South African Barley Breeding Institute

SABBI

GUIDELINES FOR THE PRODUCTION OF MALTING BARLEY UNDER IRRIGATION

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GUIDELINES FOR THE PRODUCTION OF MALTING BARLEY UNDER IRRIGATION

G J Kotzé
SAB Maltings (Pty) Ltd
P O Box 402 / KIMBERLEY / 8300
Tel: 0861722525 / Cell: 082 921 7966

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From the results obtained from the research programme as well as experience from some commercial plantings in this area in the past, the following recommendations can serve as guidelines for the production of malting barley.

Soil Preparation

Soil preparation for the production of barley is the same as for wheat. It must, however, be emphasised that a fine and very even seedbed is prepared. An uneven seedbed causes uneven development of the crop and in the end also uneven ripening and quality.

Cultivars

The barley cultivars, Cocktail and Puma are at this point in time the recommended cultivars for commercial production of malting barley under irrigation. During the 2011 season it is planned to produce 25 000 tons of Cocktail, 22 000 tons of Puma and 3 000 tons of SSG 585. It is important to note that the 2011 season will be the last season that SSG 585 will be accepted as malting grade barley. This step is only to get the last seed out of the system and no further seed multiplications of this variety will be done and producers must not hold back any seed.

The malting characteristics of these cultivars differ and for this reason the mixing of these cultivars must be prohibited at all costs. It is thus imperative that the different cultivars are transported, handled and stored separately.

Seed of the three commercial cultivars will be available at the local co-operative and only at the depots as communicated prior to the planting season. The seed will be treated with a fungicide as well as an insecticide. This is for the prevention of powdery mildew during the development stages (approximately 10 weeks) of the seedlings and also to prevent covered smut and loose smut, while the insecticide will protect the seed against insect damage for a limited period before it is planted.

Agronomic characteristics

Cultivar choice is economically a very important decision to the producer as it is one of the easiest ways to achieve higher and more stable income with the least risk. Factors that determine cultivar choice are thus fundamental to this decision. Only the most important factors are discussed briefly and for this reason Table 1, which characterises cultivars in terms of agronomic and quality characteristics, is included.

Growth period

Growth period refers to the average number of days that it takes from emergence to physiological maturity. For this reason cultivars must be planted that are adapted to the climatic conditions, such as growing season, rainfall pattern and temperature of the area.

Straw strength

Straw strength is the ability of a cultivar to remain standing (no lodging) under extreme conditions and is largely determined by straw length and thickness. The lodging of barley often results in considerable yield and grain quality losses, which can largely be attributed to the resulting decrease in kernel plumpness. It is largely a problem where critical yield potential conditions have been exceeded, but bad irrigation practices with a strong wind and excessive nitrogen fertilisation and/or seeding density can also play a role.

Peduncle strength

This characteristic refers to the strength of the straw between the flag leaf and the head/ear, and thus to the susceptibility of the cultivar to wind damage (Table 1). The greatest risk of the latter is just prior to harvesting.

Kernel plumpness

The percentage plump kernels largely determines the grade of the grain. This characteristic is strongly cultivar related (Table 1). Under conditions where soil water deficits and heat stress occur during the grain filling period and where lodging occurs, considerable losses could occur with the downgrading of the crop due to a low kernel plumpness percentage.

Table 1. Agronomic and quality characteristics of barley cultivars

Cultivars	Growth period	Straw length	Straw strength	Peduncle strength	Kernel Plumpness (%)
Puma	ME	MS	G	M	M
Cocktail	M	MS	G	M	ML

Growth period: ME = Medium Early; M = Medium
Straw length: MS = Medium Short
Straw strength: G = Good
Peduncle strength: M = Medium
Kernel Plumpness(%) M = Medium; ML = Medium Low

Planting Practices

The planting equipment used for the planting of wheat is also suitable for the planting of barley. It is very important that barley is not planted too deep, because this can be detrimental to emergence of the seedlings and also tillering.

The optimum planting dates for the different irrigation areas are as follows:

Region	June				July			
	1	2	3	4	1	2	3	4
Vaalharts / Taung	■	■	■					
Riet River			■	■	■			
Douglas			■	■	■			
Luckhoff/Hopetown			■	■	■			
Barkly-West		■	■	■				

These are only optimum planting dates and do not mean that in certain micro-climates in the mentioned areas, a later or an earlier planting date will not be successful.

