.7	0.77
13 Jan	70	Mid	1.8	0.25	73	93	46.6	0.0	0.0	66.6	0.77
23 Jan	80	End	1.9	0.43	87	95	47.6	0.0	0.0	68.0	0.79
28 Jan	End	End	0.0	1.00	93	31					

Totals:

Total gross irrigation	444.7 mm	Total rainfall	46.9 mm
Total net irrigation	311.3 mm	Effective rainfall	46.5 mm
Total irrigation losses	0.0 mm	Total rain loss	0.3 mm
Actual water use by crop	373.4 mm	Moist deficit at harvest	15.5 mm
Potential water use by crop	451.8 mm	Actual irrigation requirement	405.3 mm
Efficiency irrigation schedule	100.0 %	Efficiency rain	99.3 %
Deficiency irrigation schedule	17.4 %		

Yield reductions:

Stagelabel	A	B	C	D	Season
Reductions in ETc	0.0	4.4	25.1	9.9	17.4 %
Yield response factor	0.40	0.80	1.00	0.40	0.85
Yield reduction	0.0	3.5	25.1	3.9	14.8 %
Cumulative yield reduction	0.0	3.5	27.7	30.6	%

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CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: Wheat Planting date: 30/10
Rain station: Modified OVRF Soil: Loamy sand Harvest date: 08/03

Yield red.: 15.8 %
Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	Eta %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
8 Nov	10	Init	0.0	1.00	100	35	8.0	0.0	0.0	11.4	0.13
18 Nov	20	Init	0.0	1.00	100	25	7.5	0.0	0.0	10.8	0.12
28 Nov	30	Init	0.0	1.00	100	26	9.6	0.0	0.0	13.7	0.16
8 Dec	40	Dev	0.0	1.00	100	48	21.7	0.0	0.0	31.0	0.36
18 Dec	50	Dev	0.0	0.78	97	72	37.7	0.0	0.0	53.9	0.62
28 Dec	60	Dev	0.0	0.51	87	83	49.6	0.0	0.0	70.9	0.82
7 Jan	70	Mid	1.9	0.38	81	87	52.4	0.0	0.0	74.9	0.87
17 Jan	80	Mid	1.8	0.33	78	89	53.4	0.0	0.0	76.4	0.88
27 Jan	90	Mid	1.9	0.31	77	90	53.9	0.0	0.0	77.0	0.89
6 Feb	100	Mid	0.0	0.24	75	92	55.3	0.0	0.0	79.0	0.91
16 Feb	110	End	0.0	0.34	84	91	54.5	0.0	0.0	77.9	0.90
26 Feb	120	End	0.0	0.99	100	79	47.4	0.0	0.0	67.7	0.78
8 Mar	End	End	0.0	1.00	100	33					

Totals:

Total gross irrigation	644.4 mm	Total rainfall	71.3 mm
Total net irrigation	451.1 mm	Effective rainfall	65.1 mm
Total irrigation losses	0.0 mm	Total rain loss	6.2 mm
Actual water use by crop	536.2 mm	Moist deficit at harvest	20.1 mm
Potential water use by crop	621.4 mm	Actual irrigation requirement	556.3 mm
Efficiency irrigation schedule	100.0 %	Efficiency rain	91.2 %
Deficiency irrigation schedule	13.7 %		

Yield reductions:

Stagelabel	A	B	C	D	Season
Reductions in ETc	0.0	6.8	22.3	7.6	13.7 %
Yield response factor	0.40	0.60	0.80	0.40	1.15
Yield reduction	0.0	4.1	17.8	3.0	15.8 %
Cumulative yield reduction	0.0	4.1	21.2	23.6	%

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CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: Vegetables Planting date: 15/06
Rain station: Modified OVRF Soil: Loamy sand Harvest date: 17/09

Yield red.: 47.1 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow

					mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
24 Jun	10	Init	0.0	0.25	51	89	14.2	0.0	0.0	20.3	0.23
4 Jul	20	Init	0.0	0.22	54	89	17.4	0.0	0.0	24.9	0.29
14 Jul	30	Dev	0.0	0.18	54	92	21.2	0.0	0.0	30.2	0.35
24 Jul	40	Dev	0.0	0.16	52	94	24.9	0.0	0.0	35.6	0.41
3 Aug	50	Dev	1.1	0.17	52	94	28.2	0.0	0.0	40.3	0.47
13 Aug	60	Mid	1.1	0.11	50	96	28.9	0.0	0.0	41.3	0.48
23 Aug	70	Mid	1.3	0.12	49	96	28.8	0.0	0.0	41.2	0.48
2 Sep	80	Mid	0.0	0.04	48	99	29.6	0.0	0.0	42.3	0.49
12 Sep	90	End	0.0	0.04	49	99	29.6	0.0	0.0	42.3	0.49
17 Sep	End	End	0.0	0.79	100	72					

Totals:

Total gross irrigation	318.4 mm	Total rainfall	26.0 mm
Total net irrigation	222.9 mm	Effective rainfall	23.4 mm
Total irrigation losses	0.0 mm	Total rain loss	2.7 mm

Actual water use by crop	267.7 mm	Moist deficit at harvest	21.5 mm
Potential water use by crop	506.2 mm	Actual irrigation requirement	482.8 mm

Efficiency irrigation schedule	100.0 %	Efficiency rain	89.7 %
Deficiency irrigation schedule	47.1 %		

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	47.6	47.2	51.0	38.1	47.1	%
Yield response factor	0.80	0.40	1.20	1.00	1.00	
Yield reduction	38.1	18.9	61.2	38.1	47.1	%
Cumulative yield reduction	38.1	49.8	80.5	87.9		%

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CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: Haricotbean Planting date: 25/10
Rain station: Modified OVRF Soil: Loamy sand Harvest date: 11/02

Yield red.: 30.0 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
3 Nov	10	Init	4.8	0.95	92	58	12.3	0.0	0.0	17.5	0.20
13 Nov	20	Init	4.9	1.00	98	53	14.4	0.0	0.0	20.5	0.24
23 Nov	30	Dev	4.0	0.85	95	64	21.1	0.0	0.0	30.1	0.35
3 Dec	40	Dev	2.8	0.52	82	79	30.7	0.0	0.0	43.8	0.51
13 Dec	50	Dev	1.9	0.36	73	85	38.4	0.0	0.0	54.9	0.63
23 Dec	60	Mid	1.9	0.25	67	90	40.5	0.0	0.0	57.9	0.67
2 Jan	70	Mid	0.0	0.16	64	94	42.2	0.0	0.0	60.4	0.70
12 Jan	80	Mid	0.0	0.14	63	94	42.5	0.0	0.0	60.7	0.70
22 Jan	90	Mid	0.0	0.14	62	94	42.5	0.0	0.0	60.7	0.70
1 Feb	100	End	0.0	0.18	71	93	41.8	0.0	0.0	59.7	0.69
11 Feb	End	End	0.0	1.00	55	68					

Totals:

Total gross irrigation	466.3 mm	Total rainfall	60.1 mm
Total net irrigation	326.4 mm	Effective rainfall	54.3 mm
Total irrigation losses	0.0 mm	Total rain loss	5.8 mm
Actual water use by crop	411.2 mm	Moist deficit at harvest	30.5 mm
Potential water use by crop	556.3 mm	Actual irrigation requirement	502.0 mm
Efficiency irrigation schedule	100.0 %	Efficiency rain	90.4 %
Deficiency irrigation schedule	26.1 %		

Yield reductions:

Stagelabel	A	B	C	D	Season
Reductions in ETc	4.6	18.6	36.0	18.7	26.1 %
Yield response factor	0.20	0.60	1.00	0.20	1.15
Yield reduction	0.9	11.1	36.0	3.7	30.0 %
Cumulative yield reduction	0.9	12.0	43.7	45.8	%

Cropwat 8.0 Bèta 21/05/15 10:25:07 AM

CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: Sesame Planting date: 01/11
Rain station: Modified OVRF Soil: Loamy sand Harvest date: 10/03

Yield red.: 23.1 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
10 Nov	10	Init	0.0	0.74	97	68	13.1	0.0	0.0	18.7	0.22
20 Nov	20	Init	0.0	0.94	99	57	13.4	0.0	0.0	19.1	0.22
30 Nov	30	Dev	0.0	0.87	99	60	16.5	0.0	0.0	23.6	0.27
10 Dec	40	Dev	0.0	0.47	85	79	25.1	0.0	0.0	35.9	0.42
20 Dec	50	Dev	0.0	0.30	73	88	31.4	0.0	0.0	44.9	0.52
30 Dec	60	Dev	0.0	0.20	64	92	36.9	0.0	0.0	52.7	0.61
9 Jan	70	Mid	0.0	0.13	60	95	38.0	0.0	0.0	54.3	0.63
19 Jan	80	Mid	0.0	0.12	57	96	38.3	0.0	0.0	54.7	0.63
29 Jan	90	Mid	0.0	0.11	56	96	38.4	0.0	0.0	54.9	0.64
8 Feb	100	Mid	0.0	0.12	54	96	38.3	0.0	0.0	54.7	0.63
18 Feb	110	End	0.0	0.12	55	96	38.3	0.0	0.0	54.7	0.63
28 Feb	120	End	0.0	0.23	65	92	36.7	0.0	0.0	52.4	0.61
10 Mar	End	End	0.0	0.53	100	80					

Totals:

Total gross irrigation	520.6 mm	Total rainfall	71.3 mm
Total net irrigation	364.4 mm	Effective rainfall	70.9 mm
Total irrigation losses	0.0 mm	Total rain loss	0.4 mm
Actual water use by crop	467.2 mm	Moist deficit at harvest	31.9 mm
Potential water use by crop	697.9 mm	Actual irrigation requirement	627.0 mm
Efficiency irrigation schedule	100.0 %	Efficiency rain	99.4 %
Deficiency irrigation schedule	33.1 %		

Yield reductions:

Stagelabel	A	B	C	D	Season
Reductions in ETc	1.6	25.8	39.7	38.6	33.1 %
Yield response factor	0.20	0.80	0.60	0.20	0.70
Yield reduction	0.3	20.7	23.8	7.7	23.1 %
Cumulative yield reduction	0.3	20.9	39.7	44.4	%

Cropwat 8.0 Bèta 21/05/15 10:49:06 AM

CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: MANGO Planting date: 26/06
Rain station: Modified OVRF Soil: Loamy sand Harvest date: 25/06

Yield red.: 7.0 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
5 Jul	10	Init	0.0	0.81	98	74	46.3	0.0	0.0	66.1	0.77
15 Jul	20	Init	0.0	0.78	97	75	47.1	0.0	0.0	67.3	0.78
25 Jul	30	Init	0.0	0.73	97	77	48.0	0.0	0.0	68.6	0.79

