Central University of Technology, Free State

EVALUATION OF IRRIGATION MANAGEMENT PRACTICES OF BARLEY FARMERS IN THE TAUNG IRRIGATION SCHEME

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EVALUATION OF IRRIGATION MANAGEMENT PRACTICES OF BARLEY FARMERS IN THE TAUNG IRRIGATION SCHEME

by

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Dissertation submitted in fulfilment of the requirements for the degree

Magister Technologiae: Agriculture

in the

School of Agriculture and Environmental Sciences
Faculty of Health and Environmental Sciences

at the

Central University of Technology, Free State

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Bloemfontein
December 2004

Central University of Technology, Free State

DECLARATION OF INDEPENDENT WORK

I, **JOHANNES ESPHA KOKOME**, identity number [redacted] and student number [redacted] do hereby declare that this research project submitted to the Central University of Technology, Free State, for the degree **MAGISTER TECHNOLOGIAE: AGRICULTURE**, is my own independent work; and complies with the code of Academic Integrity, as well as other relevant policies, procedures, rules and regulations of the Central University of Technology, Free State; and has not been submitted before to any institution by myself or any other person in fulfilment (or partial fulfilment) of the requirements for the attainment of any qualification.

.... 16/03/2005

Signature Date

ACKNOWLEDGEMENTS

I would like to thank the staff of the Department of Agriculture, Taung sub-region, North West Province, as well as the producers in five different farmers support units, for their cooperation and assistance with regard to the interviewing of respondents.

I also appreciate the guidance and advice I received from the Central University of Technology, Free State. My sincerest gratitude goes to my supervisor, Prof. C. van der Westhuizen, for his guidance.

I am indebted to the National Research Foundation and the Central University of Technology, Free State, Innovation Fund Grant for Post-Graduate Study for financial support throughout the period of study.

I thank my son, Itumeleng, who helped with the typing of the document.

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Central University of Technology, Free State

CHAPTER 1

INTRODUCTION

1.1 Background and problem

Since 1996, about 202 small-scale farmer irrigation schemes involving 47 486 ha have been established in South Africa. Of the 37 198 participants, only 37% can be regarded as being commercially orientated. The remaining 63% are food-plot holders who may sometimes sell a proportion of their produce. In addition, there are a large number of smaller schemes (< 2 ha) comprising commercial gardens, food-plots and household gardens (Bembridge, 1996).

The South African Breweries (SAB) has been using malt barley for the brewing of beer for more than 100 years. South African Breweries is one the big companies listed on the Johannesburg Stock Exchange (JSE), with a market capitalization in excess of about R40bn ($7bn). In the 1997/98 fiscal year alone, SAB breweries used a total of 280 000 tons of malt barley for the production of beer. Sixty-five percent of this 280 000 tons of barley was supplied by local producers, while the rest (about 35%) had to be imported from other countries such as Canada and the European Union (Tregurtha and Vink, 1999:2). South African Breweries is committed to the development of the barley production industry in South Africa. Hence, this has prompted SAB to give local farmers a guarantee that it will source almost all its barley from them. SAB makes its beer for the world market. The beer industry requires malt barley with a nitrogen content of between 1.5% and 2.0%. Therefore, all agronomic practices that are associated with optimum barley production (such as fertiliser application and pest control) must be taken into account (Anderson, 1998).

The demand for water for uses other than those that concern agriculture has increased in the course of time. The amount of available good quality irrigation water, however, has decreased to approximately 50% of available water. Inefficiencies in water use can no longer be ignored because of increasing public awareness of the responsible use of non-renewable resources (Meyer *et al*., 1990). This necessitates the best possible use of the available water, thus emphasising optimal water use efficiency (WUE). Unfortunately, the approach of many farmers is that inexpensive inputs are not a limiting factor. Previously, this has often resulted in over-irrigation with low economic water use efficiency. Poor water management and poor WUE have been identified as some of the major problems experienced by farmers in most developing countries. Most countries do not monitor the performances of their irrigation systems (Hennessy, 1993). There are many factors that can affect the efficiency of any given system or method, especially the level and design of the system, the design of the sprinkler nozzle, spray devices, capacities and pressure at which water is injected in relation to soil texture, topography and agro-climatic conditions. In addition, farm management can have a major impact on efficiencies, even with regard to the best-designed systems.

The production of barley is said to be affected by soil, water, climate and crop management factors. Among these, water use and the application of fertilisers, especially nitrogen, are the most limiting factors in determining irrigation requirements and planning future water management projects. Barley's seasonal water use could vary widely, depending on agro-climatic conditions, soil types, quality and quantity of irrigation supplies and irrigation management practices (Hussain & Al-Jaloud, 1998).

Given the above, it is clear that there are several external and internal factors influencing the effectiveness and efficiency of any given irrigation scheme. Therefore, this study was conducted to determine whether the barley farmers in the Taung irrigation scheme are using correct/efficient irrigation management practices.

1.2 Hypotheses

The following two hypotheses were formulated:

H_0 = Barley producers in the Taung irrigation scheme are not using good irrigation management practices, whic affect the quality and yield of the barley production and increase the input costs.

H_1 = Barley producers in the Taung irrigation scheme make use of an acceptable irrigation management program.

1.3 Objectives

The overall objective of this study is to evaluate the irrigation practices of barley farmers in the Taung irrigation scheme.

Specific objectives are:

- To determine whether the farmers are using the correct irrigation practices (including irrigation scheduling) for barley production.
- To assess whether the producers are checking on nozzle blockages and the reasons for these blockages.
- To determine whether producers understand the water requirements of the barley crop.
- To determine to what extent producers are aware of the cost implications of misusing irrigation water.
- To determine to what extent farmers give due consideration to the crop water requirements during different plant growing phases in the irrigation process.
- To determine to what extent producers are on-site to identify and manage problems that may occur.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Various human activities over the years have led to the deterioration of the quality of the available water. These losses come from the increasing use of water for civil and industrial settlements, road networks and agriculture. Agriculture uses about 60% of the available water throughout the world. In South Africa, however, agriculture uses about 50% of the available water (Water Research Commission, 1996; Tognoni *et al*., 1998).

The approach of many farmers is that inexpensive inputs are not a limiting factor. Previously, this has often resulted in over-irrigation, with low economic water use efficiency (WUE) (Water Research Commission, 1996). Poor water management and poor WUE have been identified as some of the major problems experienced by farmers in most developing countries. Most countries do not monitor the performance of their irrigation systems (Hennessy, 1993). Inefficiencies in water use can no longer be ignored because of increasing public awareness of the responsible use of non-renewable resources (Meyer *et al*., 1990).

Many factors can affect the efficiency of any given system or method. For instance, properly levelled and designed systems can have efficiencies up to 75%, whereas poorly designed and managed surface irrigation system may have efficiencies of less than 60%. A low pressure, down-spray sprinkler can range in efficiency from 75% to 90%. Design of the sprinkler nozzle, spray devices, capacities and the pressure at which water is injected must be in line with the site-specific soil texture, topography and agro-climatic conditions to maximise efficiency of the system (Cornish, 1988:18). In addition, farm management can have a major impact on efficiencies, even with regard to the best-designed systems.

The quality and quantity of barley is determined by the correct supply of irrigation water and other factors. The irrigation water should be of high quality and the centre pivots should be in good condition so that the crop receives sufficient water.

2.2 Barley production in South Africa

2.2.1 Planting and production

Barley is produced mainly in the Western Cape (81%) under dry land conditions and in the Northern Cape (13%) under irrigation (Vaalharts area). Until four years ago, South Africa produced an average of 250 000 tons of barley per year, about 90% of which was malting grade, compared to an average of 147 000 tons a year during the past four years. Substantially more barley is now produced in the Taung and Vaalharts areas, where yields are better and more stable than the Western Cape.

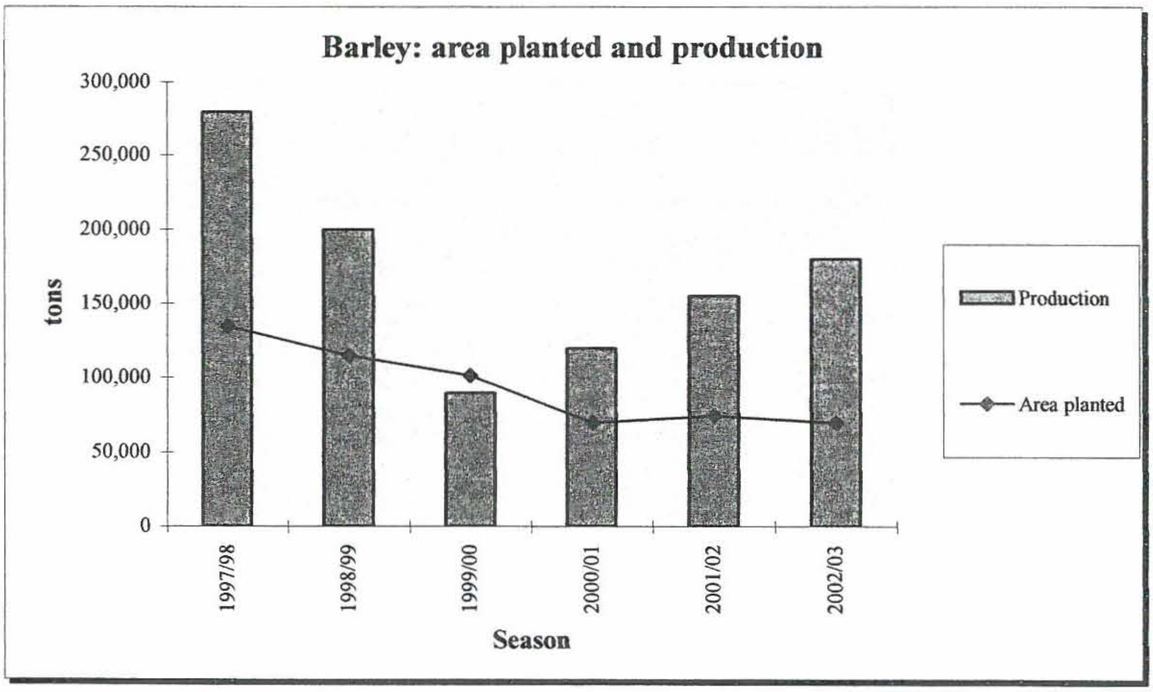

Figure 2.1: Barley; area planted and production 1997/99-2002/03 (National Department of Agriculture, 2004)

2.2.2 Consumption

Barley is used mainly for the production of malt (which is used for the production of beer), animal feed and pearl barley. Part of the South African barley production is less suitable for malting purposes and is therefore used as animal feed.

An estimated 330 400 tons of barley were available for local consumption during the 2001/02 marketing season. Carry over stocks for 2001 amounted to 51 300 tons, deliveries from farms during the 2001/02 production season were approximately 140 000 tons, while 139 000 tons of barley were imported.

It is estimated that during the 2001/02 marketing season, approximately 245 000 tons of barley were used for human consumption, 41 000 tons for animal feed, 4000 tons for seed and approximately 1000 tons were exported. The total demand for barley for the 2001/02 season was therefore an estimated 298 000 tons. On 30 September 2002 carry-out/takeaway stock was estimated to be approximately 32 300 tons. This is lower than the required 3 month pipeline stock of 35 800 tons. Barley imported as malt is not included in these calculations.

2.2.3 Prices

Although large amounts of barley are imported, the price of barley in South Africa varies between years. Table 2.1 provides the average producer price of barley for the past few years.

Table 2.1: The average estimated producer prices of malting barley from 1997/98 to 2001/02 (National Department of Agriculture, 2004).

Season	**1997/98**	**1998/99**	**1999/00**	**2000/01**	**2001/02**
Producer prices	R 800.00	R 750.00	R 758.24	R 800.00	R 1,000.00

2.2.4 Marketing

There is only one major barley buyer in South Africa, namely South Associated Maltsters (SAM), which supplies its major shareholder, SAB, with malted barley. Barley producers have guaranteed market and fixed forward contracts.

2.2.5 Imports

Over the past four years, the weather has caused wide fluctuations in barley quality and yields in South Africa. When local crop has fallen short of the requirements, SAM has imported barley from the EU, where barley production is subsidised. However, most barley is imported from Canada and Australia, where no subsidies apply.

Table 2.2: Barley and malt imports from 1997/98 to 2001/02 (National Department of Agriculture, 2004).

Season	**1997/98**	**1998/99**	**1999/00**	**2000/01**	**2001/02**
Barley imports	138 000	71 186	157 300	134 800	139 100
Malt imports	112 000	133 761	87 300	67 000	54 200

2.2.6 Barley yield

The production of barley in the Taung irrigation scheme is monitored by different Farmer Support Units (FSUs). Because of differences in, amongst other things, management practices and soil characteristics, the yields of the respective FSUs differ from one irrigation scheme to the next . Figure 2 indicates the yield at five separate FSUs for the period 2000 to 2003.

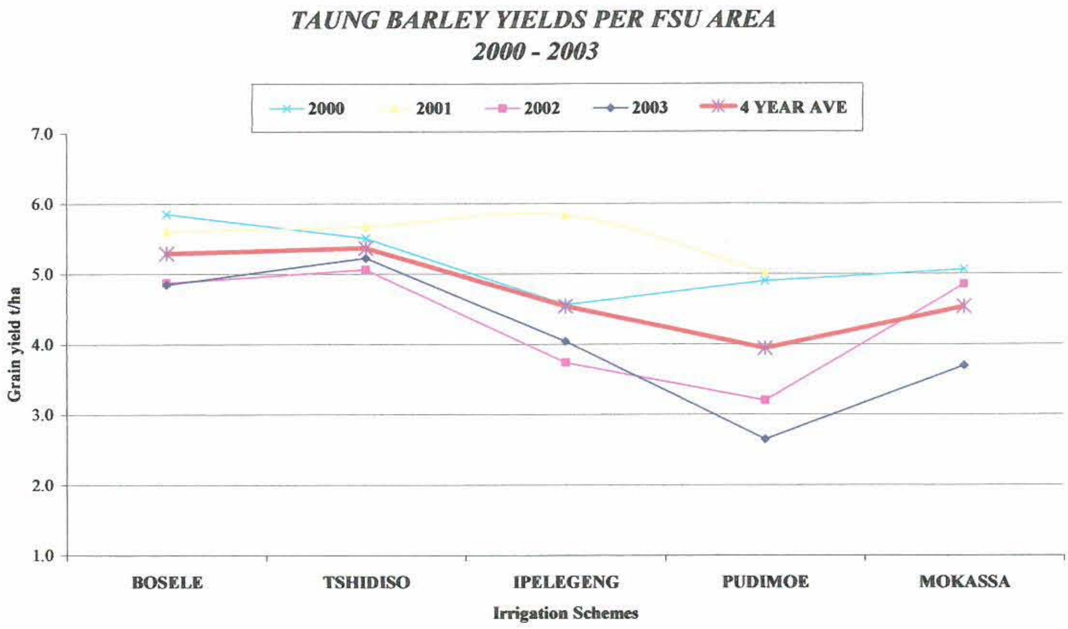

Figure 2.2: Barley average yield of the five Taung irrigation schemes for the year 2000/01/02/03.

The data in Figure 2 shows that the yield varies between 2.7 tons and 5.9 tons. It is also evident that the yield varied little between years at the Tshidiso scheme (between 5.0 and 5.7 t/ha) whereas it varied considerably between years at the Pudimoe scheme/FSU (between 2.7 and 5.0 t/ha). The 4-year average yield at the FSUs varied between 4.0 and 5.4 t/ha.

2.3 The Southern Associated Maltsters (SAM)

The Southern Associated Maltsters (SAM) started with barley trials at the Taung Experimental Farm in 1991. During the period 1991 to 1998, in situ trials were conducted on the premises of semi-commercial farmers. In 1998, SAM started producing barley for commercial purpose in the Taung irrigation scheme. In the beginning of the project, 55 farmers were involved on 556 hectares of irrigation land. In the 1998 production year, barley was sold to SAB for R3 m and the profit was shared among the 55 farmers. Since 2000, the number of barley farmers has increased (because farmers share their pivots with their colleagues) although the area of production remains unchanged.

2.4 Quality requirements for barley

South African Breweries has several requirements regarding the quality of barley. These quality requirements are:

- Germinative capacity: minimum 98%
- Germinative energy: minimum 97%
- Plumpness >2,50 mm: minimum 70%
- Screenings <2,20 mm: maximum 5%
- Total nitrogen (dry basis): minimum = 1,5% and maximum = 2,0%
- 80% hectolitre mass

Poor quality barley is barley with a too high or too low nitrogen content. The malting barley should be within the parameters set by the brewers. The nitrogen content is tested/confirmed through protein tests at the silo. Screening also has certain parameters that must be taken into account during grading. Subsequently, barley with a too low or very high nitrogen content is regarded as low grade.

2.5 Pivot irrigation system

When flood irrigation was used as the method of irrigation, farmers were much involved because they had to be on the land to control the water. They were afraid of leaving the water without supervision for fear that over-irrigation would wash out all the nutrients, and the possibility that the excess water would damage other farmers' crops. Another reason for the on-site presence of farmers was that they used to take (steal) each other's water if there was no one present to control it. At present, farmers are leaving the centre pivots to run alone while moveable pipes (sprinklers) are left in one place for more hours than needed. There is a tendency towards over- or under irrigation as the farmers stop pivots when they feel like it or leave them running for too long.

Most pivots require a medium operating pressure of ±300 kPa and are therefore capable of applying 50 mm water every six days. The power requirement is in the order of 40 KVA per pivot (Eksteen *et al.*, 1985)

2.6 Water source

Water for the Taung irrigation scheme is sourced from the Vaal River at Warrenton. There is a main canal from the source (the weir at Warrenton) to the Taung dams. The north canal enters the Taung irrigation scheme at the eastern corner of the irrigation area, at an elevation of ±1145 m AMSL. The capacity of the north canal carrying water from Warrenton to Taung is 2,45 m^3/s at the rightful discharge rate.

The water users are required to register the use of irrigation water for pricing purpose and for determining the annual irrigation water requirement. The Taung water quota is 37x67x106 m^2 per annum (Loxton *et al.*, 1982:29).

The allocation of water is based on a quota system, according to which producers are paying R229,50/ha per season. Before 1994, producers received a 100% subsidy from the former Bophuthatswana Government. Pivot maintenance was also subsidised. The Department of Water Affairs has no proper and appropriate measure for water usage and simply divides the total usage by the number of producers. Sometimes parts of the land are not cultivated and the affected farmers have to pay for water they have not used during a particular season.

Measurements of water flows in irrigation canals are usually costly, too often questionable in accuracy and otherwise difficult to apply to the field situation.

The irrigation scheme comprises 3500 ha and at the end of each season the Department of Water Affairs expects an amount of money equal to the hectares at the Taung irrigation scheme multiplied by the cost/ha. Water is supplied to three big dams, which supplies smaller dams at pump-houses. Each of the smaller pump-dams supplies between three to six pivots.

2.7 Water and fertiliser requirements of barley

Irrigation water requirements concern the quantity and quality of water that must be supplied to satisfy evapo-transpiration. Different crops require different amounts of water, and the quantities of water used by a particular crop also vary with its stages of growth (Stern, 1979:70). It is known that during early growth most crops have a relatively low demand for water. The water requirements of barley depends on the cultivar, target yield and crop management.

Barley requires between 390 and 430 mm of water for optimum yield. Malt barley may require more water over the growing season than feed barley. This additional water is required to maintain the protein content of the grain and meet the standards set by maltsters.

During initial growth stages, crop water use will range from 1 - 3 mm/day, rising to a high of 7 - 8 mm/day during the flag leaf to flowering stages. In soils well-suited for irrigation, barley develops an active rooting depth of approximately 1.0 m. By the flowering stage, full canopy cover is established and the active rooting depth has been reached. Approximately 70 % of the crop water use comes from the top 0.5 m of the root zone, but the crop will use soil moisture to a depth of 1.0 m. Maximum water use will occur between 21 to 28 days after planting.

Crop response to drought stress at any stage of crop growth can cause irreversible yield losses. The severity of the losses will depend on the timing, length, and seriousness of the drought period. Yield reduction can be due to loss of tillers, reduced kernel weights or fewer kernels. Research indicates that stress prior to, or just after, the onset of flowering, reduces yields the most. The yield-reducing effects of stress can be offset somewhat if the stress is relieved later in the season, but the yield recovery from stress near the flowering stage is lower than recovery from stress in the vegetative stages of earlier growth. Moisture stress can also result in higher protein contents and a shortening of the grain filling period, leading to earlier maturity. Barley is not tolerant of prolonged or excessive drought. It will tolerate soil moisture depletion of 30-35 per cent of available moisture during grain formation and 10-20 per cent near maturity. Protein content of the grain increases when available soil moisture drops below 50 per cent for extended periods of time. For optimum yield and quality, it is important to monitor soil moisture conditions regularly throughout the growing season and irrigate accordingly.

Excessive soil moisture during the jointing and boot stage, coupled with high nitrogen fertility, may promote vegetative growth that could result in logging as the crop develops. Irrigation after the crop is well developed also promotes logging. Excessive soil moisture during the tillering and flowering stages will not depress yield nearly as much as during earlier stages of growth.

The irrigation farmers were advised to use the difference between the upper or wet boundary of plant-available water and water content where plant-water stress appears for refining irrigation management and scheduling or planning of the system and cycle used.

With over-irrigation, there is wastage of water and electricity while valuable nitrogen will also be leached out of the root zone, resulting in low nitrogen content in the grain. As mentioned before, nitrogen, or otherwise in wheat grading referred to as protein, is one of the factors determining the grade (and price) of barley.

2.8 Other related research / case studies

Farded & Persalakli (1995) concluded that the barley grain yield could be optimised if water requirements are met on the 7th day after planting. It was also found that barley was less sensitive to water stress than wheat. Tiwari *et al.* (1978) mention that frequent irrigation at the tillering and milk ripens stages is effective in increasing the grain yields and uptake of P and K in that most of the P is translocated to the grains. Sigh & Kumar (1979) did research on the influence of irrigation on the leaf water potential and yield. They irrigated barley at different growth stages. The first irrigation took place when there was 75% soil moisture depletion in the active root zone, while the second irrigation took place at the critical point of yelting. The authors found that the effect of the frequency of irrigations on leaf water potential was greater at the highest development stage. The lowest leaf water potential was recorded in barley with the most frequent irrigation treatment. At all levels of irrigation, leaf water potential in barley was higher than in wheat. According to Cheema *et al.* (1977) there was no increase in grain yield with an increase in irrigation given in any stage other than the tillering stage. In another experiment, wheat and barley were comparatively researched to determine the response to different frequencies and timing of irrigation (Bhan & Dhama, 1977). Wheat showed an increase in grain yield after increasing the number of irrigations from two to three, while there was no further yield response with a similar increase in the number of irrigations with regard to barley. The application of water to barley should therefore not be more than what is required/recommended. According to Spashka (1978) the barley crop was irrigated mostly in three growing stages, namely the heading, flowering and dough stages respectively. The highest water requirements were during the heading and flowering stages, with the highest water efficiency obtained during irrigation in the flowering stage.

2.9 Irrigation schedule

Planning an irrigation schedule necessitates taking into account two major factors, namely crop requirements and evaporation. For a prospective irrigation farmer, the first and most important step is to determine the crop water requirement per physiological stage of the plant. However, various other factors must also be taken into account when a correct decision on irrigation scheduling for the barley crop is needed. These factors include the layout of the farm, the labour schedule on the farm, tillage schedule and available kW's on the farm, water supply programme (calendar showing when water will be available and when the dam will be empty for cleaning and other reasons), as well as soil variability (that illustrates differences in texture, structure, infiltration rate and soil water capacity). Planners and producers will then be able to develop an appropriate irrigation management system for the specific crop on a specific farm or in a particular production area. It usually necessitates a compromise between water availability, crop water requirements and farming constraints.

2.10 Factors affecting irrigation

Many factors affecting irrigation should be taken into consideration, including the type of soil, crop water requirements, climate, cycle length, infiltration tempo, pressure and spacing, transpiration component and scheduling. Soil water affects plant growth directly, but also indirectly through its effect on soil temperature, soil aeration, and nutrient leaching. According to Hillel (1982:26) maximum plant protection may not be the only goal for irrigation management practices. It is often necessary to minimise the environmental impact of irrigation to maximise production based on scarce resources like water. The factors dictate that the goal and principles of irrigation management practices should be clear in the mind of the user in order to be successful (Hillel, 1982:26). Water is retained by the soil after irrigation because of air pores and the adhesive and cohesive forces involved. Irrigation can adversely affect leaf water potential by cooling the soil.

2.11 Soils

The arable soils of Taung are mostly Hutton forms that are suitable for crop production. The different soils consist mainly of Lavas of the All-ridge formation (Ventersdorp family) with sedimentary rocks (quartzite) of the Bothaville formation occurring towards the east. These rocks do, however, provide an excellent foundation for large or heavy structures. According to Eksteen, Van der Walt and Nissan (1981:3) irrigation soils in Taung are generally classified as sandy loam, and available soil moisture is taken as 120 mm/m.

