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CHAPTER 8

RELATIONSHIP BETWEEN SEED QUALITY AND EASILY MEASURABLE SEED CHARACTERISTICS

INTRODUCTION

South African sunflower seed quality parameters vary considerably. Judged from the results of the annual national cultivar trials, oil content ranges between 36 and 50% and protein content between 10 and 24%. Hullability, which is the percentage hull that can easily be removed, varies between 45 and 94% (Chapter 4). This variation in the quality parameters consequently gives rise to variation in the value of the seed for the oil expressing industry.

Most of the high oil content sunflower is currently traded without grading the seed in terms of its processing value. This lack of a grading system often leads to a purchase price that is not in line with the processed value of the seed, which puts the oil expressing industry under unnecessary financial risk. On the other hand, producers may not be adequately remunerated for high quality seed produced. In some cases, the seed oil content is measured and the price adjusted accordingly, while the protein content and hullability, the other two quality characteristics, are not taken into account. The value of the oil cake is approximately 20% of the total value of the seed for the oil expressing industry, depending on the current price of oil and oil cake and the yield of these entities from the seed (Fourie, 1999).

The lack of a grading system for sunflower seed and related pricing structure does not motivate farmers to produce seed with a high processing quality. Thus seed yield per ha remains the only measure of success for the sunflower producer. This will not enhance the competitiveness of the sunflower industry.

No grading system other than the statutory limits set on the amount of poisonous seed and foreign matter in the seed is currently in use worldwide, although price is determined by oil content in certain countries. A distinction between high and low oil content sunflower is also made locally without quantifying the oil contents of these two types. Seed protein content and hullability are

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not taken into account. According to Fourie (1999) the existing South African infrastructure does not cater for the classification and storage of different grades. The cost of equipment and the slow and tedious procedure to determine oil and protein contents are reasons for the lack of grading. Currently, equipment to measure the hullability quickly and accurately on a routine basis is unavailable.

The possibility exists that seed quality can be estimated from easily measurable seed characteristics. Research has indicated that seed characteristics such as seed size and seed density, which are easily measurable, correlate poorly to reasonably well with some of the quality parameters like hullability (Chapter 4, Dedio, 1993; Baldini & Vannozzi, 1996). The estimation of the quality parameters may even improve if multiple regression techniques are used. If these relationships between the easily measurable characteristics and quality parameters are universal, and capable of estimating seed quality with acceptable accuracy, it will provide a practical procedure for classifying seed according to its processing value.

In Chapter 4, simple correlation coefficients between seed quality parameters and easily measrable seed characteristics are reported for only five cultivars grown at six environments. At least 15 cultivars are commercially available annually which are grown at various and diverse locations. The objectives of the investigation reported in this chapter were to analyse seed from all the available cultivars produced at various environments:

1. To quantify the easily measurable seed characteristics (hectolitre mass, thousand seed mass and seed size distribution), the not so easily measurable seed characteristics (hull content and seed dimensions) and the seed quality characteristics (oil content, protein content, hullability and amount of fine material produced).

2. To determine if any reliable relationships exist between the seed quality parameters (oil content, protein content and hullability) and the easily measurable seed characteristics for application in a seed grading system through multiple regression analyses.

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MATERIALS AND METHODS

Seed samples of the 19 cultivars included in the national cultivar trials, produced during the 1999/2000 season in 11 trials at various localities were used for the analyses. Easily measurable seed characteristics were considered to be the moisture content, thousand seed mass, hectolitre mass and seed size distribution. The seed moisture content was measured by means of the near infrared method by the PPECB Quality Assurance Laboratory (P.O. Box 433, Silverton 0127, South Africa). The thousand seed mass was measured by recording the mass of 100 randomly selected seeds and the hectolitre mass by determining the mass of 0.5 l seed. To determine the seed size distribution, two sieves with slot sizes of 3.0 and 3.5 mm were used to classify approximately 300 ml of seed into small, medium and large size classes. All measurements were done in triplicate.

The seed dimensions and hull content are considered less easily measurable seed characteristics due to the time it takes to determine them and the precision required. Seed dimensions (length, width and thickness) were measured using a caliper on 10 randomly chosen seeds. A seed sample of between 1.5 and 2 g was manually dehulled for hull content determination as described in Chapter 2.

Seed dehulling, separation into the different fractions, calculation of hullability, fines produced and chemical analyses were done as described in the materials and methods of Chapter 5. The other two seed quality parameters, namely the oil and protein contents, were determined with the near infrared method by the PPECB Quality Assurance Laboratory. Multiple linear regression equations were developed relating the seed quality parameters firstly with the easily measurable seed characteristics and secondly with both the easily and not so easily measurable seed characteristics, by means of the step up variable selection procedure of the Statgraphics *Plus* for Windows statistical software package (Manugistics Inc., 2115 East Jefferson Street, Rockville, Maryland 20852, USA).