4 Aug	40	Init	0.0	0.72	96	77	48.3	0.0	0.0	69.0	0.80
14 Aug	50	Init	0.0	0.70	96	78	48.7	0.0	0.0	69.6	0.81
24 Aug	60	Init	0.0	0.69	96	78	49.0	0.0	0.0	70.1	0.81
3 Sep	70	Init	1.3	0.69	95	78	49.0	0.0	0.0	70.0	0.81
13 Sep	80	Init	1.4	0.68	95	79	49.2	0.0	0.0	70.4	0.81
23 Sep	90	Init	2.5	0.71	95	78	48.6	0.0	0.0	69.5	0.80
3 Oct	100	Dev	3.9	0.79	96	75	47.2	0.0	0.0	67.4	0.78
13 Oct	110	Dev	5.0	0.84	97	74	46.3	0.0	0.0	66.2	0.77
23 Oct	120	Dev	4.8	0.83	97	75	46.6	0.0	0.0	66.5	0.77
2 Nov	130	Dev	0.0	0.61	94	82	50.9	0.0	0.0	72.8	0.84
12 Nov	140	Dev	0.0	0.58	93	82	51.6	0.0	0.0	73.7	0.85
22 Nov	150	Dev	0.0	0.56	93	83	52.0	0.0	0.0	74.3	0.86
2 Dec	160	Dev	0.0	0.51	91	85	52.9	0.0	0.0	75.6	0.88
12 Dec	170	Dev	0.0	0.46	89	86	54.0	0.0	0.0	77.1	0.89
22 Dec	180	Dev	0.0	0.41	87	88	55.0	0.0	0.0	78.6	0.91
1 Jan	190	Mid	0.0	0.36	85	90	55.9	0.0	0.0	79.9	0.93
11 Jan	200	Mid	0.0	0.36	85	90	56.1	0.0	0.0	80.1	0.93
21 Jan	210	Mid	0.0	0.33	83	91	56.8	0.0	0.0	81.1	0.94
31 Jan	220	Mid	0.0	0.30	82	92	57.3	0.0	0.0	81.8	0.95
10 Feb	230	Mid	0.0	0.27	80	93	57.9	0.0	0.0	82.7	0.96
20 Feb	240	Mid	0.0	0.24	78	93	58.4	0.0	0.0	83.4	0.97
2 Mar	250	Mid	0.0	0.28	81	92	57.7	0.0	0.0	82.5	0.95
12 Mar	260	Mid	0.0	0.26	80	93	58.0	0.0	0.0	82.8	0.96
22 Mar	270	Mid	0.0	0.29	81	92	57.5	0.0	0.0	82.1	0.95
1 Apr	280	End	0.0	0.35	85	90	56.2	0.0	0.0	80.3	0.93
11 Apr	290	End	0.0	0.66	96	80	50.3	0.0	0.0	71.9	0.83
21 Apr	300	End	0.0	0.84	99	75	46.6	0.0	0.0	66.6	0.77
1 May	310	End	0.0	0.88	99	73	45.7	0.0	0.0	65.3	0.76
11 May	320	End	0.0	0.89	99	72	45.2	0.0	0.0	64.5	0.75
21 May	330	End	0.0	0.94	99	71	44.2	0.0	0.0	63.1	0.73
31 May	340	End	0.0	0.92	99	71	44.5	0.0	0.0	63.6	0.74
10 Jun	350	End	0.0	0.89	99	72	44.9	0.0	0.0	64.2	0.74
20 Jun	360	End	0.0	0.86	99	73	45.5	0.0	0.0	65.0	0.75
25 Jun	End	End	0.0	1.00	0	29					

Totals:

Total gross irrigation	2613.5 mm	Total rainfall	254.8 mm
Total net irrigation	1829.5 mm	Effective rainfall	209.9 mm
Total irrigation losses	0.0 mm	Total rain loss	44.9 mm

Actual water use by crop	2057.8 mm	Moist deficit at harvest	18.4 mm
Potential water use by crop	2256.6 mm	Actual irrigation requirement	2046. mm

Efficiency irrigation schedule	100.0 %	Efficiency rain	82.4 %
Deficiency irrigation schedule	8.8 %		

Yield reductions:

Stagelabel	A	B	C	D	Season
Reductions in ETc	3.9	7.2	18.3	3.1	8.8 %
Yield response factor	0.80	0.80	0.80	0.80	0.80
Yield reduction	3.2	5.7	14.7	2.5	7.0 %
Cumulative yield reduction	3.2	8.7	22.1	24.1	%

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CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: Forage Planting date: 26/06
Rain station: Modified OVRF Soil: Loamy sand Harvest date: 25/06

Yield red.: 18.9 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
5 Jul	10	Init	0.0	0.36	81	86	34.6	0.0	0.0	49.4	0.57
15 Jul	20	Init	0.0	0.32	78	88	35.2	0.0	0.0	50.3	0.58
25 Jul	30	Init	0.0	0.30	77	89	35.5	0.0	0.0	50.7	0.59
4 Aug	40	Init	0.0	0.30	76	89	35.5	0.0	0.0	50.7	0.59
14 Aug	50	Init	0.0	0.29	75	89	35.6	0.0	0.0	50.9	0.59
24 Aug	60	Init	0.0	0.29	75	89	35.7	0.0	0.0	51.0	0.59
3 Sep	70	Init	1.3	0.30	74	89	35.5	0.0	0.0	50.7	0.59
13 Sep	80	Init	1.4	0.30	74	89	35.5	0.0	0.0	50.7	0.59
23 Sep	90	Init	2.5	0.35	74	87	34.8	0.0	0.0	49.7	0.57
3 Oct	100	Init	3.9	0.45	77	83	33.4	0.0	0.0	47.7	0.55
13 Oct	110	Init	5.0	0.53	80	80	32.1	0.0	0.0	45.9	0.53
23 Oct	120	Init	4.8	0.55	82	80	31.8	0.0	0.0	45.5	0.53
2 Nov	130	Init	0.0	0.31	80	88	35.3	0.0	0.0	50.5	0.58
12 Nov	140	Init	0.0	0.32	81	88	35.2	0.0	0.0	50.3	0.58
22 Nov	150	Dev	0.0	0.32	81	88	35.1	0.0	0.0	50.2	0.58
2 Dec	160	Dev	0.0	0.30	79	89	35.6	0.0	0.0	50.8	0.59
12 Dec	170	Dev	0.0	0.27	76	90	36.0	0.0	0.0	51.5	0.60
22 Dec	180	Dev	0.0	0.24	74	91	36.5	0.0	0.0	52.2	0.60
1 Jan	190	Dev	0.0	0.20	71	93	37.1	0.0	0.0	53.0	0.61
11 Jan	200	Dev	0.0	0.20	71	93	37.2	0.0	0.0	53.2	0.62
21 Jan	210	Mid	0.0	0.17	68	94	37.7	0.0	0.0	53.8	0.62
31 Jan	220	Mid	0.0	0.16	67	95	37.9	0.0	0.0	54.1	0.63
10 Feb	230	Mid	0.0	0.15	65	95	38.0	0.0	0.0	54.3	0.63
20 Feb	240	Mid	0.0	0.13	64	96	38.2	0.0	0.0	54.6	0.63
2 Mar	250	Mid	0.0	0.16	67	95	37.8	0.0	0.0	54.0	0.63
12 Mar	260	Mid	0.0	0.13	65	96	38.2	0.0	0.0	54.6	0.63
22 Mar	270	Mid	0.0	0.14	67	95	38.0	0.0	0.0	54.3	0.63
1 Apr	280	Mid	0.0	0.18	71	94	37.5	0.0	0.0	53.6	0.62
11 Apr	290	Mid	0.0	0.33	85	88	35.2	0.0	0.0	50.3	0.58
21 Apr	300	Mid	0.0	0.42	89	85	33.9	0.0	0.0	48.5	0.56
1 May	310	Mid	0.0	0.41	88	85	34.0	0.0	0.0	48.6	0.56
11 May	320	Mid	0.0	0.39	87	86	34.3	0.0	0.0	48.9	0.57
21 May	330	End	0.0	0.40	87	85	34.0	0.0	0.0	48.6	0.56
31 May	340	End	0.0	0.40	86	85	34.0	0.0	0.0	48.5	0.56
10 Jun	350	End	0.0	0.40	85	85	34.0	0.0	0.0	48.6	0.56
20 Jun	360	End	0.0	0.38	84	86	34.2	0.0	0.0	48.9	0.57
25 Jun	End	End	0.0	1.00	0	42					

Totals:

Total gross irrigation	1828.8 mm	Total rainfall	254.8 mm
Total net irrigation	1280.2 mm	Effective rainfall	206.6 mm
Total irrigation losses	0.0 mm	Total rain loss	48.2 mm

Actual water use by crop	1503.5 mm	Moist deficit at harvest	16.8 mm
Potential water use by crop	1967.3 mm	Actual irrigation requirement	1760. mm

Efficiency irrigation schedule	100.0 %	Efficiency rain	81.1 %
Deficiency irrigation schedule	23.6 %		

Yield reductions:

Stagelabel	A	B	C	D	Season
Reductions in ETc	22.6	25.0	27.0	13.3	23.6 %
Yield response factor	0.80	0.80	0.80	0.80	0.80
Yield reduction	18.1	20.0	21.6	10.6	18.9 %
Cumulative yield reduction	18.1	34.5	48.6	54.1	%

Cropwat 8.0 Bèta 21/05/15 10:57:34 AM

Option II

CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: COTTON Planting date: 05/05
Rain station: Modified OVRF Soil: Sandy Loam Harvest date: 28/09

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
14 May	10	Init	0.0	1.00	100	24	9.6	0.0	0.0	13.6	0.16
24 May	20	Init	0.0	1.00	100	21	10.9	0.0	0.0	15.6	0.18
3 Jun	30	Dev	3.9	1.00	100	24	15.8	0.0	0.0	22.6	0.26
13 Jun	40	Dev	2.9	1.00	100	35	28.1	0.0	0.0	40.2	0.47
23 Jun	50	Dev	2.3	1.00	100	45	41.9	0.0	0.0	59.8	0.69
3 Jul	60	Dev	1.5	1.00	100	52	55.5	0.0	0.0	79.3	0.92
13 Jul	70	Mid	0.8	1.00	100	60	65.5	0.0	0.0	93.6	1.08
23 Jul	80	Mid	0.9	1.00	100	63	68.1	0.0	0.0	97.3	1.13
2 Aug	90	Mid	0.0	1.00	100	64	69.9	0.0	0.0	99.8	1.16
12 Aug	100	Mid	0.0	1.00	100	65	70.8	0.0	0.0	101.1	1.17
22 Aug	110	End	0.0	1.00	100	65	70.5	0.0	0.0	100.7	1.17
1 Sep	120	End	0.0	1.00	100	60	65.1	0.0	0.0	92.9	1.08
11 Sep	130	End	0.0	1.00	100	51	54.9	0.0	0.0	78.5	0.91
21 Sep	140	End	0.0	1.00	100	42	46.2	0.0	0.0	66.0	0.76
28 Sep	End	End	0.0	1.00	97	18					

Totals:

Total gross irrigation	961.0 mm	Total rainfall	70.2 mm
Total net irrigation	672.7 mm	Effective rainfall	60.8 mm
Total irrigation losses	0.0 mm	Total rain loss	9.4 mm

Actual water use by crop 753.4 mm Moist deficit at harvest 19.9 mm
Potential water use by crop 753.4 mm Actual irrigation requirement 692.6 mm

Efficiency irrigation schedule 100.0 % Efficiency rain 86.6 %
Deficiency irrigation schedule 0.0 %

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	0.0	0.0	0.0	%
Yield response factor	0.20	0.50	0.50	0.25	0.85	
Yield reduction	0.0	0.0	0.0	0.0	0.0	%
Cumulative yield reduction	0.0	0.0	0.0	0.0		%

Cropwat 8.0 Bèta 21/05/15 11:03:43 AM

CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: Vegetables Planting date: 15/06
Rain station: Modified OVRF Soil: Sandy Loam Harvest date: 17/09