Barley can be grown on almost any kind of topography or land conformation that can be cultivated, if all factors are agronomically positive. Barley can also be grown in a wide range of soil types - from granite sands (up to a depth of ±1 m to allow root development) to clay soils.

Excess rain or irrigation water either collects on or runs off the soil surface. Too much water can in some cases result in a partially sealed soil surface. If the soil surface is sealed, infiltration may be negatively disturbed, therefore more run-off takes place. Barley can do well in a well-drained heavy loam soil; the soil should not be rich in nitrogen, while an alkaline soil is also preferred. Soil with a high pH will, however, be less restricting for barley production (Kotze, 1996:7). The soil should be relatively uniform to obtain maturing and avoid green patches at harvesting. The seedbed should not be pulverised to powder, as it will tend to break down with the application of irrigation, which will affect the soil contact with the seeds. Although barley can withstand considerable drought, prolonged dry conditions can seriously damage/harm the crop potential.

2.12 Water use efficiency and irrigation efficiency

2.12.1 Physical water use efficiency

Physical water use efficiency (WUE) may be measured as a ratio of dry matter produced per unit area (t ha^{-1}) per unit evapo-transpiration (mm) (Jansen *et al.*, 1981). WUE can also be defined as crop yield divided by the amount of water used: WUE = Mcrop/Vwuse (Mcrop = mass of crop; Vwuse = the amount of water used). Increases in WUE can be accomplished either by increases in Mcrop relative to Vwuse, or by decreases in Vwuse relative to the Mcrop. Both techniques may increase the beneficial use of water (Lamm, 1997). Water use efficiency can be improved in a number of ways. In a thorough review of crop yield response to water use, Howell *et al.* (1990) suggested the following to increase WUE:

- Increase the harvest index (ratio of crop economic yield to the total dry matter production).
- Reduce the transpiration ratio (ratio of transpiration to dry matter production).
- Reduce the root mass needed to initiate the first increment of economic yield.
- Increase the transpiration component (percentage of total water used) by reducing evaporation, drainage and run-off.

2.12.2 Water loss

Water loss is defined as water that is not used by the intended crops as transpiration. Water loss can be categorized as atmospheric losses, surface losses, or drainage losses.

Atmospheric losses

- Evaporation from open water (reservoirs, canals, and fields).
- Wind drift and spray evaporation from overhead irrigation systems.
- Evaporation from bare soil.
- Transpiration from vegetation that is not the intended crop.

Surface losses

- Run-off from fields.
- Flow from drainage pipes.

Drainage to ground water

- Seepage losses from canal pipes.
- Seepage losses from the field.

Losses matter if:

- the loss performs no useful function;
- the lost water is not recovered downstream from the point of loss;
- the loss causes some detrimental environmental impact; or
- the loss increases capital or recurrent costs.

Losses do not matter if:

- the lost water has no value; or
- the lost water can be recovered downstream.

2.12.3 Water economics

The most cost effective way of increasing the productivity of irrigation water is to increase the WUE of crops. Therefore, economic water use efficiency (economic WUE) is another parameter that can be used to optimise water savings. It reflects the net income generated per unit of water consumed (R m^{-3}). When comparing the WUE of different crops, the economic WUE should be taken into account. The physical WUE is necessary in analysing the efficiency of management practices for a given crop or group of similar crops. Economic WUE of irrigated crops in South Africa varies from less than R0.20 m^{-3} to more than R10.00 m^{-3}. This depends entirely on the input costs, yield and the price of the produce. The economic WUE of grain crops is often very low. The approach of many farmers is that inexpensive inputs are not limiting. This often results in over-irrigation with a low economic WUE as the unintended effect (Water Research Commission, 1996).

Poor water management and poor WUE have been identified as major problems experienced by farmers in most developing countries. Most countries do not monitor the performance of irrigation systems (Hennessy, 1993).

2.13 Specific requirements of barley

Although barley can be planted in various types of soil, a relatively uniform well-drained soil is preferred. The pH of the soil may vary, but can rather be higher (alkali) than acid (>pH5.5) (Kotze, 1995).

Fertilisation of barley does not require soil with a high nitrogen content; when planted with a nitrogen deficiency present, very few tillers are produced. Soil sampling must be done before deciding on the fertilisation programme. The nitrogen requirement for an optimum yield for barley crop is 120 kgN/hectare. When barley is cultivated after a cotton or maize crop, 140 kg/ha should be applied. Nitrogen should be applied as a split (more than one application) to overcome too long a negative period.

The total average rainfall in the Taung area adds up to 408 mm per year. The barley crop requires 600 mm of water in a growing season, therefore dry-land barley production in the Taung area is not possible. It is very important that irrigation should not be stopped too early to avoid shrinking and the resulting high level of nitrogen in grains.

CHAPTER 3

METHODOLOGICAL FRAMEWORK

3.1 Description of the research site

Taung is situated in the North West Province at the junction of the main route (N18) linking Mmabatho (North West) with Kimberly (Northern Cape), and the R372 linking Taung with Reivilo. The town is approximately 70 km south of Vryburg and 40 km north of Jan Kempdorp. Taung is connected to the extended main railway line between Kimberley and Cape Town (Western Cape).

The Batlhaping tribe, under the leadership of Chief Mankuroane, inhabits the Taung area. In general, the soils in the Taung territory are shallow, but the listed areas are suitable for cultivation. Approximately 3500 hectares are under irrigation (excluding vegetables gardens and woodlots). The biome in the Taung area is classified as thorn bushveld within a semi-arid climatic zone characterised by warm hot days during summer, and cold days and nights during the winter months (Accocks, 1975:18).

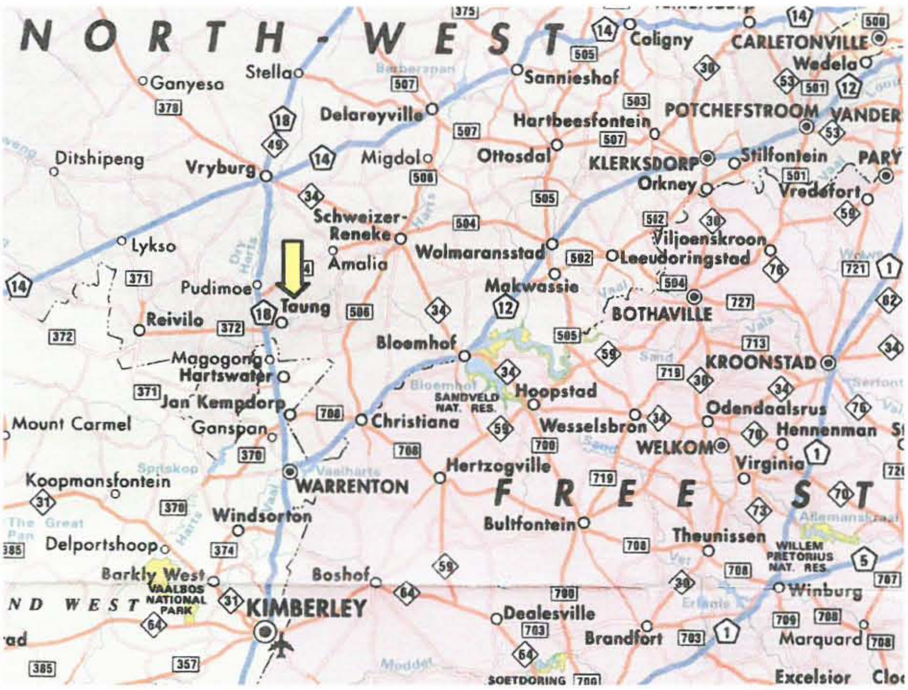

Figure 3.1: General location of the study area.

3.2 Irrigation schemes

When the Taung irrigation scheme was initially formed, it consisted of small plots of between 1.5 and 1.7 hectares. During the development of the irrigation scheme in 1978, flood irrigation was replaced by centre pivots and overhead sprinklers. Larger units of up to 10 ha replaced the small plots. The main crops that are cultivated in the Taung region are barley, maize, groundnuts, wheat, vegetables and fruit trees.

Water used by the Taung irrigation scheme is sourced from the Vaal River at Warrenton. There is a main canal from the weir at Warrenton to the Taung dams. The north canal enters the Taung irrigation scheme at the eastern corner of the irrigation area, at an elevation of ±1145 m AMSL. The capacity of the north canal carrying water from Warrenton to Taung is 2,45 m^3/s at the rightful discharge rate. Three receiving dams feed other smaller dams. A water bailiff controls the water at each dam. This means that water is distributed to different areas/FSUs by water bailiffs. The water bailiff is supposed to check the dam levels and report to the relevant section to open or close the water.

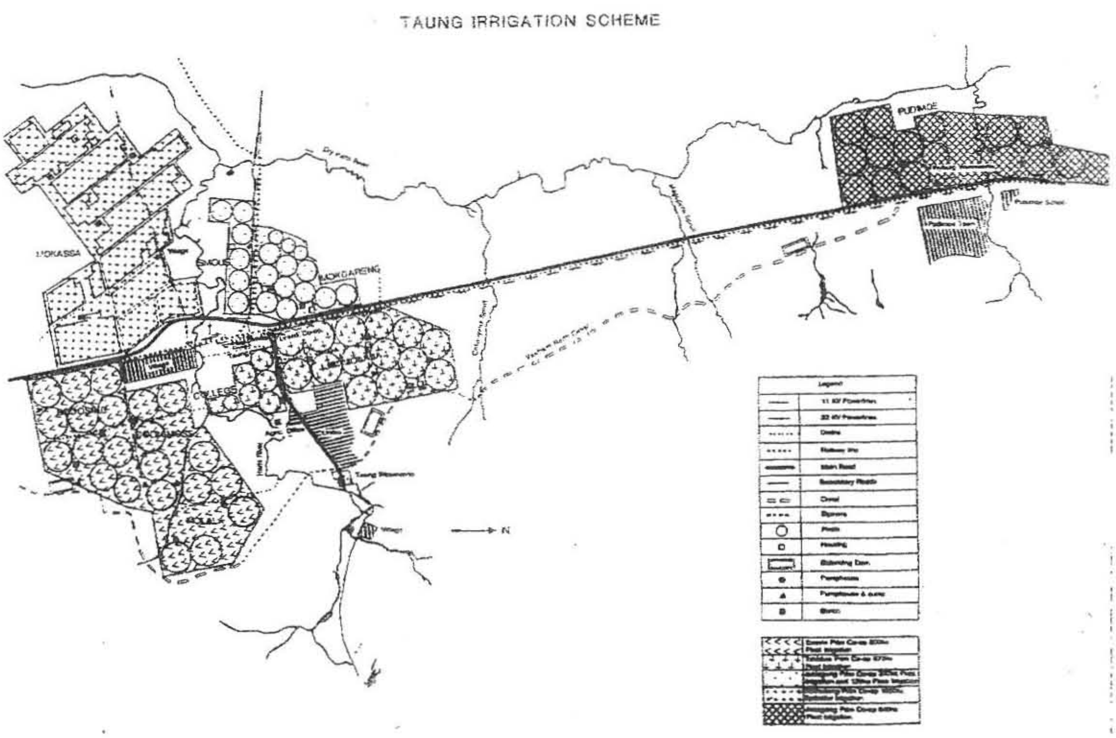

Figure 3.2: Layout of the Taung Irrigation Scheme

3.3 Irrigation dams and pivots supported

The dams in the five FSUs as well as the number of centre pivots supplied by them are the following:

3.3.1 Tshidiso

Tshidiso irrigation is supplied by Dam 6. There are three feeder dams at Tshidiso. They are the Jim Molale Middle dam with six centre pivots, the Jim Molale South dam with four centre pivots and the Jim Molale North feeder dam with four centre pivots.

3.3.2 Bosele

Bosele is supplied by Dam 1 and has four small dams. They are Molale East with five centre pivots, Molale West also with five centre pivots, Bogosing Northeast dam with two centre pivots, and Bogosing Middle and West with six centre pivots.

3.3.3 Ipelegeng

Ipelegeng has three dams, namely Mokgareng North with six centre pivots, Mokgareng South with six centre pivots and Smous dam with six centre pivots (of 20 hectares each).

3.3.4 Mokassa/Rethuseng

Rethuseng is under overhead sprinklers supplied directly from Dam 1. The water is gravitationally supplied.

3.3.5 Are Ageng

Are Ageng is supplied by Dam 7. It is the lowest area and suffers the most from poor water distribution. There are two small dams, namely Pudimoe South with six centre pivots (of 40 hectares each), and Pudimoe Middle and South with ten 40 ha centre pivots. This FSU sometimes stays for three days without water, and naturally, this affects the grain yield.

3.4 Data collection

3.4.1 Sources of information used

Much information used in this study was obtained from secondary sources such as textbooks, journals, reports and the Internet, while contact was also made with several experts. Because all the required information could not be sourced from secondary sources, a questionnaire was developed as a primary source (see Appendix A). In addition to this, information was also obtained through formal and informal discussions with staff members from the Department of Agriculture, the Department of Water Affairs, as well as a number of farmers.

3.4.2 Sample size

There are five Farmer Support Units (FSUs) servicing 411 farmers. Every farmer was eligible as a respondent because of the mixed farming system in Taung. From this population of 411 farmers, 75 respondents were randomly selected, and all of them were barley producers (Figure 3.1). The respondents were selected using a stratified random sampling technique in that fifteen respondents from each FSU were selected.

3.4.3 Interviewing and procedures

A period of three weeks was set aside in order to explain the significance of conducting a study of this nature to the producers, the FSU committees, and agricultural technicians. A briefing was also held with technicians from the Department of Agriculture seconded to the Taung irrigation scheme. A series of meetings were held with all the FSU committee members for three consecutive weeks. During these three sessions, the technicians were trained as enumerators to assist with the completion of questionnaires. All the respondents selected were again contacted to confirm their availability for the interviews on the specified dates. The questionnaire was tested using three respondents at different FSUs. These respondents were interviewed by agricultural technicians It took an average of 48 minutes for the completion of each questionnaire. Final adjustments were made to the questionnaire and its final version was reproduced. The questionnaire used is attached as Appendix A.

3.4.4 Quantitative reliability

Observation during the growing season of the barley crop was also done. An eye was kept on every small activity and information opportunity that could be of help. Before the interviewing process started, a strict precautionary measure was followed in that details of the interview procedures were again emphasised to all the enumerators and interviewees. To avoid embarrassment, respondents were again checked according to the name list of those randomly selected. These precautionary measures were taken to ensure the accuracy of the collected data (Bembridge, 1978). Survey-type research methods (questionnaires) are accepted by the scientific community as an efficient tool for assessing a specific situation.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Biography

Several biographical aspects of the respondents were determined and are presented in the following paragraphs.

4.1.1 Age

The age of the producers plays an important role in the agricultural industry. Heavy machinery is involved and demanding physical work must be performed, like the shifting of pipes, unblocking of nozzles, filling of deep wheel tracks on the land, and the watching of pivots/pipes during the night. Old people or small children would find it difficult to perform such work. Age is a personal characteristic that affects the thinking and behaviour of an individual, and adult learning is interwoven with many other activities and responsibilities. The age of the respondents ranges from 23 to 81 years. Figure 4.1 gives an indication of the age spread of respondents (grouped in clusters of 10 years).

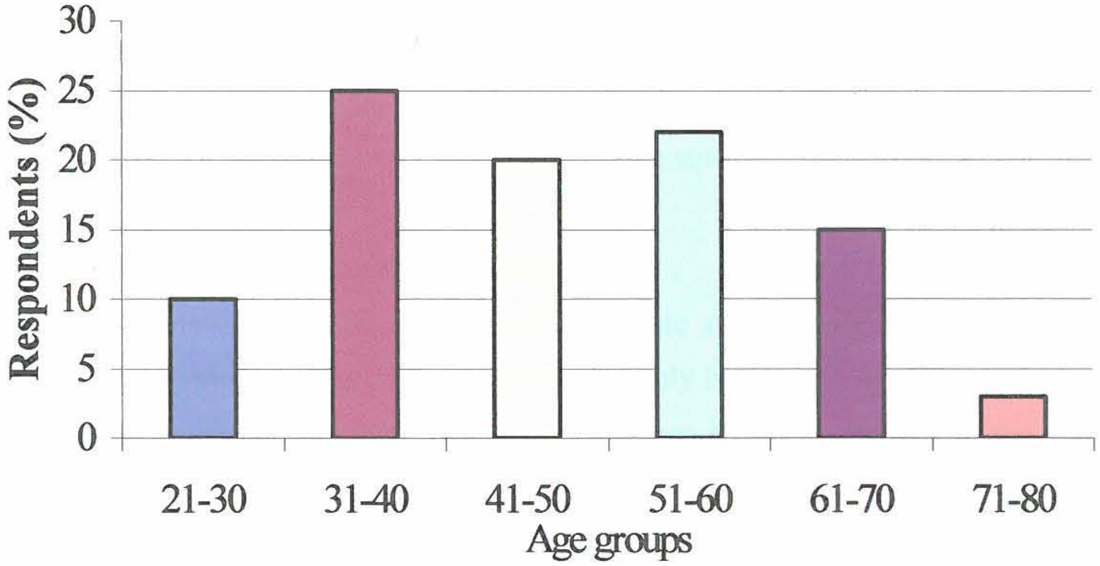

Figure 4.1: Age of respondents grouped into categories spanning 10 years each

Figure 3 shows that most respondents (25) were between 31 and 40 years, while the second largest frequency group (22 respondents) was in the 51 to 60 years category. The average age of the respondents was calculated as 47.2 years.

4.1.2 Gender

Gender affects the role an individuals plays in agriculture, especially in the farming sector. During discussions with women and enumerators, it was mentioned that men are physically stronger than women and that they (men) have to perform most work on the land. However, another argument mentioned was that female farmers could be well educated and that they are fast learners. Women also functioned as secretaries for three of the five farmers' support units. Of the respondents, 18 (24.3%) were female and 56 (75.7%) male.

4.1.3 Marital status

Some researchers are of the opinion that marital status plays an important role in the agricultural industry, especially in the farming sector. According to Tshenkeng (1999:95), married men are likely to progress faster than unmarried men because of the support they receive from family members. In some cases unmarried women are deprived of certain opportunities, e.g. they often struggle to obtain financial loans due to a lack of or inferior security. When the loan application is turned down, these women are unable to plant because they lack implements and other inputs required. Of the 74 people that responded to this question, 40 (54.1%) indicated that they were married. A high marriage rate has a positive impact on social stability, which influences the sustainability of a long-term farming strategy.

4.1.4 Occupational status of the respondents

If a high percentage of physically strong men are supplementing their income by working permanently or as commuters on a monthly basis, farming performance and progress is detrimentally affected as women, old men and inexperienced workers tend to be less successful farmers. The absence of physically strong people leads to stress and a loss of cohesion. In this sample, each farmer had 3.7 children on average. According to Maruping (2002, personal discussion), children are leaving school at a young age to look for work because there is no money for their schooling. The profit that is made from the land is too little to provide support for the children's education and upbringing. Very few of the respondents' children wanted to take up farming because there is little profit to be made.

4.1.5 Educational level

Respondents with some education can obtain better information by reading and studying appropriate magazines, books and other written materials. The educational levels of the respondents range from none to those with tertiary qualifications. We need to continuously acquire knowledge as we live in an era where things change rapidly and new technology is introduced on a regular basis. People with limited education struggle to cope with new technology. Respondents should be aware of current affairs so that they are informed about what is happening around them, especially in the agricultural industry. With a little knowledge, one can plan and set goals. Farmers with an education tend to be receptive to new technology and ideas. The educational levels of the respondents are provided in Figure 4.2.

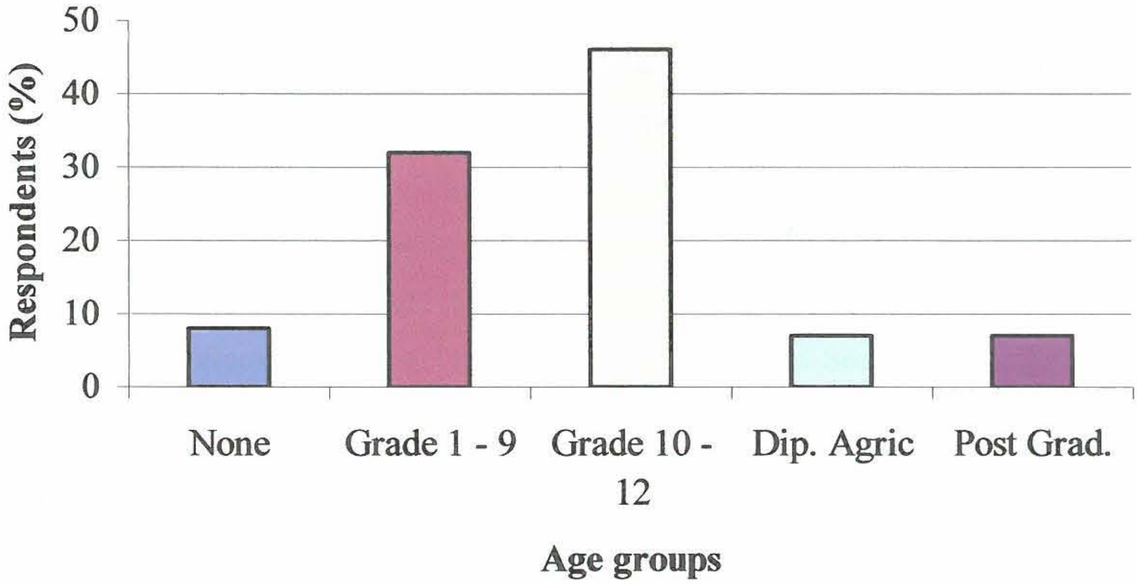

Figure 4.2: Educational levels of the respondents grouped into certain categories

Figure 4.2 indicates that 8% of the respondents (n=74) never had the opportunity to attend school, while 32% left school before they reached Grade 9. The majority (46%)

had training up to grades 10 to 12. Few respondents (7%) obtained an agricultural diploma, while a similar number had other tertiary qualifications.

4.1.6 Language

There are no language barriers that act as an obstacle to the success of the irrigation scheme, with the exception of communication with contractors who are coming in to do soil preparation or pivot maintenance. There were 10.8% Xhosa and 89.2% Setswana speaking respondents (n = 74). The Xhosa speaking people can also speak fluent Setswana; therefore, there were no communication problems amongst the respondent farmers.

4.1.7 Discussion of the biographical aspects of respondents

Most of the farmers in the Taung irrigation scheme are residents of the Taung area, even though the villages are scattered over a large area. The irrigation farmers have to be in the fields on a full-time basis. The former Bophuthatswana Government erected houses close to the irrigation project to enable farmers to manage the irrigation scheme properly. The idea was to help farmers manage the infrastructure, water and other valuable assets.

The irrigation scheme provides work to both old and newly settled inexperienced farmers. It is evident that the older farmers, female farmers and inexperienced farmers are less likely to check on the level of dams and unblock the nozzles during the night, weekends and holidays. It means that these farmers should be motivated to be more dutiful. There is no doubt that the year 2002 has brought about a tremendous change, which affected both the Taung barley producers and Southern Associated Maltsters. This was due to damage caused by a heat wave as well as the appearance of frost. Most barley fields were affected by these factors. Majola (2003, personal communication) is of the opinion that the Taung producers are investing more of their time in other commitments, claiming that they need money for their daily food as the crops are only paying at the end of the season.

4.1.8 Farming experience of respondents

Irrigation water is an important form of crop security for the Taung irrigation scheme (including the malting barley farmers). Irrigation water allows the production of two concurrent crops per year - the sole income for the Taung farmers. The problems encountered in the irrigation scheme with regard to irrigation management practices include:

- pivot breakages,
- nozzle blockages,
- shortages of irrigation water,
- power failures, and
- no water personnel during weekends and public holidays.

Most of the respondents in the irrigation scheme have been involved in the project for a relatively long period. Some were in the scheme before the 1978 developments (during the 1.7 ha flood irrigation era). Some respondents were also in the scheme before the introduction of malting barley production. Figure 4.3 shows the distribution of respondents according to their experience and years in the Taung irrigation scheme.

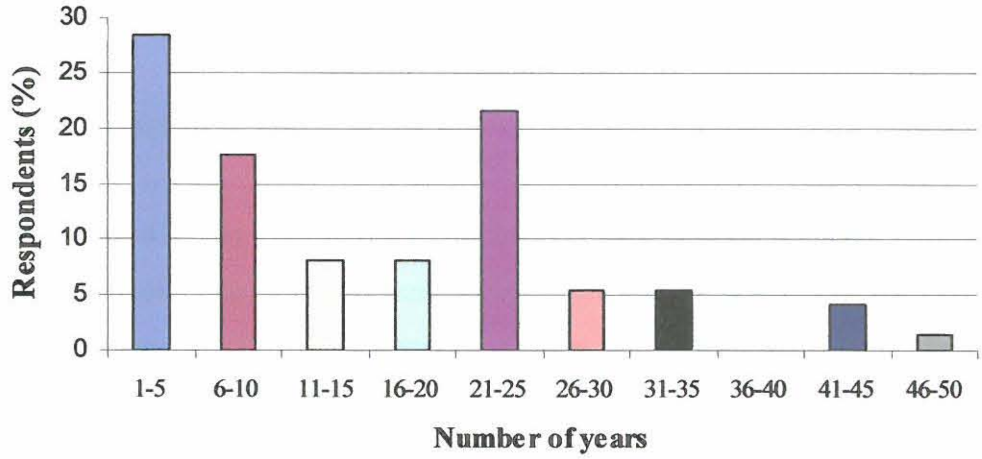

Figure 4.3: Distribution of respondents according to the number of years they have been in the Taung irrigation scheme.