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RESULTS AND DISCUSSION

Seed characteristics

Table 33 shows the F-values from the analyses of variance, means, standard deviations, minimum and maximum values for the easily measurable seed characteristics for the 1999/2000 season. Due to the analysis of only one sample replicate, the effect of the cultivar × environment interaction could not be calculated. Mean values for these characteristics for each cultivar and locality are shown in Table 34. The F values for the easily measurable characteristics indicate that locality was a larger source of variation than cultivar, with the exception of seed length and hull content which were more affected by cultivar. Seed moisture content ranged from 5.9 to 8.1%. This range in moisture content might be less than what can be expected for commercially produced fields as the upper limit of 10% moisture content is set for storage. All the other easily measurable characteristics showed large variations, as indicated by the minimum and maximum values recorded (Table 33).

Table 35 shows the F-values from the analysis of variance, and the mean, standard deviation, maximum and minimum values measured for the seed quality parameters for the 1999/2000 season. Mean values for these characteristics for each cultivar and locality are shown in Table 36. All the seed quality parameters were affected more by the environment than by cultivar, as indicated by the F-values. The ranges of these characteristics were also wide, as indicated by the minimum and maximum values recorded.

Relationships

Table 37 shows the multiple regression equations obtained with the highest R^2-values. Hullability is poorly related to the easily measurable and not so easily measurable seed characteristics, as indicated by the relatively low R^2-values and high mean absolute errors of the estimate. However, comparing the mean absolute error with the range in hullabilities found (Table 35), the equations might be useful for the estimation of the hullability in order to divide seed into two broad hullability classes.

Table 33 Results of the analyses of variance and summary statistics for the moisture content (MO), hectolitre mass (HM), thousand seed mass (TM), percentages of small (SS), medium (MS) and large seed (LS), seed length (DL), seed width (DW), seed thickness (DT) and hull content (HC) of sunflower seed produced from 19 cultivars at 11 localities during the 1999/2000 season

	DF	MO (%)	HM (kg hl^{-1})	TM (g)	SS (%)	MS (%)	LS (%)	DL (mm)	DW (mm)	DT (mm)	HC (%)
F-values from the analyses of variance											
Cultivar	18	6**	7**	11**	10**	4**	9**	13**	10**	5**	12**
Locality	10	8**	26**	29**	13**	16**	22**	9**	18**	39**	8**
Total	208										
CV(%)		3	5	9	41	24	32	4	6	8	8
Summary statistics											
Mean		6.9	41.7	65.4	24.0	33.9	42.1	11.1	5.4	3.2	27.3
Standard dev.		0.3	2.7	10.7	15.0	11.3	22.1	0.6	0.5	0.4	3.3
Minimum		5.9	31.1	35.7	1.0	3.3	1.8	9.6	4.3	2.3	19.8
Maximum		8.1	50.2	100.6	85.6	61.2	95.6	12.7	7.3	4.9	37.6

** Significant at the 0.01 probability level.

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Table 34 Mean values for the moisture content (MO), hectolitre mass (HM), thousand seed weight (TW), percentages of small (SS), medium (MS) and large seed (LS), seed length (DL), seed width (DW), seed thickness (DT) and hull content (HC) of sunflower seed produced from 19 cultivars at 11 localities during the 1999/2000 season