Yield red.: 23.7 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
24 Jun	10	Init	0.0	0.40	70	78	21.6	0.0	0.0	30.9	0.36
4 Jul	20	Init	0.0	0.43	75	75	25.5	0.0	0.0	36.5	0.42
14 Jul	30	Dev	0.0	0.43	77	77	30.9	0.0	0.0	44.1	0.51
24 Jul	40	Dev	0.0	0.41	76	81	37.1	0.0	0.0	53.0	0.61
3 Aug	50	Dev	1.1	0.41	78	82	42.9	0.0	0.0	61.3	0.71
13 Aug	60	Mid	1.1	0.33	75	86	44.9	0.0	0.0	64.2	0.74
23 Aug	70	Mid	1.3	0.32	75	86	45.0	0.0	0.0	64.3	0.74
2 Sep	80	Mid	0.0	0.28	74	88	46.0	0.0	0.0	65.7	0.76
12 Sep	90	End	0.0	0.29	76	88	46.2	0.0	0.0	66.0	0.76
17 Sep	End	End	1.1	1.00	100	44					

Totals:

Total gross irrigation 485.9 mm Total rainfall 26.0 mm
Total net irrigation 340.1 mm Effective rainfall 23.4 mm
Total irrigation losses 0.0 mm Total rain loss 2.7 mm

Actual water use by crop 386.3 mm Moist deficit at harvest 22.8 mm
Potential water use by crop 506.2 mm Actual irrigation requirement 482.8 mm

Efficiency irrigation schedule 100.0 % Efficiency rain 89.7 %
Deficiency irrigation schedule 23.7 %

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	27.6	23.1	25.4	17.5	23.7	%
Yield response factor	0.80	0.40	1.20	1.00	1.00	
Yield reduction		22.1	9.2	30.5	17.5	23.7 %
Cumulative yield reduction	22.1	29.3	50.8	59.4	%	

Cropwat 8.0 Bèta 21/05/15 11:06:20 AM

CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: MANGO Planting date: 26/06
Rain station: Modified OVRF Soil: Sandy Loam Harvest date: 25/06

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
5 Jul	10	Init	0.0	1.00	100	43	47.2	0.0	0.0	67.5	0.78
15 Jul	20	Init	0.0	1.00	100	44	48.4	0.0	0.0	69.1	0.80
25 Jul	30	Init	0.0	1.00	100	46	49.8	0.0	0.0	71.1	0.82
4 Aug	40	Init	0.0	1.00	100	46	50.2	0.0	0.0	71.8	0.83
14 Aug	50	Init	0.0	1.00	100	47	50.9	0.0	0.0	72.7	0.84
24 Aug	60	Init	0.0	1.00	100	47	51.4	0.0	0.0	73.4	0.85
3 Sep	70	Init	1.3	1.00	100	48	51.7	0.0	0.0	73.8	0.85
13 Sep	80	Init	1.4	1.00	100	48	52.1	0.0	0.0	74.4	0.86
23 Sep	90	Init	2.5	1.00	100	47	51.4	0.0	0.0	73.4	0.85
3 Oct	100	Dev	3.9	1.00	100	45	49.4	0.0	0.0	70.5	0.82
13 Oct	110	Dev	5.0	1.00	100	44	48.2	0.0	0.0	68.8	0.80
23 Oct	120	Dev	4.8	1.00	100	45	48.5	0.0	0.0	69.3	0.80
2 Nov	130	Dev	0.0	1.00	100	50	54.5	0.0	0.0	77.8	0.90
12 Nov	140	Dev	0.0	1.00	100	51	55.6	0.0	0.0	79.4	0.92
22 Nov	150	Dev	0.0	1.00	100	52	56.4	0.0	0.0	80.6	0.93
2 Dec	160	Dev	0.0	1.00	100	54	58.6	0.0	0.0	83.7	0.97
12 Dec	170	Dev	0.0	1.00	100	56	61.0	0.0	0.0	87.1	1.01
22 Dec	180	Dev	0.0	1.00	100	58	63.5	0.0	0.0	90.6	1.05
1 Jan	190	Mid	0.0	1.00	100	61	66.3	0.0	0.0	94.7	1.10
11 Jan	200	Mid	0.0	1.00	100	61	66.6	0.0	0.0	95.1	1.10
21 Jan	210	Mid	0.0	1.00	100	63	69.0	0.0	0.0	98.6	1.14
31 Jan	220	Mid	0.0	1.00	100	65	70.8	0.0	0.0	101.1	1.17
10 Feb	230	Mid	0.0	0.99	100	67	73.1	0.0	0.0	104.5	1.21
20 Feb	240	Mid	0.0	0.95	99	69	75.0	0.0	0.0	107.2	1.24
2 Mar	250	Mid	0.0	1.00	100	67	72.5	0.0	0.0	103.6	1.20
12 Mar	260	Mid	0.0	0.99	100	68	73.4	0.0	0.0	104.9	1.21
22 Mar	270	Mid	0.0	1.00	100	66	71.5	0.0	0.0	102.1	1.18
1 Apr	280	End	0.0	1.00	100	61	66.8	0.0	0.0	95.4	1.10
11 Apr	290	End	0.0	1.00	100	49	53.1	0.0	0.0	75.9	0.88
21 Apr	300	End	0.0	1.00	100	44	47.6	0.0	0.0	68.0	0.79
1 May	310	End	0.0	1.00	100	43	46.4	0.0	0.0	66.3	0.77
11 May	320	End	0.0	1.00	100	42	45.8	0.0	0.0	65.4	0.76
21 May	330	End	0.0	1.00	100	41	44.5	0.0	0.0	63.6	0.74

31 May	340	End	0.0	1.00	100	41	44.9	0.0	0.0	64.2	0.74
10 Jun	350	End	0.0	1.00	100	42	45.5	0.0	0.0	65.0	0.75
20 Jun	360	End	0.0	1.00	100	42	46.2	0.0	0.0	66.0	0.76
25 Jun	End	End	0.0	1.00	0	17					

Totals:

Total gross irrigation	2896.7 mm	Total rainfall	254.8 mm
Total net irrigation	2027.7 mm	Effective rainfall	209.9 mm
Total irrigation losses	0.0 mm	Total rain loss	44.9 mm

Actual water use by crop	2256.0 mm	Moist deficit at harvest	18.4 mm
Potential water use by crop	2256.6 mm	Actual irrigation requirement	2046. mm

Efficiency irrigation schedule	100.0 %	Efficiency rain	82.4 %
Deficiency irrigation schedule	0.0 %		

Yield reductions:

Stagelabel	A	B	C	D	Season
Reductions in ETc	0.0	0.0	0.1	0.0	0.0 %
Yield response factor	0.80	0.80	0.80	0.80	0.80
Yield reduction	0.0	0.0	0.1	0.0	0.0 %
Cumulative yield reduction	0.0	0.0	0.1	0.1	%

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CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: Forage Planting date: 26/06
Rain station: Modified OVRF Soil: Sandy Loam Harvest date: 25/06

Yield red.: 3.1 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
5 Jul	10	Init	0.0	0.88	99	62	43.2	0.0	0.0	61.7	0.71
15 Jul	20	Init	0.0	0.83	98	64	44.6	0.0	0.0	63.7	0.74
25 Jul	30	Init	0.0	0.80	97	66	45.6	0.0	0.0	65.2	0.75
4 Aug	40	Init	0.0	0.79	97	66	45.9	0.0	0.0	65.6	0.76
14 Aug	50	Init	0.0	0.78	97	67	46.4	0.0	0.0	66.3	0.77
24 Aug	60	Init	0.0	0.77	97	67	46.7	0.0	0.0	66.8	0.77
3 Sep	70	Init	1.3	0.77	96	67	46.8	0.0	0.0	66.8	0.77
13 Sep	80	Init	1.4	0.76	96	68	47.0	0.0	0.0	67.2	0.78
23 Sep	90	Init	2.5	0.79	96	66	46.2	0.0	0.0	66.0	0.76
3 Oct	100	Init	3.9	0.86	97	63	44.0	0.0	0.0	62.8	0.73
13 Oct	110	Init	5.0	0.94	99	60	41.7	0.0	0.0	59.6	0.69
23 Oct	120	Init	4.8	0.97	99	58	40.7	0.0	0.0	58.1	0.67
2 Nov	130	Init	0.0	0.84	98	64	44.5	0.0	0.0	63.5	0.74
12 Nov	140	Init	0.0	0.86	99	63	44.1	0.0	0.0	62.9	0.73
22 Nov	150	Dev	0.0	0.86	99	63	43.9	0.0	0.0	62.8	0.73
2 Dec	160	Dev	0.0	0.82	98	65	45.2	0.0	0.0	64.6	0.75

12 Dec	170	Dev	0.0	0.78	97	67	46.6	0.0	0.0	66.6	0.77
22 Dec	180	Dev	0.0	0.73	96	69	48.1	0.0	0.0	68.8	0.80
1 Jan	190	Dev	0.0	0.68	94	72	49.9	0.0	0.0	71.2	0.82
11 Jan	200	Dev	0.0	0.66	94	73	50.5	0.0	0.0	72.2	0.84
21 Jan	210	Mid	0.0	0.61	92	75	52.1	0.0	0.0	74.4	0.86
31 Jan	220	Mid	0.0	0.58	92	76	52.9	0.0	0.0	75.6	0.87
10 Feb	230	Mid	0.0	0.55	90	78	54.0	0.0	0.0	77.2	0.89
20 Feb	240	Mid	0.0	0.52	89	79	55.0	0.0	0.0	78.5	0.91
2 Mar	250	Mid	0.0	0.56	91	77	53.6	0.0	0.0	76.5	0.89
12 Mar	260	Mid	0.0	0.54	90	78	54.2	0.0	0.0	77.4	0.90
22 Mar	270	Mid	0.0	0.57	91	77	53.3	0.0	0.0	76.1	0.88
1 Apr	280	Mid	0.0	0.64	94	74	51.2	0.0	0.0	73.1	0.85
11 Apr	290	Mid	0.0	0.89	99	63	43.7	0.0	0.0	62.5	0.72
21 Apr	300	Mid	0.0	1.00	100	58	40.5	0.0	0.0	57.8	0.67
1 May	310	Mid	0.0	0.98	100	58	40.7	0.0	0.0	58.1	0.67
11 May	320	Mid	0.0	0.96	100	59	41.2	0.0	0.0	58.9	0.68
21 May	330	End	0.0	0.97	100	58	40.7	0.0	0.0	58.2	0.67
31 May	340	End	0.0	0.97	100	58	40.7	0.0	0.0	58.1	0.67
10 Jun	350	End	0.0	0.95	100	59	41.2	0.0	0.0	58.8	0.68
20 Jun	360	End	0.0	0.93	99	60	41.8	0.0	0.0	59.7	0.69
25 Jun	End	End	0.0	1.00	0	24					

Totals:

Total gross irrigation	2383.3 mm	Total rainfall	254.8 mm
Total net irrigation	1668.3 mm	Effective rainfall	206.6 mm
Total irrigation losses	0.0 mm	Total rain loss	48.2 mm

Actual water use by crop	1891.6 mm	Moist deficit at harvest	16.8 mm
Potential water use by crop	1967.3 mm	Actual irrigation requirement	1760. mm

Efficiency irrigation schedule	100.0 %	Efficiency rain	81.1 %
Deficiency irrigation schedule	3.8 %		

Yield reductions:

Stagelabel	A	B	C	D	Season
Reductions in ETc	2.4	3.9	6.2	0.4	3.8 %
Yield response factor	0.80	0.80	0.80	0.80	0.80
Yield reduction	2.0	3.1	5.0	0.3	3.1 %
Cumulative yield reduction	2.0	5.0	9.7	10.0	%

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CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: MAIZE (Grain) Planting date: 30/10
Rain station: Modified OVRF Soil: Sandy Loam Harvest date: 03/03

