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Barley is, after wheat, the most important small grain in South Africa. The cultivation area for malting barley under dry land conditions is at present restricted to a very specific region, viz. the Southern Cape, which stretches from Bot River in the west to Heidelberg in the east.

There are various advantages attached to the arrangement that production of a relatively minor commodity, such as malting barley, is restricted to certain and specific areas. Production is concentrated, which facilitates transport, storage and control. Extension and research are cheaper and facilitated more readily. The single most important disadvantage is, however, that the risk of unpredictable weather conditions cannot be reduced and therefore barley production has also been introduced to the Cooler Central irrigation areas.

For the purpose of these production guidelines only malting barley cultivars will be discussed.

Plant Breeders' Rights (Act 15 of 1976)

The act renders legal protection to the breeders and owners of cultivars. The awarding of rights stipulates that cultivars must be new, distinguishable, uniform and stable, and protection is granted for a 20 year period. The rights of the owner/ breeder entail that no party may multiply propagating material (seed), process it for planting, sell it, import it, export it or keep it in stock without the necessary authorization or license of the holders of the rights. The act makes provision for the court to grant compensation of R10 000.00 to the holder of Plant Breeder's Rights in cases of breaching of rights.

Seed certification and Table 8, as described in the Plant Improvement Act

The main aim of certification of seed is to maintain cultivars. Seed laws and regulations prescribe the minimum physical requirements, while certification of seed strives to achieve high standards of genetic purity and other quality requirements. Seed certification is a voluntary action that is administered by SANSOR on behalf of the Minister of Agriculture. However, if a cultivar is listed in Table 8, it is subject

to compulsory certification. Hereby cultivator purity as well as good seed quality is guaranteed, and renders protection and peace of mind to the buyer (farmer), as

well as an improved control system for acting on complaints and claims. The costs involved are surely a minimal price to pay for the peace of mind of both the buyer and seller of certified seed.

Cultivars

At present four cultivars are recommended for malting barley production in the Southern Cape, viz. Kadie, Hessekwa and Elim. The malting characteristics of these cultivars differ especially in terms of their dormancy (period from harvesting up to the stage where the barley meets the germination requirements for malting), and for that 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.

As it is difficult to distinguish between some cultivars in the field, it is imperative that chances for mixing are prevented. The first possibility for mixing is on the farm itself. This can be prevented by not planting a different cultivar to the one planted on that land the previous year. Producers must also ensure that planters and harvesters are cleaned thoroughly before moving to a field with a different cultivar. The chances of mixing are also greatly reduced if only one cultivar is grown on a farm.

The retaining of grain as seed for the next year is strongly discouraged. The problems of maintaining cultivar-pure and insect free seed with good viability safely on the farm is the reason why seed should not be kept back by producers.

Agronomic Characteristics

Economically cultivar choice is a very important decision for 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.

Table 1. Agronomic and quality characteristics of barley cultivars

Cultivars	Growth period	Straw length	Straw strength	Peduncle strength	Kernel plumpness
Kadie	ME	MK	G	G	H
Hessekwa	M	M	G	MG	H
Elim	ML	M	G	MG	H

E = Early *ME = Medium early* *M = Medium* *S = Short*
MS = Medium short *ML = Medium long* *L = Long* *MG = Medium good*
G = Good *MH = Medium high* *H = High* *P = Poor*

Growth period

Growth period refers to the average number of days that it takes from emergence to physiological maturity (Table 1). For this reason cultivars that are adapted to the climatic conditions, such as growing season, rainfall pattern and temperature, of the area must be planted.

Straw strength

Straw strength is the ability of a cultivar to remain standing (un-lodged) 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 increased infestation of fungal plant diseases. It is largely a problem where critical yield potential conditions have been exceeded, but rain with a strong wind and excessive nitrogen fertilization can also play a role.

Peduncle strength

This characteristic refers to the strength of the culm 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. It is advisable to rather cut the crops into windrows prior to harvesting if the cultivar is susceptible to this phenomenon.