Of the respondents, 37.8% are reported to have been in the irrigation scheme for more than twenty years, while a large proportion (28.4%) have 1-5 years' experience, or 10 years or less experience (46%). Although most of the respondents have more than 10

4.1.9 Respondents' visits to the land

The respondents were asked how often they visit their lands when there is a crop. (Figure 4.5).

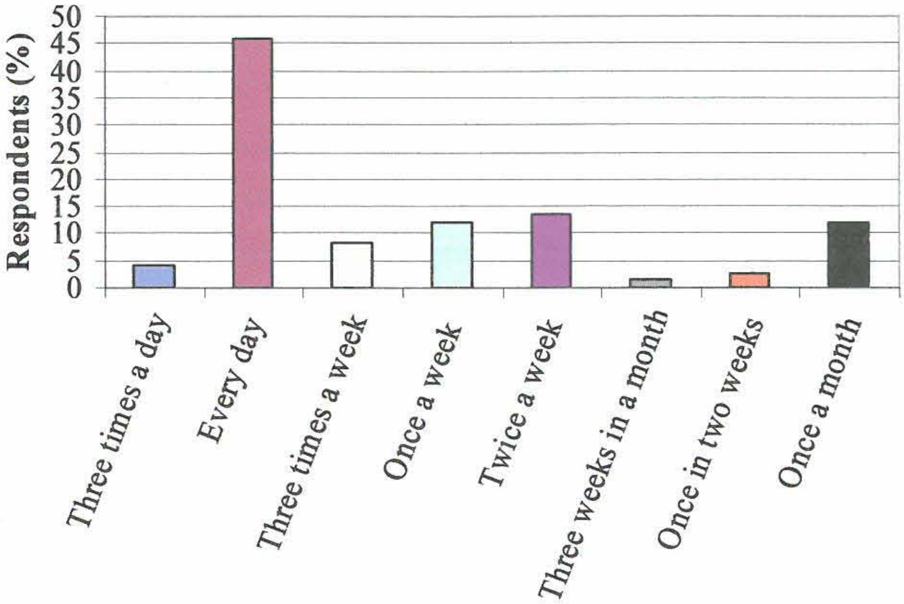

Figure 4.5: Frequency of visits to land by responding farmers.

Half of the farmers indicated that they were visiting their fields at least once a day, 37.8% reported that they were visiting the land at least once a week, 13.5% reported that they were visiting their land twice a week, and 12.2% indicated that they were visiting the cultivated fields only once per month. Visiting a running pivot regularly is most important, as there are a number of potential problems that can occur. The nozzles may be blocked, and/or the motor or gearbox may be broken. Farmers need to be on the land almost the whole day to check on the machines and the water levels of dams. As some of the farmers are visiting their land only once or twice a month, they have very little chance to notice and repair breakages in time. This leads to an increase in the number of damaged pivots and the wastage of resources.

4.1.10 Respondents' distance from the land

It is known that there is a problem with nozzle blockages and power tripping of machines during the night or public holidays as farmers are not living close to the land. Farmers just start the pivot and leave for home, without knowing what will happen. Some respondents indicated that they stay 35 km away from the land/fields. The former Bophuthatswana Government had houses built for the project to give farmers enough time to be on the land. The problem is that the houses are not occupied by farmers, but are rented to people like teachers and other professionals. Costly breakages occur when the farmers are absent from the fields. Sometimes a wheel gets stuck in the mud and a gearbox suffers damage because there is no one to attend to the problem. A small obstacle will break the driving shaft, gearbox and even the motor. As a gearbox costs approximately R2500.00 and a motor ±R7000.00, the total cost that farmers will incur is about R10000.00 (including labour and transport). The completion of an irrigation cycle is most important, but farmers do not adhere to this requirement during the night. They stop the pivots so they can go home early.

4.2 Fertilisation

A fertilisation program can only be useful if the crop requirements with regard to acidity and other factors are met. According to Kotze (1995), a pH of 5.5 to 6.0 should be maintained as severe yield loss can occur at a low soil pH. Kotze (1995) further mentions that the unnecessary increase in pH could lead to a zinc and manganese deficiency. Soil analysis is essential to verify the quantity of every element in the soil, as the absence of some elements could be detrimental to crop production. Potassium deficiencies are possible in the lighter texture soil in irrigation areas. It is imperative for farmers to guard against potassium deficiency so that they can produce quality malting barley. According to Kotze (1995:2), "malting barley requires 120 kgN/hectare in a cooler area and 140 kgN/hectare on a land that was previously planted with maize." Fertiliser can be spread in different growing stages of the plant's development. The last fertilisation should not be after 70 days of emergence. Nutrient uptake is coupled with moisture uptake, thus it is obvious that if moisture is applied it should take place during the first and last period. A range of nutrients is necessary for healthy plants.

4.2.1 Types of fertiliser used on malting barley

Respondents were asked what fertilisers they were using on their malting barley. Fourteen percent indicated that they did not know the kind of fertiliser they were using. Fifty-six percent indicated that Lime Ammonium Nitrate (LAN) is the most common fertiliser used, while 20% indicated that 3:2:1 is mainly used on barley. The 3:2:1 fertiliser mentioned was last used in 1999 and since 2000 7:2:1 and 4:2:1 were used during planting, while LAN was used as top-dressing. This lack of relevant knowledge regarding the type of fertiliser used, is an indication that many respondents do not follow a scientific approach to farming.

4.2.2 Top-dressing

Top-dressing should be applied six weeks after emergence. Application of top-dressing at a later stage would result in high nitrogen kernel barley that is not suitable for malting. Applying nitrogen on time will allow the plant to utilise nutrients effectively and economically. Respondents were asked when the top-dressing is applied. Twenty-six percent reported that the top-dressing is applied eight weeks after emergence, 8% reported that it is applied nine weeks after emergence, while only 23% reported that top-dressing is applied six weeks after emergence. The fertiliser used for top-dressing should also not lie on the soil for a long time before water/irrigation is applied.

4.2.3 Nitrogen requirement for barley.

Kotze (1995) mentions that malting barley requires between 120 and 140 kgN/ha for optimum yield. The 120 kg should be given in different stages, but six weeks seemed to give better results. The kernels during grading should have a nitrogen content of not more than 2% and less than 1.5% as the maltsters will not use barley with a nitrogen content outside their spectrum.

The farmers were asked about the nitrogen requirement of malting barley. Half of the respondents (50%) indicated that they do not know, while 8% indicated that malting barley requires 120 kg/N/hectare; they also mentioned that this depends on the soil structure and the previous crop.

Excessive and late application of nitrogen is very detrimental as it can bring about logging of the plants and excessive vegetative growth that can contribute to delayed ripening.

4.2.4 Side-effects of fertiliser

Of the 74 respondents, 81% reported that the fertiliser had no side-effects. Twelve percent reported that over-fertilization has a burning effect, while 6% reported that a side-effect of poor fertilisation is a high or low nitrogen content that will affect the grade. One of the farmers mentioned that in 1999, he had fertilised during the tenth week and his barley was under-grade and sold as animal feed. A ton of feed grade grain was sold at R450.00, while malting barley was sold at R1050/ton. Due to the untimely application of nitrogen, the farmer had lost a lot of money, sacrificing R600/t. With regard to the 40 tons produced by this farmer, the total loss due to the late application of top-dressing amounted to R24000 – a situation that very few farmers/families in Taung can afford.

4.3 Soil

The Taung soil where the crop can be grown is mostly Hutton. According to Eksteen, Van der Walt and Nissan (1981:3), the irrigation soils of Taung are generally classified as sandy loam soil, while available soil moisture is taken as 120 mm/m. The water table is, in most of the cases, not a limiting factor, indicating the vast number of possibilities that exist for crop production. The availability of moisture is up to 120 mm in pivots. In the Rethuseng, areas there are lands with a soil profile of up to 120 mm, while others are only 50 mm deep before mother rock is found. There is a tendency to irrigate up to 7 mm during the first irrigations. The pivots are running at 100% speed and are accordingly only able to deposit a relatively small quantity of water. This inadequate form of irrigation is practiced for almost eighth weeks after planting. The result is that the water dries up.

4.3.1 Soil types

There are different types of soil in the Taung irrigation scheme. According to Eksteen, Van der Walt and Nissan (1981) the soil consists mainly of Lavas and is classified as sandy loam. The respondents were asked to identify their soil types (Table 4.1).

Table 4.1: Distribution of respondents according to their knowledge of the soil types on their lands.

Category	**Number of respondents**	**%**
Sandy loam	10	13.5
Loam	8	10.8
Sandy clay	12	16.2
Sand	18	24.3
Clay	17	23.0
Hutton	4	5.4
Clay loam	2	2.7
Do not know	3	4.1
Total	**74**	**100**

Regarding their soil types (Table 4.1), 13.5% respondents indicated that their soil type is sandy loam, 16% reported that the soil type is sandy clay, and 23% reported that it is clay soil. Just over four percent of respondents indicated that they had no knowledge of their soil type. It is clear that the people involved in the irrigation scheme still have to learn about their soil types and its attributes. It can be expected that the soil types will differ between respondents.

4.3.2 Soil depth

A large part of the land in Taung is shallow, varying from 400 mm to 1200 mm in depth. During the application of neutron probes by a private company it was found that most of the Rethuseng soils were between 300 mm and 900 mm deep, but all in all the soil is between 300 mm and 1200 mm deep (Jansen contractor). The respondents were asked about the soil depth of their lands and a large component of the respondents (38.6%) indicated that their soil depth is 1000 mm. Twenty-five percent indicated that their soil is 500 mm deep.

4.3.3 Soil structure

Farmers were asked to identify the structure of their soil and 14% indicated that they do not know, 40% indicated that it is a coarse sandy soil, while 18% reported that it is fine clay soil. From the discussions with respondents, it became clear that much work remains to be done with regard to the study of the soil structure in the area.

Respondents were further asked how the soil structure affects the irrigation scheduling for the cultivation of malting barley . Twenty-five percent indicated that sandy soil needs little water and that a short irrigation cycle (intervals) is appropriate. Seven percent reported that clay soil has a better water holding capacity and that the irrigation cycle should be longer than with sandy soils. The largest group (56%) indicated that only agricultural technicians know the water holding capacity of their soil as well as the applicable irrigation cycle for the crops.

4.3.4 Determination of soil moisture

Soil moisture determination is very important for crop irrigation as it would help one to decide when and how much to irrigate. Respondents were asked to describe the method they used to determine the soil moisture (Table 4.2).

Table 4.2: Soil moisture determination by farmers in the irrigation schemes.

Category	**Number of respondents**	**%**
Nothing	2	2.7
Just looking	18	29.3
Using hands	14	18.9
Spade or soil auger	25	33.8
Stick or iron	7	9.5
Guided by the schedule	1	1.4
Extensions	3	4.1
Just irrigate	4	5.4
Total	**74**	**100**

More than 33% of the respondents indicated that they were using a spade or soil auger, while 29% indicated that they just look at the soil and start the pivot. These practices explain why there is such high electricity use and excessive pivot maintenance costs. Of the respondents, 18% indicated that they were using their hands to determine the amount of moisture in the soil. Four percent reported that they just start the pivot without knowing the moisture level of the soil and how much of the water should be supplemented. The respondents did not even irrigate according to evaporation as 51% indicated that they did not know what evaporation is. The result is over-irrigation and/or under-irrigation. However, in some instances the neutron probes were not accurate in that they indicated that 20 mm of water was lost from the soil, while in actual fact 35 mm had been removed. In the Rethuseng area where overhead sprinklers are used, some of the fields show a moisture level of 60 mm.

4.3.5 Evaporation.

High water evaporation is expected in September and October when the plants are big; during September, evaporation can be up to 35 mm a week. When evaporation is high, more water is removed from the soil. In order to replace the removed water one should have correct and relevant water management information at hand. Respondents were asked to state what they think evaporation is. Of the respondents, 51% reported that they do not know what it is, 21% reported that evaporation is the loss of water as a result of the sun's heat, while 16% reported that evaporation is the movement of water from the soil to the air. Because evaporation can affect the irrigation cycle during hot months, one has to adjust the cycle to take account of the water removed from the soil. It is always better to irrigate during the night, as evaporation is low. It is not always practicable to irrigate only during the night as the irrigation cycle will not be completed and irrigation during the day will be necessary.

4.3.6 Slope

Respondents were asked how a slope can affect their irrigation practices. They responded as follows: 37% indicated that they do not know whether a sloping area will affect their irrigation scheduling and use of water. They also reported that they do not know of any relationship between irrigation water and the slope of the land. Thirty-three percent mentioned that water runs fast from a high area to a lower area and said that pivots should be adjusted to avoid run-off. The respondents were concerned that the higher situated plants will dry up very fast and be vulnerable to drought, while the plants in the lower areas will lodge and lose nutrients. The other 5% respondents were concerned about the soil erosion caused by water running from higher areas to the lower areas, and the unevenness of the land. This results in the removal of fertile soil from areas where it can be productively used. Weak plants are found in areas where there is little water as well as in over-irrigated areas. It is very important that farmers should be involved in any planning/development/designing in an area so that they know why an adjustment is made.

4.3.7 Root depth

Barley crop has a shallow adventitious secondary root system. It has rougher roots than wheat, but finer than oats. The root system is mostly branched and similar in soil area to wheat; thus, it is also a heavy feeder. Barley needs water throughout the growing season as the roots are near the soil surface and are easily damaged by heat waves. The lateral distribution of barley roots is 15 to 30 cm from the stem, and it may penetrate the ground to a depth of 1.6 m. When barley germinates, it develops five to seven primary side roots from coleorhizae. (The growth stages of the barley plant are provided in Appendix B.) After four weeks, development of adventitious secondary roots takes place from the first node of the plant. At the beginning, more of the roots appear to be on a horizontal level in the soil. The root becomes thicker with small branches. In cases where the secondary roots develop in top dry soil, the plant reaches maturity through the help of the primary root system. The primary roots can stop functioning and may disappear during the season. In deep soil, the root system can penetrate the soil to a depth of 1.8 m to 2.1 m. The primary roots penetrate the deepest, while the secondary roots are located in the top soil.

With the aid of the questionnaire, the respondents were again requested to provide their opinion on the depth of the roots of the barley plant. Their responses are illustrated in Figure 4.6.

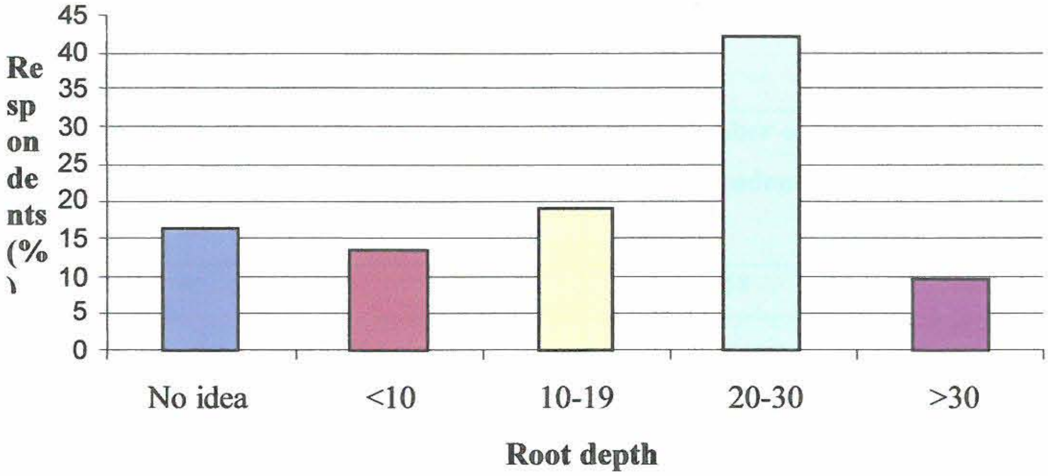

Figure 4.6: Respondents' perspectives on the root depth (cm) of the barley plant.

The confusing aspect here is that most respondents, even though they have been planting and irrigating barley for more than four years, do not know the root depth of the barley crop at all, or regard it as less than 30 cm. It can therefore be assumed that the crop is probably not irrigated according to crop water requirements. The farmers do not want to take the trouble to establish the correct root depth as there was no workshop or training to date that focused on this problem in the Taung Irrigation Scheme.

4.4 Water management

Irrigation water is flowing from the Warrenton weir through canals controlled by water bailiffs in the Taung irrigation scheme. There are three big dams in the irrigation scheme that feed smaller dams as well as the Mokassa pipelines. The feeder canals run through the scheme to smaller dams. These canals are cleaned by the Department of Water Affairs and the Department of Agriculture. The capacities of the Pudimoe dams are smaller and cannot carry enough water for the 640 hectares of land.

4.4.1 Irrigation needs per hectare

The respondents were asked how much water they use in a cropping season (Table 4.3).

Table 4.3: Shows the distribution of respondents according to their knowledge of irrigation water per hectare.

Total water usage per irrigation application	Total water usage per cropping season (mm per season)	Number of respondents	%
Do not know	-	58	79.5
15	150	1	1.4
25	250	2	2.7
27	270	1	1.4
35	350	1	1.4
42	420	1	1.4
46	460	2	2.7
50	500	1	1.4
72	720	1	1.4
420	420	1	1.4
460	460	1	1.4
579	579	1	1.4
750	5620	1	1.4
0	450	1	1.4

Seventy-nine percent of the respondents reported that they do not know how much irrigation water per hectare they use for barley production in the course of the season. This is an indication that many respondents in the Taung irrigation scheme are unaware of the importance of a scientific approach to plant irrigation and are therefore just irrigating as much as possible. This is a possible reason why many farmers do not understand why they should pay for water. Because they are charged per hectare per season, they misuse the water as they are not charged for what they have actually used. Sometimes there is no irrigation water available because the planning was very poor. The reason for this may be as simple as the fact that water was not ordered - they expected someone else to have applied on their behalf.

Respondents were asked to give an indication of the months during which they thought the barley crop needed more irrigation water (Table 4.4).

Table 4.4: The months during which the barley crop needs more water, according to respondents.

Category	**Number of respondents**	**%**
September-October	32	43.2
August-September-October	11	14.9
September-October-November	9	12.2
August-September	5	6.8
August-September-October-November	3	4.1
August-October	3	4.1
October-November	2	2.7
May -June	1	1.4
May-July-October	1	1.4
June-July-August	1	1.4
June-July-August-September-October	1	1.4
July-August	1	1.4
July-August-September	1	1.4
November	1	1.4
No idea	1	1.4
Summer months when it is hot	1	1.4
Total	**74**	**100**

Forty-three percent of the respondents reported that the barley crop needs more water during September and October, which are the hottest months in the barley growing season. Only one respondent indicated no knowledge of the months during which the barley crop needs more irrigation water. It is evident that farmers have a general idea of the time of year that additional irrigation must be provided, although they do not record the month and events specifically. The water planning should be done in such a way that during the warm months of September and October, when excessive heat frequently occurs, water should be sufficiently available. The three dams in the irrigation scheme should therefore be full at the start of these months.

4.4.2 Diversity of water problems

The respondents were asked to mention the irrigation water related problems that they experience in the Taung irrigation scheme. Many respondents (37%) indicated that their biggest problem is that water arrives very late at the pump-house dams. There is also no water during holidays and weekends, while there is no one who controls the water during the nights. Some respondents also indicated that the capacity of some dams are too small to supply the pivots in the area, and that the sluices are sometimes not functioning (and affecting everybody downstream). During dry weeks, users are not informed that on a specific date there will not be water available for irrigation. This omission also do not take the crop stage (when water is a critical requirement) into consideration. The valves may present problems with regard to air lodging, and when canals need to be cleaned, farmers are not made aware of that activity. If farmers were made aware of the unavailability of the water at a specific time, they will take steps to overcome the problem.

4.4.3 Electricity supply

Farmers in certain FSUs (e.g. Mokassa) do not have problems with the supply of electricity. The biggest electricity related problem in the irrigation scheme is that using the reporting channel/route takes too long and problems are not addressed immediately. High winds and heavy rains affect the electricity supply and power failures occur up to three times a week. Electricity bills are based on estimates, while actual readings are only taken at the end of the season. If the farmer has underestimated his demand, a big amount/balance on the account will have to be paid at the end of the period/year.

4.4.4 Knowledge about the cessation of irrigation

Barley farmers do not know exactly when they have to cease irrigating their barley crop for harvest time preparation. There are cases where screenings are too high because irrigation was stopped before the correct time, resulting in the appearance of green kernels during harvest time. As these kernels are not ripe yet, its nutrient status and moisture content could result in the allocation of a lower grade. Respondents were asked to provide their perspectives regarding the appropriate time to cease irrigation before harvesting takes place (Table 4.5).

Table 4.5: Respondents' perspectives on the time to stop irrigation before harvest.

Category	**Number of respondent's**	**%**
1 day before harvest	7	9.5
2 days before harvest	3	4.1
4 days before harvest	1	1.4
1 week before harvest	22	29.7
2 weeks before harvest	6	8.5
October	3	4.1
November	24	32.4
December	3	4.1
When kernels are matured	4	5.4
No idea	1	1.4
TOTAL	**74**	**100**

Thirty-two percent of the respondents indicated that they irrigate their barley until November, while twenty-nine percent reported that they irrigate their barley crop until one week before harvest time. The remaining respondents (38%) provided a variety of answers to the question of when to stop irrigating before harvest time. The respondents knew that they had to stop watering before harvest time, but were not sure of the exact time. The irrigation cessation date depends on the soil type and the readiness of the kernels. With regard to heavy soils, cessation takes place 3-5 days before harvesting to avoid pivots to get stuck. Early cessation of irrigation may result in the problem of high screenings.

4.4.5 Water conservation

Respondents were asked to provide their perspectives on ways to conserve water: 15% recommended irrigation during the night and stressed measures to avoid using leaking pipes. Eight percent indicated that one should irrigate during the afternoon while the temperature is low. It seems that farmers understand that during hot sunny days more water is used due to high temperatures and wind. A lot of evaporation takes place during hot sunny days. The respondents also mention that leaking pipes have an impact on water wastage. An important factor, which has a big influence on future water conservation, is to irrigate during the night when evaporation is low. An important point is that farmers should remember that over-irrigation does not result in a higher yield.

4.4.6 Water supply to the pivots/pipes

Farmers need electricity - a very expensive input - to irrigate their barley crop. Sometimes producers are using too much electricity because of over-irrigation. Water is pumped to the pivots with electrical pumps and the result is that farmers have to pay up to R560 per hectare for electricity. The Mokassa farmers have an advantage because they do not use electricity but gravitational force to transport their water to the pivots. The motor pumps frequently give problems and need reconditioning. It is very expensive to replace a motor and a pump (up to R40 000) and the farmers cannot afford to replace the motors every season, as there will then not be any net income (profit) from the crop. Water distribution is affected downstream as waste plastics from dam one block the Mokassa pipes. This causes a low water supply as well as blocked nozzles. The sieves at the pump-houses may also be blocked and need to be checked frequently. When the pipes are blocked in this manner, ±1500 hectares of irrigated land are affected.

4.5 Pivot management

In order to manage a pivot properly, many steps need to be taken, e.g. checking of nozzles, unblocking of nozzles, and investigating the reasons why the nozzles got blocked.

4.5.1 Knowledge of nozzle types

Respondents were asked whether they know the sizes of their nozzles. The majority (66%) indicated that they do not know the sizes of their nozzles. The rest (34%) claimed to know the sizes of their pivot's nozzles. Some respondents (32%) indicated that the nozzles on the pivot that gave them the most problems were the ones at tower number six or towards the outer end of the pivot. Twenty-five percent indicated that the smallest nozzles were the ones giving the most problems. Fine sand or other objects (as mentioned in paragraph 4.5.3) are sometimes deposited at the end of the pivot and these block the nozzles. If the drainage pipe is not cleaned every time, more of the material will be deposited and the pipe will start to rust. The overhang pipes are always giving problems with regard to nozzle blockage and this causes damage to the pipes.

4.5.2 Frequency of checking nozzles

Respondents were asked about the frequency with which they check the pivot's nozzles and the results are provided in Table 4.6.

Table 4.6: Distribution of respondents according to checking of nozzles

Category	**Number of respondents**	**%**
Once a week	26	35.0
Every day	23	31.1
Before starting	11	14.9
Monthly	7	9.5
Once in 2 weeks	4	5.4
Twice a day	1	1.4
Three times a day	1	1.4
After an hour	1	1.4
Total	**74**	**100**

About 50% of the respondents check the nozzles at least once a day (including the 15% that check it beforehand and those that check it more than once a day), while 35% indicated that they check their nozzles once a week. The rest of the respondents (15%) do the checking less frequently.