Yield red.: 4.6 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha

8 Nov	10	Init	0.0	1.00	100	21	8.0	0.0	0.0	11.4	0.13
18 Nov	20	Init	0.0	1.00	100	16	7.9	0.0	0.0	11.3	0.13
28 Nov	30	Dev	0.0	1.00	100	31	18.6	0.0	0.0	26.5	0.31
8 Dec	40	Dev	0.0	1.00	100	50	35.2	0.0	0.0	50.3	0.58
18 Dec	50	Dev	0.0	0.97	100	63	51.7	0.0	0.0	73.9	0.85
28 Dec	60	Mid	0.0	0.75	97	73	63.1	0.0	0.0	90.2	1.04
7 Jan	70	Mid	1.9	0.68	94	75	65.6	0.0	0.0	93.7	1.08
17 Jan	80	Mid	1.8	0.63	93	77	67.1	0.0	0.0	95.9	1.11
27 Jan	90	Mid	1.9	0.60	92	78	68.2	0.0	0.0	97.5	1.13
6 Feb	100	End	0.0	0.63	94	79	69.1	0.0	0.0	98.7	1.14
16 Feb	110	End	0.0	1.00	100	69	60.3	0.0	0.0	86.1	1.00
26 Feb	120	End	0.0	1.00	100	47	41.0	0.0	0.0	58.6	0.68
3 Mar	End	End	0.0	1.00	100	10					

Totals:

Total gross irrigation	794.0 mm	Total rainfall	67.7 mm
Total net irrigation	555.8 mm	Effective rainfall	61.5 mm
Total irrigation losses	0.0 mm	Total rain loss	6.2 mm

Actual water use by crop	626.0 mm	Moist deficit at harvest	8.7 mm
Potential water use by crop	649.9 mm	Actual irrigation requirement	588.5 mm

Efficiency irrigation schedule	100.0 %	Efficiency rain	90.8 %
Deficiency irrigation schedule	3.7 %		

Yield reductions:

Stagelabel	A	B	C	D	Season
Reductions in ETc	0.0	0.1	6.3	3.0	3.7 %
Yield response factor	0.40	0.40	1.30	0.50	1.25
Yield reduction	0.0	0.1	8.2	1.5	4.6 %
Cumulative yield reduction	0.0	0.1	8.2	9.6	%

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CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: Mung bean Planting date: 05/11
Rain station: Modified OVRF Soil: Sandy Loam Harvest date: 22/02

Yield red.: 9.1 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
14 Nov	10	Init	0.0	1.00	100	37	13.7	0.0	0.0	19.5	0.23
24 Nov	20	Init	0.0	1.00	100	33	15.6	0.0	0.0	22.3	0.26
4 Dec	30	Dev	0.0	1.00	100	43	24.7	0.0	0.0	35.2	0.41
14 Dec	40	Dev	0.0	0.87	98	59	40.0	0.0	0.0	57.1	0.66

24 Dec	50	Dev	0.0	0.72	94	67	52.2	0.0	0.0	74.5	0.86
3 Jan	60	Mid	1.9	0.59	89	73	57.2	0.0	0.0	81.7	0.95
13 Jan	70	Mid	1.8	0.55	87	75	58.7	0.0	0.0	83.8	0.97
23 Jan	80	Mid	1.9	0.52	86	76	59.7	0.0	0.0	85.3	0.99
2 Feb	90	Mid	0.0	0.47	86	78	61.2	0.0	0.0	87.5	1.01
12 Feb	100	End	0.0	0.65	94	73	56.9	0.0	0.0	81.3	0.94
22 Feb	End	End	0.0	1.00	100	44					

Totals:

Total gross irrigation	628.4 mm	Total rainfall	53.9 mm
Total net irrigation	439.9 mm	Effective rainfall	50.0 mm
Total irrigation losses	0.0 mm	Total rain loss	3.9 mm

Actual water use by crop	524.0 mm	Moist deficit at harvest	34.1 mm
Potential water use by crop	568.8 mm	Actual irrigation requirement	518.9 mm

Efficiency irrigation schedule	100.0 %	Efficiency rain	92.7 %
Deficiency irrigation schedule	7.9 %		

Yield reductions:

Stagelabel	A	B	C	D	Season
Reductions in ETc	0.0	3.0	12.9	3.7	7.9 %
Yield response factor	0.20	0.60	1.00	0.20	1.15
Yield reduction	0.0	1.8	12.9	0.7	9.1 %
Cumulative yield reduction	0.0	1.8	14.5	15.1	%

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CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: Soybean Planting date: 30/10
Rain station: Modified OVRF Soil: Sandy Loam Harvest date: 22/01

Yield red.: 0.6 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
8 Nov	10	Init	0.0	1.00	100	30	13.8	0.0	0.0	19.8	0.23
18 Nov	20	Dev	0.0	1.00	100	30	20.0	0.0	0.0	28.5	0.33
28 Nov	30	Dev	0.0	1.00	100	52	45.4	0.0	0.0	64.8	0.75
8 Dec	40	Mid	0.0	0.98	100	68	59.3	0.0	0.0	84.7	0.98
18 Dec	50	Mid	0.0	0.90	99	71	61.7	0.0	0.0	88.1	1.02
28 Dec	60	Mid	0.0	0.86	99	72	63.0	0.0	0.0	90.0	1.04
7 Jan	70	Mid	1.9	0.84	98	73	63.6	0.0	0.0	90.8	1.05
17 Jan	80	End	1.8	1.00	100	60	52.2	0.0	0.0	74.5	0.86
22 Jan	End	End	0.0	1.00	100	21					

Totals:

Total gross irrigation	541.3 mm	Total rainfall	47.8 mm
Total net irrigation	378.9 mm	Effective rainfall	47.8 mm
Total irrigation losses	0.0 mm	Total rain loss	0.0 mm

Actual water use by crop	445.3 mm	Moist deficit at harvest	18.6 mm
Potential water use by crop	448.4 mm	Actual irrigation requirement	400.5 mm

Efficiency irrigation schedule	100.0 %	Efficiency rain	100.0 %
Deficiency irrigation schedule	0.7 %		

Yield reductions:

Stagelabel	A	B	C	D	Season
Reductions in ETc	0.0	0.0	1.1	0.0	0.7 %
Yield response factor	0.40	0.80	1.00	0.40	0.85
Yield reduction	0.0	0.0	1.1	0.0	0.6 %
Cumulative yield reduction	0.0	0.0	1.1	1.1	%

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CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: Haricotbean Planting date: 25/10
Rain station: Modified OVRF Soil: Sandy Loam Harvest date: 11/02

Yield red.: 8.2 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	Eta %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr l/s/ha	Flow
3 Nov	10	Init	4.8	1.00	100	38	14.1	0.0	0.0	20.1	0.23
13 Nov	20	Init	4.9	1.00	100	32	14.8	0.0	0.0	21.2	0.25
23 Nov	30	Dev	4.0	1.00	100	39	22.6	0.0	0.0	32.2	0.37
3 Dec	40	Dev	2.8	0.93	99	57	38.4	0.0	0.0	54.8	0.63
13 Dec	50	Dev	1.9	0.75	95	65	50.9	0.0	0.0	72.7	0.84
23 Dec	60	Mid	1.9	0.61	90	72	56.1	0.0	0.0	80.2	0.93
2 Jan	70	Mid	0.0	0.54	88	75	58.9	0.0	0.0	84.1	0.97
12 Jan	80	Mid	0.0	0.51	87	77	60.0	0.0	0.0	85.7	0.99
22 Jan	90	Mid	0.0	0.50	87	77	60.0	0.0	0.0	85.8	0.99
1 Feb	100	End	0.0	0.66	95	72	56.4	0.0	0.0	80.5	0.93
11 Feb	End	End	0.0	1.00	100	39					

Totals:

Total gross irrigation	617.2 mm	Total rainfall	60.1 mm
Total net irrigation	432.1 mm	Effective rainfall	54.3 mm
Total irrigation losses	0.0 mm	Total rain loss	5.8 mm

Actual water use by crop 516.9 mm Moist deficit at harvest 30.5 mm
Potential water use by crop 556.3 mm Actual irrigation requirement 502.0 mm

Efficiency irrigation schedule 100.0 % Efficiency rain 90.4 %
Deficiency irrigation schedule 7.1 %

Yield reductions:

Stagelabel	A	B	C	D	Season
Reductions in ETc	0.0	2.6	11.8	3.4	7.1 %
Yield response factor	0.20	0.60	1.00	0.20	1.15
Yield reduction	0.0	1.6	11.8	0.7	8.2 %
Cumulative yield reduction	0.0	1.6	13.2	13.8	%

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CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: Sesame Planting date: 01/11
Rain station: Modified OVRF Soil: Sandy Loam Harvest date: 03/02

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at 100 % depletion
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
12 Nov	12	Init	0.0	1.00	100	49	18.6	0.0	0.0	26.6	0.26
24 Nov	24	Dev	0.0	1.00	100	49	24.0	0.0	0.0	34.3	0.33
2 Dec	32	Dev	0.0	1.00	100	48	27.3	0.0	0.0	39.1	0.57
9 Dec	39	Dev	0.0	1.00	100	52	33.0	0.0	0.0	47.2	0.78
15 Dec	45	Dev	0.0	1.00	100	51	35.5	0.0	0.0	50.6	0.98
21 Dec	51	Mid	0.0	1.00	100	53	37.2	0.0	0.0	53.1	1.02
26 Dec	56	Mid	0.0	1.00	100	46	32.3	0.0	0.0	46.1	1.07
31 Dec	61	Mid	0.0	1.00	100	49	34.1	0.0	0.0	48.8	1.13
5 Jan	66	Mid	0.0	1.00	100	48	33.3	0.0	0.0	47.6	1.10
10 Jan	71	Mid	0.0	1.00	100	48	33.3	0.0	0.0	47.6	1.10
15 Jan	76	Mid	0.0	1.00	100	49	34.4	0.0	0.0	49.2	1.14
20 Jan	81	End	0.0	1.00	100	49	34.4	0.0	0.0	49.2	1.14
26 Jan	87	End	0.0	1.00	100	48	33.3	0.0	0.0	47.6	0.92
2 Feb	94	End	0.0	1.00	100	55	38.1	0.0	0.0	54.4	0.90
3 Feb	End	End	0.0	1.00	0	0					

Totals:

Total gross irrigation 641.3 mm Total rainfall 53.4 mm
Total net irrigation 448.9 mm Effective rainfall 40.1 mm
Total irrigation losses 0.0 mm Total rain loss 13.3 mm

Actual water use by crop 489.0 mm Moist deficit at harvest 0.0 mm
Potential water use by crop 489.0 mm Actual irrigation requirement 448.9 mm

Efficiency irrigation schedule 100.0 % Efficiency rain 75.0 %
Deficiency irrigation schedule 0.0 %

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	0.0	0.0	0.0	%
Yield response factor	0.20	0.80	0.60	0.20	0.70	
Yield reduction	0.0	0.0	0.0	0.0	0.0	%
Cumulative yield reduction	0.0	0.0	0.0	0.0		%

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Option III

CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: COTTON Planting date: 01/11
Rain station: Modified OVRF Soil: Clay & Silt clay Harvest date: 27/03