The planting density can vary from 65 kg/ha to 100 kg/ha depending on the status of the seedbed, the planting date, irrigation method and the planter used. The average recommended planting density is 80 kg/ha if the seed have 100% germination capacity and a thousand kernel mass of approximately 40 grams. Their must be aimed at establishing 130 to 140 plants/m² at harvesting. Due to this reason 65 to 80 kg seed per hectare ought to be sufficient under centre pivot conditions where seedbed preparation is optimum, It is important to note that seedbed preparation plays a vital role where lower planting densities is used. Under flood irrigation conditions the planting density should be adjusted upwards. The producer must be aware of the fact that the thousand kernel mass and the germination capacity of the seed can vary from year to year and that he must adjust his seeding density accordingly.

The following table indicates the planting density in kg/ha at the different 1000 kernel masses of the seed in order to realise the **desired number of plants/m² at harvesting,** with an expected survival of 80%.

PLANTING DENSITY IN Kg/Ha												**80**		**% Germination**		
1000 Kernel Weight (g) of Seed	TARGET NUMBER OF PLANTS/M² AT HARVESTING															
	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250
35	44	48	53	57	61	66	70	74	79	83	88	92	96	101	105	109
36	45	50	54	59	63	68	72	77	81	86	90	95	99	104	108	113
37	46	51	56	60	65	69	74	79	83	88	93	97	102	106	111	116
38	48	52	57	62	67	71	76	81	86	90	95	100	105	109	114	119
39	49	54	59	63	68	73	78	83	88	93	98	102	107	112	117	122
40	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125
41	51	56	62	67	72	77	82	87	92	97	103	108	113	118	123	128
42	53	58	63	68	74	79	84	89	95	100	105	110	116	121	126	131
43	54	59	65	70	75	81	86	91	97	102	108	113	118	124	129	134
44	55	61	66	72	77	83	88	94	99	105	110	116	121	127	132	138
45	56	62	68	73	79	84	90	96	101	107	113	118	124	129	135	141
46	58	63	69	75	81	86	92	98	104	109	115	121	127	132	138	144
47	59	65	71	76	82	88	94	100	106	112	118	123	129	135	141	147

The data of the previous four seasons are shown in the following three tables.

Table 2. Average yield (ton/ha) of barley cultivars in the irrigation regions for the period 2007-2010

Cultivar	2007	2008	2009	2010	Average
Puma	8.78	8.14	6.70	6.52	**7.54**
Cocktail	8.94	9.14	6.99	7.61	**8.17**
Average	8.86	8.64	6.84	7.06	**7.85**

Table 3. Average kernel plumpness (%) of barley cultivars in the irrigation regions for the period 2005-2008

Cultivar	2007	2008	2009	2010	Average
Puma	92.1	95.4	93.1	90.2	**92.7**
Cocktail	85.6	91.0	86.4	83.8	**86.7**
Average	88.9	93.2	89.8	87.0	**91.5**

Table 4. Average kernel nitrogen (%) of barley cultivars in the irrigation regions for the period 2005-2008

Cultivar	2007	2008	2009	2010	Average
Puma	1.78	1.68	1.86	1.95	**1.82**
Cocktail	1.65	1.56	1.75	1.78	**1.69**
Average	1.89	1.62	1.81	1.87	**1.75**

FERTILISATION

Soil acidity requirements

The management of an effective fertilisation programme entails soil analyses just prior to the season. As is the case with all crops, a fertilisation programme can only be successful if the crop's minimum acidity requirements are met. For barley this has been established at a pH of 5.5 (KCl medium) and the target for lime application to the soil should therefore be to create a pH of 5.5 to 6.0. The pH of the soil can rather be higher than 6.0 than lower than 5.5. Yield losses could be severe at lower pH values, but could also occur if the pH is injudiciously raised by more than one pH unit. Unnecessary increases in pH could lead to zinc and manganese deficiencies, something to which barley is very sensitive.

Phosphorus

It is generally accepted that the phosphorus requirement of barley is higher than that of wheat, and that soil analyses are essential for estimating the fertilisation requirement. The objective should be to reach 30 mg/kg citric acid soluble phosphorus, or 20 mg/kg Bray 1 soluble phosphorus in the soil. To achieve this, 4 kg P/ha can be applied for each 1 mg/kg which the analyses is below 30 mg/kg (citric acid), or 6 kg P/ha for each 1 mg/kg which the analysis is below 20 mg/kg (Bray 1). For analyses higher than the above, 12 to 15 kg P/ha is applied, which is adequate to maintain soil fertility.