Kernel plumpness

The percentage plump kernels largely determine the grade of the grain. This characteristic is strongly cultivar related (Table 1). In areas where soil water deficits and heat stress occur during the grain filling period and where certain plant diseases, such as *Rhynchosporium commune* (scald), are common, considerable losses could occur with the downgrading of the crop due to a low kernel plumpness percentage.

Disease characteristics

In the Southern Cape, barley cultivars are often infected by various fungal diseases. Depending on environmental conditions, the levels of infestation differs from year to year. Although different levels of resistance against these fungal diseases exists, a complete spraying programme should still be followed. High levels of infestation has a negative influence on the yield and quality of the harvest.

Table 2 gives an indication of the resistance status of the cultivars to the most important fungal diseases in the area. The nomenclature used to indicate status can be explained as follow:

- Susceptible: The cultivar has no resistance against the pathogen and the disease spreads fast when conditions are favourable.

- Moderately susceptible: The cultivar has no resistance against the pathogen but the spreading of the disease is slightly slower under favourable conditions and under less favourable conditions it can be less harmful.

- Moderately resistant: The cultivar has quite good but not complete resistance against the pathogen. Although symptoms can be observed, the development of the disease is slow and it normally has little effect.

- Resistant: No scars or evidence of the disease is visible.

Table 2. Disease resistance of cultivars in the Southern Cape

Cultivars	Leaf blotch	Net form Net blotch	Leaf rust	Spot form Net blotch
Kadie	MR	MR	MR	MS
Hessekwa	R	MS	MR	MS
Elim	MR	MR	R	S

S = Susceptible *MS = Moderately Susceptible*
MR = Moderately resistant *R = Resistant*

Quality

Maltsters require barley that malts homogeneous and modifies quickly, requires no or little cleaning and that will deliver malt of an acceptable and consistent brewing quality. Therefore, maltsters set certain quality standards for malting barley to ensure that the end product is produced in the most economical 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 germinate 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 98% after the breaking of the dormancy period. It is very important that cultivars are not mixed, but stored separately due to the fact that they differ with regards to their malting characteristics. To qualify as malting barley a cultivar needs to be 95% pure.

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 that the barley then germinates unevenly or poorly 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. Although grain with a nitrogen content of between 1.50% and 2.00% is accepted as malting barley, the premium is only payable on grain with a nitrogen content of between 1.70% and 2.00%. It is important to note that the cut-off and turning points can differ from season to 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 produce lower nitrogen content despite higher nitrogen fertilization. Such a characteristic of a cultivar would be beneficial as it is not only high nitrogen fertilization 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 consider the nitrogen supply capability of his soils, and here soil tillage and the preceding crop are of importance.

Kernel plumpness

Kernel plumpness is important for homogeneous malting. Thin kernels absorb water faster than plump kernels. Thin kernels also have a relatively higher percentage husk, which gives beer an astringent taste. Therefore, uniform plumpness will result in better malting quality. Barley qualify as malting barley when the kernel plumpness is from 70% upwards, as measured with a 2.5mm sieve. As in the case of nitrogen content, the cut-off point 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, such as late ears that have ripened too fast or if an initial yield potential exceeds the capacity of the environment at the grain-filling stage. Certain cultivars however, also genetically tend to have low kernel plumpness and therefore, breeders specifically select for lines with high kernel plumpness. The kernel plumpness of all the present barley cultivars currently in the market can be described as good to very good.

Screenings, foreign matter and mechanical damage

The material that is so small it falls through a 2.2-mm sieve, are called screenings. This material generally consists of shriveled kernels, broken kernels, small weed seeds, glumae, awns, dead insects and dust. The top limit at which screenings can still be delivered is 5%. Again the cut-off points must be confirmed with the grain handler

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 accordingly 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 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 from 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. Too high percentage of endosperm exposed kernels results in several processing problems in the malting process (fungal growth, foam in steep tanks etc).