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
10 Nov	10	Init	0.0	1.00	100	13	11.6	0.0	0.0	16.5	0.19
20 Nov	20	Init	0.0	1.00	100	9	11.2	0.0	0.0	16.0	0.19
30 Nov	30	Dev	0.0	1.00	100	11	16.6	0.0	0.0	23.8	0.28
10 Dec	40	Dev	0.0	1.00	100	17	31.4	0.0	0.0	44.9	0.52
20 Dec	50	Dev	0.0	1.00	100	21	45.5	0.0	0.0	65.0	0.75
30 Dec	60	Dev	0.0	1.00	100	25	60.8	0.0	0.0	86.8	1.01
9 Jan	70	Mid	0.0	1.00	100	28	69.8	0.0	0.0	99.8	1.15
19 Jan	80	Mid	0.0	1.00	100	29	73.2	0.0	0.0	104.6	1.21
29 Jan	90	Mid	0.0	1.00	100	30	75.3	0.0	0.0	107.6	1.25
8 Feb	100	Mid	0.0	1.00	100	31	77.6	0.0	0.0	110.9	1.28
18 Feb	110	End	0.0	1.00	100	32	78.8	0.0	0.0	112.6	1.30
28 Feb	120	End	0.0	1.00	100	28	70.0	0.0	0.0	100.0	1.16
10 Mar	130	End	0.0	1.00	100	23	56.8	0.0	0.0	81.2	0.94
20 Mar	140	End	0.0	1.00	100	18	44.9	0.0	0.0	64.1	0.74
27 Mar	End	End	0.0	1.00	0	6					

Totals:

Total gross irrigation	1033.7 mm	Total rainfall	92.2 mm
Total net irrigation	723.6 mm	Effective rainfall	90.6 mm
Total irrigation losses	0.0 mm	Total rain loss	1.6 mm

Actual water use by crop	828.3 mm	Moist deficit at harvest	14.0 mm
Potential water use by crop	828.3 mm	Actual irrigation requirement	737.6 mm

Efficiency irrigation schedule	100.0 %	Efficiency rain	98.3 %
Deficiency irrigation schedule	0.0 %		

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	0.0	0.0	0.0	%

Yield response factor	0.20	0.50	0.50	0.25	0.85	
Yield reduction	0.0	0.0	0.0	0.0	0.0	%
Cumulative yield reduction	0.0	0.0	0.0	0.0		%

Cropwat 8.0 Bèta 21/05/15 12:09:51 PM

CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: Vegetables Planting date: 15/06
Rain station: Modified OVRF Soil: Clay & Silt clay Harvest date: 17/09

Yield red.: 0.7 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
24 Jun	10	Init	0.0	0.80	95	49	31.1	0.0	0.0	44.4	0.51
4 Jul	20	Init	0.0	0.86	97	44	34.5	0.0	0.0	49.2	0.57
14 Jul	30	Dev	0.0	0.93	99	44	40.7	0.0	0.0	58.2	0.67
24 Jul	40	Dev	0.0	0.98	100	46	49.1	0.0	0.0	70.2	0.81
3 Aug	50	Dev	1.1	1.00	100	46	55.7	0.0	0.0	79.6	0.92
13 Aug	60	Mid	1.1	1.00	100	50	60.4	0.0	0.0	86.2	1.00
23 Aug	70	Mid	1.3	0.99	100	51	61.1	0.0	0.0	87.3	1.01
2 Sep	80	Mid	0.0	0.97	100	52	62.3	0.0	0.0	89.1	1.03
12 Sep	90	End	0.0	1.00	100	51	61.4	0.0	0.0	87.7	1.01
17 Sep	End	End	1.8	1.00	100	19					

Totals:

Total gross irrigation	651.8 mm	Total rainfall	26.0 mm
Total net irrigation	456.3 mm	Effective rainfall	23.4 mm
Total irrigation losses	0.0 mm	Total rain loss	2.7 mm
Actual water use by crop	502.4 mm	Moist deficit at harvest	22.8 mm
Potential water use by crop	506.2 mm	Actual irrigation requirement	482.8 mm
Efficiency irrigation schedule	100.0 %	Efficiency rain	89.7 %
Deficiency irrigation schedule	0.7 %		

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	3.8	0.3	0.2	0.0	0.7	%
Yield response factor	0.80	0.40	1.20	1.00	1.00	
Yield reduction	3.1	0.1	0.2	0.0	0.7	%
Cumulative yield reduction	3.1	3.2	3.4	3.4		%

Cropwat 8.0 Bèta 21/05/15 12:18:21 PM

CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: MANGO Planting date: 26/06
Rain station: Modified OVRF Soil: Clay & Silt clay Harvest date: 25/06

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
5 Jul	10	Init	0.0	1.00	100	19	47.2	0.0	0.0	67.5	0.78
15 Jul	20	Init	0.0	1.00	100	19	48.4	0.0	0.0	69.1	0.80
25 Jul	30	Init	0.0	1.00	100	20	49.8	0.0	0.0	71.1	0.82
4 Aug	40	Init	0.0	1.00	100	20	50.2	0.0	0.0	71.8	0.83
14 Aug	50	Init	0.0	1.00	100	20	50.9	0.0	0.0	72.7	0.84
24 Aug	60	Init	0.0	1.00	100	21	51.4	0.0	0.0	73.4	0.85
3 Sep	70	Init	1.3	1.00	100	21	51.7	0.0	0.0	73.8	0.85
13 Sep	80	Init	1.4	1.00	100	21	52.1	0.0	0.0	74.4	0.86
23 Sep	90	Init	2.5	1.00	100	21	51.4	0.0	0.0	73.4	0.85
3 Oct	100	Dev	3.9	1.00	100	20	49.4	0.0	0.0	70.5	0.82
13 Oct	110	Dev	5.0	1.00	100	19	48.2	0.0	0.0	68.8	0.80
23 Oct	120	Dev	4.8	1.00	100	19	48.5	0.0	0.0	69.3	0.80
2 Nov	130	Dev	0.0	1.00	100	22	54.5	0.0	0.0	77.8	0.90
12 Nov	140	Dev	0.0	1.00	100	22	55.6	0.0	0.0	79.4	0.92
22 Nov	150	Dev	0.0	1.00	100	23	56.4	0.0	0.0	80.6	0.93
2 Dec	160	Dev	0.0	1.00	100	23	58.6	0.0	0.0	83.7	0.97
12 Dec	170	Dev	0.0	1.00	100	24	61.0	0.0	0.0	87.1	1.01
22 Dec	180	Dev	0.0	1.00	100	25	63.5	0.0	0.0	90.6	1.05
1 Jan	190	Mid	0.0	1.00	100	27	66.3	0.0	0.0	94.7	1.10
11 Jan	200	Mid	0.0	1.00	100	27	66.6	0.0	0.0	95.1	1.10
21 Jan	210	Mid	0.0	1.00	100	28	69.0	0.0	0.0	98.6	1.14
31 Jan	220	Mid	0.0	1.00	100	28	70.8	0.0	0.0	101.1	1.17
10 Feb	230	Mid	0.0	1.00	100	29	73.2	0.0	0.0	104.5	1.21
20 Feb	240	Mid	0.0	1.00	100	30	75.4	0.0	0.0	107.8	1.25
2 Mar	250	Mid	0.0	1.00	100	29	72.5	0.0	0.0	103.6	1.20
12 Mar	260	Mid	0.0	1.00	100	29	73.5	0.0	0.0	105.1	1.22
22 Mar	270	Mid	0.0	1.00	100	29	71.5	0.0	0.0	102.1	1.18
1 Apr	280	End	0.0	1.00	100	27	66.8	0.0	0.0	95.4	1.10
11 Apr	290	End	0.0	1.00	100	21	53.1	0.0	0.0	75.9	0.88
21 Apr	300	End	0.0	1.00	100	19	47.6	0.0	0.0	68.0	0.79
1 May	310	End	0.0	1.00	100	19	46.4	0.0	0.0	66.3	0.77
11 May	320	End	0.0	1.00	100	18	45.8	0.0	0.0	65.4	0.76
21 May	330	End	0.0	1.00	100	18	44.5	0.0	0.0	63.6	0.74
31 May	340	End	0.0	1.00	100	18	44.9	0.0	0.0	64.2	0.74
10 Jun	350	End	0.0	1.00	100	18	45.5	0.0	0.0	65.0	0.75
20 Jun	360	End	0.0	1.00	100	18	46.2	0.0	0.0	66.0	0.76
25 Jun	End	End	0.0	1.00	0	7					

Totals:

Total gross irrigation	2897.5 mm	Total rainfall	254.8 mm
Total net irrigation	2028.3 mm	Effective rainfall	209.9 mm
Total irrigation losses	0.0 mm	Total rain loss	44.9 mm

Actual water use by crop	2256.6 mm	Moist deficit at harvest	18.4 mm
Potential water use by crop	2256.6 mm	Actual irrigation requirement	2046. mm

Efficiency irrigation schedule 100.0 % Efficiency rain 82.4 %

Deficiency irrigation schedule 0.0 %

Yield reductions:

Stagelabel	A	B	C	D	Season
Reductions in ETc	0.0	0.0	0.0	0.0	0.0 %
Yield response factor	0.80	0.80	0.80	0.80	0.80
Yield reduction	0.0	0.0	0.0	0.0	0.0 %
Cumulative yield reduction	0.0	0.0	0.0	0.0	%

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CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: Forage Planting date: 26/06
Rain station: Modified OVRF Soil: Clay & Silt clay Harvest date: 25/06

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
5 Jul	10	Init	0.0	1.00	100	27	43.7	0.0	0.0	62.5	0.72
15 Jul	20	Init	0.0	1.00	100	28	45.5	0.0	0.0	65.1	0.75
25 Jul	30	Init	0.0	1.00	100	29	46.9	0.0	0.0	67.0	0.78
4 Aug	40	Init	0.0	1.00	100	30	47.3	0.0	0.0	67.6	0.78
14 Aug	50	Init	0.0	1.00	100	30	48.0	0.0	0.0	68.5	0.79
24 Aug	60	Init	0.0	1.00	100	30	48.4	0.0	0.0	69.2	0.80
3 Sep	70	Init	1.3	1.00	100	30	48.7	0.0	0.0	69.5	0.80
13 Sep	80	Init	1.4	1.00	100	31	49.1	0.0	0.0	70.1	0.81
23 Sep	90	Init	2.5	1.00	100	30	48.2	0.0	0.0	68.8	0.80
3 Oct	100	Init	3.9	1.00	100	28	45.3	0.0	0.0	64.7	0.75
13 Oct	110	Init	5.0	1.00	100	26	42.4	0.0	0.0	60.5	0.70
23 Oct	120	Init	4.8	1.00	100	26	40.9	0.0	0.0	58.5	0.68
2 Nov	130	Init	0.0	1.00	100	28	45.3	0.0	0.0	64.7	0.75
12 Nov	140	Init	0.0	1.00	100	28	44.8	0.0	0.0	64.0	0.74
22 Nov	150	Dev	0.0	1.00	100	28	44.6	0.0	0.0	63.8	0.74
2 Dec	160	Dev	0.0	1.00	100	29	46.3	0.0	0.0	66.1	0.77
12 Dec	170	Dev	0.0	1.00	100	30	48.2	0.0	0.0	68.9	0.80
22 Dec	180	Dev	0.0	1.00	100	31	50.3	0.0	0.0	71.9	0.83
1 Jan	190	Dev	0.0	1.00	100	33	53.0	0.0	0.0	75.7	0.88
11 Jan	200	Dev	0.0	1.00	100	34	54.0	0.0	0.0	77.2	0.89
21 Jan	210	Mid	0.0	1.00	100	35	56.7	0.0	0.0	81.0	0.94
31 Jan	220	Mid	0.0	1.00	100	36	58.1	0.0	0.0	83.1	0.96
10 Feb	230	Mid	0.0	1.00	100	38	60.2	0.0	0.0	86.0	1.00
20 Feb	240	Mid	0.0	1.00	100	39	62.1	0.0	0.0	88.7	1.03
2 Mar	250	Mid	0.0	1.00	100	37	59.3	0.0	0.0	84.7	0.98
12 Mar	260	Mid	0.0	1.00	100	38	60.5	0.0	0.0	86.4	1.00
22 Mar	270	Mid	0.0	1.00	100	37	58.8	0.0	0.0	83.9	0.97
1 Apr	280	Mid	0.0	1.00	100	34	55.1	0.0	0.0	78.7	0.91
11 Apr	290	Mid	0.0	1.00	100	28	44.4	0.0	0.0	63.4	0.73
21 Apr	300	Mid	0.0	1.00	100	25	40.5	0.0	0.0	57.8	0.67
1 May	310	Mid	0.0	1.00	100	25	40.7	0.0	0.0	58.2	0.67
11 May	320	Mid	0.0	1.00	100	26	41.4	0.0	0.0	59.2	0.69