Potassium

Potassium deficiencies are possible in the lighter textured soils in the irrigation areas and where deficiencies do occur, the following guidelines apply:

Table 5. Potassium fertilisation according to soil analysis

Citric acid soluble or ammonium acetate soluble Potassium (mg/kg)	Potassium fertiliser (kg K/ha)
20 - 30	40 - 30
30 - 50	30 - 15
50 - 70	15 - 0

In soil analyses below 50 mg/kg an extra, 15 kg k/ha can be applied for each ton of hay baled or removed. Experience had shown that a split application of potassium (with planting and at 8 weeks after planting) can decrease the risk of lodging.

Nitrogen

Nitrogen fertilisation can be applied at different growth stages during the development of the barley plant. Under dryland conditions, rainfall is regarded as the most important factor for determining the nitrogen requirements of barley. Under irrigation this is, however, not such a decisive factor and the production system and soil type play a more important role. The first nitrogen is applied just prior to or during the planting process. Top dressing of nitrogen is, according to trial results, beneficial to higher yields and more so for overhead irrigation than flood irrigation. Split applications of nitrogen fertiliser are also more beneficial on lighter sandy soils than on heavier clay soils.

With the increase in yield over the last couple of years, mainly due to genetic improvement, improved production practices and optimum irrigation scheduling, it appears that a total nitrogen application of 140 kg/ha, depending on the soil texture and rotation system seems to be sufficient for optimum yield and quality. It must further be taken into account that the newest addition to the commercial cultivars, Cocktail, has a genetically higher yield potential and lower kernel nitrogen content than the other cultivars. Due to this Cocktail must be fertilised with approximately 20 to 30 kg N/ha more in order to obtain its genetic potential to achieve the same kernel nitrogen levels than the other cultivars.

On a cotton rotation system, and where a lot of maize harvest rests are present just prior to planting, the nitrogen application rate can be higher (approximately 20 - 30 kg N/ha more, depending on the soil texture) and must be applied as a split application to overcome the nitrogen negative period. On very sandy soils, where leaching of nitrogen is a major problem, an additional 20 kg N/ha is also recommended. Although it is not recommended to plant barley directly after lucern, this practice is widely used. It is important to note that under this condition, N fertilisation needs to be decreased to 100 kg/ha and preferably all applied with planting. Split application of nitrogen fertilisation is more important under overhead irrigation (specifically centre pivot) and sandy soils than under flood irrigation and heavy clay soils. A split of two thirds of the total nitrogen with planting and the rest 6 weeks after emergence, seem to give the best results. On very sandy soils where leaching is a problem and a history of low nitrogen content in the grain is experienced, the topdressing can be applied at a later stage but not later than the flag leaf stage. Barley tends to dislike a small application of nitrogen with planting followed by a couple of topdressings. Limestone ammonium nitrate (LAN) appeared to be the best source of nitrogen for topdressing and where nitrogen topdressing is applied through the irrigation system, an ammonium nitrate based fertiliser is recommended. It is also recommended that some part of the nitrogen that is applied at planting, is ammonium nitrate based. Additional nitrogen topdressing after exceptionally heavy rains could be economically beneficial as late as 65 to 70 days after emergence.

POST SEEDING PRACTICES

Weed control

Together with fertilisation, the control of weeds can be seen as most important. Barley is very sensitive to competition of weeds and even more so in the early developmental stages of the plants. Early control measures will therefore enhance the yield potential of barley and must preferably be done as soon as possible after most weeds have germinated and infestation is high enough to justify control measures. The same guidelines as for weed control in wheat apply for barley. Weeds must be correctly identified (broadleaf and grass weeds) because different herbicides are used for the control of broadleaf and grass weeds. The only herbicides for the control of grass weeds in barley are Hoelon/Ravenger and Grasp. Under no circumstances must herbicides like Topic and Puma be sprayed on barley. The correct amount of herbicide, as recommended on the label, must be applied because too high dosages can be detrimental to the barley plant and too low dosages will be ineffective. Only herbicides registered specifically on barley, according to the label, are allowed to be used.