Fungal infestation

Malting barley infested with fungi is not fit for human consumption and is downgraded to undergrade. Some fungi produce mycotoxins (DON) when under stress. Fungal infestation usually takes place when windrows are subjected to continual moist conditions or when barley with a too high moisture content is harvested and stored on the farm under unfavourable conditions. Barley with a high moisture content (>13%) should be dried according to specifications as soon as possible. Barley cultivars have no genetic resistance to these grain fungi.

Moisture content

Malting barley that is delivered and stored with too high a moisture content can

result in fungal development and also a decrease in germination capacity. Therefore,

no malting barley with a moisture content of higher than 13% are accepted and a pro rata premium is paid for grain with the moisture content decreasing from 13% to 9.5%.

Barley Passport

In the 2005 season, a system was implemented by which the producer is obliged to submit a passport before he can deliver his 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.

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 contacted.

Recommendations

The yield and quality data for the previous four seasons are shown in the following tables (Tables 3 – 11).

Table 3. Average yield (ton/ha) of barley cultivars in the Southern Rûens for the period 2014 - 2018 (Localities: Napier, Klipdale, Bredasdorp and Protem)

Cultivar	2015	2016	2017	2018	2019	Average
Kadie	5.24	5.42	3.32	5.45	3.40	4.57
Hessekwa	5.40	5.08	3.12	5.67	3.20	4.49
Elim	5.26	5.27	3.02	5.51	3.00	4.41
Average	**5.30**	**5.26**	**3.15**	**5.54**	**3.20**	**4.49**

Table 4. Average yield (ton/ha) of barley cultivars in the Western Rûens for the period 2014 - 2018 (Localities: Caledon, Rietpoel, Greyton and Riviersonderend)

Cultivar	2015	2016	2017	2018	2019	Average
Kadie	3.95	5.70	4.83	6.29	3.70	4.89
Hessekwa	4.32	5.25	4.35	6.12	3.50	4.71
Elim	3.96	5.26	4.10	6.22	3.40	4.59
Average	**4.08**	**5.40**	**4.43**	**6.21**	**3.53**	**4.73**

Table 5. Average yield (ton/ha) of barley cultivars in the Eastern Rûens for the period 2014 - 2018 (Localities: Napkei, Swellendam, Heidelberg and Heidelberg Flats)

Cultivar	2015	2016	2017	2018	2019	Average
Kadie	4.51	4.42	3.31	2.58	3.60	3.68
Hessekwa	4.44	4.16	3.51	2.94	3.50	3.71
Elim	4.42	4.91	3.34	3.11	3.50	3.86
Average	**4.46**	**4.50**	**3.39**	**2.88**	**3.53**	**3.75**

Table 6. Average kernel plumpness (%) of barley cultivars in the Southern Rûens for the period 2014 - 2018 (Localities: Napier, Klipdale, Bredasdorp and Protem)

Cultivar	2015	2016	2017	2018	2019	Average
Kadie	95.80	93.97	97.19	90.41	64.00	88.27
Hessekwa	96.33	91.72	96.45	90.05	77.00	90.31
Elim	95.00	95.06	97.58	87.58	84.00	91.84
Average	**95.71**	**93.58**	**97.07**	**89.35**	**75.00**	**90.14**

Table 7. Average kernel plumpness (%) of barley cultivars in the Western Rûens for the period 2014 - 2018 (Localities: Caledon, Rietpoel, Greyton and Riviersonderend)

Cultivar	2015	2016	2017	2018	2019	Average
Kadie	96.13	95.09	94.46	96.77	81.20	92.73
Hessekwa	94.63	94.10	95.27	96.97	74.30	91.05
Elim	95.17	94.17	93.50	97.18	80.10	92.02
Average	**95.31**	**94.45**	**94.41**	**96.97**	**78.53**	**91.94**

Table 8. Average kernel plumpness (%) of barley cultivars in the Eastern Rûens for the period 2014 - 2018 (Localities: Napkei, Swellendam, Heidelberg and Heidelberg Flats)