21 May	330	End	0.0	1.00	100	26	40.9	0.0	0.0	58.4	0.68
31 May	340	End	0.0	1.00	100	26	40.8	0.0	0.0	58.4	0.68
10 Jun	350	End	0.0	1.00	100	26	41.4	0.0	0.0	59.2	0.68
20 Jun	360	End	0.0	1.00	100	26	42.1	0.0	0.0	60.2	0.70
25 Jun	End	End	0.0	1.00	0	10					

Totals:

Total gross irrigation	2491.4 mm	Total rainfall	254.8 mm
Total net irrigation	1744.0 mm	Effective rainfall	206.6 mm
Total irrigation losses	0.0 mm	Total rain loss	48.2 mm

Actual water use by crop	1967.3 mm	Moist deficit at harvest	16.8 mm
Potential water use by crop	1967.3 mm	Actual irrigation requirement	1760. mm

Efficiency irrigation schedule	100.0 %	Efficiency rain	81.1 %
Deficiency irrigation schedule	0.0 %		

Yield reductions:

Stagelabel	A	B	C	D	Season
Reductions in ETc	0.0	0.0	0.0	0.0	0.0 %
Yield response factor	0.80	0.80	0.80	0.80	0.80
Yield reduction	0.0	0.0	0.0	0.0	0.0 %
Cumulative yield reduction	0.0	0.0	0.0	0.0	%

Cropwat 8.0 Bèta 21/05/15 12:22:03 PM

CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: MAIZE (Grain) Planting date: 30/10
Rain station: Modified OVRF Soil: Clay & Silt clay Harvest date: 03/03

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
8 Nov	10	Init	0.0	1.00	100	9	8.0	0.0	0.0	11.4	0.13
18 Nov	20	Init	0.0	1.00	100	7	7.9	0.0	0.0	11.3	0.13
28 Nov	30	Dev	0.0	1.00	100	14	18.6	0.0	0.0	26.5	0.31
8 Dec	40	Dev	0.0	1.00	100	22	35.2	0.0	0.0	50.3	0.58
18 Dec	50	Dev	0.0	1.00	100	28	51.9	0.0	0.0	74.1	0.86
28 Dec	60	Mid	0.0	1.00	100	33	65.5	0.0	0.0	93.6	1.08
7 Jan	70	Mid	1.9	1.00	100	35	70.0	0.0	0.0	100.0	1.16
17 Jan	80	Mid	1.8	1.00	100	36	72.7	0.0	0.0	103.9	1.20
27 Jan	90	Mid	1.9	1.00	100	37	74.9	0.0	0.0	107.0	1.24
6 Feb	100	End	0.0	1.00	100	37	73.7	0.0	0.0	105.3	1.22
16 Feb	110	End	0.0	1.00	100	30	60.3	0.0	0.0	86.1	1.00
26 Feb	120	End	0.0	1.00	100	20	41.0	0.0	0.0	58.6	0.68
3 Mar	End	End	0.0	1.00	100	4					

Totals:

Total gross irrigation	828.2 mm	Total rainfall	67.7 mm
Total net irrigation	579.8 mm	Effective rainfall	61.5 mm
Total irrigation losses	0.0 mm	Total rain loss	6.2 mm

Actual water use by crop	649.9 mm	Moist deficit at harvest	8.7 mm
Potential water use by crop	649.9 mm	Actual irrigation requirement	588.5 mm

Efficiency irrigation schedule	100.0 %	Efficiency rain	90.8 %
Deficiency irrigation schedule	0.0 %		

Yield reductions:

Stagelabel	A	B	C	D	Season
Reductions in ETc	0.0	0.0	0.0	0.0	0.0 %
Yield response factor	0.40	0.40	1.30	0.50	1.25
Yield reduction	0.0	0.0	0.0	0.0	0.0 %
Cumulative yield reduction	0.0	0.0	0.0	0.0	%

Cropwat 8.0 Bèta 21/05/15 12:24:30 PM

CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: Wheat Planting date: 30/10
Rain station: Modified OVRF Soil: Clay & Silt clay Harvest date: 08/03

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	Eta %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
8 Nov	10	Init	0.0	1.00	100	9	8.0	0.0	0.0	11.4	0.13
18 Nov	20	Init	0.0	1.00	100	6	7.5	0.0	0.0	10.8	0.12
28 Nov	30	Init	0.0	1.00	100	6	9.6	0.0	0.0	13.7	0.16
8 Dec	40	Dev	0.0	1.00	100	12	21.7	0.0	0.0	31.0	0.36
18 Dec	50	Dev	0.0	1.00	100	19	39.0	0.0	0.0	55.7	0.64
28 Dec	60	Dev	0.0	1.00	100	24	57.2	0.0	0.0	81.8	0.95
7 Jan	70	Mid	1.9	1.00	100	27	65.5	0.0	0.0	93.6	1.08
17 Jan	80	Mid	1.8	1.00	100	29	69.3	0.0	0.0	99.0	1.15
27 Jan	90	Mid	1.9	1.00	100	30	71.4	0.0	0.0	101.9	1.18
6 Feb	100	Mid	0.0	1.00	100	31	74.2	0.0	0.0	106.0	1.23
16 Feb	110	End	0.0	1.00	100	27	65.4	0.0	0.0	93.5	1.08
26 Feb	120	End	0.0	1.00	100	20	47.4	0.0	0.0	67.8	0.78
8 Mar	End	End	0.0	1.00	100	8					

Totals:

Total gross irrigation	766.1 mm	Total rainfall	71.3 mm
Total net irrigation	536.3 mm	Effective rainfall	65.1 mm
Total irrigation losses	0.0 mm	Total rain loss	6.2 mm

Actual water use by crop	621.4 mm	Moist deficit at harvest	20.1 mm
Potential water use by crop	621.4 mm	Actual irrigation requirement	556.3 mm

Efficiency irrigation schedule 100.0 % Efficiency rain 91.2 %
Deficiency irrigation schedule 0.0 %

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	0.0	0.0	0.0	%
Yield response factor	0.40	0.60	0.80	0.40	1.15	
Yield reduction	0.0	0.0	0.0	0.0	0.0	%
Cumulative yield reduction	0.0	0.0	0.0	0.0		%

Cropwat 8.0 Bèta 21/05/15 12:26:14 PM

CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: Soybean Planting date: 30/10
Rain station: Modified OVRF Soil: Clay & Silt clay Harvest date: 22/01

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
8 Nov	10	Init	0.0	1.00	100	13	13.8	0.0	0.0	19.8	0.23
18 Nov	20	Dev	0.0	1.00	100	13	20.0	0.0	0.0	28.5	0.33
28 Nov	30	Dev	0.0	1.00	100	23	45.4	0.0	0.0	64.8	0.75
8 Dec	40	Mid	0.0	1.00	100	30	59.4	0.0	0.0	84.9	0.98
18 Dec	50	Mid	0.0	1.00	100	31	62.3	0.0	0.0	89.0	1.03
28 Dec	60	Mid	0.0	1.00	100	32	64.0	0.0	0.0	91.4	1.06
7 Jan	70	Mid	1.9	1.00	100	32	64.8	0.0	0.0	92.6	1.07
17 Jan	80	End	1.8	1.00	100	26	52.2	0.0	0.0	74.5	0.86
22 Jan	End	End	0.0	1.00	100	9					

Totals:

Total gross irrigation 545.6 mm Total rainfall 47.8 mm
Total net irrigation 381.9 mm Effective rainfall 47.8 mm
Total irrigation losses 0.0 mm Total rain loss 0.0 mm

Actual water use by crop 448.4 mm Moist deficit at harvest 18.6 mm
Potential water use by crop 448.4 mm Actual irrigation requirement 400.5 mm

Efficiency irrigation schedule 100.0 % Efficiency rain 100.0 %
Deficiency irrigation schedule 0.0 %

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	0.0	0.0	0.0	%
Yield response factor	0.40	0.80	1.00	0.40	0.85	
Yield reduction	0.0	0.0	0.0	0.0	0.0	%
Cumulative yield reduction	0.0	0.0	0.0	0.0		%

Cropwat 8.0 Bèta 21/05/15 12:28:19 PM

CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: Mung bean Planting date: 05/11
Rain station: Modified OVRF Soil: Clay & Silt clay Harvest date: 22/02

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
14 Nov	10	Init	0.0	1.00	100	16	13.7	0.0	0.0	19.5	0.23
24 Nov	20	Init	0.0	1.00	100	14	15.6	0.0	0.0	22.3	0.26
4 Dec	30	Dev	0.0	1.00	100	19	24.7	0.0	0.0	35.2	0.41
14 Dec	40	Dev	0.0	1.00	100	26	40.6	0.0	0.0	58.0	0.67
24 Dec	50	Dev	0.0	1.00	100	31	55.6	0.0	0.0	79.4	0.92
3 Jan	60	Mid	1.9	1.00	100	36	64.8	0.0	0.0	92.5	1.07
13 Jan	70	Mid	1.8	1.00	100	38	67.6	0.0	0.0	96.6	1.12
23 Jan	80	Mid	1.9	1.00	100	39	69.9	0.0	0.0	99.8	1.16
2 Feb	90	Mid	0.0	1.00	100	40	71.7	0.0	0.0	102.4	1.19
12 Feb	100	End	0.0	1.00	100	34	60.6	0.0	0.0	86.5	1.00
22 Feb	End	End	0.0	1.00	100	19					

Totals:

Total gross irrigation	692.4 mm	Total rainfall	53.9 mm
Total net irrigation	484.7 mm	Effective rainfall	50.0 mm
Total irrigation losses	0.0 mm	Total rain loss	3.9 mm

Actual water use by crop	568.8 mm	Moist deficit at harvest	34.1 mm
Potential water use by crop	568.8 mm	Actual irrigation requirement	518.9 mm

Efficiency irrigation schedule	100.0 %	Efficiency rain	92.7 %
Deficiency irrigation schedule	0.0 %		

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	0.0	0.0	0.0	%
Yield response factor	0.20	0.60	1.00	0.20	1.15	
Yield reduction	0.0	0.0	0.0	0.0	0.0	%
Cumulative yield reduction	0.0	0.0	0.0	0.0		%

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CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: Haricotbean Planting date: 05/11
Rain station: Modified OVRF Soil: Clay & Silt clay Harvest date: 22/02