4.5.3 Nozzle Blockage

Respondents were asked to provide their opinions on the reasons for nozzle blockages. The majority of respondents believe that the following material causes most of the blockages:

- mud,
- algae,
- dirt,
- small fishes,
- sand particles, and
- grass materials.

Two respondents indicated that they do not have any idea of what causes nozzle blockages.

4.5.4 Effects of nozzle blockages

The farmers are concerned about the effect of nozzle blockages on the barley crop. The respondents identified poor germination of the seed, uneven growing of the plant, poor quality during harvesting, poor water distribution on the field, low yield and a low-grade malting product as the main effects. All of the above-mentioned factors result in a small income for the farmer (sometimes the farmer do not even recover the input costs).

4.5.5 Avoiding nozzle blockages

Nozzle replacement takes place every day because of blockages and broken drop pipes. Respondents were asked what they could do to avoid nozzle blockages, and they responded as follows: 62% indicated that blockages could be avoided by cleaning the dams and canals, flushing the drainage pipes, and repairing rusted pipes. Eight percent reported that if sieves are kept clean and old sieves are replaced, fewer blockages should occur. The cost of repairing the damage caused by the blockage of nozzles and drop pipes can amount to R54 000 in one cropping season for the Taung irrigation area.

4.5.6 Pivot speed /pipe running hours

The respondents were asked about the relationship between the speed of the pivot and water deposition. The respondents have different perspectives on this issue as listed in Table 4.7.

Table 4.7: The distribution of respondents according to their knowledge of the relationship between the speed of the pivot and water deposition.

Category	Number of respondents	%
Running at low speed deposits more water	10	13.5
Running at fast speed deposits more water	23	31.1
Running at high speed deposits less water	7	9.5
Running at low speed deposits less water	27	36.5
No relationship	2	2.7
No idea	5	6.7
Total	**74**	**100**

Table 4.7 shows that confusion reigns among respondents because many of them do not know when the pivot is running at a fast speed or slow speed. Of the 74 respondents, 36.5% reported that when the pivot runs at a slow speed it deposits little water, while 31.1% were of the opinion that at a fast speed it deposits more water. Another seven respondents either had no idea or could not see the relationship between speed and irrigation precipitation. Thus, 44 respondents (74%) would be unable to correctly manage the speed of the pivots in order to manipulate precipitation.

Pivot speed varies according to motor capacity. Some of the pivots run at 2.7m/minute and others at 1.7m/minute. The precipitation rate produced by a slow running pivot is higher as the pivot stays relatively longer in one place. A pivot with an end wheel speed of 2.5 m/minute deposits 5.8 mm of water when run at 100%; when it is run at 5%, it deposits 115 mm. A pivot with an end wheel speed of 1.9 m/minute when run at 100% deposits 6 mm of water, but when run at 5% it deposits 152 mm of water. Most of the pivots in the irrigation scheme are running at 1.9 m/minute. The nozzle package also plays an important role in the speed of the pivot. Barley needs different amounts of water during different growing stages. During the hot sunny days of September and October the pivot should be run at 45% to replace the water that is lost because of evaporation. The respondents at Mokassa usually run their pipes for a period of 1 to 6 hours at a time, while they run it for 5 hours during hot sunny days. Sometimes the pipes are left for up to 12 hours, which causes over-irrigation.

4.5.7 Reporting of breakages

The frequency with which respondents experienced and reported breakages during the past six months are reflected in Table 4.8.

Table 4.8: Distribution of respondents according to reporting of breakages on the pivots during a growing season (± 6 month period).

Frequency	**Number of respondents**	**%**
No report	10	13.5
Once	3	4.1
Twice	13	17.6
Thrice	1	1.4
Four times	10	13.5
Five times	5	6.8
Six times	6	8.1
Seven times	4	5.4
Eight times	3	4.1
Nine times	4	5.4
Ten times	2	2.7
Eleven times	1	1.4
Twelve times	4	5.4
Thirteen times	1	1.4
Fourteen times	4	5.4
Twenty times	3	4.1
Total	*74*	*100*

Seventeen percent indicated that they had reported the breakages two times in the past growing season. Eight percent said that they had reported pivot breakages six times, meaning that they had reported one breakage per month. Thirteen percent reported breakages four times a month. One can deduce that the pivots are showing signs of wear and tear, and that maintenance is becoming a problem.

4.5.8 Condition of pivots and pipes

Respondents indicated that the pivots and the Mokassa pipes are in a bad condition. The main problem is the high age of the pipes. Nineteen percent of the farmers reported that their pivots are in a good condition, while twenty-eight percent said that they are in a bad condition. There is a need for the reconditioning of the pivots in the irrigation scheme. The service rate and maintenance cost of the old pivots are too high. It must also taken into account that pivot maintenance is not guaranteed.

4.5.9 Parts that give most problems

Respondents were asked which parts were giving most problems on the pivots. The most problematic parts are:

- the gearbox,
- universal joints,
- couplings,
- driving shaft,
- motor,
- overhang pipes,
- main pipes,
- nozzles,
- punctures,
- rubber boot, and
- leaking of pipes.

The breakages are mainly caused by poor maintenance and the age of the pivots. Contractors will often be called back to work on the same problem again. Sometimes they will bring spare parts with them before they even had a chance to look at the problem. This shows that they know that the previous repair job was not done properly. The farmers are not always present when repairs are carried out.

4.5.10 Availability of pivot spare parts

The pivot parts are not easily obtainable. Big parts like motors and gearboxes are not easy to come by; farmers have to register with the relevant supplier to get such spare parts.

4.5.11 Training

Respondents were asked whether they needed training on pivot maintenance (Figure 4.7).

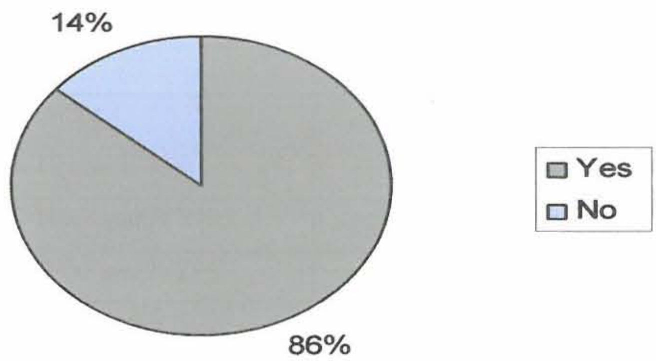

Figure 4.7: Distribution of farmers according to need for training in pivot maintenance.

Eighty-six percent indicated that they needed training on pivot maintenance, while a relative small portion reported that they had no need for such training. The important aspects that they needed training on were:

- electricity,
- repairing of gearbox,
- welding of pipes,
- working on pipes to solve air lodging problems,
- fixing of punctures,
- fixing of driving shaft, and
- reconditioning of motors and gearboxes.

4.5.12 Money spent on pivot maintenance

Respondents were asked how much they spent on pivot maintenance during the barley season (Table 4.9):

Table 4.9: Distribution of farmers according to money spent on pivot maintenance during the barley season.

Category	**Number of respondents**	**%**
Do not remember	9	12.2
Between R 10 and R 999	8	10.8
Between R 1000 and R 1999	8	10.8
Between R 2000 and R 2999	10	13.5
Between R 3000 and R 3999	9	12.2
Between R 4000 and R 4999	1	1.4
Between R 5000 and R 5999	14	19
Between R 6000 and R 6999	1	1.4
Between R 7000 and R 7999	6	8.1
Between R 8000 and R 8999	5	6.8
Between R10 000 and R10 999	1	1.4
More than R11 000	2	2.7
TOTAL	**74**	**100**

Twelve percent indicated that they do not remember the amount they spent on pivot maintenance. Nineteen percent reported that they had spent between R 5000 and R 5999, thirteen percent reported that they had spent between R 1000 and R 1999 during the barley season, while ten percent reported that they had spent an amount of between R 10 and R 999, mainly for new/replacement sprinklers. If farmers would be provided with the necessary spare parts and do the repair work themselves, it would be much cheaper because they would save on the transport and labour fee.

In response to a question, it was reported by respondents that the maintenance work was done by private contractors in most cases. Only five percent reported that they were doing their own maintenance work.

4.5.13 Irrigation system improvement

Respondents were asked to make recommendations on what, in their opinion, would improve the irrigation system they were using to produce crops. The major recommendations by respondents were:

- The introduction of a sprinkler system.
- Allocation of more land to young farmers to improve the profitability of the scheme.
- Training of farmers on the management of the available resources.
- Adjustment of land tenure to enhance farmers' sense of ownership, commitment and responsibility.
- Increasing the capacity of canals and dams.
- Introduction of a good drainage system in all areas to reduce water logging.
- Installation of new main pipes that will not be affected by the cold winter.
- A new contractor to come in as the current contractor is charging high prices and there is no competition.
- The land should be levelled to curb run-off and soil erosion.
- The pressure of the pivots to be increased, meaning that the electricity supply should be increased as the electricity is being affected by wind and light rains.
- One farmer to manage 40 hectares' pivots to bring out the best in him/her.

4.5.14 Suitability of the irrigation system

Respondents were asked whether the irrigation system is suitable for their circumstances. Eighty-three percent indicated that the system suited them, while twenty-four percent reported that the system did not suit them. The main reason for the latter perception is that there is a feeling that the government should revive the system by introducing new management structures, that pivots are old and need to be upgraded and that the water capacity/provision should be increased. Another aspect is that the pivot system is too expensive to run.

4.5.15 The most common problems with regard to the scheme

The following answers were obtained from a question regarding the most common problems of the scheme:

- Loss of water pressure in the pivot;

- Lack of cohesion amongst farmers;
- Poor management;
- Bending of the pivots and instability of the driving shafts;
- Damaging of hydrants by the contractors;
- Pipes are stolen (Mokassa under sprinklers);
- Water that arrives late and no water during weekends;
- Burning of motors and pumps;
- Bursting of underground pipes;
- Lack of urgency shown by the contractor to perform maintenance/repair of pivots (especially in critical plant stages);
- Actions like ploughing, chemical spraying, harvesting and transporting are sometimes difficult. The crops sometimes remain on the land until January the following year and then loses its quality.

4.5.16 Sources of irrigation water

The respondents were asked to identify the source of their irrigation water. This question was accorded different interpretations by the respondents. The source was variously regarded as: the feeder dam, the canal, the Vaalharts River, or even the Warrenton weir. More communication is necessary to educate farmers on the principles of resource management and the basics of inputs and outputs required for effective and economic production.

4.6 Drainage

The drainage system of Taung is poor with the result that the removal of excess water is inadequate, thus contributing to the poor soil aeration. Poor soil aeration affects the root zone of the crop. This means that the nutrients within the soil are not available to the crop. The water table is also not controlled, as it is never checked. Nutrients (nitrogen) in the soil at the end of the growing season due to poor drainage, reduces the potential of plants. Water logging and other problems in the root zone may pose a threat to the crop. A better drainage system is required to control the problems caused by water logging and root zone salinity. Drainage water may contain substances like herbicides, fertilisers, pesticides, salts and trace elements.

The respondents were asked about the drainage system in the planting areas. Sixty-four percent indicated that there is no drainage system in the farming area, ten percent did not have any idea of what a drainage system is, and eighteen percent reported that there are underground pipes to the canal. A drainage system exists at Mokassa, but is sometimes blocked, thus serving no purpose. Half of the land in the Mokassa area can no longer be used because of water logging. Tshidiso also has a problem with water logging. In 2001, there were 60 hectares of barley that could not be harvested because of water logging. The Taung Irrigation Scheme needs sufficient drainage to reduce the salinity levels in the ground. In two or three years time, cultivation of some fields will have to cease because of this problem.

4.7 Cleaning of canals

The distribution of water also plays an important role in the irrigation scheme. If the canals that are carrying water from the big dams to the small dams are not clean, spillages occurs. The respondents do not understand that the farmers and the Department of Water Affairs and Department of Agriculture must share responsibilities. The respondents also do not know when the cleaning of the canals and dams takes place. The respondents were questioned regarding the responsibility of cleaning the canals (Figure 4.8).

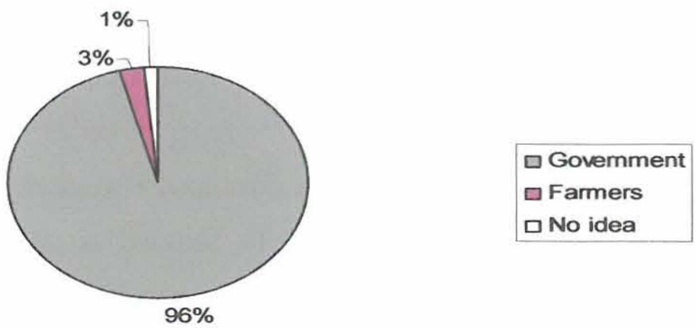

Figure 4.8: Respondents' opinions on whose responsibility it is to clean the canals.

The respondents were also asked about the intervals between cleanings. Although some farmers reported that the canals are never cleaned or that they are not aware of such cleanings, the majority (54%) reported that the canals are cleaned once in a year, while 17% were of the opinion that it is done once in a season. Farmers should be present during the cleaning of canals to ensure that the job is done properly .

4.8 Cleaning of dams

The cleaning of the two pump-dams is the responsibility of the farmers, while the cleaning of the big buffer dams are the responsibility of the water user association. Farmers have not yet fully accepted this responsibility. Dams are getting dirty and this affects the efficiency of the nozzles - and yet farmers do not clean the dams. Nozzles have to be replaced every week due to the dirty dams, which drives up costs.

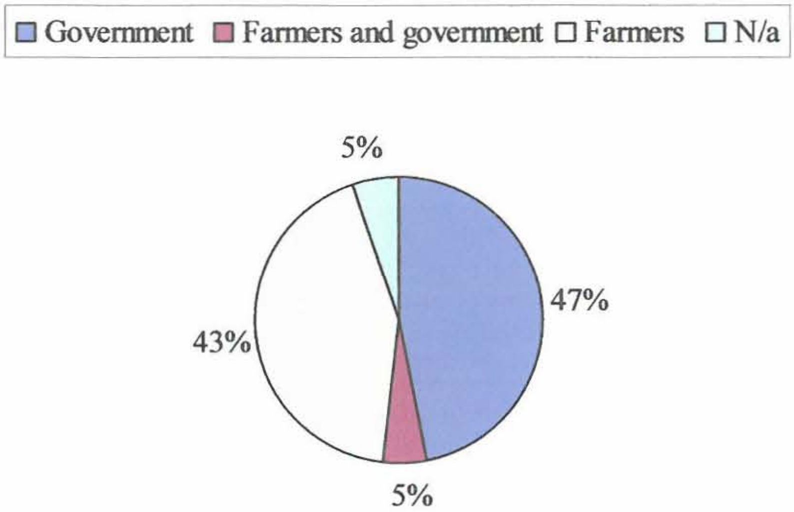

Figure 4.9: Farmers' response to who is responsible for the cleaning of dams.

As can be seen from Figure 4.9, there is confusion amongst respondents regarding this responsibility. This confusion is because of the shared responsibility between government and the farmers as mentioned. The farmers must clean the pump-dams and the government must provide the tools/machinery to do so when available.

Respondents were asked to mention the frequency with which the dams are cleaned. The responses gathered here were influenced by the fact that nobody wanted to accept responsibility for this task. Fifty-three percent reported that the dams were cleaned once a year, seventeen percent reported that the dams were cleaned seasonally, while six percent reported that they were cleaned every two years. Farmers were unable to share responsibility for cleaning the storage and supply dams among themselves. If farmers have such high levels of uncertainty regarding the frequency with which the dams must be cleaned, they would be unable to control/monitor any government cleaning operations. It would be almost impossible to organise the farmers with a view to clean their own dams.

CHAPTER 5

RECOMMENDATIONS

5.1 Land use

- There is no written contract between farmers and the tribal authority/government (represented by the Department of Agriculture) that shows who owns the land and who should be responsible for the land and the maintenance thereof. The responsibility for the maintenance of the infrastructure, pivots, canals, dams, and roads are a murky issue, and hence the farmers are not committed to the preservation of their resources. Land tenure should be changed so that farmers know and understand what their responsibilities and the government's responsibilities in the Taung irrigation scheme are.
- A rental fee should be set for the farmers to pay for the soil they are farming on, and it should be coupled to the inflation rate (annual increases).
- The farmers should be fully responsible for the maintenance of the scheme, including roads, pump-houses, fences, and the cleaning of canals and dams.
- A contract between the farmers and the tribal authority/Department of Agriculture should be in place. In the contract, it should be stipulated categorically that the tribal authority has the right to repossess the land if the farmers are not farming according to the rules of the irrigation scheme. By introducing rules and regulations, it should help all the parties concerned to understand and accept their responsibilities, which should be stipulated in the contract and provided to each farmer/land user.

5.2 Infrastructure

The infrastructure is in poor condition and needs to be attended to before responsibility for it is delegated to the farmers. The pivots in particular are old and have high maintenance costs.

- *Pivots:* The pivots are in poor condition and need to be serviced. The farmers should then take care of them. The government takes responsibility for certain parts and that causes confusion among all the parties. The maintenance costs of some pivots may sometimes reach a very high R 54 000 per season.
- *Canals:* The capacity of the canals should be increased, especially the Pudimoe canal. The unity house that is closed at Bosele should be open for emergencies, e.g. when the valves are broken, or when the Mokassa pipeline is broken (affecting 960 hectares of land). Some of the slaps are broken and should also be repaired before the handover to farmers takes place. All the valves between dams and canals should be repaired or replaced (especially at Dam One, Tshidiso, Bosele, and Pudimoe Middle Dam).
- *Energy supply:* The electricity supply (kVAs) at the pump-houses is insufficient and cannot be used by all the pivots in that area. The problem at Tshidiso North was that the four pivots couldn't run at the same time because the transformer was not big/powerful enough. The circuit breaker was also too small (pivot maintenance officials). After the voltage at Jim Molale South pump was increased, all four pivots could run simultaneously without any stoppages. The unavailability of a continuous supply of electricity affects the yield and quality of the barley crop negatively.
- *Transportation:* Due to poor roads, much barley is lost from vehicles and do not reach the cooperative. In 2002, three 10-ton trailers broke down at Bosele River, five 8-ton trailers broke down in the Tshidiso area, while two 20-ton trucks broke down at Mokassa and Pudimoe. Little or no road maintenance is performed. A private contractor should maintain the roads on behalf of the farmers. Most of the roads are porous and gravel should be used to make it more roadworthy. Contractors with big trucks are not willing to transport barley because their vehicles are damaged. The farmers feel that the contractors should pay for the wasted barley.

5.3 Training of farmers

- Skills and practical training is undoubtedly the key factor in ensuring the development of a strong viable farming community. As the tempo of change with regard to agricultural technology increases, more training for the farmers in irrigation practices will be necessary. Most of the farmers in the Taung irrigation scheme do not have any access to scientific information. The barley producers in the Taung Irrigation Scheme need training and motivation to effectively look after their infrastructure.
- Training in the management of pivots is essential. A course in minor pivot maintenance, draining of oil, fixing of punctures, welding of drop pipes, greasing of nipples, resetting of overloaded pivots, and fixing of drive-shafts should be considered.
- Irrigation management practices and water use/conservation should also be on the training list of the farmers as a priority. Producers should also undergo refresher courses on water management and scheduling.

5.4 Record-keeping

- A simple record-keeping course should be arranged for the farmers so that they can properly record the relevant events and practices, as well as the payments, accounts payable and production statistics.

5.5 Irrigation and pivot management

- All canals should be cleaned for better water flow, especially the one to Pudimoe, and the broken slaps should be repaired.
- Unless irrigation management is improved and irrigation projects designed in conjunction with existing knowledge of the Taung soils and crop water requirements, irrigation will be of no avail.

- Seasonal water allocation to producers must be based on the requirements of the crop. At the beginning of the season, producers should convey information about the water requirements and the crop to be planted to the relevant body. The producers/farmers who need more water should motivate their request and reach an agreement on the matter with the relevant body.
- There should be an irrigation programme that will have a significant economical and social impact on the Taung irrigation scheme.
- During the presentation of agricultural courses, the focus should be on identified problems and not on what the presenters think is important or what the compilers of the course think the farmers lack.
- Producers should be monitored to ensure that they are applying the knowledge they had acquired during workshops or courses. Support for FSUs is also essential.
- Scheduling should be based on the soil moisture retention, meaning that a tension meter / A-pan / neutron probe is needed, as well as the crop feature and physiological growth stage.
- The producer should accept the new farming practice of irrigation scheduling/management, and master it so that it can be performed well. In order to keep the wasted water to a minimum, the basic water rate payable must be market related. The government should install a water meter at every pivot to provide every producer with information about his/her individual water usage for the year or season.
- Researchers and/or agricultural technicians must think through situations and attempt to foresee the needs of producers. Often it is necessary, and desirable, for agriculturists to do a little stage setting and manipulate the environment to enable needs and purposes to emerge.
- Agricultural technicians and other specialists must make it their role to organise and guide learning experiences so that the desired innovation, education and/or training can be achieved while farmers are realising their own objectives. Failure to take cognisance of the farmers' needs and requirements may result in ineffective training, and can contribute to a negative attitude towards new ideas and reduce participation by farmers who should use the new technology.

- Besides optimising the available local resources and supporting farmers institutionally, the mobilising and grass roots participation of farmers is fundamental to the achievement of success in the agricultural industry.
- The agriculturists must consider the following issues: Are the objectives achievable? What is the level of concern? What is the maturity of the farmers involved? What resources are available?
- The plants must be irrigated according to their requirements, and the fact that there was a previous crop on the soil should not be ignored.
- Most of the time, plants are given little water and the water table is not filled up. During dry periods, plants suffer a great deal. It is therefore advisable to fill up the water table during the first month and avoid the gap so that the crop has reserve water during a dry period or machine breakages.
- The pivots should be run at a slow speed so that it can deposit more water. Water must not be used as a reserve, but to support the plant.
- The producers should use the rain gauges to control the amount of water in the soil and check the moisture in the soil.
- All the dams should be cleaned on a seasonable basis (six month period). The Pudumoe canal capacity should be revised to check on the cruds of slaps and irrigation soil.
- Fish species that feed on water grass should be introduced into dams.
- Surplus water for the Taung irrigation scheme should be sold to neighbouring farms to help cover the cost of the planted area (i.e. to subsidise production).
- All the internal roads need to be serviced by a professional/reputable company.
- There is a need to modify technology in order to make certain that new farming practices meet the requirements of the Taung farmers.
- Irrigation management planning should be directed at solving the problems of the Taung irrigation scheme. All stakeholders should be involved in the planning stage, e.g. the farmers, the tribal authority, the political leadership, etc. These role-players should be familiar with the farmer's value structure. The latter is based on the farmer's understanding of his duties and his knowledge of the available resources. All of this must be taken into account when new ideas are adopted or when the farming system is changed. In most instances development planners are largely ignorant of the most important factor in the

faming equation, namely the human factor – the reason why most development projects fail.

5.6 Summary

- Minimise the responsibility of financiers and the government in terms of irrigation management.
- Make producers responsible for their own decisions regarding irrigation and farming practices.
- Establish practical and advantageous land ownership structures for farmers.
- Improve the management of the irrigation scheme.
- Optimise the effectiveness of the operation and maintenance of the irrigation scheme.

Central University of Technology, Free State

CHAPTER 6

CONCLUSION

South Africa has limited resources and high potential agricultural land in relation to the demand for these resources. Agricultural development depends on the development of water and land, as they are scarce resources. Lack of knowledge about the utilisation of these scares resources may lead to destruction of the resources.

Lack of knowledge, skills and understanding of farming practices is one of the biggest constrains to improving crop production. Crop producers need to be provided with information so that they can evaluate different scenarios in the farming sector, and make their own well-informed decisions. There is a great need for training the Taung farmers in irrigation management practices.

The implication of the findings of this report for irrigation management is that the training of producers should be high on the priority list. The producers, many of whom cannot read or write, are sometimes resistant to change, and/or very sensitive to the whole issue of change. Their criteria for accepting new ideas vary widely according to their demographical profile and needs.

The government should encourage crop producers to be involved in all planning activities to ensure that optimum utilisation of water and land takes place. It is doubtful whether the Department of Water Affairs has the capacity to provide a full range of services to the Taung irrigation scheme. Therefore, the Department has to review its approach regarding the checking and monitoring of pump-dams and canals.

A look at the future of the farming industry highlights many challenges. Population growth will mean an increase in the demand for food, while there is no concurrent increase in the available land and water. Irrigation water is the scarcest resource among the non-renewable ones. It presents a challenge to water users to start/continue their commitment to the proper use of the irrigation water.

The most common problems mentioned by the farmers were nozzle blockages, shortage of water during weekends and holidays, problems with electricity, poor pivot maintenance, unavailability of pivots part, farmers who do not understand the irrigation scheme, dirty dams and canals, pivot breakages (especially gearboxes and driving shafts), punctures and the breaking of drop pipes. The situation is worse during the hot summer months when the barley is in a critical period whilst establishing its yield. The irrigation water should, therefore, be controlled so that there is enough water and the minimum number of pivot breakages (and speedy repairs if necessary) during the critical time.