Cultivar	2015	2016	2017	2018	2019	Average
Kadie	95.13	93.03	97.17	89.30	89.20	92.77
Hessekwa	94.25	89.49	96.66	91.05	80.90	90.47
Elim	94.28	91.15	98.19	92.31	83.10	91.80
Average	**94.55**	**91.22**	**97.34**	**90.89**	**84.40**	**91.68**

Table 9. Average kernel nitrogen (%) of barley cultivars in the Southern Rûens for the period 2014 - 2018 (Localities: Napier, Klipdale, Bredasdorp and Protem)

Cultivar	2015	2016	2017	2018	2019	Average
Kadie	1.85	1.85	2.07	2.20	2.40	2.07
Hessekwa	1.88	1.88	1.92	2.24	2.40	2.06
Elim	1.86	1.86	2.07	2.20	2.50	2.10
Average	**1.86**	**1.86**	**2.02**	**2.21**	**2.43**	**2.08**

Table 10. Average kernel nitrogen (%) of barley cultivars in the Western Rûens for the period 2014 - 2018 (Localities: Caledon, Rietpoel, Greyton and Riviersonderend)

Cultivar	2015	2016	2017	2018	2019	Average
Kadie	1.76	1.89	2.28	1.90	2.20	2.00
Hessekwa	1.77	1.86	2.18	1.85	2.20	1.97
Elim	1.84	1.87	2.24	1.88	2.30	2.02
Average	**1.79**	**1.87**	**2.23**	**1.88**	**2.23**	**2.00**

Table 11. Average kernel nitrogen (%) of barley cultivars in the Eastern Rûens for the period 2014 - 2018 (Localities: Napkei, Swellendam, Heidelberg and Heidelberg Flats)

Cultivar	2015	2016	2017	2018	2019	Average
Kadie	1.68	2.02	1.97	2.26	2.50	2.08
Hessekwa	1.74	2.00	1.91	2.27	2.40	2.06
Elim	1.71	2.03	1.88	2.26	2.60	2.10
Average	**1.71**	**2.02**	**1.92**	**2.26**	**2.50**	**2.08**

Planting date

Despite barley being planted over a relatively short period, it is common knowledge that the earlier plantings generally have a higher yield potential. This results in greater yield increases with disease and pest control programmes in earlier plantings. Barley thus planted later than the optimum planting date, as indicated in Table 12, is therefore at greater risk in terms of yield and quality.

Table 12. Optimum planting date of barley cultivars for the Southern Cape

Region	Cultivar*	Planting date (weeks)							
		April		May				June	
		3	4	1	2	3	4	1	2
Western Rûens: Caledon	Kadie (PBR)								
	Hessekwa (PBR)								
	Elim (PBR)								
Western Rûens: Riviersonderend	Kadie (PBR)								
	Hessekwa (PBR)								
	Elim (PBR)								
Southern Rûens: Western Strandveld Area	Kadie (PBR)								
	Hessekwa (PBR)								
	Elim (PBR)								
Southern Rûens: Eastern and Vlakte Area	Kadie (PBR)								
	Hessekwa (PBR)								
	Elim (PBR)								
Eastern Rûens:	Kadie (PBR)								
	Hessekwa (PBR)								
	Elim (PBR)								

** These cultivars are accepted for malting purposes by SAB Maltings.*
PBR: Cultivars protected by Plant Breeders' Righ

Planting rate

Heads/m² is the yield component that makes the greatest contribution to grain yield. The number of heads is, amongst others, determined by tillering ability, seeding rate and survival of seedlings. Seeding rate must also compensate for lower germinative capacity, poor emergence, "damping off" of seedlings and the planting method used. Thousand kernel mass is an important characteristic that determines the number of kernels per kilogram seed and this can vary from 36 - 54 g/1000 kernels, which can have a distinct influence on seeding rate.

Typically 130 - 170 plants/m² will be sufficient. Planting rate (kg/ha) = Plants per m² x 1 000 kernel mass / Survival %

The following table can be used in the calculation of seeding rate for the conventional sowing method. Survival percentage for this method was taken at 70%.