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
14 Nov	10	Init	0.0	1.00	100	16	13.7	0.0	0.0	19.5	0.23
24 Nov	20	Init	0.0	1.00	100	14	15.6	0.0	0.0	22.3	0.26
4 Dec	30	Dev	0.0	1.00	100	19	24.7	0.0	0.0	35.2	0.41
14 Dec	40	Dev	0.0	1.00	100	26	40.6	0.0	0.0	58.0	0.67
24 Dec	50	Dev	0.0	1.00	100	31	55.6	0.0	0.0	79.4	0.92
3 Jan	60	Mid	1.9	1.00	100	36	64.8	0.0	0.0	92.5	1.07
13 Jan	70	Mid	1.8	1.00	100	38	67.6	0.0	0.0	96.6	1.12
23 Jan	80	Mid	1.9	1.00	100	39	69.9	0.0	0.0	99.8	1.16
2 Feb	90	Mid	0.0	1.00	100	40	71.7	0.0	0.0	102.4	1.19
12 Feb	100	End	0.0	1.00	100	34	60.6	0.0	0.0	86.5	1.00
22 Feb	End	End	0.0	1.00	100	19					

Totals:

Total gross irrigation	692.4 mm	Total rainfall	53.9 mm
Total net irrigation	484.7 mm	Effective rainfall	50.0 mm
Total irrigation losses	0.0 mm	Total rain loss	3.9 mm
Actual water use by crop	568.8 mm	Moist deficit at harvest	34.1 mm
Potential water use by crop	568.8 mm	Actual irrigation requirement	518.9 mm
Efficiency irrigation schedule	100.0 %	Efficiency rain	92.7 %
Deficiency irrigation schedule	0.0 %		

Yield reductions:

Stage label	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	0.0	0.0	0.0	%
Yield response factor	0.20	0.60	1.00	0.20	1.15	
Yield reduction	0.0	0.0	0.0	0.0	0.0	%
Cumulative yield reduction	0.0	0.0	0.0	0.0		%

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CROP IRRIGATION SCHEDULE

ETo station: Final Modi Omo V Crop: Sesame Planting date: 01/11
Rain station: Modified OVRF Soil: Clay & Silt clay Harvest date: 03/02

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)

Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	Eta %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
10 Nov	10	Init	0.0	1.00	100	17	13.9	0.0	0.0	19.8	0.23
20 Nov	20	Dev	0.0	1.00	100	13	13.9	0.0	0.0	19.9	0.23
30 Nov	30	Dev	0.0	1.00	100	21	27.2	0.0	0.0	38.8	0.45
10 Dec	40	Dev	0.0	1.00	100	31	45.6	0.0	0.0	65.1	0.75
20 Dec	50	Mid	0.0	1.00	100	38	60.7	0.0	0.0	86.7	1.00
30 Dec	60	Mid	0.0	1.00	100	40	64.5	0.0	0.0	92.2	1.07
9 Jan	70	Mid	0.0	1.00	100	42	66.4	0.0	0.0	94.9	1.10
19 Jan	80	Mid	0.0	1.00	100	43	68.7	0.0	0.0	98.1	1.14
29 Jan	90	End	0.0	1.00	100	35	56.3	0.0	0.0	80.4	0.93
3 Feb	End	End	1.8	1.00	100	12					

Totals:

Total gross irrigation	596.0 mm	Total rainfall	53.4 mm
Total net irrigation	417.2 mm	Effective rainfall	53.1 mm
Total irrigation losses	0.0 mm	Total rain loss	0.3 mm
Actual water use by crop	489.0 mm	Moist deficit at harvest	18.7 mm
Potential water use by crop	489.0 mm	Actual irrigation requirement	435.9 mm
Efficiency irrigation schedule	100.0 %	Efficiency rain	99.4 %
Deficiency irrigation schedule	0.0 %		

Yield reductions:

Stage label	A	B	C	D	Season
Reductions in ETc	0.0	0.0	0.0	0.0	0.0 %
Yield response factor	0.20	0.80	0.60	0.20	0.70
Yield reduction	0.0	0.0	0.0	0.0	0.0 %
Cumulative yield reduction	0.0	0.0	0.0	0.0	%

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9. Post-Harvest Technology and Agro - Processing

The most important measures to improve organic cotton quality during and after harvest are the important aspect of management. Pick only mature cotton. Unripe cotton fibers do not absorb dyes well enough.

Ginning is one of the processes in cotton post harvest technology. For the ginning purpose it is important not to pick too early or late in the day as green leaf in the seed cotton provides an additional source of moisture. It is also recommended that the producer contact the gin prior to harvest to ensure that timely ginning of the seed cotton can be achieved. Ginners can often make adjustments in the ginning process to help preserve fiber quality if they are aware of issues that may require special attention.

Value addition is a systematic approach towards maintaining the desired quality standards of the cotton. Prevent cotton from becoming contaminated with dust or chemicals, and other liquid substances.

9.1. Post harvest Operation

Post-harvest operation of cotton relates to all operations such as cleaning and grading (separation), drying or dehydration, storage, packaging, transportation and handling carried out from stage of harvesting till its utilization. Remove leaves, capsules and damaged bolls from the cotton harvest. Pick and transport harvested cotton in clean cotton cloth material, never in nylon or other synthetic fabrics in order to avoid contamination with foreign fibers (from clothes, human hair, packaging material, etc.).

9.1.1 Drying

Keep the cotton harvest dry. It should be picked in dry conditions, avoiding harvesting when there is morning dew or after rainfall. Storage also needs to be in a dry place. Proper drying at recommended temperature to safe moisture percentage will preserve the standard. In other words, to prevent heating, mould growth and loss of quality the product must be dried to a safe moisture levels depending on the recommendation for cotton crop and how long the product is stored. The safe moisture level for most products varies between 4-12 percent. There are different methods of drying which include natural drying which takes place on the mother plant, sun drying and artificial drying which as the name implies is an artificial way of drying the product by using heated air to pass through the lot.

9.2. Storage

Perish ability is responsible for high post harvest losses and marketing cost, market glut, price fluctuation and other similar problems in marketing of cotton. The storage losses are both qualitative and quantitative, affecting use value of cotton.
The cotton harvest must be stored in a safe place until it is used for various purposes. The longevity of the stored product depends on the system of storage which in turn depends on the available facilities. To minimize damage to the stored cotton products storage facilities must have proper protection from fire hazards, water, contamination, rodents, insects and proper ventilation allowing free movement of air.

10. Production package and Projection of cotton crop

10.1 Production package

Cotton, Gossypium hirsutum

Introduction

Cotton is one of the most important fiber crops in the world. Cotton is mainly grown for its fiber used to manufacture clothes. In addition to its fiber, it is also used for edible oil which is extracted from its seeds. The pressed cake obtained after the extraction of oil is a good source of concentrate feed for livestock. The major cotton growing countries in the world are USA, Russia, India, China, Brazil, Egypt, Turkey, Mexico and Sudan.

General Growth Requirements

Cotton performs best in tropical and sub-tropical climates. A minimum of 16^{o}C is required for germination, 21-27^{o}C for proper growth and development and it can tolerate temperatures as high as 43^{o}C. In short, cotton requires maximum sunshine and high temperature and cannot withstand frost.

Good cotton yield can be obtained in areas receiving an annual rainfall of about 500 mm provided that the distribution is uniform throughout the growing season. It responds well to irrigation and the yield obtained under irrigated condition is quite substantial.

Cotton can be grown on a range of soil types and it can be successfully grown on sandy loam, alluvial, and black cotton soils. For optimum production, the soils must have good fertility condition, well drained and with good water retention capacity. Cotton cannot withstand water logged condition in general. Optimum soil PH for cotton is 5.5-8.5.

Improved Cotton Varieties

Some of the improved Cotton varieties particularly developed and recently released for irrigated condition include: - Gloria, Candia, Claudia, STG–14, VBCHB-1527, YD-670, YD-195, VBCH-1203, YD-223, YD-206, YD-211, Ionia and NEBAH (Stam-59A). These varieties have got their own agronomic characteristics relatively better one over the other which helps to select superior performing ones for the development program.

Cotton crop varieties	Seed rate kg/ha	Days to mature	No. of bolls	Lint yield qt/ha	Seed cotton yield qt/ha	Suitability	
						Defoliation	Mechanical harvesting
Gloria	10-15 & up to20	150	22.3	18.5	42.6	High	High
Candia	10-15 & up to30	145	20.9	18.0	40.6	Very High	Very High
Claudia	10-15 & up to20	150	19.7	17.6	38.4	High	High
STG-14	10-15 & up to30	145	20.0	16.6	38.8	Very High	Very High
VBCHB-1527	10-15	135-140	75-81	13.2	36.8-40.3	NA	NA
YD-670	10-15	130	27	14.76	33	NA	NA
YD -195	10-15	135	25	13.08	33	NA	NA
VBCHB-1203	10-15	160-170	68-73	11.6	29.6-33.3	NA	NA
YD-223	10-15	133	42	16.2	47	NA	NA
YD -206	10-15	134	38	16	46	NA	NA
YD -211	10-15	133	43	15.1	43	NA	NA
Ionia	10-15	NA	14.7	11.18	28.92	NA	NA
NEBAH (Stam-59A)	12-16	125	16.7	14.3	33.4	NA	NA

NA = Not Available

Cultural Practices.

Land Preparation

In order to ensure good germination and proper growth and development of Cotton, the seed bed should be well prepared by plowing/harrowing it 2-3 times. The field must be free from clods and weeds as well as other crop debris.

Planting Method

Row planting method is recommended for optimum production of Cotton. Therefore, cotton will be planted with the respective inter-row and intra-row spacing of 80 by 25cm or 90 by 20cm.

Seed Rate

The seed rate can vary depending on variety, seed size, germination percentage, planting method, soil moisture, fertility condition and management practices adopted. For cotton plant a seed rate in the range of 10-30 kg/ha is advisable for the different varieties. In general a plant population of ranging between 50,000-55,000/hectare will be maintained. Cottonseeds are covered with short fibers or lint called fuzz which makes the seeds to cling to each other and hence make planting very difficult. In order to avoid this problem, the seed must be delinted by either mechanical or chemical method (Sulphuric Acid is used for the purpose).

Planting Depth

Seed germination and early crop establishments will be adversely affected if optimum planting depth is not used. Therefore, a planting depth of 4-5 cm is recommended for cotton plant.

Gap filling and Thinning

Due to poor germination of the seed and other factors open gaps are created in the field. These gaps must be filled immediately after emergence in order to maintain the required plant population per hectare. In this case seeds soaked in water are used to facilitate quick germination.

Similarly in case of excess germination of seedlings thinning should be practiced to maintain optimum plant population. Thinning operation must be done about three weeks after emergence.

Fertilizer Application

Cotton is a heavy feeder of nutrients and proper manuring and fertilizer application is recommended for optimum production. As per the experiences in middle Awash areas, the cotton farm has been receiving urea at the rate of 100kg/ha in split application, i.e., half at planting and half at flowering times (አርከበ ገ / እግዚአብሄር እና ሌሎች). This experience can be adopted at Omo Valley project command for there is agro-ecological similarity. The application of urea to the cotton plant should not be prior to the consultation of the experts of the project and/or should be based on soil test results of the area.

Crop Protection

Weed Control

Cotton requires a weed free field particularly during its early stage of growth that is up to 40-50 days after emergence. Proper hand weeding and chemical control methods can be used. Hoeing or cultivation between rows is also recommended as it helps in controlling weeds and also improves aeration and water intake. Chemicals in use for weed control are tabulated as follows.