The study presents evidence that all barley farmers are not committed to proper farming practices as they are sometimes not aware of blocked nozzles and may take up to one month to visit their land. They do not know their soils, the fertilisers used for barley production, the root depth of the barley crop and even their water sources. It is essential that farmers should be motivated to use the correct irrigation information channels so that they are informed about the scheduling.

Some farmers have reported that they do not know the irrigation schedule, while others have indicated that they couldn't read the schedule. This supports the hypothesis that farmers are not using irrigation scheduling - an omission which affects the quality and quantity of the crop. Farmers reported that at 100% speed the pivots deposits between 5.87 mm and 7.60 mm of water and the root depth is 30 cm. The frequency of nozzle blockages and the wastage of water provides proof that farmers do not manage their available irrigation water properly. The efficiency of the canals is also reduced through the presence of stones and tree branches in the canals.

The poor condition of pivots, the high cost of pivot maintenance, and the large number of nozzle blockages mean that the quality and quantity of barley should be very low. It is necessary to motivate farmers to monitor the pivots and water allocated to their dam. Farmers do not understand the water requirements of barley, and many have no idea of soil and root depth. It is desirable that farmers should be trained in pivot maintenance and the appropriate water management practices with regard to barley and other crops. Centre pivots have a high purchasing cost, a medium operating cost, high irrigation efficiency, and low labour requirements. It also requires relatively little management, although it needs to be checked regularly for blocked nozzles. The sprinkler system has lower purchasing and operating costs, but demands a lot in terms of management and labour.

Irrigation management practices and farming systems should be regularly reviewed and updated, and therefore necessitates persistent and continuous monitoring and modification. Improvements in this regard may well lead to a significant rise in production and profits.

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EVALUATION OF IRRIGATION MANAGEMENT PRACTICES OF BARLEY FARMERS IN THE TAUNG IRRIGATION SCHEME

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ABSTRACT

Although there is soil available for crop production in South Africa, the production of barley is limited to certain areas of the country due to restrictions on water, more specifically, irrigation water. It is therefore essential to concentrate on the promotion of barley production in the Taung irrigation scheme because the necessary and required scarce resources are available. The available resources should be used effectively to benefit the Taung farming communities. The 3500 hectares cultivated by the farming community should be utilised properly to alleviate the poverty in the area. This study investigated the irrigation practices of barley farmers in the Taung irrigation scheme. The aim of the study is to help farmers in the irrigation scheme to irrigate according to crop water requirements, soil depth/ water holding capacity, and the money available for centre pivot maintenance and electricity usage.

The canals that enter Taung, more especially the north canal, should have flow measuring structures at the inlet of Dam One, as well as at the lower outlets to the pump-dams. Estimations of the amount of water that is allocated to Taung are based directly on

the available arable hectares in the Taung area, and not on the water requirements of the envisaged crops. This provision of water is supposedly based on the relationship of trust that exists between the Department of Water Affairs and the scheme farmers. There is, however, nobody who monitors the flow of water in the canals on its way to Dam One to prevent water theft. Nobody is sure of how much water is lost because of wood, tree branches and dead animals. In order to save on water wastage and operating expenses, there should be better water management.

To restore national and international competitiveness, the Taung irrigation scheme management authorities, the Department of Agriculture, as well as the tribal authority concerned will have to review the management and use of the irrigation scheme by the farming communities. While it is accepted that the introduction of centre pivots represents an improvement, it is conceded that this development alone could not act as a primary growth vehicle for the irrigation scheme. The irrigation scheme requires immediate attention to grow economically; there is not enough time to wait while farmers debate the merits of what constitutes the best irrigation management practices.

One solution entails that the authorities transfer the right of land ownership to the farmers/respondents. The respondents must also be given the responsibility to maintain the infrastructure (centre pivots, roads) and clean the canals and dams. It is clear that the community should be actively involved in generating their own development programs, and that they should also develop their capacity to do so. Respondents should have no misgivings about the fact that all practices are intertwined; they all affect one another. Trying to correct one practice does not mean that others should be neglected. Working on the nitrogen problem does not mean that one should not irrigate correctly or omit control of insect pests.

Irrigation is one of the most important practices in barley production and should be performed correctly to obtain quality malting barley. To achieve this goal, money has to be spent on equipment like neutron probes and/or tension meters to determine the available water in the soil. Southern Associated Maltsters has gone to great lengths in this regard and has contracted a private company that uses neutron probes, which are checked on a weekly basis by the University of Pretoria. The producer must use the recommended quantity of water as determined by the neutron probes and the tension meters. It remains the producers' responsibility to see to it that the quality of their malting barley meets the required grading specifications, because low quality and low quantity will result in low income for them. The resources, strategies and skills required to overcome irrigation problems illustrate the need for a well-developed water management system..

Given the chance, farmers will utilise the available human resources to develop an accurate and understandable irrigation scheduling system. The need for optimum water management is emphasised by the fact that Southern Associated Maltsters has contracted the University of Pretoria to monitor water usage. This gives the barley farmer access to external expertise and secondary information. A long-term irrigation programme that includes the observations of farmers is thus needed.

EVALUASIE VAN BESPROEIINGSBESTUURSPRAKTYKE VAN GARSBOERE IN DIE TAUNG-BESPROEIINGSKEMA

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OPSOMMING

Alhoewel heelwat grond vir gewasproduksie in Suid-Afrika beskikbaar is, word die produksie van gars tot sekere gebiede in ons land beperk weens 'n tekort aan besproeiingswater. Dit is daarom noodsaaklik dat die produksie van gars in die Taung-besproeiingskema bevorder word aangesien die hulpbronne wat nodig is vir die produksie daarvan, wel beskikbaar is. Hierdie hulpbronne moet doeltreffend aangewend word tot voordeel van die Taung-boerderygemeenskap. Die 3500 ha wat deur die boerderygemeenskap bewerk word, moet behoorlik benut word ten einde armoede uit te wis. Dié studie het die besproeiingspraktyke van garsboere in die Taung-besproeiingskema ondersoek. Die doel van die studie is om boere in die besproeiingskema te help om besproeiingstegnieke toe te pas wat die waterbehoeftes van die gewas, die diepte en waterhouvermoë van die grond, en die beskikbaarheid van die fondse wat benodig word vir die onderhoud van spilpunte en die gebruik van elektrisiteit, in ag neem.

Die kanale wat Taung binnekom, veral die noordelike kanaal, behoort 'n struktuur te hê wat die watervloei monitor waar dit Dam Een binnekom. Dit geld ook die uitlate na die pompdamme verder af in die onderste gedeelte van die kanaal/skema. Die hoeveelheid water wat aan Taung toegewys word, word beraam op die basis van die aantal hektaar beskikbare besproeiingsgrond, en nie op grond van die waterbehoeftes van die betrokke gewasse wat aangeplant word nie. Hierdie watervoorsiening word gebaseer op die veronderstelde vertrouensverhouding tussen die Departement van Waterwese en die skemaboere. Daar is niemand wat die moontlike diefstal van water uit kanale tot by Dam Een monitor nie. Niemand is ook bewus van die omvang van verliese wat veroorsaak word deur hout, boomtakke of dooie diere nie. Ten einde die vermorsing van water te bekamp en bedryfskoste in toom te hou, moet beter waterbestuurspraktyke gevolg word.

Met die oog daarop om nasionale en internasionale mededingendheid te verhoog, behoort die Taung-besproeiingskema se bestuur, die Departement van Landbou en die betrokke stamowerheid die beheer en gebruik van die besproeiingskema deur die boerderygemeenskappe te herevalueer. Hoewel aanvaar kan word dat die gebruik van spilpunte 'n verbetering teweeggebring het, moet toegegee word dat hierdie ontwikkeling op sigself nie in staat is om as primêre stimulus vir ekonomiese groei te dien nie. Die besproeiingskema benodig onmiddellike aandag indien dit winsgewend bedryf wil word.

Een moontlike oplossing is dat die owerheid dit moet oorweeg om die boere/respondente eiendomsreg op die grond te gee. Die respondente moet ook die verantwoordelikheid gegee word om na die infrastruktuur (spilpunte, paaie) en die skoonmaak van kanale en damme om te sien. Dit is duidelik dat die gemeenskap aktief betrokke moet wees in die skep van hul eie ontwikkelingsprogramme, en dat hulle hul vermoë om dit te kan doen, dienooreenkomstig moet ontwikkel. Respondente moet ook duidelik begryp dat alle praktyke mekaar wedersyds beïnvloed. Om een praktyk reg te stel, beteken nie dat ander praktyke afgeskeep moet word nie. Deur byvoorbeeld op die stikstofinhoudprobleem te fokus, beteken nie dat besproeiingskedulering of insektebeheer suboptimaal moet wees nie. Besproeiing is van kritieke belang vir garsproduksie en moet korrek toegepas word om gars van 'n hoë gehalte te produseer.

Met die oog op korrekte besproeiing moet in neutronvogmeters en/of tensiometers belê word. Die Suidelike Geassosieerde Mouterye (SGM) het baie gedoen om die skema se gekontrakteerde maatskappy sover te kry om neutronvogmeters te gebruik. Dié meters word weekliks deur die Universiteit van Pretoria (UP) gemonitor. Die produsent moet die aanbevole hoeveelheid water, soos vereis/bepaal deur die tensiometers en neutronvogmeters, gebruik. Die onus rus steeds op die produsent om optimaal te produseer sodat daar voldoen word aan die vereiste graderingspesifikasies. Lae kwantiteit en kwaliteit produksie lei tot 'n lae inkomste. Die hulpbronne, strategieë en vaardighede wat nodig is om besproeiingsprobleme te oorkom, is 'n aanduiding van die behoefte aan 'n goed ontwikkelde waterbestuurstelsel.

Indien boere die kans gegun word, sal hulle die beskikbare menslike hulpbronne gebruik om 'n akkurate en verstaanbare besproeiingskeduleringstelsel te ontwikkel. Die behoefte aan optimale waterbestuur word beklemtoon deur die feit dat SGM die UP gekontrakteer het om die vogmeters te monitor. Deur hierdie kontrak word eksterne kundigheid en sekondêre inligting vir die garsboer op die skema bekom. 'n Langtermyn besproeiingsprogram, wat ook die observasies van skemaboere insluit, word dus benodig.

Central University of Technology, Free State

TITLE: **Questionnaire for the evaluation of the irrigation practices of barley farmers in the Taung irrigation scheme**

For office use only

1 BIOGRAPHICAL INFORMATION

Number of respondent / questionnaire .... [ ] 1

1.1 F.S.U. .... [ ] 2

1.2 Age of respondent... [ ] 3

1.3 Sex of respondent .... [ ] 4

1.4 Marital status of the respondent.................................. [ ] 5

1.5 Occupation of the respondent..................................... [ ] 6

1.6 Number of children of respondent .... [ ] 7

1.7 Level of education of respondent .... [ ] 8

1.8 Which language do you use ?..................................... [ ] 9

1.9 Do you own the land you use ?.................................... [ ] 10

1.10 How long have you been in the farming industry ?.................. [ ] 11

1.11 How far is your plot from your residential area ?..................... [ ] 12

1.12 From the children living at home how many come to the plot ?.......... [ ] 13

1.13 How often do you visit the plot ?.................................... [ ] 14

2 IRRIGATION TYPE

2.1 How old is the system you are using ?.............................. [ ] 15

2.2 Is the system functioning well ?....................................... [ ] 16

2.3 In what condition is your pivot ?....................................... [ ] 17

2.4 In what condition are your pipes ?.................................... [ ] 18

2.5 What problems do you encounter with your pivots ?................ [ ] 19

.... [ ] 20

.... [ ] 21

.... [ ] 22

2.6 What problems do you encounter with your water ?................ [ ] 23

………… ………………………………………………………………… 24

………… ………………………………………………………………… 25

2.7 What problems do you encounter with electricity ?……………… 26

………… ………………………………………………………………… 27

………… ………………………………………………………………… 28

2.8 What is the type of the drainage system(s) ?………………………… 29

………… ………………………………………………………………… 30

2.9 What is the source(s) of irrigation water ? ………………………… 31

………… ………………………………………………………………… 32

2.10 What is the most common problems with the system you are using ?

………… ………………………………………………………………… 33

2.11 How much water do you use on barley crop for the season per ha ? 34

………… ……………per ha ? ………… ……………total crop ? 35

2.12 How much money do you spend on your irrigation for barley ? 36

………… ……………per ha ? ………… ……………total crop ? 37

2.13 What is the water requirements for barley crop ? ………………… 38

………… ……………per ha ? ………… ……………total crop ? 39

2.14 Which months do you irrigate more on your barley crop ?

……………………… …………………………………………………… 40

……………………… …………………………………………………… 41

2.15 When do you stop irrigating your barley crop ?…………………… 42

2.16 Do you know the size of your nozzles ?…………………………… 43

2.17 What types of nozzle give more problems ?……………………… 44

……………………… …………………………………………………… 45

2.18 How often do you check your nozzles ?…………………………… 46

2.19 In your opinion what influences nozzles blockages ?…………… 47

……………………… …………………………………………………… 48

……………………… …………………………………………………… 49

.... 50

2.20 What is the effect of nozzle blockages ?............................. 51

.... 52

.... 53

2.21 How often do you flush your pivot ?................................... 54

2.22 How do you think you can avoid nozzle blockages ?............... 55

.... 56

.... 57

2.23 What is the speed you run your pivot ?.............................. 58

2.24 How do you get your water to your pivot ?.......................... 59

2.25 Who cleans the supply canals ? 60

.... 61

2.26 How often is the supply canals cleaned ?........................... 62

2.27 How often is the supply dam cleaned ?.............................. 63

2.28 Who cleans the storage dam ?... 64

.... 65

2.29 Do you think that the irrigation system used is suitable for your farm ? Please explain.

.... 66

.... 67

2.30 How do you think the irrigation system can be improved ?.........

.... 68

.... 69

2.31 In your opinion, what is an irrigation schedule ?.....................

.... 70

.... 71

2.32 Do you have an irrigation schedule ?.................................. 72

Please describe your irrigation schedule ?.......................... 73

.... 74

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.... 75

2.33 Does irrigation affect the quality of barley ?.......................... 76

2.34 If "yes", how does irrigation affect the quality of barley ?..........

.... 77

.... 78

2.35 How does irrigation affect yield ?..................................... 79

2.36 How does the Government control the use of water ?...............

.... 80

2.37 During which growing phase do you use more water ?............

.... 81

2.38 Which is the common breakages on your pivot ?..................

.... 82

.... 83

2.39 In your opinion, what causes the breakages of your pivot system?

.... 84

.... 85

2.40 Do you have maintenance skills ?...................................... 86

2.41 Who is doing the maintenance of your pivot ?........................ 87

.... 88

.... 89

.... 90

2.42 In your opinion is there a need for training?.......................... 91

Specify your biggest training needs? 92

.... 93

.... 94

2.43 On average how much do you spend on maintenance of the pivot

during the barley season ?... 95

2.44 What parts of the pivot is giving more problems ?................... 96

.... 97

.... 98

.... 99

2.45 Are spare parts easily obtainable ?.................................... 100

2.46 How many times have you reported a breakage for the past six months ?... 101

3 SOIL

3.1 What is your soil type ?.. 102

3.2 How deep is your soil ?... 103

3.3 What is the soil structure ?.. 104

3.4 In your opinion how can the slope affect your irrigation ?.......... 105

.... 106

.... 107

3.5 How can the structure affect the irrigation schedule ?.............. 108

.... 109

.... 110

3.6 What is your land's water holding capacity ?......................... 111

.... 112

3.7 How do you determine the moisture content of the soil ?......... 113

.... 114

3.8 What is evaporation ?... 115

.... 116

3.9 How does evaporation affect your irrigation ?......................... 117

.... 118

3.10 What is the root depth of the barley crop ?......................cm 119

3.11 What is the relationship between the speed and the water put down?

.... 120

.... 121

3.12 What would you say is the best way of water conservation ? 122

.... 123

.... 124

4 FERTILIZATION

4.1 What type of fertilizers do you use on the barley crop ?........... 125

.... 126

.... 127

.... 128

4.2 What is your nitrogen content requirement ?......................... 129

4.3 How much topdressing do you give ?.................................. 130

4.4 When (if any) do you apply the topdressing ?......................... 131

4.5 What problems have you encountered caused by fertilization ? 132

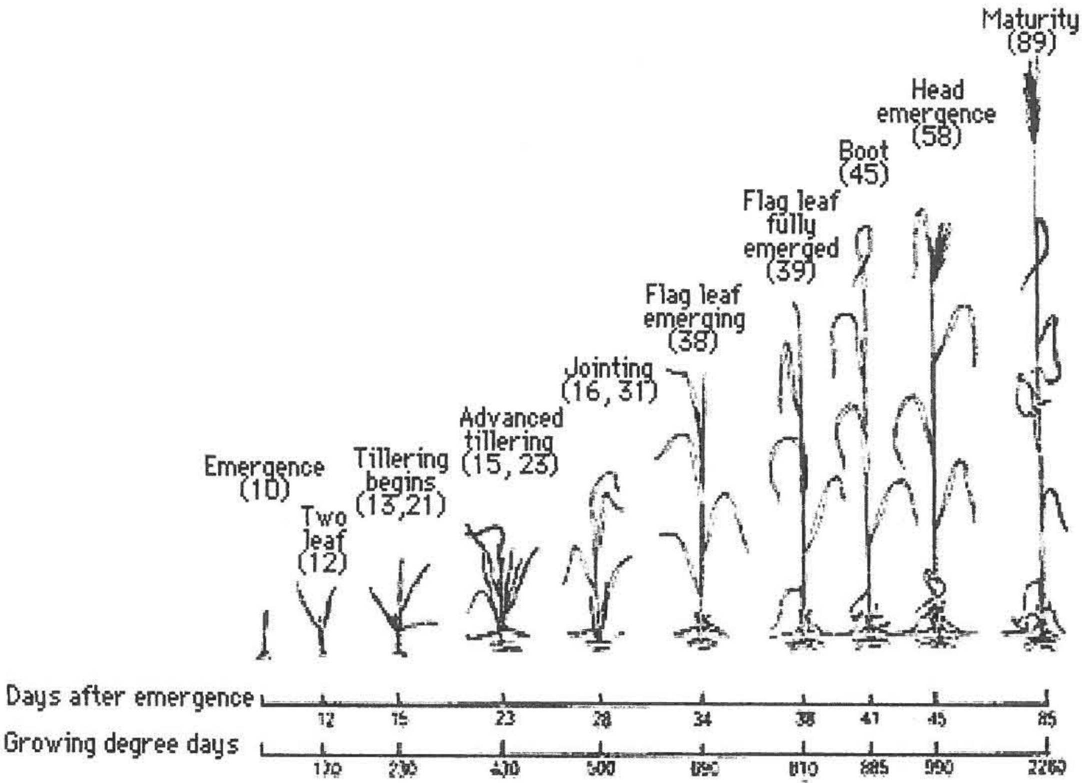
.... 133

.... 134

.... 135

APPENDIX B

Growth stages of the barley plant


Maturity (89)
Head emergence (58)
Boot (45)
Flag leaf fully emerged (39)
Flag leaf emerging (38)
Jointing (16, 31)
Advanced tillering (15, 23)
Tillering begins (13,21)
Two leaf (12)
Emergence (10)
Days after emergence
Growing degree days

Central University of
Technology, Free State

APPENDIX C

Code list

Questionnaire for the evaluation of the irrigation practices of barley farmers in the Taung irrigation scheme.

CODES

1.1	Tshidiso	1	
	Bosele	2	
	Areageng	3	
	Ipelegeng	4	
	Rethuseng	5	
1.2	Give in years		
1.3	Male	1	
	Female	2	
1.4	Married	1	
	Single (widow)	2	
1.5	Farmer	1	
	Part-time farmer	2	
	Stay at home	3	Bosele nr.8
	Clerk	4	Areageng nr.2
	Work at Engen (Nosang Motors)	5	Areageng nr.9
	Unemployed	6	
	Agric Technician	7	
	Tshdiso	8	Areageng 15
	Student	9	
	Pensioner	10	
	Accountant	11	
	Teacher	12	
	Hawker	13	
	Taxi driver	14	

2.32	N/A	0	72, 73, 74, 75
	No, form germination we run pipes with less hours then increases hours with crop growth	1	
	Yes, after planting pipes run at less hours, during germination and food making more water is needed, until crop is fully grown	2	
	No	3	
	Yes, time table	4	
	Yes, I cannot read it	5	
	Yes, when to increase water and which week to stop irrigating	6	
	Yes, a book or paper in which speed allowance is written on	7	
	Yes, young crops small amount of water, depending of type of crop and weather, at least water twice within 7 days	8	
	Yes, we start the pivot with 100 % then decrease the speed as our barley grows	9	
	Yes, know time and crop stage	10	
	Yes, vegetative stage: 80 % - 70%, reproduction stage: 60 % - 65%, maturity stage: 80 %	11	
	Yes, crop need less water after germination while it grows in need water more at reproduction stage and again less to maturity	12	
	Yes, irrigate at 100 % how many times a week and 12mm	13	
	Yes, date quantity of water put down, total amount required.	14	
	Yes, date for irrigation, speed of pivot, amount of water	15	
	Yes, it is difficult to understand	16	
	Yes, irrigate according to that I get from the extension officer	17	
	Yes, irrigation before plowing, immediate after planting and growing period	18	
	Yes, difficult to discuss	19	
2.33	I don't know	0	76
	Yes	1	
	No	2	
	Not really	3	
	Low quality	4	
2.34	N/A	0	77, 78

1.6	Give	
1.7	Grade 1 - 7	1
	Grade 8 - 12	2
	Diploma Agriculture	3
	Diploma - Other	4
1.8	Xhoza	1
	Setswana	2
	Tswana	3
1.9	No	0
	Yes	1
1.1	Give in years	
1.11	Give in km	
1.12	Give	
1.13	Everyday	1
	Three times a week	2
	Four times a week	3
	Once a week	4
	Every second day	5
	Twice a week	6
	Every third day	7
	Once a month	8
	Once in two weeks	9
	Three times a day	10
	Every time	11
	Three weeks a month	12
2		
2.1	Give in years	
2.2	Yes	1
	No	2
	Some how; Partially	3
	Not well	4
	Fairly well	5

	Little water gives more screening, nitrogen content to high	1	
	Less irrigation – resulted into feed barley	2	
	Have less money due to small grain	3	
	If you irrigate properly you set good quality	4	
	Feed barley are harvested from your land if you do not irrigate well	5	
	The barley crop need +/- 500mm and if less is given high nitrogen content and if less low	6	
	Over irrigation, leaches nitrogen	7	
	More farmers in Ipelengeng has feed barley due to water problem	8	
	People who had not irrigated or have pivot problems had feed barley	9	
	If you give little water you will have poor quality	10	
	If you give more water your nitrogen will be low	11	
	Kernels are shrinking	12	
	Shortage of water or electricity and breakdown of irrigation	13	
	The condition of the apparatus used and the pressure of water from pipes	14	
	High nitrogen content with poor or less irrigation, low nitrogen with over irrigation	15	
	No	16	
	If irrigation not sufficient you get more screens	17	
	More water feed barley under irrigation, low Quality	18	
	By low grade	19	
	More water leaves nitrogen, less kills plant	20	
	If pipes breaks you will get feed barley	21	
	Salty soil can effect the quality of barley	22	
	It determines the quality and size of grains and even amount of folder	23	
	If you leave your popes for long hours better quality	24	
	To be on for buyers and with required standard	25	
	Small grains, low nitrogen	26	
	If it's very hot and there is no water the sun burns the barley and if its cold it shrink	27	
	Got little money in 2002 due to screenings	28	
2.35	No idea	0	79
	Correct irrigation, enough yield	1	
	More water, more yield	2	
	Less hours water, low yield	3	
	By not watering well	4	
	It does not affect it	5	
	Too much irrigating	6	
	Less tons	7	
	If don't irrigate low yield	8	
	By little yield	9	
	By irrigating more will cause soil erosion	10	
	Smaller grains gives small yield if irrigation is not enough	11	