	MO (%)	HM (kg hl^{-1})	TW (g)	SS (%)	MS (%)	LS (%)	DL (mm)	DW (mm)	DT (mm)	HC (%)
Cultivars										
AG SUN 5551	6.71	39.5	66.6	20.2	36.5	43.3	11.3	5.22	3.04	25.5
AG SUN 8751	6.86	40.3	64.5	26.0	35.5	38.5	11.0	5.15	3.19	27.2
CRN 1414	6.62	37.2	66.6	18.6	30.0	51.3	11.0	5.74	3.34	25.4
CRN 1424	6.65	37.5	70.9	16.2	31.0	52.8	11.8	5.73	3.37	30.7
CRN 1435	6.95	37.5	63.4	19.3	30.9	49.9	10.3	5.87	3.46	26.1
HV 3037	6.77	39.2	73.5	12.5	26.2	61.3	11.8	5.38	3.30	24.7
HYSUN 333	7.15	40.2	67.4	23.3	37.2	39.5	11.1	5.35	3.04	26.8
HYSUN 345	7.03	36.9	54.6	32.2	32.3	35.5	10.4	5.41	3.22	27.6
HYSUN 350	6.89	36.7	52.0	52.3	34.4	13.4	10.8	4.81	2.83	28.6
LG 5630	6.73	39.8	65.2	19.0	29.6	51.4	10.5	5.48	3.24	23.0
PAN 7351	7.13	39.4	66.2	23.4	41.9	34.7	11.3	5.10	3.08	30.2
PAN 7355	7.18	40.7	64.0	35.5	41.9	22.7	11.4	5.09	3.00	31.9
PAN 7371	7.09	39.4	61.3	34.9	39.5	25.5	11.5	5.12	3.01	29.7
PAN 7392	6.99	37.2	66.5	19.7	39.3	40.9	11.5	5.30	3.14	27.2
PHB 6488	6.66	37.7	61.7	26.3	34.7	39.1	11.6	5.20	3.12	26.8
PHB 6500	6.90	40.8	60.4	24.0	36.1	39.9	10.6	5.39	3.30	26.8
SNK 50	6.74	39.5	73.4	16.0	28.0	56.0	10.8	5.77	3.52	28.0
SNK 73	6.98	38.0	69.6	19.1	31.1	49.8	11.1	5.44	3.24	28.0
SNK 77	6.8	38.7	74.9	17.4	27.4	55.1	11.1	5.67	3.36	24.4
$LSD_{(P = 0.05)}$	0.17	1.4	5.1	8.2	6.8	11.2	0.3	0.25	0.22	1.9
Localities										
Bloemfontein	7.17	41.5	74.3	18.4	36.3	45.3	11.5	5.43	3.49	27.9
Koppies	6.83	37.7	68.1	24.6	31.4	44.0	10.9	5.24	3.32	27.6
Marikana	6.71	38.3	56.9	29.0	39.8	31.2	11.1	5.19	2.80	27.6
Potchefstroom 1	6.68	41.6	65.8	36.9	42.8	20.3	10.8	5.08	3.25	27.3
Potchefstroom 2	6.96	38.9	63.8	34.2	39.0	26.8	10.8	4.98	3.16	25.1
Potchefstroom 3	6.94	37.1	51.5	32.8	36.9	30.3	10.8	5.19	2.72	26.7
Settlers	6.65	38.8	67.3	18.5	34.3	47.2	11.3	5.42	2.91	27.4
Theunissen	7.23	36.5	71.3	12.9	16.5	70.6	11.5	6.02	4.00	28.5
Ventersdorp	6.70	35.7	59.1	17.8	31.3	50.9	10.8	5.54	3.03	30.1
Viljoenskroon	7.03	40.0	75.9	18.2	26.3	55.4	11.2	5.63	3.57	26.9
Warmbaths	6.85	40.1	65.4	20.5	38.1	41.4	11.3	5.44	2.96	25.1
$LSD_{(P = 0.05)}$	0.13	1.1	3.8	6.3	5.2	8.5	0.3	0.19	0.17	1.4
Mean	6.89	38.7	65.4	24.0	33.9	42.1	11.1	5.38	3.21	27.3

Table 35 Results of the analyses of variance, mean, standard deviation, minimum and

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maximum for the hullability (H), amount of fine material produced (F), oil content (O) and the protein content (P) of sunflower seed produced from 19 cultivars at 11 localities during the 1999/2000 season

Source	DF	Hull-ability (%)	Fine material (%)	Seed oil (%)	Seed protein (%)
F-values from the analyses of variance					
Cultivar	18	7**	7**	6**	6**
Locality	10	11**	13**	21**	37**
Total	208				
CV (%)		14	11	3	6
Summary statistics					
Mean		73.1	6.3	43.8	18.3
Standard dev.		14.3	1.0	1.8	2.0
Minimum		37.5	3.7	39.1	12.7
Maximum		100.0	9.8	49.0	22.4

** Significant at the 0.01 probability level.

Seed oil content is also poorly related to both the easily measurable and not so easily measurable seed characteristics with its R^2-values below 59%. The mean absolute error (MAE) of 1.2% or less for both equations is small, however, considering the range of oil contents involved (Table 35). Either of these two equations can thus be used to classify seed into two or three oil content classes, especially if the threshold values dividing these classes are several percentage points apart. Although seed might be wrongly classified, the mean oil content of this seed will only be one percentage point above or below the threshold value as the mean absolute error equals 1% (Table 37).

Seed protein content is poorly related to the measured seed characteristics, even less so than the hullability and oil content. The mean absolute error is again small in relation to the range of measured protein contents, making the equation useful if the seed is to be separated into two or three classes (Table 37).