Name of chemicals	Type of action	Rate of application (liter/ha)
Ajil 15%	NA	1.5
Seelect 15%	NA	0.4
Fusilade 15%	NA	1.5
Nanoethyl	Pre-emergence	NA
Nanotechlus	Post-emergence	NA

NA = Not Available

Insect Control

Cotton plant is attacked by different insect pests of economic importance like African Boll Worm, Pink Boll Worm, Spotted Boll worm, Cotton Leaf roller, Jassids, White flies, Aphids and Thrips. Boll Worms are controlled by spraying the cotton plant with Tayodan,Tayonex and Ethiosulfan 25 % ULV at the rate of 3 lit/ha at early stage. Endosulfan 35% E.C 2.5 lit/ha and Lambdacyhalothrin, (Karate 5 E.C) with the amount of 100–500 ml/ha at the end of harvesting with 200-250 lit of water/ha.

Mealybugs feed on cotton and induce leaf drop. They also act as a vector for several plant diseases. A variety of control measures are available. Ladybird larvae and adults feed on mealy bugs, and can be used to control their numbers. Mealy bugs can be controlled using the fungal biocontrol agent Lecanicillium lecanii. Insecticidal soap spray is effective against mealybugs. It is commercially available or can be made of certain types of household soap. Chemical treatments include the use of organophosphates. Diazinon can be used effectively, but requires multiple applications before the infestation is eliminated.

Aphids are controlled by field sanitation and spraying the crop with Carbosulfan at the rate of 2 lit/ha or Polo 500 SC at the rate of 0.5–0.6 lit/ha. Moreover, Politrin-C 220 ULV at the rate of 3 lit/ha and seed treatment with Cruzer 350 FS reduce early attack of aphids.

White fly are controlled by spraying the crop with Polo 500 SC at the rate of 0.5–0.6 lit/ha, Lambdacyhalothrin, (Karate 5 E.C) at the rate of 100–500 ml/ha, Politrin C 220 ULV at the rate of 3lit/ha and seed treatment with Cruzer 350 FS reduce early attack of white fly.

Jassids are controlled by spraying the crop with Polo 500 SC at the rate of 0.5–0.6 lit/ha and Politrin C 220 ULV at the rate of 3lit/ha. Moreover, seed treatment with Cruzer 350 FS and the use of hairy varieties reduce early attack of aphids and jassid infestation respectively.

Disease Control

Some diseases attack Cotton plant and unless proper control measures are taken in time substantial yield reduction could be encountered. The most important disease of cotton is Fusarium wilt. Fusarium Wilt is controlled by the use of resistant varieties, proper land preparation and choice of an irrigation system.

Harvesting

Cotton is harvested in 2 pickings depending upon the maturity habit of the variety. Picking should be done when the bolls burst fully and when the fiber begins to hang down. It is true that good quality lint could be maintained by hand picking but for a larger and expanding area like the Omo Valley farm hand picking is tedious and time taking, rather mechanized harvesting is more preferable. Prior to the process of harvesting, the use of harvest aid products like defoliants or boll openers like Diuron + Thidiazuron can be put in use to lessen trash mix-up and preserve the quality of harvestable cotton product. Currently, the major drawback associated with mechanized harvesting is the mixing of left-over trash materials with the lint yield upon harvesting. This will be minimized by integrating manual cleaning operation, which certainly will reduce trash content mix-up before the harvested cotton bail is to be transported to the ginnery thereby imparting quality fiber.

10.2 Yield Projections for the Command Area

According the farm senior staff information during the visit to the farm the cultivable area in the project is 5,600 ha. Therefore, the following assumptions were made in the process of determining yield projections for the command area. The yield projection of the project has been proposed based on the availability of the unexploited resources that could go in the production of improved crop varieties and the adoption of improved agricultural practices to increase productivity. In this regard, some supporting opportunities/conditions of the command area are briefly described below.

1) The newly developing farm area is virgin and has been under vegetation cover; as a result soil degradation is low and the fertility status is in good condition.
2) The farm area is endowed with a good supply of moisture from Omo river.
3) Agro-ecological suitability.

The yield projections for cotton crop was made based on available data/information obtained during field assessment. The first year estimate was the farm's current yield of cotton and at the end of the fifth year the current obtainable yield under research was considered. For the other years in between the two extremes yield was estimated based on the personal experience of the consultant and more importantly from field observation. Therefore, the cotton yield increment for the three years is 34, 19 and 7% respectively

For the other subsidiary crops, the first year estimate was the farm's current yield of the crops and at the end of the fifth year the current obtainable yield under research was considered. For the other years in between the two extremes yield was estimated based on the personal experience of the consultant and more importantly from field observation. Therefore, for the crops maize, haricot-bean soybean ,sesame, tomato and mango increment in percent are (27,18,11),(40,28,22),(39,25,13) (42,25,8),(19,13,5) and (18,9,5) respectively

It is assumed that crops yield will increase for the coming five consecutive years beginning from the project implementation period. At the beginning of the period, under existing cropping patterns large scale farming will not attain the maximum projected crop yields in the first 1-2 year rounds, although there is a gradual yield increment on yearly basis. The trend in yield increment reveals that there is an increase in yield with increasing rate until it attains a constant or optimum level of production. The increase in yield will assume a constant increment beyond the five developmental periods unless there is technology breakthrough in-respect of crop varieties and irrigated field management practices by the country's national and regional research institutes.

Taking in to account the land use pattern as assumed by the client, the interest is nearly 100% coverage of cotton but assuming the inclusion of subsidiary crops like maize, sesame, soybean, haricot-bean and mango about 10% of the area will be allotted. Hence the cotton crop would have 90% of the total area. As shown in Table 10.1, year-1 crop yields are obtained from the existing farmer's field, whereas year-5 crop yields are research results. The rest figures are estimates based on the gradual yield increase due to technology use on

a wider scale, intensive water application, introduction of varieties and control measures that safeguard crop enemies.

Table 10. 1: Omo Valley Farm proposed projected outputs of crops under irrigated farming.

S.No	Crops	Unit	Project years				
			Year-1	Year-2	Year-3	Year-4	Year-5
1	Cotton	Yield (qt/ha)	25	28	34	39	42
2	Maize	Yield (qt/ha)	50	62	70	76	85
3	Haricot bean	Yield (qt/ha)	12	15	18	22	25
4	Soya bean	Yield (qt/ha)	8	10	12	14	16
5	Sesame	Yield (qt/ha)	5	7	9	11	12
6	Tomato	Yield (qt/ha)	250	300	325	350	370
7	Mango	Yield (qt/ha)	200	225	250	260	275

11. Conclusion and Recommendations

11.1 Conclusion

According the study undertaken, the Omo Valley Farm Project has got tremendous irrigation development potential in terms of large irrigable land and good quality irrigation water to promote modern cotton irrigation scheme. The Omo project area lies in Omo - Gebi river basin and according to the master plan study as referred the irrigation potential of the basin in general and the target area in particular is quite substantial. However, this potential is not exploited at all and the company request is proper and timely. This condition has to change radically in order to bring sustainable economic development for the company.

The available irrigation potential is so huge that it may not be possible to be fully utilized by the project alone. There are a wide range of opportunities in which the farm could participate such as involvement in the production of high quality Industrial product of Cotton and still this has to continue in a more pronounced manner in future as well.

11.2 Recommendations

The important recommendations from the above study on cotton agronomy for Omo Valley Farm Irrigation Project, in view of the introduction of totally new irrigation production system to the farm, the following recommendation are forwarded:

1) Frequency of tillage under cotton farm is 2-3 times.
2) Manage problematic weeds, hoeing or cultivation between rows, using chemicals like Ajil, Seelect and Fusilade 15% at the rate of 1.5, 0.4 and 1.5 lit/ha. respectively.
3) Insect-pest management
    - To control Boll worms spray the cotton plant with Tayodan,Tayonex and Ethiosulfan 25 % ULV at the rate of 3 lit/ha at early stage. Endosulfan 35% E.C 2.5 lit/ha and Lambdacyhalothrin, (Karate 5 E.C) with the amount of 100–500 ml/ha at maturity with 200-250 lit of water/ha.
    - To control Mealybugs raring and releasing Ladybird larvae and adults and fungal Lecanicillium lecanii as a biological control method. Spray the cotton plant with Insecticidal soap spray against mealybugs. Chemical treatments include the use of organophosphates. Diazinon can be used effectively, but requires multiple applications before the infestation is eliminated.
    - To control Aphids employ field sanitary measures. Spray the cotton plant with Carbosulfan at the rate of 2 lit/ha, Polo 500 SC at the rate of 0.5–0.6 lit/ha, and Politrin-C 220 ULV at the rate of 3 lit/ha. Treat cotton seeds with Cruzer 350 FS to reduce early attack of aphids. The use of hairy varieties also reduces early attack of aphids.
    - To control White flies spray the cotton plant with Polo 500 SC at the rate of 0.5–0.6 lit/ha, Lambdacyhalothrin, (Karate 5 E.C) at the rate of 100–500 ml/ha and Politrin C 220 ULV at the rate of 3lit/ha. Treat cotton seeds with Cruzer 350 FS to reduce early attack of white flies.
    - To control Jassids spray the cotton plant crop with Polo 500 SC at the rate of 0.5–0.6 lit/ha and Politrin C 220 ULV at the rate of 3lit/ha. Treat cotton seeds

with Cruzer 350 FS to reduce early infestation of jassids. The use of hairy varieties also reduces early infestation of jassids.

4) Manage Fusarium wilt disease by using resistant varieties and proper land preparation.

5) Fertilizer management
   - Urea should be applied at the rate of 100kg/ha in split application, i.e., half at planting and half at flowering times.
6) Diuron + Thidiazuron should be used for defoliating cotton leaves towards to maturity.
7) In the project command where medium to light soils of sandy loam and loamy sand components are predominantly high, soil amendment measures like green manuring and organic fertilizer (manure and compost) applications should be applied. This will gradually improve the water holding capacity and plowing depth of the soil. For the details on locations of the soil types, refer the soil mapping unit in the sectoral report of Soil Survey and Land Suitability Evaluation.
8) In the project command where heavy soils of clay and silt clay components are predominantly high, drainage and workability problems would be too high. Such soils by virtue of their properties are rock hard when they are dry thereby preclude deep tillage. Such condition should be ameliorated through intensive agronomic management measures like compost and/or manure application, green fallowing, high moisture stress tolerant varieties, cropping system approach, deep ploughing to encourage subsurface drainage, draining excess water, etc…. For the details on locations of the soil types, refer the soil mapping unit in the sectoral report of Soil Survey and Land Suitability Evaluation.
9) Crack and rift appearances in the Project Command should be improved through land leveling and preparation. Furthermore, long years of green fallowing with leguminous crops and the application of farm-yard manure and compost are paramountly important to improve such type of soils.
10) Commercial cotton varieties, which are responsive to irrigation water and other production inputs, to use include: Gloria, Candia, Claudia, STG-14, VBCHB-1527, YD-670, YD-195, VBCHB-1203, YD-223, YD-206, YD-211, Ionia and NEBAH (Stam-59A).
11) Seed rate varies among varieties. The amount ranges 10-30 kg/ha.
12) De-lint seeds ready for sowing, mechanically or by using sulphuric acid.
13) Cotton seed is planted on top layer of the soil surface and the depth should be 4-5cm.
14) Inter-row and intra-row spacing with the respective values of 80 by 25cm or 90 by 20cm should be used for optimum plant population and reasonable yield.
15) All recommended varieties should be verified on cum-demonstration plot for their agronomic performances like suitability to mechanization, tolerance to pest attack (weeds, insect-pests and diseases) etc….
16) The varieties of the proposed subsidiary crops (maize, haricot-bean, soybean, sesame etc…) that will be introduced in to the Project Command should be verified on cum-demonstration plot for area suitability and yield performance before planting them out on a wider scale.
17) Experts should be well trained to execute activities that should be carried out on cum-demonstration plots.

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