2.3	Old	1	
	Fair	2	
	Bad condition; Poor	3	
	Good condition	4	
	N/A	N/A	
2.4	Good	1	
	Bad; Poor; No condition	2	
	Old	3	
	Fair	4	
	N/A	N/A	
	Need repair; Leaking	5	
2.5	No problems	0	19 & 20
	Gearbox	1	21 & 22
	Water problems, repaired everyday	2	
	Breakage pipes	3	
	Leaking pipes need to be renewed	4	
	Trip timorously at pump house, rubber boots	5	
	The nozzle blockages	6	
	Pivot breakages	7	
	Tripping of motor in pump house and centre	8	
	No, proper pivot maintenance and lack of water	9	
	Breakages of overhang pipes and bending at pivots	10	
	Only when underground pipe has broken	11	
	Leaking of hydrends	12	
	Leakages and sprinkler malfunction	13	
	They use to block mostly because of mousse and fish	14	
	Theft of pipes and taps	15	
	No commitment from farmers	16	
	Tripping at pump house, blockage of nozzles	17	
	Falling of driving shaft and leaking pipes	18	
	Tripping of electricity and leaking pipes	19	
	Bending of the pivot, burning of the motor	20	
	Breakages of pipes and nozzle blockages	21	
	Tripping of power and burning of the motor	22	
	Blocking of main pipe	23	
	Poor repairs, lack of proper services	24	
	Leaking of rubber boots	25	
	Puncher, gearbox	26	
	Leaking of rubber boot, falling of driving shaft	27	
	Puncher, strapping of the Centre	28	
	Charging of water pump every day	29	
	Stopping of the pivot, Electricity and Gearbox	30	
	Blocked, breakdown pulling water in pump house	31	
	Gearbox and tyres give problems	32	

	Not follow it, less yield	12	
	I had 20 tons from 10 ha	13	
	Less irrigation, less tons	14	
	Tons improve	15	
	Under irrigate	16	
	Wrong irrigation i.e. too much water/ too little water	17	
2.36	No idea	0	80
	Giving farmers accounts	1	
	Cleaning dams	2	
	Paying by farmers	3	
	Cleaning of dams and canals	4	
	I don't recall the control	5	
	Nothing is done at this moment	6	
	By giving water	7	
	Clean dams and account	8	
	Giving bailiffs and cleaning dams	9	
	By limiting the water	10	
	Using a meter and safe water	11	
	By giving us people who scale water and to sent water we need	12	
	No control	13	
	Payments of account, supply water bailiffs	14	
	By giving us the amount of water we need	15	
	Orders from Jan Kempdorp	16	
	By education farmers to follow schedule	17	
	By paying of the water	18	
	By given program of dry weeks	19	
	Water bailiff	20	
	Cleaning dams and opening up sluice	21	
	By dividing the FSU with dams	22	
	By placing an order for farmer before planting, and when to irrigate	23	
	Measuring water to dams	24	
	Water is controlled by a private company	25	
	Repair canals, dams, and sluice	26	
	Storage dam have enough water	27	
	Payment supply of cleaners and bailiffs	28	
2.37	No idea	0	81
	At booting stage	1	
	During reproduction stage	2	
	After germination	3	
	Flowering phase	4	
	Germination and food making	5	
	When it is about to reap	6	
	After planting we can use more water	7	
	Ripening phase	8	

	Water arrives late	33	
2.6	Dam small, cannot accommodate all pivots	1	23 & 24 &25
	Bailiff stop water without informing farmers	2	
	Dry week, water bailiff not working weekends	3	
	Sometimes we did not get water properly when the canals are being cleaned	4	
	Lack of water during night and holidays, no water bailiffs	5	
	Wait for too long for water to arrive at dam Bailiffs not working from 16h30	6	
	Little water	7	
	Sometimes closed	8	
	Shortage of water from the dam to the field	9	
	Water arrived very late at the pump dams, there is nobody to supply water during weekends	10	
	Sluice not functioning well, water bailiff not available	11	
	No water in dam	12	
	Blockage of sieves	13	
	We do have some days without water. Due to delay	14	
	Dirty dams	15	
	No water during weekends, no water bailiff during night	16	
	Shortage and delivery, no control at last	17	
	Air logging at the Valve, no water during weekends	18	
2.7	N/A	N/A	26 & 27 & 28
	No idea	0	
	Report area to far, weak electricity	1	
	Delay in repairing	2	
	Electricity cut and fair by lightning, week electricity	3	
	Cut of electricity after +/- 2 days, supply box not functioning	4	
	Failure of electricity, take long to fix	5	
	Power failure almost 2 times a week. Reports takes long time to attend	6	
	Do not use electricity	7	
	No statements	8	
	Traps at center, fails at pump house	9	
	Traps at center, reporting will be attached after 2 days	10	
	Shortage of electricity during week time	11	
	Not that much problems	12	
	During rains estimates on meter reading	3	

	September	9	
	Before flowering	10	
	During dipping	11	
	All the stages	12	
	The worker know	13	
	Before germination	14	
	Through growing season	15	
	Water believes take control of water	16	
	Reproduction and Ripening	17	
	Towards harvesting time	18	
2.38	Pivot trip on the centre, puncture	1	82, 83
	Gearbox coupling motors	2	
	Trip at pump house, electricity, broken overhang pipes	3	
	Tripping of pivots, broken pipes	4	
	Electricity	5	
	Driving shaft and gearbox	6	
	Bending of machine, falling of driving shaft	7	
	Universal joints and pipes	8	
	On the sprayer	9	
	Breaking of underground pipes	10	
	Main line pipe broken	11	
	Pipe clips and sprinklers	12	
	When cleaning dam	13	
	Broken main pipe and underground pipe	14	
	Wheel punch	15	
	Motor trapping, universal joint falling	16	
	Motor, blockage of nozzles	17	
	Falling of driving shaft, leaking of nozzles, broken overhang pipes	18	
	Overhang pipes, falling of driving shaft, trapping of pumps	19	
	Trapping of pivot, bending of pivot	20	
	Motor gearbox, overhang pipes	21	
	Overhang pipes, trapping of pivot at centre, block nozzles	22	
	Gearbox and bending of pivot	23	
	Electricity cut, driving shaft breakages	24	
	Pipes blockage	25	
	Gearbox, falling of driving shaft, burning of motor pump	26	

	When fuses fallen from pole	14	
	Cut of the pulsar but do come for repair	15	
	An electric shock	16	
	Good electricity but costs is very high	17	
2.8	No idea	0	29 & 30
	Pipe underground to canal	1	
	No drainage	2	
	Pipe drainage system	3	
	Drain system	4	
	N/A	N/A	
	Pump house	5	
	Our soul have good texture and water scheduling allows for water penetration	6	
	Use a compressor	7	
2.9	No knowledge	0	31,32
	Dam	1	
	Dam and canals	2	
	River (Vaalharts)	3	
	Warrenton Weir	4	
	Canals to pump dams	5	
	Canals	6	
	Pipes	7	
	We give enough water so that crop could grow	8	
2.1	Repairs take too long	1	33
	Pivot breakages	2	
	Pivot looses pressure	3	
	Lack of cohesiveness of farmers	4	
	None	5	
	Pivot maintenance	6	
	Puncture and blocking of nozzles	7	
	Water and electricity	8	
	Broken pipes, failure of electricity	9	
	Electricity	10	
	No funds for planting	11	
	Leaking of pipes and over irrigation	12	
	Damage of rubbers and hydrant caps	13	
	Underground pipe bursts	14	
	Damage by contractors, stolen pipes	15	
	Theft	16	

	Motor burning, bending of pivot	27	
	Driving shaft broken, bending of pivot, burning of motor pump	28	
	Gearbox motors and pump	29	
	Motors prop shaft	30	
	Motors, wheel nuts	31	
	Wheel control and puncture	32	
	Gearbox, falling of driving shaft, universal joints	33	
	Puncture and driving shaft	34	
	Puncture, motor and cable	35	
	Gearbox, falling of driving shat, overhang pipes broken	36	
	Leaking of overhang and puncture, rubber boot	37	
	Motor, pipes	38	
	Common breakage mostly on old pipes	39	
2.39	No idea	0	84, 85
	Poor maintenance service, deep wheel track	1	
	Dirt in pipes	2	
	Old pivots and poor maintenance	3	
	Deep wheel track, dirty dam	4	
	Poor pivot maintenance	5	
	Uneven land	6	
	Pivot are not properly serviced	7	
	Dirty dam, air logging	8	
	Dirty dam, old motor and bad service	9	
	Negligence of punctures, deep wheel tracks	10	
	Negligence of farmers, operate pivot without inspecting	11	
	Uneven soil, deep wheel track	12	
	Deep wheel track, unnoticed puncture	13	
	Electricity, pressure of water	14	
	Worker not at the field	15	
	Normally when winter comes we do experience that breakages on pipes	16	
	Wear and tear	17	
	When cleaning dams and canals	18	
	They must be hold very carefully don't drop them	19	
	Pressure and cold	20	
	Maintenance and water	21	
	Poor water supply	22	
	Poor electricity and poor pivot maintenance	23	
	When gearbox had a problem or when motor had a problem	24	
2.4	No idea	0	86
	Yes	1	
	No	2	
2.41	Contractor pipe people from the government	1	87, 88,

	Poor management	17	
	Water arrives late, breakages of pivot	18	
	Driving shaft falling, gearbox	19	
	Bending of pivot and driving shaft falling	20	
	Burning of motor pump	21	
	Stoppage of the wheels	22	
	Puncture, driving shaft	23	
	Air inside the pipes	24	
	Standing or stopping of pivot	25	
	Bending of pivot	26	
2.11	Give in ha		34
	Total crop		34
2.12	Give in ha		36
	Total crop		37
2.13	Give in ha		38
	Total crop		39
2.14	August – September	1	40,41
	September – October	2	
	September, October, November	3	
	October – November	4	
	August, September, October	5	
	August, September, October, November	6	
	Summer months when we experience hot days	7	
	May and July, October	8	
	August and October	9	
	June, July, August	10	
	June, July, August, September October November	11	
	July, August	12	
	End of May to the 15 June or the end of June	13	
	July, August and September	14	
	No idea	15	
	Deepening	16	
2.15	November	1	42
	28-Nov	2	
	1 week before harvest	3	
	Before harvest	4	
	End November	5	

			89, 90
	Jaco working for contractor, Paul	2	
	Private people form Hartswater	3	
	Contractor	4	
	Contractor and myself	5	
	Company from outside the farmers	6	
	Contractor, groundnuts international	7	
	Myself	8	
	S.A.M	9	
2.42	Yes	1	91
	No	2	
	<u>Specify</u>		
	Electricity on pivot, repairing gearbox	3	92, 93, 94
	Repair pivot	4	
	Gearbox maintenance, learn the universal joints, driving shaft	5	
	Motors repair	6	
	Gearbox, driving shaft rubber, electrical motor	7	
	No	8	
	Wilding of pipes, underground pipes	9	
	Maintain pipes (how to)	10	
	Gearbox, setting of timer	11	
	I don't have a clue	12	
	Repair gearbox, wilding of overhang pipes	13	
	Gearbox	14	
	Operating the pivot repairing gearbox, repairing pipes and knowing electricity of the pivot	15	
	Fix pipes, repair driving shaft, electricity at centre	16	
	School leavers to be trained in motor repairs, gearbox fix	17	
	Working with air log	18	
	To take care of our land or plot	19	
	To know the farm and irrigation maintenance	20	
	Men to do the work but not electric problems	21	
	Driving shaft	22	
	Fix puncture, drain oil, repair gearbox and motor pump	23	
	Maintenance	24	
2.43	Do not remember	1	95
	Between R1 000 and R1 999	2	
	Between R11 000 and R11 999	3	
	Between R5 000 and R5 999	4	
	Between R3 000 and R3 999	5	
	Between R8 000 and R8 999	6	
	Between R7 000 and R7 999	7	
	Between R10 000 and R10 999	8	

	Mid November	6	
	2 weeks before harvest	7	
	2 days before harvest	8	
	Harvesting time	9	
	28-Oct	10	
	No idea	11	
	December	12	
	October	13	
	After inspection	14	
	4 days before harvest	15	
	When matured	16	
	When kernels are hard	17	
	2nd week in November	18	
	When is totally ripen	19	
	Day before harvest	20	
2.16	Yes	1	43
	No	2	
	Not all	3	
	Know only by looking	4	
	I don't know	5	
	No idea	6	
2.17	None	0	44, 45
	Nozzle at the end of the pivot	1	
	Fine once	2	
	Nozzle from the centre pivot	3	
	All of the nozzles	4	
	Smallest at the end	5	
	Size 20 and Size 22	6	
	No knowledge	7	
	Not all but at the end	8	
	Smallest and the one at the end	9	
	Small and fine nozzles	10	
	Tower six at one end	11	
	The small at the beginning of the pivot	12	
	7's and 8's	13	
	Small nozzles	14	
	Smallest at the standpoint	15	
	Size 15	16	
	Big	17	
	Springers	18	
	No. 18	19	
	The front one	20	

	Between R2 000 and R2 999	9	
	Between R6 000 and R6 999	10	
	Between R10 and R999	11	
	Between R4 000 and R4 999	12	
2.44	Cannot remember	0	96, 97, 98, 99
	Gearbox, puncher, nuts	1	
	Couplings, gearbox, motor	2	
	Coupling, driving shaft	3	
	Gearbox, driving shaft, puncher, electricity	4	
	Gearbox, breaking of overhanging pipes	5	
	Universal joints, couplings, nozzles	6	
	Sprinklers, nipples	7	
	Underground pipes	8	
	Nipples	9	
	Sprinklers	10	
	On the connection joining the spray and the main pipe and the spray blocking	11	
	Reverse and Rubber path	12	
	Gearbox, gearbox shaft rubbers	13	
	Gearbox, universal joints, driving shaft	14	
	Don't know pivot parts	15	
	Overhang pipes, driving shaft, universal joints, coupling	16	
	Universal joints, pipes	17	
	Gearbox, prop shaft and the front nozzles	18	
	Gearbox	19	
	Only main pipe	20	
	Gearbox, motor, puncher	21	
	Universal joints, driving shaft, gearbox, punctures	22	
	Driving shaft, electricity	23	
	Driving shaft, puncher, motor	24	
	Universal joint, gearbox	25	
	Gearbox, driving shaft	26	
	Pipe rusting	27	
	Driving shaft, universal joints, couplings, tubes	28	
	Gearbox, motor pump, switch at pump house	29	
	Gearbox, pump	30	
	Driving shaft, gearbox, motor pump, overhang pipes	31	
	Driving shaft, gearbox, overhang pipes	32	
	Universal joint, gearbox, motor pump, couplings	33	
	Motors, gearbox, tyres	34	
	Motor pumps, gearbox, driving shaft	35	
	Overhang pipes, nozzles, gearbox	36	
	Prop shaft	37	
	Universal joints, motor	38	

	The once at the stand block and at the end of pivot	21	
	No problem	22	
	10mm nozzles	23	
	Those at the end and beginning	24	
	Size 20 at the end of the machine	25	
2.18	Everyday	1	46
	Once a week	2	
	When starting the pivot	3	
	Daily	4	
	Everyday if pivot runs	5	
	Twice in 3 days	6	
	2 times in a day	7	
	Before opening the pivot	8	
	Everyday before opening	9	
	After 2 weeks	10	
	Before operating machine	11	
	Before starting	12	
	Once in two weeks	13	
	Weekly	14	
	After hour	15	
	Incoming to time	16	
	During irrigating	17	
	Once a month	18	
	When blocked	19	
	Monthly	20	
	3 times a day	21	
	Everyday when irrigating	22	
	Twice a week	23	
	After 3 weeks	24	
	When operating pivot	25	
	After 1 day	26	
2.19	I think when water have mud, dirty or any material that cones with water	1	47, 48, 49, 50
	When the water is dirty	2	
	Silt, Small fishes, Algae	3	
	I have no idea	4	
	Algae	5	
	Dirty dam, Small fishes, Silt from canals	6	
	Dirty dam, Small fishes	7	
	No idea as there is more algae in dams	8	
	Dirty dam, Sieves that is damaged	9	
	Algae and Small fishes	10	
	Dirty dam, Small nozzles	11	
	Dirty dam, wrong size of nozzles	12	

	Water pump	39	
	Driving shaft, motor	40	
	Couplings, tube, tyres	41	
	Motor and cable	42	
	Gearbox, driving shaft, puncture	43	
	Wheels, pipes leaking	44	
	Puncture, nozzles, drainage pipe	45	
	Motor, nozzles	46	
2.45	I don't know	0	100
	Contractor knows	1	
	No	2	
	Yes	3	
	Repaired by someone	4	
2.46	No idea	0	101
	2 times	1	
	3 times	2	
	5 times	3	
	Many times	4	
	10 times	5	
	4 times	6	
	I do not report worker do	7	
	1 time	8	
	Nothing	9	
	7 times	10	
	9 times	11	
	8 times	12	
	6 times	13	
	More than 6 times	14	
	12 times	15	
	13 times	16	
	I cannot remember but more than once	17	
	11 times	18	
	10 to 20 times	19	
	16 times	20	
	14 times	21	
3.1	I don't know	0	102
	Sandy loam	1	
	Loam	2	
	Sandy clay	3	
	Clay	4	
	Sand	5	
	Hutton	6	

	Government not cleaning dams, not cleaning canals and Contractor with wrong nozzles	13	
	Dirty in the pipe lines	14	
	Dirty dams, Branches of tree in canals, unattached Sieves	15	
	Dirty dam, Dirty canal, Airy pipes	16	
	Algae, Small fishes, Small stones	17	
	Small fish and mud	18	
	Dirty dam and dirty canal	19	
	Dam with more algae and with more sand particles	20	
	Dam that is not regularly cleaned	21	
	Air logging, dirty dam, nozzles	22	
	Spirogyra and mud	23	
	Mud, Grass, materials and fishes	24	
	Rust in pipe and dirty water from old system	25	
	Small fishes	26	
	Filthy dam, filthy pipes	27	
	Fishes, leaves and mice	28	
	Unfiltered water for small particles and fishes	29	
	Fishes and insects	30	
	Blockage caused by algae in the dam and some soil particles that is drown by the pumps	31	
	Dirty dam	32	
	Sand, Algae, Dirty canals, Differed nozzle Sizes	33	
	Small fishes and stones	34	
	Dust, Small fish and Algae	35	
	Foreign materials, Dirt due to unclean water sources	36	
	Dirty pipes	37	
	Dirty dam, Small fishes and Stones and Sand	38	
	Green leaves and mud that comes with water	39	
	Poor government service to dams and canals	40	
	Silt, Small fishes, Algae, Un flush of drainage pipe	41	
	Lack of Sieves, empting the dam	42	
	Patches on the land, uneven yield, uneven quality	43	
	Fishes, Algae, Sand, Poor maintenance	44	
2.2	No idea	0	51, 52, 53
	Does not supply enough water to plant	1	
	Crop don't grow well and even	2	
	Poor germination patches	3	
	No water thus, poor irrigation and unevenness of water to plants	4	
	No adequate water flow	5	
	After been stopped for a long time	6	

	Clay loam	7	
	Turf/Sandy clay	8	
	Combine sandy loam and clay	9	
	Red soil	10	
3.2	Don't know	0	103
	1,5 m	1	
	mid	2	
	50cm	3	
	Spade depth	4	
	2m	5	
	30 cm	6	
	1m	7	
	3m	8	
	6 cm	9	
	45 cm	10	
	20 cm	11	
	25 cm	12	
	60 cm	13	
	40 cm	14	
	70 cm	15	
	100 cm	16	
	15 cm	17	
3.3	Don't know	0	104
	Fine	1	
	Coarse	2	
	Soft	3	
	Drained	4	
	Only extensionist know	5	
	Coarse and fine	6	
	Loose	7	
	Arrangement of soil particles	8	
	Mixed clay	9	
	Clay	10	
	Petulance	11	
	Sandy loam soil	12	
3.4	No idea	0	105, 106, 107
	Causes soil erosion, and upper land doesn't get enough water	1	

Grass, Small fishes	7
Mostly the sprays	8
Unbalanced irrigation	9
Less money, under graded	10
Have never seen	11
Poor production	12
Patches on the land and low production	13
Dry area which resulted to uneven growth, uneven nitrogen content	14
Dry places	15
They will damage the crop	16
Poor germination of seed, Patches on the land	17
Low yield and poor quality	18
White straps on the plant dry areas, low yield and screenings	19
The mud that comes with water	20
Tod pores, tree leaves and other material comes with water	21
The dirt that comes with water	22
Mud, Fishes, Algae	23
Patches on field affected and crop dies	24
Burning of the crop	25
Dirty dam and canal	26
Little growing of seed, no germination	27
Cloth on the land	28
Poor yield	29
Feed barley	30
Feed barley and plant are suspectible to front damage	31
Poor quality, low yield, uneven growth	32
White patches	33
Big white patches on the field that resulted to feed barley	34
Rust in pipe	35
The area won't get enough water and barley won't grow well	36
Nozzle blockage cause crops to retard in growing	37
Dying of the plant	38
Low quality crop and yield, high nitrogen content	39
White patches, poor quality, low yield	40
Less water to plant, plant dies and screenings	41
Uneven germination and poor quality	42

More water lodge at the lower point	2
Yes, low area gets more water and top area dries quickly	3
The area dries from one area	4
It cannot affect irrigation	5
It causes the soil erosion	6
Erosion is made in the land to lower area	7
We don't get or receive enough water	8
Crops on slope side won't grow well because water will accentuate in one place	9
Water will not drain thus runoff	10
Have no slope in my area	11
Yes	12
There is too much runoff to low area and erosion is caused	13
Water will not infiltrate it will just cause erosion and run away	14
Runoff will increase and crop will grow unevenly	15
Water runs to low area and pivot need to go slow on high area	16
Water runoff due to slope and crops on upper hand or slope will every time in short of water	17
Low area lodges plants, up area suffer irrigation	18
Runoff and soil erosion	19
Erosion if pivot runs slow	20
Yes, by having erosion on more watered area	21
Water runs fast on sloppy land, and cycle must change	22
Erosion on high area and need machine to run fast	23
Water flow downwards	24
Not yet observed	25
Top area need water regularly in a short period while lower one need longer	26
Excess water put down on one place and erosion occurs	27
Slope affect irrigation by taking soil to low area	28
It is slope water cannot stay for a long time	29
The higher the slope the more runoff and the more water needed. While low slope hand better water put down	30
High area becomes dry too quick and need pivot adjustment	31
Area that is on high normally need water often because when irrigating water runoff to the lower area	32
Water runoff causes by slope causes barley not to grow according – retard growth	33
Top area dries fast as water runs to lower area	34
Take more water to low area to slow pivot at sometimes	35
By running water fast to low area and fry easily, correct schedule	36
Receive more water at one cycle and need to change speed	37
We experience water runoff, and soil erosion, crop won't have good quality	38
Diminishes absorption of water	39

2.21	Daily	1	54
	Every time I change the pipes	2	
	Everyday	3	
	3 times a day	4	
	After opening	5	
	Every time before irrigating	6	
	When blocked	7	
	Not at all	8	
	Never done	9	
	Every week	10	
	Twice a year	11	
	Once a week	12	
	When starting pivot	13	
	After 2 days	14	
	Twice in 2 days	15	
	Before starting pivot	16	
	After a week	17	
	After first irrigation	18	
	Pipe too high	19	
	1 month	20	
	3 times in a year	21	
	Once in 2 weeks	22	
2.22	No knowledge	0	55, 56, 57
	Government providing manpower for cleaning, get new contractor	1	
	Clean dams, clean pipes by flushing	2	
	Cleaning of dams and canals, maintenance people fit correct nozzles	3	
	Clean dams and clean canals	4	
	Cleaning of dams every 6 months	5	
	Government to clean the dam, to clean canals an d repair pipes	6	
	Cleaning of dams	7	
	Cleaning of dams, canals and flushing pipes	8	
	Correct air logging system, clean dam	9	
	By flushing now and then	10	
	Clean sieves	11	
	Cleaning dams and sieves	12	
	Cleaning dams and cut grass on canals	13	
	Using sieve in the entrants, close canals	14	
	Clean pipes	15	

3.5	No idea	0	108, 109, 110
	Changing of speed	1	
	Sandy and clay soil differ in irrigation cycles	2	
	You can irrigate long hours on soil that has clay	3	
	Sand need good cycle	4	
	Water stays on the clay for long time than on sandy soil	5	
	Clay soil has better holding capacity	6	
	Sandy soil looses water fast	7	
	The irrigation must be adjusted to suit the soil structure to avoid lodging	8	
	It cannot affect	9	
	The coarse soil need water often rather than the fine soil	10	
	Sand need light irrigation with short cycle	11	
	The more fine the structure the less you can apply	12	
	To irrigate timely	13	
	The coarser the soil the more the be irrigated	14	
	Clay and sand differ, clay need low speed, sand need high speed with short cycle	15	
	Sand need short cycle with shallow irrigation	16	
	I belief erosion	17	
	Fine structure hold water longer than coarse structure	18	
	More water flows out	19	
	More water is used than expected	20	
	The water lodges and crop dies	21	
	Clay soil need more water	22	
	If it develop strongly the plant root find it hard to penetrate	23	
	Sandy soil need more water as compare to clay soil	24	
	Soil can adhere to water without releasing it to crop	25	
	I have to irrigate often on sandy soil, because it has a worse soil	26	
	Sand need more water at short intervals	27	
	Sand need more water, dries up quickly	28	
3.6	Don't know	0	111, 112
	40cm	1	
	More than 50	2	
	30 mm rain it is damming	3	
	Extensionist know	4	
	579 mm	5	
	Department of water affairs and forestry	6	
	Average	7	