Insect control

Barley is a natural host plant for the well known Russian wheat aphid and some other plant aphids. For early infestation by aphids, an insecticide can be applied with the herbicide. For a late infestation an insecticide has to be applied on its own. The same guidelines apply as for wheat. Barley is, as wheat, susceptible to bollworm damage and the same guidelines for bollworm control apply as for wheat.

Currently leaf miners also seem to become an increasing problem in all production areas. For the interim an emergency registration was obtained on the product Unimectin 18EC for the control of leaf miners.

During the 2010 season the false armyworm caused huge damage to plantings, especially in the Vaalharts area. It was, however was noticed throughout the entire production areas and producers must be on the lookout for this insect. In Australia this is a sporadic plague and not necessary a year to year phenomenon. The Small Grain Institute is currently hard at work to determine a control strategy for this plague. Although no insecticide is specifically registered for the control of false armyworm, the general feeling is that insecticides used for the control of bollworm can also be successful for the control of false armyworm. The Small Grain Institute also plan to put out traps this coming season to monitor moth flights of the false armyworm. By doing this agriculturalists can notify producers in advance of a possible infestation.

Growth regulation

Although the new cultivars Cocktail, Puma and SSG 585 (in order of straw strength) are more resistant to lodging than Chariot was, it is also prone to lodging under very high potential conditions and more so under overhead systems. This problem can be minimised if the crop is not over-irrigated during the early stages of plant development. If the producer is of the opinion that his barley is too lush during the early growth stages and feel that lodging may become a problem, he can stress his crop by applying less water for the period 10 to 14 weeks after planting. At this specific stage, water stress will have the least negative effect on yield.

Lower planting densities (<140 plants/m²) can also play a significant role in the decrease of lodging given that the seedbed preparation is optimal. Higher seeding densities (>140 plants/m²) leads to longer plants with weak straw, which is caused by excessive competition for air and light.

Lodging can also be limited by applying a growth regulator, but presently no growth regulator is registered on barley in South Africa. Trials that were executed for registration purposes showed that these growth regulators did more harm than good.

The only way therefore to minimise lodging is not to:

- apply too much nitrogen fertiliser,
- use a too high planting rate,
- over irrigate during the early growing stages of the crop,
- apply too heavy irrigation during the ripening stage of the barley and
- apply irrigation when strong winds prevail.

Fungal control

Fungal diseases do not seem to be a problem in barley under the dry and hot conditions in the irrigation areas. If any diseases do appear in the barley, a representative of SAB Maltings must be informed immediately for the necessary recommendations.

Fungal contamination of the barley grain in this area is, however, common. Some of these fungi can produce toxic substances (DON) that can be detrimental to humans and livestock. It is therefore essential that the crop must be harvested as soon as it is ready, in order to minimise the risk of ripe barley being exposed to rain during harvesting.

Irrigation
Irrigation scheduling must be according to evaporation and needs, as per growth stage. This information is available from your SAB Maltings representative. It is, however, very important that irrigation is not stopped too early and the last irrigation must be applied when the total plant is almost discoloured. This is to ensure an even ripening and to produce grain with a high percentage kernel plumpness and acceptable nitrogen content. As mentioned, skillful irrigation practices can minimise lodging and optimise yield and quality (Refer to section under growth regulation).

HARVESTING

In the traditional barley producing area, barley is swathed and windrowed before it is threshed. This is mainly done to reduce the risk of damage by strong winds. Barley ears bend downwards when they mature and are prone to be blown off by strong winds and this can cause huge yield losses. The producers in the irrigation areas, however, are not equipped for this practice. It is therefore crucial that the barley must be harvested as soon as it reaches a moisture content of 12.5% in order to minimise the risk of ripe barley being exposed to possible damage by wind and hail for prolonged periods. Barley can be harvested with the same equipment as for wheat with minor adjustments to the drum speed, concave setting and wind. Since the contracts are for the supply of malting barley, it is essential that skinning of the grain be avoided during harvesting. Skinning impairs germination and introduces problems during malting. Thus the combine harvester operation should not be as aggressive as for wheat and care should be taken to avoid an excessively fast drum speed and/or an excessively tight concave setting.