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Table 36 Mean values for hullability, amount of fine material produced, seed oil content and the seed protein content of sunflower seed produced from 19 cultivars at 11 localities during the 1999/2000 season

	Hullability (%)	Fine material (%)	Seed oil (%)	Seed protein (%)
Cultivars				
AG SUN 5551	72.3	6.97	45.1	18.1
AG SUN 8751	70.6	6.87	44.4	18.1
CRN 1414	82.3	6.79	44.9	17.1
CRN 1424	81.2	6.10	43.9	17.8
CRN 1435	75.4	5.87	43.2	19.1
HV 3037	70.3	6.38	44.6	19.3
HYSUN 333	71.6	5.30	43.0	19.4
HYSUN 345	60.2	5.95	42.8	18.9
HYSUN 350	59.1	6.33	42.3	18.5
LG 5630	58.0	6.84	43.8	20.1
PAN 7351	81.6	5.59	42.9	17.7
PAN 7355	76.5	5.97	42.9	17.7
PAN 7371	74.7	5.67	43.4	18.0
PAN 7392	82.7	5.79	43.8	17.5
PHB 6488	66.2	7.37	45.2	17.6
PHB 6500	66.7	6.41	43.6	18.4
SNK 50	81.8	6.48	44.2	18.0
SNK 73	82.9	6.17	43.5	18.1
SNK 77	72.8	6.87	45.2	17.7
$LSD_{(P = 0.05)}$	8.4	0.58	1.0	0.9
Localities				
Bloemfontein	80.1	6.52	44.0	18.5
Koppies	77.8	6.12	45.5	15.0
Marikana	73.9	6.46	43.5	18.8
Potchefstroom 1	65.9	7.44	45.3	17.3
Potchefstroom 2	71.2	6.43	44.3	17.7
Potchefstroom 3	65.5	6.21	42.8	18.4
Settlers	66.1	6.41	43.7	19.6
Theunissen	87.8	5.04	41.1	20.5
Ventersdorp	78.4	6.41	44.7	15.5
Viljoenskroon	73.7	6.01	43.7	19.1
Warmbaths	62.5	6.26	43.5	19.5
$LSD_{(P = 0.05)}$	6.4	0.44	0.7	0.7
Mean	73.0	6.30	43.8	18.3

Table 37 Results of the regression analyses relating the seed quality characteristics to both the easily and the not so easily measurable seed characteristics

Equations	R^2 (%)	MAE[c] (%)
Hullability		
H^a = 10.12MO - 2.219HM + 0.5381TM - 0.4223SS - 0.1913LS + 72.25	41.2	8.7
H^b = 8.368MO - 1.621HM + 0.4326TM - 0.2402SS + 0.7386HC + 35.51	42.3	8.6
Oil content		
O^a = -3.897MO + 0.068TM - 0.029LS + 67.44	51.4	1.0
O^b = -3.73MO + 0.06TM + 0.035MS - 0.328DL - 1.162DW + 0.661DT - 0.067HC + 74.01	58.3	1.2
Protein content		
P^a = 1.482MO + 0.153HM - 0.06MS + 4.175	18.3	1.4
P^b = 2.186MO + 0.178HM - 0.053MS + 1.601DW - 1.501DT - 0.095HC - 1.987	27.8	1.3
Fine material		
F^a = -2.006MO + 0.104HM + 0.01SS + 15.83	49.6	0.5
F^b = -1.919MO + 0.094HM + 0.01SS - 0.034HC + 16.54	50.7	0.5

DL = seed length (mm); DW = seed width (mm); DT = seed thickness (mm); HC = hull content (%); H = hullability (%); HM = hectolitre mass (kg hl^{-1}); LS = large seed (%); MO = moisture content (%); MS = medium seed (%); O = oil content (%); P = protein content (%); SS = small seed (%); TM = thousand seed mass (g).

[a] Only easily measurable seed characteristics included. [b] Both easily and not so easily measurable seed characteristics included.

[c] Mean absolute error.

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Poor relationships also exist between the amount of fine material produced and the easily and not so easily measurable seed characteristics. The mean absolute error associated with these relationships, however, indicates that they too can be used as a measure for the classification of seed into a few classes.

Seed moisture content plays an important role in all the relationships found between the seed quality parameters and measurable seed characteristics (Table 37). Moisture loss can occur during storage. This can be expected if harvest and delivery for storage take place at a relatively high (10%) moisture content, followed by a relatively long period of storage and aeration with relatively dry air.

A decline in the moisture content will affect the quality parameters of the seed and will probably alter the classification of the seed, especially those close to the threshold value dividing different classes. Seed left to dry naturally usually reach a constant moisture content of approximately 6%. Assuming that this is also the case during storage, this drying (from 10% to 6%) will lead to an increase in the seed oil content of less than 1.8 percentage points and less than 0.8 percentage points for the protein content. The hullability and production of fine material can increase by up to 8 and 4 percentage points respectively (Chapter 2).

CONCLUSION

Although relationships between the seed quality parameters and the easily measurable seed characteristics are generally poor, as indicated by their low R^2-values, reasonably accurate classification of seed seems possible using the easily measurable seed characteristics due to the relatively small absolute errors found.