	By putting on sieves to block the dirty materials to pass on		16	
	Placing sifts in hydrant taps		17	
	If the water could be drained direct from the dam		18	
	Catching the fishes		19	
	Hire somebody		20	
	Cleaning dams and cleaning of nozzles		21	
	Cleaning dam, cleaning sieves, flush drainage pipe		22	
	Level the sieves and avoid empting the dam		23	
	Introduce new system of pipes		24	
	Cleaning furrow and dam		25	
2.23	Two hours		1	58
	3 hours		2	
	3 hours and change them to other place		3	
	As specified by extension programmer		4	
	6 hours		5	
	Long hours more watch		6	
	3 hours 45 min		7	
		70%	8	
	60% and for 3 rounds		9	
	Worker know		10	
	100 % - 65 %		11	
	100% - 70 %		12	
	Depending on the growing phase of the plant		13	
	100 % - 80%		14	
	100 for new crop and increase when crop grow		15	
	2,5 hours		16	
	100% - 80%, 60 %		17	
	100, 80, 70, 75		18	
	Start with 100 % and control by program		19	
	80 % for 3 days a week		20	
		60%	21	
	80 % is very hot 90%		22	
		100%	23	
	75 and 100		24	
	50 % - 65 %		25	
	100% - 50 %		26	
	60 % - 70 %		27	
	100% - 90% - 65%		28	
	60% - 80%		29	
	50% - 80%		30	
		80%	31	

	50cm		8	
	Only Agriculturists knows		9	
	20 cm		10	
	Good		11	
	80 cm		12	
		40%	13	
	20 mm		14	
	A lot		15	
	10 mm		16	
	10 cm		17	
	50 mm		18	
		80%	19	
3.7	Nothing		0	113, 114
	Look by the eyes		1	
	Digging by spade		2	
	Just irrigate after 7 days		3	
	Look at the soil		4	
	By using my hand		5	
	By using soil auger		6	
	Irrigate after 2 days no moisture check		7	
	Spade and sometimes soil auger		8	
	Stick		9	
	By using moisture tension meter		10	
	Extension tell to irrigate		11	
	Just look and start the machine		12	
	Stick or iron meter		13	
	My hands or iron metal		14	
	Worker check		15	
	Mass		16	
	Guided by the schedule		17	
	Top soil dry		18	
	Just irrigating		19	
3.8	Don't remember		0	115, 116
	The loss of water due to sun		1	
	Is the heat that make smoke during hot day and takes water		2	
	Hot sun		3	
	The movement of water from the soil to the air		4	
	Is the rising of water in the form of vapor		5	
	When it is regulative converted and during winter is minimum		6	
3.9	Have no idea		0	117,

2.24	Pipes	1	59
	Pump	2	
	Motor – pipes	3	
	Canal	4	
	Pump the motor	5	
	Engine	6	
	Underground	7	
	Under water	8	
	Pump from dam	9	
	By opening the tap	10	
	Open the valve	11	
	Irrigation	12	
	Pivot	13	
	By electricity	14	
2.25	No idea	0	60, 61
	Government	1	
	Maintenance staff	2	
	Department of Agriculture	3	
	The personnel from water supply	4	
	Ourselves	5	
	Water Board Department	6	
	Dwaf and doace	7	
	Government and farmers	8	
	People who supply us with water	9	
2.26	No idea	0	62
	After long time	1	
	Once a year	2	
	Once in 2 years	3	
	Never cleaned	4	
	2 times per year	5	
	Once in 6 months	6	
	Once	7	
	Winter	8	
	After harvest	9	
	Once in a season	10	
	After 2 weeks	11	
	When blocked	12	
	Government	13	
2.27	I don't know	0	63
	Once a year	1	

			118
	Give more water during irrigation cycle	1	
	Lost more water need more irrigation	2	
	The soil get dry quickly	3	
	During hot sunny day more water is needed	4	
	More water is lost during hot windy days	5	
	Water from the pipes is not going direct to the soil	6	
	Have to cover large area in specific timeframe	7	
	If the evaporation is too high then high application of water will be needed	8	
	Take more water	9	
	By draining water	10	
	High evaporation means more often irrigation or irrigate for longer periods	11	
	If very hot a crust is formed	12	
3.1	No idea	0	119
	20 cm	1	
	6 cm	2	
	100 cm	3	
	25 cm	4	
	10 cm	5	
	30 cm	6	
	51 cm	7	
	1,2 cm	8	
	60 cm	9	
	3 cm	10	
	5 cm	11	
	15 cm	12	
	80 cm	13	
	10 – 15 cm	14	
	2 cm	15	
	16 cm	16	
3.11	No idea	0	120, 121
	If run slow put down more water	1	
	Run high speed give more water	2	
	Run pipes long hours have more than enough water	3	
	No relationship	4	
	High speed to pivot little amount of water	5	
	No relation, the water is the same only the speed makes difference	6	
	To have the right quantity of the right time	7	
	If run at low speed it gives little water	8	
	If pivot stand at one place it gives more water when it runs at high speed less water is given	9	
	100 % little water, 50 % more water	10	
	Equal	11	

	2 times a year	2	
	Once in a Season	3	
	After six months	4	
	Not have one	5	
	After 2 week	6	
	When dirty/blocked	7	
	Once in 2 year	8	
	Long time	9	
	Government	10	
	After 5 years	11	
	Once after 6 years	12	
	Never cleaned	13	
	After 10 years	14	
	Once	15	
	After harvest	16	
2.28	N/A	0	64, 65
	Government	1	
	Farmers and government	2	
	Farmers	3	
	Once a year	4	
	Department of Water affairs	5	
	Department of Agriculture	6	
	I have not seen them	7	
	Doace	8	
2.29	I do not have clue	0	66, 67
	Yes, it is cheap and give enough water	1	
	Yes, pipes are ok, soil is ok, farmer is there to change pipes	2	
	Yes when leaving pipes for long hours more water	3	
	The system does not have electricity and maintenance	4	
	Yes	5	
	Yes, it is because of production that improves	6	
	Yes, you irrigate any time you want	7	
	The system is quite right for my farm, if they cannot be improved	8	
	Yes, is cheaper than pivot	9	
	It could be used to prevent frost damage and it can be apply under set condition	10	

	work hand in hand to give out god quality of barley	12	
	2 hours	13	
	More hours too much water	14	
	Slow speed gives little water, and high speed give more water	15	
3.12	I don't have an idea	0	122, 123, 124
	Irrigate during the night and avoid leaking pipes	1	
	Pivot services and wilding of pipes	2	
	Irrigate in the afternoon and mornings only	3	
	Irrigate when it is cool or during night	4	
	Building big dams	5	
	New pivots to be installed	6	
	Irrigate during nights	7	
	Repair the leaking pipes	8	
	To irrigate if you do order water	9	
	To check your pivot when is running and stop it when finished	10	
	Run your pivot at a low speed	11	
	Irrigate correct	12	
	Using of sprinklers	13	
	By not over irrigating	14	
	Check that machines runs always and dam do not over flow	15	
	By using the water properly not using leaking pipes	16	
	Pipes irrigation	17	
	Irrigate when there is no wind	18	
	High speed round 3 times	19	
	Best way is to keep water in dam	20	
	By maintaining the good pivot speed during irrigation and long irrigation period, water will be well concerned	21	
	Run machine at a period of 2 days and stop	22	
	Medium speed	23	
4.1	No idea	0	125, 126, 127, 128
	LAN, 3:2:2	1	
	03:02:01	2	
	4:2:1 , KAN	3	
	3:2:1 , LAN	4	
	3:2:1 , LAN , 4:2:1	5	

It's quicker and it makes work easier for farmers	11
Yes, irrigate by hiring people, easy no education needed	12
Yes, high speed gives more water	13
No, too expensive to maintain	14
Yes, easy to operate and safes lot of water	15
Yes, easy to operate	16
Yes, it help a lot during winter and irrigate faster than famous	17
It is good because it gives the correct amount of water and labour is less	18
Yes, by upping the pivot and we do plant twice a year	19
No, government to revive the system by new management	20
Yes, because you can irrigate evenly if nozzles are clean	21
Yes, better irrigating than furrow, water is not wasted	22
Pivots are old and gives more problems	23
Yes, because if it does not have problem I get something during harvesting time	24
Yes, because by using this system our production is too high and need less labour	25
Yes, more water will run off, erosion will take place	26
Yes, do not get in touch with water, do not get sick	27
Rhinatism is avoided, farmers are used to them	28
Yes, less work to be done	29
Yes, because I can irrigate the crop until its ripen	30
No, there must be enough water to supply all small dams	31
Yes, easy operated, less labour	32
Yes, easy operated, but it is too costly	33
Yes, can irrigate more, area within a period of time, less labour	34
Yes, irrigate according to requirement of the crop	35
Yes, it is easy operation, no night working	36
Yes, it's the best and easiest way	37
Yes, because the farmer knows the amount of water he wants	38
Yes, by controlling the speed you want to irrigate with	39
Yes, high run, less water	40
Yes, gives challenge to be there at all times, less labour	41
Yes, efficient water supply	42
Most of the work lies on the farmer, as government doe everything	43
Yes, easy operated and spare time	44

	onium		6	
	3:2:1 , Ammonium nitrate		7	
	KAN, LAN , 4:2:1		8	
		03:02:03	9	
	Kynoch, LAN 28		10	
		04:02:01	11	
	Solid fertilizer, Liquid fertilizer		12	
	LAN		13	
	LAN 28 , 4:2:1		14	
	2:3:0 or 2:3:2		15	
	4:3:2 , LAN		16	
	Liquid fertilizer		17	
	4:1:1 , KAN (28%)		18	
	2:3:2 , Ammonium sulphate		19	
	3:2:2 , Ammonium sulphate		20	
	Liquid fertilizer, ASN		21	
	LAN, Ammonium sulphate, 7:2:1 , 3:2:1		22	
	ASN		23	
	Kalksteen, Ammonium nitrate		24	
	LAN, 3:2:2 , ASN		25	
	3:2:1:, 4:2;1 , 7:2:1, LAN		26	
	LAN, Ammonium		27	
	LAN, 4:2:3, 2:3:4		28	
4.2	Not know		0	129
	50 kg bag		1	
	120 kg/h		2	
	40 bags/ ASN/ 10 h		3	
	80 kg		4	
	6 bag/ h		5	
	50 bag/10 h		6	
	Plants		7	
	125 kg/h		8	
	150 kg/h		9	

2.3	No idea	0	68, 69
	To provide people for cleaning canals, hire people for running pivots	1	
	Level the land	2	
	To increase the capacity of the canal and dam	3	
	To improve water system canal, to bring bailiffs during weekends	4	
	To improve maintenance attendance	5	
	Demolish the pivots and introduce sprinklers	6	
	Introduce a system that will reduce money but effective	7	
	Give farmers more ha as 10h is little, Increase water capacity	8	
	Provision of sprinkler irrigation, give one farmer 40h	9	
	New pivots with better pivot maintenance	10	
	Re-service the machine	11	
	Service, fitting new pipe and pump in pump house	12	
	By renovating of the pivots and building of a bigger dam	13	
	By renovating the pivot	14	
	By increasing the pivot pressure	15	
	Introduction of sprinklers	16	
	Give one farmer 40h, change system	17	
	Introduce land ownership to farmers	18	
	New motors and driving shaft	19	
	One farmer per pivot, introduce sprinklers	20	
	Training of farmers, farmer to control everything	21	
	If they can install metal pipes and not plastic	22	
	New pipes	23	
	Put on wheels on pipes	24	
	By installing new canals and new pipes	25	
	Proper main pipe to be installed	26	
	By putting water drainer in all the main pipes from the dam	27	
	People of maintenance to respond on time	28	
	Because without irrigation no plan, you cannot use more water	29	
	Allocate more land to small farmers	30	
	Bring in new contractor	31	
	More land to upcoming kids	32	
	Replacing old gearbox and tyres and increase water storage dams, particularly at Arreageng	33	
	By increase the pipeline and main pipe	34	
	Bailiffs to work during weekends and holidays, better pivot maintenance people	35	

	40 bags LAN		10	
	2 something		11	
	160 kg/h		12	
	38 bag/ 8h		13	
	60 bags		14	
	20 bags Ammonium		15	
	60 bags/ 10h		16	
	30 bags LAN		17	
	48bags		18	
	Prescription blend		19	
	60 bags/ 7,5h		20	
	84 kg/ h		21	
	200 kg / ha		22	
	100 kg/ h		23	
		5%	24	
4.3	No idea		0	130
	42 kg/nitrogen /h		1	
	38 bag/ 8h		2	
	30 bags KAN		3	
	4,5 bag / h		4	
	30 bag/h		5	
	53,2 kg /h		6	
	3 /h		7	
	48 bags		8	
	22 bags		9	
	LAN 28		10	
	45 kg/h		11	
	40 kg/h		12	
	150kg / h		13	
	6 bag / h		14	
	36 bag / h		15	
	30 bag/ 10 h		16	
	30 bags LAN		17	
	4 bags per h		18	
	2 bag/ h		19	
	Soil		20	

	Introduce management committee, give each farmer 40h pivot	36	
	Improve the gearbox	37	
	Look on the electricity and pivot maintenance	38	
	Leadership	39	
	Parts to be available	40	
	Farmers to be at te field at most times	41	
	Pipes to avoid dams, mud	42	
	Bringing in more water during weekends	43	
	Renting more to people and cover dams	44	
2.31	I don't know	0	70, 71
	Is to irrigate your crop according to crops need	1	
	I don't have a light	2	
	Water management	3	
	To know duration and amount of water the crop needs	4	
	Is the period of pivot irrigation	5	
	I have seen a paper but cannot read it	6	
	Is the way/program used to irrigate the Barley during different stages	7	
	It is a pattern in which farmers should do things	8	
	To help you to know when to irrigate	9	
	Help speed control	10	
	System to monitor water	11	
	The schedule indicating the use of water for a period of time	12	
	Is the taken up of water by the hot sun	13	
	Is to conserve water, crop get enough water, spare electricity	14	
	I have seen it but don't understand it	15	

	One bag/h	21	
	60 bags / 10 h	22	
	Extensionist knows	23	
4.4	8 weeks	1	131
	After 6 weeks	2	
	4 weeks	3	
	2 months	4	
	3 months	5	
	August	6	
	9 weeks	7	
	When plants covered the ground	8	
	7 weeks	9	
	After fertilization	10	
	5 – 6 weeks	11	
	10 weeks	12	
	3 weeks	13	
	After 6th leave stage	14	
	After 5th leave stage	15	
	1 month	16	
	12 weeks	17	
	After wonder till	18	
4.5	None	1	132, 133, 134, 15
	Burning on over fertilized	2	
	Crop have high nitrogen content than required by buyer	3	
	Grade has been negatively affected to such an extent that part of crop become fodder grade	4	
	After fertilizer, applicant must use water immediately	5	
	Change of color of leaves if irrigation is not done in time	6	

APPENDIX D

Data

TITLE: **Questionnaire for the evaluation of the irrigation practices of barley farmers in the taung**

1	**BIOGRAPHICAL INFORMATION**	**odes**																																							
	Number of respondent / questionnaire	**1**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**									**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**
1.1	F.S.U.	**2**	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3
1.2	Age of respondent.	**3**	74	43	43	40	69	65	32	29	40	47	68	36	34	39	45	63	68	48	62	65	52	47	40	32	53	70	39	77	55	44	41	40	38	55	38	54	32	60	35
1.3	Sex of respondent	**4**	1	1	1	1	1	1	1	2	1	1	1	1	1	2	1	1	1	1	2	1	1	2	2	1	1	1	1	1	1	2	2	2	1	1	1	1	1	1	1
1.4	Marital status of the respondent	**5**	1	2	1	2	1	1	1	1	1	1	1	2	2	2	2	1	1	1	2	1	1	2	2	1	1	1	2	1	1	2	1	2	1	1	2	1	2	1	2
1.5	Occupation of the respondent	**6**	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1	2	4	1	1	1	1	1	1	5
1.6	Number of children of respondent	**7**	8	3	5	4	4	10	1	2	3	3	8	0	1	4	2	10	6	3	1	8	6	4	3	2	7	9	3	11	5	2	0	3	2	6	4	4	0	6	3
1.7	Level of education of respondent	**8**	0	1	2		2	0	2	2	1	1	1	2	2	1	2	1	1	1	1	0	1	2	2	3	2	0	2	2	1	2	4	2	2	1	4	1	3	1	2
1.8	Which language do you use ?	**9**	2	2	3	3	2	2	3	3	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	1	2	2	2	2	2	2	2	2	3	2	2	2	3
1.9	Do you own the land you use ?	**10**	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
1.10	How long have you been in the farming ii	**11**	49	19	20	13		45	1	5	17	26	25	2	6	16	20	28	22	10	41	2	24	13	2	7	25	22	10	34	10	12	5	12	3	41	3	31	3	28	5
1.11	How far is your plot from your residential	**12**	14	10	0.5	1	3	2	0.5	0.3	1	0.4	15	0.3	1	0.5	1.5	3	17	1.5	4		14	5	1.5	1	17	1	8	10	1	15	20	25	2	1	7	2	1	4	0.3
1.12	From the children living at home how ma	**13**	1	0	3	4	2	5	1	0	1	3	1	0	0	1	0	3	2	2	0	3	6	1	0	0	2	1	0	4	0	0	0	0	0	6	2	0	0	1	1
1.13	How often do you visit the plot ?	**14**	1	2	1	1	1	1	2	1	3	1		4	1	1	5	3	1	3	6	1	1	4	6	1	1	1	3	1	5	4	7	8	1	3	1	2	9	6	10
2	**IRRIGATION TYPE**																																								
2.1	How old is the system you are using ?	**15**	20	20	23	22	21	21	20	21	21	22	21	18	20	21	21	25	20	21	20	26	24	20		21	19	22		20	10	20				20	17	20	21	18	21
2.2	Is the system functioning well ?	**16**	1	2	1	2	1	1	2	1	2	1	1	2	1	1	3	1	2	1	1	1	1	2	4	1	1	1	1	1	1	1	1		2	1	1	1	1	4	1
2.3	In what condition is your pivot ?	**17**	4	3	4	1	3	4	3	4	1	3	1	3	4	2	2	2	1	1	3	3	4	1	3	2	2	1	4	1	3	4	2	3	3	1	2	3	3	3	4
2.4	In what condition are your pipes ?	**18**	1		2	3		N/A	4		3	2	3		1	N/A	N/A					2	1	3	2	2	4	1	5	2	N/A	N/A	4		2	1	5	2	2	2	1
2.5	What problems do you encounter with yo	**19**	0	2	1	3	4	0	5	6	7	4	8	9	7	8	10	8	4	7	0	7	26	7	27	19	4	7	7	7	28	7	6	6	19	7	29	6	30	20	31
2.7	What problems do you encounter with ele	**26**	2	0	1	2	3	4	5	2	2	5	1	1	5	2	6	1	13	0	5	5	14	0	1	3	5	3	2	2	13	0	1	12	1	15	1	12	3	1	12
2.8	What is the type of the drainage systems	**29**	2	1	1	2	0	0	1	2	0	0	2	2	2	2	2	2	2	2	0	0	2	2	2	2	2	2	3	2	2	2	2	2	2	2	N/A	0	2	2	5
2.9	What is the (sources) of irrigation water ?	**31**	1	2	1	1	2	2	1	2	1	1	2	4	1	3	3	6	5	1	1	1	1	1	4	3	3	1	1	1	1	3	1	1	2	1	3	3	3	1	0
2.10	What is the most common problems with	**33**	2	3	1	2	4	5	6	7	5	8	9	6	2	10	11	12	6	2	22	2	19	5	12	10	12	5	2	2	23	2	7	8	8	2	24	2	25	18	7
2.11	How much water do you use on barley crop for the season per ha ?																																								
	per ha ?	**34**	27	0	0	35	0	0	0	579	0	0	46	0	0	0	0	0	0	0	0	0	0	0	0	50	46	0	0	0	0	0	0	0	25	0	0	0	42	15	0
	total crop ?	**35**	270	0	0	350	0	0	0	579	0	0	460	0	0	0	0	0	0	0	0	0	0	0	0	500	460	0	0	0	0	0	0	0	250	0	0	0	420	150	0
2.12	How much money do you spend on your irrigation for barley ?																																								

																																			Average	codes	SD	Blanks	Code N/A	Code0	Code1
40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60									69	70	71	72	73	74	37.500	1	21.51	0	0	0	1
3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	2.946	2	1.39	0	0	0	15
30	30	43		47	57	28	25	23	61	58	42	32	55		53	55	57	59	37	64	65	58	28	48	59	31	42	32	27	56	53	66	29	35	47.181	3	13.71	2	0	0	0
1	1	1	1	1	1	1	1	1	2	2	1	1	2	2	1	2	2	1	1	1	1	1	1	1	2	1	1	2	1	1	1	2	1	2	1.243	4	0.43	0	0	0	56
2	2	1	1	1	1	2	1	2	2	2	1	1	2	2	1	2	1	2	1	1	1	1	2	1	2	2	2	2	2	1	1	2	2	2	1.459	5	0.50	0	0	0	40
6	6	7	1	1	1	8	1	9	10	10	1	11	1	1	1	1	12	1	1	1	1	13	14	1	1	1	1	1	1	12	1	1	1	1	2.568	6	3.44	0	0	0	58
0	1	3		4	5	0	0	0	5	3	5	0	4	5	3	1	4	3	2	5	7	5	0	3	6	3	4	1	1	5	6	7	2	1	3.699	7	2.65	1	0	9	8
2	2	3		1	2	2	2	2	0	2		4	2	1	1	1	4	1	3	1	1	2	2	2	0	1	2	2	2	4	1	2	2	2	1.704	8	0.96	3	0	6	23
2	3	2	2	2	2	2	3	1	2	2	2	2	1	2	1	2	2	2	2	1	2	1	2	3	2	2	2	3	2	2	1	2	2	2	2.027	9	0.50	0	0	0	8
1	1	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	1	1	1	1	0.230	10	0.42	0	0	57	17
23	23	10	31	13	27	7	2	1	25	10	10	2	10	2	5	7	4	21	5	25	25	23	2	23	31	17	4	6	10	22	23	22	3	4	15.548	11	11.74	1	0	0	2
15	5	6	7	2	2		1	0.6	3	7	1	20	1	6	1	6	0.1	0.6	35	1	6	2	8	10	2	20	8	4	0.1	8	5	8	10	2	5.912	12	6.91	2	0	0	13
1	0	0	1	0	0	2	0	0	1	0	0	0	1	1	0	0	1	0	1	1	3	1	0	2	1	3	0	0	0	2	2	1	2	1	1.135	13	1.43	0	0	32	21
1	1	1	1	6	6	11	10	8	4	4	6	4	9	4	4	6	1	1	1	1	1	4	6	1	9	1	1	6	12	1	1	2	1	1	3.425	14	2.99	1	0	0	34
23	12	18	21	21	24	22		21	21	21			21	22	21	21	22	1	22	21	22	23	10	30	31	21	43	18	15		18	21	20	21	20.692	15	4.96	9	0	0	1
1	1	1	1	1	2	1	1	2	2	3	1	1	1	1	2	2	2	2	4	4	1	1	1	1	1	1	1	5	1	1	1	4	1	1	1.521	16	0.94	1	0	0	50
4	4	2	2	3	3	3	3	3	3	3	3	3	2	4	3	3	3	3	2	2	2	N/A	N/A	N/A					N/A			N/A	N/A	4	2.710	17	0.96	6	6	0	9
1	1	1		2	2	5	2	2	2		N/A		N/A	N/A		N/A		N/A	N/A	N/A	N/A	1	2	3	2	1	4	1	1	1	1	4	1	1	2.149	18	1.22	14	8	0	17
26	23	32	33	10	10	3	4	17	8	8	18	19	20	21	7	22	7	23	24	25	25	3	0	3	4	11	12	0	13	0	0	14	15	16	11.743	19	9.43	0	0	7	1
16	17	17	5	12	6	3	3	9	10	6	5	6	11	9	6	5	6	1	6	12	1	N/A	N/A	7	N/A	N/A	N/A	7	7	0	7	N/A	7	8	5.603	26	4.66	0	6	5	11
2	2	6	2	2	2	7	N/A	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	1	3	1	0	1	1	4	1	1	1.917	29	1.18	0	0	8	9
1	1	1	2	1	1		2	6	2	3	3	3	4	1	2	3	3	3	3	1	4	3	3	1	3	1	3	1	6	1	1	8	7		2.264	31	1.61	2	0	1	32
16	6	6	26	24	20	5	12	17	10	18	19	8	20	8	18	20	21	21	2	2	2	2	2	2	12	5	2	13	14	15	2	7	16	7	9.703	33	7.29	0	0	0	1
0	0	0	0	0	0	0	0	25	0	0	0	460	0	0	0	0	72	0	420	0	0	0	0	0	0	0	0	0	0	0	0	750	0		35.507	34	129.68	1	0	59	0
0	0	0	0	0	0	450	0	250	0	0	0	460	0	0	0	0	720	0	420	0	0	0	0	0	0	0	0	0	0	0	0	5625	0		155.671	35	671.94	1	0	58	0