The barley must be harvested in bulk (except where other arrangements have been made) and delivered at the depot as stipulated on the contract or as communicated during the growing season, where it will be sampled, classified and graded. The producer then gets paid according to quantity and quality. Producers will get paid for quality on a sliding scale system as stipulated in the contract.

QUALITY

As from the 2011 season the sliding scale and the consequent payment for quality of barley will be adjusted. Although the cut-off points will not be adjusted drastically the different categories within each quality parameter will differ from the previous season. It is therefore important that producers must verify these changes with their nearest SABM agriculturalist, grain dealer or member of the Barley Industry Committee.

Maltsters require barley that malts homogenous and modifies quickly, requires no or little cleaning and that will deliver malt of an acceptable and consistent quality to brewers. For this reason maltsters set certain quality standards for malting barley to ensure that the end product is produced the most economic way possible.

Nine characteristics, viz. cultivar purity, germination, nitrogen content, kernel plumpness, screenings, foreign matter, mechanical damage, fungal infestation and moisture content are of critical importance in grading and are discussed briefly.

Germination/cultivar purity
Malting barley differs from most cereals as it has to grow again during processing. Germination refers to the percentage barley kernels that are viable within a specified time. It is the most important characteristic of malting barley and must be higher than 97% after the breaking of the dormancy period. Different cultivars have different dormancy periods (rest periods) and therefore it is important that cultivars are not mixed, but stored separately.

The viability or germination energy of barley can be affected by rain prior to harvesting. If barley is subjected to rain when ripe, biochemical processes in the kernel are initiated that precede germination. The result is uneven or poor germination of the barley during the malting process and produces a poor end product.

Nitrogen content
Barley with extensively high or low nitrogen content cannot produce malt of the required quality for brewing purposes. The sliding scale, according to which the price of barley is determined, is based on a base price onto which premiums are added for

certain nitrogen levels in the grain. It is important to note that the cut-off and turning points will differ for the coming season and must be confirmed with grain traders.

Nitrogen content of barley is a characteristic that is genetically, as well as environmentally, influenced. Certain cultivars (Cocktail) produce lower nitrogen content despite higher nitrogen fertilisation. Such a characteristic of a cultivar would be beneficial as it is not only high nitrogen fertilisation that increases the nitrogen levels in the grain, but also uncontrollable factors such as drought and heat stress during the grain filling period and the nitrogen supply capacity of the soil. The producer must at all times also consider the nitrogen supply capability of his soils. Soil tillage and the preceding crop are some of the important factors to keep in mind.

Kernel plumpness

Kernel plumpness is important for homogeneity during the malting process. Thin kernels take up water faster than plump kernels. Thin kernels also have a relatively higher percentage husk, which can give beer a bitter taste. Therefore more uniform kernel plumpness will result in better malt quality. The sliding scale for plump kernels is such that more is paid pro rata for barley with a kernel plumpness that increases, measured above a 2.5 mm sieve. As in the case of nitrogen content, the cut-off point that will be in place for the coming season must be confirmed with the grain handlers.

It is also important to note that plump kernels produce malt with a higher extract, which is an important aspect in the brewing process. A low kernel plumpness percentage is the result of unfavourable conditions during the grain filling period, as late ears ripen too fast or if the initial yield potential exceeds the capacity of the environment at the grain-filling stage. Certain cultivars however, also tend to constantly have a lower kernel plumpness and for this reason breeders specifically select for lines with high kernel plumpness. The kernel plumpness of all the present barley cultivars can be described as good to very good.

Screening, foreign matter and mechanical damage

Screenings is material that is so small that it falls through a 2.2 mm sieve. This material generally consists of shrivelled kernels, broken kernels, small weed seeds, glumae, awns, dead insects and dust. There is a base price for barley deliveries within certain specifications and an increasing premium for deliveries with a less screenings. Again the cut-off points must be confirmed with the grain handlers. Thin kernels can be ascribed to factors noted, while broken kernels, glumae, awns and dust generally reflect on harvester adjustments. For this reason it is imperative that the producer adjusts his harvester correctly to ensure good quality, a good grade and thus a good price.

Dead weevils in the screenings are usually an indication of a possible infestation and this would require further investigation. The presence of weevils can lead to downgrading of the crop due to the live insects on the one hand or the presence of insect damaged kernels on the other hand.