Table 13. Table for the calculation of planting rate

Plant establishment (plants/m²)	Thousand kernel mass (g/1000 kernels)									
	36	38	40	42	44	46	48	50	52	54
100	51	54	57	60	63	66	69	71	74	77
110	57	60	63	66	69	72	75	79	82	85
120	62	65	69	72	75	79	82	86	89	93
130	67	71	74	78	82	85	89	93	97	100
140	72	76	80	84	88	92	96	100	104	108
150	77	81	86	90	94	99	103	107	111	116
160	82	87	91	96	101	105	110	114	119	123
170	87	92	97	102	107	112	117	121	126	131
180	93	98	103	108	113	118	123	129	134	139
190	98	103	109	114	119	125	130	136	141	147
200	103	109	114	120	126	131	137	143	149	154
210	108	114	120	126	132	138	144	150	156	162
220	113	119	126	132	138	145	151	157	163	170
230	118	125	131	138	145	151	158	164	171	177
240	123	130	137	144	151	158	165	171	178	185
250	129	136	143	150	157	164	171	179	186	193

Example: Thousand kernel mass of seed = 40
The preferred plant establishment = 130 - 170 plants/m²
Required planting rate: 74 - 97 kg/ha

The following table can be used in the calculation of seeding rate for producers using planters. Survival percentage for this method was taken at 85%.

Table 14. Table for the calculation of planting rate

Plant establishment (plants/m²)	Thousand kernel mass (g/1000 kernels)									
	36	38	40	42	44	46	48	50	52	54
100	42	45	47	49	52	54	56	59	61	64
110	47	49	52	54	57	60	62	65	67	70
120	51	54	56	59	62	65	68	71	73	76
130	55	58	61	64	67	70	73	76	80	83
140	59	63	66	69	72	76	79	82	86	89
150	64	67	71	74	78	81	85	88	92	95
160	68	72	75	79	83	87	90	94	98	102
170	72	76	80	84	88	92	96	100	104	108
180	76	80	85	89	93	97	102	106	110	114
190	80	85	89	94	98	103	107	112	116	121
200	85	89	94	99	104	108	113	118	122	127
210	89	94	99	104	109	114	119	124	128	133
220	93	98	104	109	114	119	124	129	135	140
230	97	103	108	114	119	124	130	135	141	146
240	102	107	113	119	124	130	136	141	147	152
250	106	112	118	124	129	135	141	147	153	159

Example: Thousand kernel mass of seed = 40
The preferred plant establishment = 130 - 170 plants/m²
Required planting rate 61 - 80 kg/ha

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Table 3. Resistance or susceptibility of oat cultivars to leaf diseases

Cultivar	Crown Rust	Stem Rust
Overberg	S	MS
Heros	S	S
Sederberg	S	S
Pallinup	S	S
Kompasberg	S	MS
SSH 405	S	R
SSH 491	MR	S

Chemical control of fungal diseases

Fungicides are routinely used to control small grain diseases that are caused by fungi. In South Africa various active ingredients are registered for the control of foliar diseases on small grains (Tables 4 and 5). Several active ingredients are registered for the control of seed and/or soil borne diseases (Table 6).

In order to apply fungicides successfully for disease control, the following aspects must be taken into account:

- The disease and causal organism of the disease should be identified correctly;
- A fungicide registered against the observed disease should be chosen;
- The susceptibility of the particular cultivar to the disease should be considered.
- In most cases resistant cultivars will not need fungicide protection against the disease to which it is resistant, unless new races of the pathogen develop;
- Timing of application is critical. One application at the correct timing can give more protection to the plants than three badly timed spray applications;
- Protection of the flag leaf is important, as this leaf greatly contributes to the productivity of the plant;
- Some fungicides require intervals before harvest or consumption of produce and this should be considered;
- Use the correct amount of water so as to ensure adequate coverage.

For any further information, you can contact one of the following:

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