Code2	Code3	Code4	Code5	Code6	Code7	Code8	Code9	Code10	Code11	Coc				e 16	Code17	Code18	Code19	Code20	Code21	Code22	Code23	Code24	Code25	Code26
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	16	15	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	2	1	1	1	2	1	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0
7	14	10	9	6	3	3	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	4	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	4	3	5	2	3	0	0	8	0	2	3	0	0	1	2	0	1	2	1	4	5	1	5	1
8	3	3	3	4	3	5	0	4	0	0	0	2	3	0	2	0	0	3	0	0	0	0	1	0
10	6	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	5	9	2	9	1	2	3	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	2	0	1	0	0	1	0	1	5	1	12	23	8	3	2	1	1
15	2	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	27	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	5	5	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	4	6	1	4	12	5	1	3	1	1	1	1	1	1	1	1	3	2	1	1	2	1	2	2
7	6	1	9	7	5	1	2	1	1	5	2	1	1	1	2	0	0	0	0	0	0	0	0	0
46	5	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	19	4	1	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	1	1	6	5	5	5	1	3	1	5	1	1	1	2	1	3	2	3	2	1	1	2	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	per ha ?	36	55	76.5	46	79.5	250	0	70.8	53.7	70.8									76.5	0	0	76.5	76.5	67.1	62.1	71	70	62.1	0	52	0	70	70	79.5	37.6	62.1	70	62.1	76.1	1162
	total crop ?	37	550	76.5	460	795	2500	0	708	537	708									7651	0	2000	7651	7651	671	621	710	700	621	0	520	0	700	700	795	376	621	700	621	761	####
2.13	What is the water requirements for barley crop ?																																								
	per ha ?	38	24	60	0	50	0	0	0	52.9	0	0	60	0	0	0	0	0	0	0	0	0	0	460	0	60	50	0	0	0	0	0	42	0	46	0	0	0	50	40	0
	total crop ?	39	240	600	0	500	0	0	0	529	0	0	600	0	0	0	0	0	0	0	0	2000	0	460	0	600	500	0	0	0	0	0	420	0	460	0	0	0	500	400	0
2.14	Which months do you irrigate more on yc	40	2	2	3	2	2	3	2	5	2	2	2	9	5	3	3	5	3	7	6	15	5	1	5	2	4	2	2	2	2	4	2	9	2	2	3	3	3	2	6
2.15	When do you stop irrigating your barley c	42	1	3	3	18	7	17	16	19	2	3	3	7	10	3	20	3	6	1	1	1	5	1	4	3	3	2	1	1	3	1	4	4	3	1	9	11	1	3	12
2.16	Do you know the size of your nozzles ?	43	1	1	1	1	3	1	1	1	1	1	1	2	2	2	2	4	2	1	2	1	1	1	2	1	2	1	2	2	1	6	2	2	1	1	1	1	1	2	1
2.17	What types of nozzle give more problem:	44	1	25	24	1	1	14	23	1	1	14	1	7	22	21	1	1	1	3	1	1	5	1	4	2	2	3	1	3	2	2	7	8	9	1	11	15	2	1	16
2.18	How often do you check your nozzles ?	46	4	10	1	3	9	8	7	12	6	5	4	2	3	2	13	11	26	23	25	1	12	10	2	1	4	4	14	17	23	24	18	18	5	17	4	5	13	14	17
2.19	In your opinion what influences nozzles b	47	7	43	10	19	7	42	2	24	2	9	41	40	39	38	44	6	3	2	10	32	9	1	8	6	7	2	2	2	4	5	2	16	16	2	18	24	3	15	25
2.20	What is the effect of nozzle blockages ?	51	2	23	18	22	15	18	21	26	20	1	19	18	1	13	4	24	41	21	24	25	18	4	24	39	40	29	37	4	38	25	10	19	19	36	29	1	13	13	35
2.21	How often do you flush your pivot/pipes ?	54	6	17	16	13	7	13	6	7	15	5	14	8	13	12	19	18	13	12	7	3	17	12	8	12	12	13	20	6	8	20	8	8	3	6	20	6	22	7	6
2.22	How do you think you can avoid nozzle b	55	12	12	10	7	7	23	12	25	7	0	22	6	12	3	4	3	14	12	7	24	4	12	6	4	13	12	12	12	0	7	20	0	3	12	5	11	6	3	10
2.23	What is the speed you run your pivot hov	58	15	21	12		22	12	21	24	20	8	19	4	18	17	14	18	8	31	23	23	18	30	14	13	13	23	17		14	13	10	27	4	21	13	26	13	26	8
2.24	How do you get your water to your pivot/p	59	5	3	3	5	14	5	3	14	1	3	5	2	5	2	2	14	6	5	2	2	9	6	6	2	5	6	5	5	9	2	13		3	6	4	3	5	2	8
2.25	Who cleans the supply canals ?	60	1	1	1	1	1	8	4	6	3	1	1	1	4	1	1	6	6	1	1	0	1	9	1	1	1	1	1	1	1	1	3	1	1	1	3	1	1	1	3
2.26	How often is the supply canals cleaned ?	62	2	2	12	2	1	10	2	12	5	13	2	1	6	3	2	2	9	5	8	2	1	6	7	3	2	2	6	6	2	5	0	2	3	2	2	0	2	2	
2.27	How often is the supply dam cleaned?	63	2	1	7	11	10	3	1	7	4	9	9	9	4	8	1	1	16	8	10	0	9	1	15	8	8	1	14	9	1	1	0	9	8	4	12	0	1	1	
2.28	Who cleans the storage dam?	64	1	1	3	1	3	3	1	3	6	3	3	1	1	1	1	3	3	1	3	0	3	1	1	3	2	1	3	1	3	4	7	1	3	3	3	3	1	2	3
2.29	Do you think that the irrigation system us	66	18	27	20	25	16	21	24	30	23	22	21	20	19	3	16	28	43	24	29	29	42	38	27	41	15	39	32	22	40	14	12	31	32	22	32	33	32	16	15
2.30	How do you think the irrigation system ca	68	0	16	40	14	39	38	3	11	10	37	20	36	14	35	43	41	21	16	17	42	20	0	19	17	18	14	14	15	10	16	44	3	4	13	5	11	3	3	12
2.31	In your opinion, what is an irrigation sche	70	7	7	10	9	0	7	4	7	9	1	7	0	7	7	0	0	14	1	0	0	7	12	0	7	13	7	7	7	0	0	0	0	7	7	11	0	7	0	0
2.32	Do you have an irrigation schedule ? Ple	72	9	13	10	12	3	6	11	10	10	6	6	3	9	6	3	3	15	12	3	4	9	18	3	10	14	9	6	12	3	3	3	3	15	6	9	15	15	3	3
2.33	Does irrigation affect the quality of barley	76	1	4	1	1	1	1	1	1	1	1	1	3	1	2	2	1	1	1	1	1	1	1	0	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1
2.34	If "yes", how does irrigation affect the qua	77	17	0	10	10	17	25	1	27	2	10	10	0	4	0		26	20	4	19	17	18	14	0	1	17	4	4	10	16	10	28	3	2	4	4	2	15	2	13
2.35	How does irrigation affect yield?	79	2	3	3	3	7	3	3	3	7	12	3	5	2	5	5	7	14	3	0	3	3		7	3	3	2	2	1	0	3	7	3	14	3	15	0	14	3	16
2.36	How does the Government control the us	80	23	28	27	23	26	20	25	3	0	0	3	24	12	5	1	1	16	15	6	3	9	17	13	9	14	12	12	12	13	1	3	3	3	12	5	1	9	2	11
2.37	During which growing phase do you use i	81	2	2	2	2	11	2	2	2	10	4	8	5	2	8	12	8	1	2	2	2	1	2	8	17	17	2	2	2	8	1	13	1	15	2	16	2	2	14	15
2.38	Which is the common breakages on youi	82	1	3	2	1	2	6	24	6	24	23	22	21	20	20	7	4	2	1	32	5	36	38	24	29	18	1	22	1	34	35	8	22	17	4	6	31	33	20	32

0	0	0	0	0	0	0	0	0	0	0	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	10	2	11	3	1	1	3	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
2	21	6	2	1	6	3	1	2	1	3	1	2	1	1	1	1	1	1	0	0	0	0	0	0
37	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	3	6	1	1	5	1	2	4	1	1	1	5	2	2	1	1	1	1	1	1	1	1	1	0
13	2	11	3	1	1	1	1	2	1	2	2	5	1	1	5	4	1	1	2	1	2	1	1	1
10	2	2	2	2	4	1	2	4	1	3	1	1	1	2	3	1	2	1	2	1	1	2	1	2
4	1	5	1	1	1	1	1	1	1	1	6	1	2	1	1	6	4	2	2	1	1	4	2	1
2	5	1	2	7	6	13	2	4	1	7	5	1	1	1	3	1	1	4	1	1	0	0	0	0
2	10	4	1	4	14	1	1	4	1	10	1	1	2	2	1	1	1	1	1	1	1	1	1	0
4	1	3	1	1	1	4	2	1	3	3	9	8	2	1	3	3	1	1	3	1	3	1	1	4
15	7	1	17	8	2	1	5	1	1	1	1	4	0	0	0	0	0	0	0	0	0	0	0	0
2	6	3	1	5	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	5	1	6	5	1	1	1	2	1	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	2	4	1	1	4	7	8	2	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
4	31	1	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	3	2	1	1	1	1	1	1	1	2	1	7	3	4	1	2	1	2	2	3	1	2	1	0
1	10	1	1	1	1	1	1	3	3	1	1	4	1	4	2	1	1	2	1	1	1	1	1	1
1	1	2	1	1	20	1	2	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
1	31	2	2	9	1	1	5	4	1	3	1	3	4	1	1	1	1	0	0	0	0	0	0	0
17	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	1	9	1	1	1	1	1	9	3	0	1	1	1	2	4	1	1	1	1	1	1	1	1	1
6	26	1	7	1	9	1	1	1	1	1	1	3	1	1	0	0	0	0	0	0	0	0	0	0
4	7	1	6	2	1	1	4	1	1	6	2	1	2	1	1	2	2	4	1	1	3	1	1	1
24	1	3	2	1	1	17	1	1	1	1	1	1	2	1	3	1	0	0	0	0	0	0	0	0
7	1	2	1	4	2	2	1	1	5	1	1	1	1	1	2	3	1	4	2	4	1	3	1	1

80	70	6000	76.6	71.8	76.1	2000	290	80	0	0	57.9	76.1	51.9	0	0	75.3	67.1	77.1	76.1	0									0	0	56	7.5	0	5843	265.346	36	972.41	0	0	16	0
800	700	####	766	718	761	708	2900	7995	0	0	579	761	519	0	0	753	671	771	761	0									0	0	420	531	0	####	2573.211	37	8439.24	0	0	16	0
0	0	0	0	0	0	0	0	450	0	0	0	500	0	0	0	0	72	0	450	0	0	0	0	0	0	0	0	0	0	0	0	750	0	0	43.472	38	134.55	0	0	57	0
0	0	0	0	0	0	0	0	450	0	0	0	500	0	0	0	0	720	0	450	0	0	0	0	0	0	0	0	0	0	0	0	5625	0	0	210.189	39	706.83	0	0	56	0
2	1	5	2	5	3	2	2	8	5	2	2	2	2	2	1	6	2	1	2	1	2	9	3	2	16	5	2	10	5	11	12	13	5	14	4.203	40	3.50	0	0	0	5
14	14	4	3	7	3	10	3	8	15	1	3	3	3	4	8	3	3	3	3	7	7	7	8	12	1	1	4	1	12	5	13	1	1	1	5.568	42	5.02	0	0	0	17
2	2	2	2	2	2	1	1	2	2	2	1	2	2	2	2	2	2	2	1	2	1	2	1	2	2	1	1	2		2	2	5	2	1	1.699	43	0.88	1	0	0	32
1	20	4	4	4	4	14	13	7	7	10	15	7	9	10	12	10	14	14	10	4	6	0	0	0	0	16	17	0		0	0	18	0	19	7.233	44	7.15	1	0	8	16
17	19	17	2	18	2	21	21	18	2	2	2	2	2	2	14	20	4	22	4	2	4	2	1	4	1	4	1	14	4	15	16	14	1		9.466	46	7.66	1	0	0	7
31	35	36	12	22	11	23	21	13	4	32	10	33	34	17	19	20	17	7	12	2	12	17	37	26	14	10	21	28	29	30	2	28	26	5	17.338	47	12.84	0	0	0	1
0	16	4	13	18	18	20	29	19	11	12	13	14	15	28	30	31	34	33	32	24	42	13	17	1	2	2	3	4	5	6	7	8	9	2	17.892	51	11.64	0	0	1	4
7	11	7	8	8	8	21	17	8	9	8	10	10	8	8	10	9	12	8	1	20	12	10	3	1	3	2	3	4	2	5	1	6	1		9.575	54	5.40	1	0	0	4
7	10	16	3	9	3	10	2	1	0	7	21	3	7	4	6	7	3	8	3	7	3	0	7	0	2	7	15	16	17	15	7	18	19	7	8.703	55	6.28	0	0	6	1
9	9	15	14	14	14	29	14	25	11	12	13	13	14	17	11	28	13	11	13	26	26	16	1	1	2	2	2	3	4	5	6	2	7	8	14.486	58	7.78	2	0	0	2
2	14	9	2	2	2	7		1	1	3	5	2	5	2	5	5	5	5	5	6	2	1	9	1	1	10	1	11	1	6	6	9	7	12	5.069	59	3.55	2	0	0	8
5	6	7	1	1	1	2	6	1	1	7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	3	1	4	3	1	2.054	60	2.02	0	0	1	52
12	12	2	2	3	2	5	5	1	2	2	2	2	2	2	4	3	2	2	2	2	2	2	2	2	2	5	2	10	2	2	2	2	6	11	3.795	62	3.25	1	0	2	4
7	7	1	1	8	1	1	9	9	1	1	1	1	1	1	13	8	1	1	1	1	1	1	1	1	1	2	1	3	1	4	1	1	5	6	4.479	63	4.29	1	0	3	33
3	3	8	1	2	3	1	1	1	3	1	3	3	1	1	1	3	3	3	3	3	2	1	1	1	0	1	3	1	1	5	1	5	6	3	2.324	64	1.55	0	0	2	30
11	17	18	32	36	14	37	35	12	0	13	14	15	16	33	14	14	14	33	34	14	44	3	4	1	0	2	3	4	5	6	7	8	9	10	20.608	66	11.93	0	0	2	1
30	11	33	3	3	16			1	31	3		3	32	3	6	7	10	3	8	9		34	34	0	2	22	23	24	0	25	26	27	28	29	17.429	68	13.09	4	0	4	1
0	8	1	0	0	0		7	1	6	0	0	7	0	0	0	0	7	7	7	0	15	0	0	0	0	1	2	3	4	0	0	0	0	5	3.699	70	4.21	1	0	33	5
3	7	8	3	16	3	17	5	14	5	3	3	6	3	3	3	3	14	6	6	3	19	3	3	0	3	1	3	3	2	3	3	3	3	4	6.757	72	4.78	0	0	1	1
1	2	1	1	1	1	2	1	1	2	2	2	1	2	0	1	1	1	1	1	2	1	2	1	2	0	1	1	1	1	2	2	2	2	2	1.257	76	0.62	0	0	3	52
10		23	10	11	21		7	1			0	11	0	0	5	2	9	8	6	0	10	16	24	0	0	4	11	4	4			22			9.308	77	8.15	9	0	10	3
	10	11	7	5	3		3	13	7	5	8	3	9	3	3	3	2	3	7	5	7	0	3	1	0	2	3	3	0	4	5	6			4.870	79	3.91	5	0	6	2
0	22	23	9	2	0	10	0	1	18	5	20	21	20	4	6	5	2	2	7	8	3	5	0	18	1	12	5	15	0	19	0	19	20	0	9.784	80	8.41	0	0	9	6
0	1	4	1	2	2	18	1	1	8	8	2	8	8	2	8	1	8	2	17	8	1	8	8	1	8	2	3	4	5	6	8	7	8	9	5.635	81	4.89	0	0	1	11
2	2	2	20	22	18	30	29	8	16	17	18	19	7	6	26	27	29	2	28	21	37	11	11	9	25	10	11	11	12	13	11	39	14	15	16.419	82	11.24	0	0	0	5

2.39	In your opinion, what causes the breakag	**84**	3	13	13	3	7	7	24	3	7								3	7	7	10	8	5	3	9	3	3	3	3	0	15	3	4	3	6	3	3	3	5
2.40	Do you have maintenance skills ?	**86**	2	2	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	2	2	2	2	1	2	2	0	2	2	2	2	1	2	2	2	2
2.41	Who is doing the maintenance of your pi	**87**	3	3	4	4	4	4	4	2	4	4	1	4	4	3	2	4	4	4	4	3	5	4	3	4	4	4	4	4	1	4	1	4	1	4	3	4	7	3	6
2.42	In your opinion is there a need for training	**91**	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	2	2	1	1	1	1	1	1	1
	Specify your biggest training needs?	**92**	4	4	4	3	3	3	4	7	4	7	16	7	4	7	7	5	4	4	21	6	4	24	8	15	15	14	4	4	9	6	8	8	5	4	4	6	17	17	20
2.43	On average how much do you spend on	**95**	5	2	4	9	12	1	2	9	5	1	5	6	2	7	1	2	10	4	4	1	5	9	4	4	4	2	9	9	4	4	4	4	5	2	2	4	5	3	3
2.44	What parts of the pivot/pipes is giving mc	**96**	4	3	2	1	27	26	24	4	24	6	6	23	22	6	0	4	22	27	45	5	44	47	0	34	34	22	25	41	42	43	6	6	6	25	31	39	26	30	40
2.45	Are spare parts easily obtainable ?	**100**	3	2	0	2	3	3	3	3	2	2	1	1	3	1	1	2	2	3	1	0	3	3	1	0	1	3	2	2	2	1	1	0	1	3	2	2	1	2	2
2.46	How many times have you reported a bre	**101**	4	3	2	1	3	6	14	6	13	8	6	9	13	13	4	5	6	6	9	6	1	1	21	6	15	1	1	9	20	10	7	1	5	10	13	6	15	16	6
3	**SOIL**																																								
3.1	What is your soil type ?	**102**	9	2	7	1	2	3	2	1	0	3	1	5	5	4	5	3	8	4	0	5	3	2	5	3	1	3	5	1	4	7	10	5	1	1	6	4	3	4	5
3.2	How deep is your soil ?	**103**	3	2	1	1	3	14	5	3	0	0	3	5	15	10	5	3	3	3	0	4	14	15	7	6	3	3	3	3	11	6	6	3	3	13	1	10	10	11	11
3.3	What is the soil structure ?	**104**	6	0	3	2	2		12	8	0	3	2	2	2	3	2	2		1	0	2	7	2	2	3	2	6	2	2	3	1	2	2	1	2	4	6	3	4	4
3.4	In your opinion how can the slope affect y	**105**	0	3	2	1	0	20	6	6	0	19	18	0	17	16	7	4	5	38	0	5	37	39	5	35	36	32	33	32	0	34	0	0	21	30	24	0	31	0	0
3.5	How can the structure affect the irrigatior	**108**	0	16	21	10	11	24	7	23	0	28	27	9	26	11	0	22	19	18	17	9	4	20	0	15	16	12	13	14	0	7	0	0	1	10	5	0	11	0	9
3.6	What is your land's water holding capacit	**111**	4	3	2	1	15	0	0	5	12	14	14	10	13	0	0	4	0	19	0	4	18	18	0	8	10	0	0	0	4	0	0	0	0	0	0	16	10	0	17
3.7	How do you determine the moisture conti	**113**	14	6	4	10	2	18	9	4	0	1	6	1	10	13	6	13	6	10	13	1	13	5		6	6	10	10	5	11	5	15	4	1	2	6	1	9		4
3.8	What is evaporation ?	**115**	3	2	0	1	4	0	0	1	0	0	3	1	1	0	0	0	1	1	3	0	0	5	0	1	1	1	1	0	0	0	1	4	0	1	1	0	1	0	0
3.9	How does evaporation affect your irrigatic	**117**	3	3	0	8	12	0	0		0	0	2	4	11	0	0	0	6	2	4	0	0	3	0	5	4	1	1	0	0	0	9	2	0	1	3	0	4	0	0
3.10	What is the root depth of the barley crop	**119**	3	1	2	1	12	12	0	5	1	0	6	6	11	9	5	4	16	1	0	5	0	5	12	9	9	12	15	6	6	4	0	3	9	11		0	9	6	6
3.11	What is the relationship between the spe	**120**	10	5	5	10	5	10	5	12	10	1	10	4	10	5	10	10	11	10	5	4	5	6	5	1	5	10	1	0	2	10	0	6	1	10	7	2	5	5	4
3.12	What would you say is the best way of wa	**122**	0	1	15	9	23	22	10	12	0	0	1	3	9	15	3	7	13	9	12	12	0	5	8	1	1	10	9	7	2	11	8	6	1	9	7	8	1	5	5
4	**FERTILIZATION**																																								
4.1	What type of fertilizers do you use on the	**125**	6	5	4	3	19	0	18	8	17	4	5	11	3	2	0	7	2	3	0	0	0	14	27	26	5	3	3	3	21	0	0	14	20	14		25	5	23	14
4.2	What is your nitrogen content requiremer	**129**	15	2	0	14	24	0	0	2	0	0	23	0		0	16	0	11		0	0	0		0	2	10	0			0	0	0	1	1	0	4	6	9	3	7
4.3	How much topdressing do you give ?	**130**	5	5	4	3	19	0	0	6	0	7	17	5	5	16	7	5	11	3	0	0	22	10	7	7	18	14	12	11	5	21	0	5	5	0	12	7	12	16	20
4.4	When (if any) do you apply the topdressir	**131**	2	2	2	2	15	5	2	2	3	2	1	7	2	7	1	3	2	2	4	4	2	18	13	1	1	2	2	2	12	1	5	7	1	2	1	5	1	1	17
4.5	What problems have you encountered ca	**132**	1	1	2	1	2	1	1	2	1	1	1	1	1	1	1	1	2	2	1	1	1	1	1	1	1	5	1	1	1	2	3	1	1	1	1	2	1	1	1

5	7	5	6	8	12	3	7	1	21	22	3	1	5	5	3	3	3	3	3	11									17	18	20	19	5	5	7.865	84	6.22	0	0	1	2
2	2	2	2	2	2	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	2	2	2	2	1	2	1	1	2	1	1.770	86	0.45	0	0	1	15
4	4	4	3	4	2	2	4	2	4	3	3	3	3	3	3	3	3	4	5	4	4	4	8	8	1	4	8	4	8	4	5	4	2	9	3.811	87	1.60	0	0	0	5
1	1	1	1	1	1	1	1	2	1	1	1	1	2	1	1	1	1	1	1	1	1	1	2	2	2	1	1	1	2	1	2	1	1	1	1.135	91	0.34	0	0	0	64
4	15	4	6	18	22	19	4	8	5	12	13	14		14	17	17	7	17	17	11	23	9	8	8	8	4	9	9		10	8	4	9		9.423	92	5.79	3	0	0	0
9	9	4	4	7	7	8	5	2	2	1	7	7	11	1	6	6	6	6	7	7	9	11	11	9	1	2	11	11	11	1	11	1	11	4	5.459	95	3.29	0	0	0	9
13	18	19	36	37	14	38	35	29	6	15	16	17	15	15	32	33	36	23	34	14	46	9	20	7	28	8	9	8	7	10	7	11	8	12	20.365	96	13.60	0	0	2	1
3	3	4	2	2	2	2	2	1	1	1	2	2	2	0	2	2	2	2	2	2	2	3	3	3	1	3	2	3	3	2	3	2	2	3	1.973	100	0.91	0	0	5	15
1	13	1	12	11	11	19	10	15	6	11	11	12	0	17	15	3	12	18	3	10	1	8	9	0	1	1	8	9	0	1	8	0	9	3	7.703	101	5.53	0	0	4	12
4	4	1	5	4	4	2	2	3	5	4	5	6	4	3	5	2	5	3	6	4	4	4	5	3	3	9	6	5	0	5	4	5	2	5	3.838	102	2.08	0	0	3	8
10	13	1	6	14	13		17	16	11	11	7	3	12	17	13	3	13	14	13	7	10	7	14	3	5	3	5	7	7	0	7	7	8	9	7.233	103	4.85	1	0	4	4
	0	11	2	3	3		5	2	2	2	2	3		3	2	2	2	2	2	2	3	3	2	9	3	6	10	0	0	0	0	0	10	0	2.986	104	2.69	5	0	10	3
6	14	15	28	0	0	29	27	23	0	0	0	13	0	0	25	22	3	0	26	0	5	0	0	8	0	9	0	10	0	0	0	0	11	12	11.378	105	12.90	0	0	28	1
0	0	25	7	6	0		7	4	9	0	11	0	9	0	0	2	8	0	6	9	0	0	0	0	3	24	9	0	0	0	9	0	0	0	7.986	108	8.43	1	0	27	1
0	10	11	0	0	0		0	14	0	9	0	0	0	4	0	0	0	0	0	0	0	0	12	0	0	0	0	0	10	0	8	6	7	0	4.274	111	5.92	1	0	41	1
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