Foreign matter's cut off point is 2%, while a price incentive applies for foreign matter under 1%. A base price is applicable for barley with a foreign matter content between 1% and 2%, but a feed grade price is applicable for barley with a foreign matter content >2%.

Mechanical damage by harvesters decreases the percentage of usable barley kernels. When embryos are damaged or, husk over the embryo is removed, the kernels cause problems in the malting process. A too high percentage of endosperm exposed kernels results in several processing problems in the malting process (fungal growth, foam in steep tanks etc).

Fungal infection

Malting barley infected with fungi is not considered fit for human consumption and is downgraded to undergrade. Some fungi produce mycotoxins (DON) when under stress. Fungal infection usually takes place when grain, that is ready for harvesting, is subjected to continual moist conditions or when barley with too high moisture content is harvested and stored on the farm under unfavorable conditions. Barley with a high moisture content (>12.5%) should be dried according to specifications as soon as possible. Barley cultivars have no genetic resistance to these fungi that occur on the grain.

Moisture Content

Malting barley that is delivered and stored with too high a moisture content can lead to fungal development and also a decrease in germination capacity. Due to this reason no malting barley with a moisture content of higher than 12.5% will be accepted and a pro rata premium is paid for grain as the moisture content decreases from 12.5% to 9.5%.

As from the 2005 season a system was implemented by which the producer is obliged to submit a passport before he can deliver his first load of barley. This barley passport entails a schedule that has to be completed by the producer in co-operation with his chemical agent and must clearly stipulate which chemicals have been applied on the barley as well as when it was applied, how it was applied and the dosage used. It is therefore of the utmost importance that the passport has to be fully completed and handed in at the delivery depot before any grain will be accepted.

Lastly it is also important to note that no grain will be accepted that was treated with an unregistered chemical, unregistered dosage or unregistered application method. For more information the local SAB Maltings representative can be contactedGermination/cultivar purity

BARLEY PASSPORT

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SUMMARY

The production of barley of good quality with an optimum yield, starts and ends at the producer and the following points are of the utmost importance:

- pH of the soil must be higher than 5.5 (KCl) and preferably between 5.5 and 6.0 (KCl).
- Phosphate status of the soil must be sufficient (30 mg/kg citric acid soluble P) or of such a nature that it can be rectified with a one-time application.
- Planting date is of the utmost importance and barley must be planted during the optimum recommended planting date for the specific area.
- Planting density may vary between 65 and 100 kg/ha depending on the status of the seedbed, irrigation method and the planting equipment that is used. Germination capacity and thousand kernel mass must also be taken into account.
- A total nitrogen fertilisation of 140 kg/ha (depending on the soil type) is optimal in terms of yield and quality. On a cotton rotation system and where a lot of maize stubble are present on the land, as well as on very sandy soils, the nitrogen application rate can be higher (+ 20-30 kg N/ha) and must be applied as a split application to overcome the nitrogen negative period. Directly after lucern the N fertilisation needs to be decreased to 100 kg/ha and preferably all needs to be applied with planting.
- Split application of nitrogen fertilisation is more important under overhead irrigation (specifically centre pivot) than under flood irrigation and also on lighter sandy soils. A split of two thirds of the total nitrogen with planting and the rest 6 weeks after emergence, seem to give the best results. In the case of very sandy soils the topdressing can be split into two applications. The last one must, however, not be applied later than the flag leaf stage.
- If lodging of barley seems to be a problem, it can be limited with discreet irrigation, planting and fertilisation practices.
- Irrigation scheduling must be according to evaporation and needs as per growth stage. Irrigation must not be withdrawn too early and the last irrigation must be applied when the crop is almost completely discoloured.
- Harvesting must commence as soon as the crop is ready for threshing (12.5% moisture content) in order to minimise possible damage by wind and hail, as well as weather damage of grain (fungal contamination).
- The combine harvester operation should not be as aggressive as for wheat in order to avoid skinning.
- Only use registered chemicals, at the registered dosage and according to the registered application method.

Barley can compete very well with wheat in the central irrigation area with regard to quality and yield, if above-mentioned criteria are adhered to and climatic conditions do not differ significantly from the long-term average.

For any further information, you can contact one of the following SAB Maltings agricultural advisors:

Burrie Erasmus (Hartswater)	*082 921 7967*
Johannes Kokome (Taung)	*082 921 7981*
Frikkie Lubbe (Kimberley)	*082 921 7994*