Application Note SC006: Report on SeedCount Image Analysis System Evaluation

DAWA GPL October 2003

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Introduction:

The SeedCount Image Analysis System was evaluated for barley and pearled barley. A set of ten barley samples were selected from 1999, 2001 and 2002 plant breeding trials over a range of grain weight and diameter as interpreted by SKCS analysis (Table 1). Two pearled barley samples were obtained from a set originally used to calibrate the Tecator Graincheck Image Analyser and contained two levels of broken pearls, 20% and 30%.

Sample	Lab No.	Variety/Line	SKCS diameter (mm)	SKCS grain wt (mg)
1	MB02-1323	Harrington	1.89	34.3
2	MB02-1291	Schooner	2.10	39.7
3	MB02-1268	Keel	2.31	46.2
4	9903-6260	Hart	2.50	47.3
5	MB02-1312	Stirling	2.64	49.0
6	MB02-1287	Brndabella	1.94	34.0
7	MB03-1348	WABAR2175	2.18	38.1
8	MB02-1346	Hamelin	2.27	41.5
9	9903-6280	Arapiles	2.38	45.0
10	MB02-1313	Barque	2.60	51.5

Table 1. Evaluation samples selected for range in grain weight and diameter.

1. Whole barley evaluation

The barley samples were loaded onto the barley indent tray using the procedure outlined in the manual and analysed in duplicate with another subsample. Of the three sample cups provided (26.2mL, 27.8mL, and 30.7mL), the 30.7 mL cup was used in the evaluation. The cups allow the user to select the appropriate volume to fill the indent tray without overloading it. The duplicate kernel weight (KW) estimates are indicated in Table 2.

Sample	KW (a)	KW (b)
1	35.5	35.4
2	39.5	40.5
3	48.6	48.1
4	48.3	47.5
5	51.1	48.7
6	35.6 / 34.0*	35.5
7	38.6	38.9
8	41.2	40.4
9	45.9	45.5
10	51.4	52.8

Table 2. SeedCount duplicate kernel weight estimates.

* kernel weight estimate for hand sorted sample (doubles manually separated).

The correlations between SKCS and SeedCount parameters are indicated in Appendix 1. SKCS grain weight average is highly correlated with SeedCount TKW, average seed area and several screening parameters. SKCS average grain diameter is also highly correlated with TKW, average seed area and screening parameters but poorly correlated with plumpness and roundness. The repeatability of replicates as determined by the t-test showed no significant differences at $\alpha = 0.05$ confidence level (Table 3). The correlation between SKCS grain weight and SeedCount TKW is indicated in Figure 1.

t-Test: Paired Two Sample for Means		
	REP A	*REP B*
Mean	43.57	43.33
Variance	38.51566667	35.97566667
Observations	10	10
Pearson Correlation	0.985740763	
Hypothesized Mean Difference	0	
df	9	
t Stat	0.722024507	
P(T<=t) one-tail	0.244306687	
t Critical one-tail	1.833113856	
P(T<=t) two-tail	0.488613374	
t Critical two-tail	2.262158887	

Table 3. t test for SeedCount repeatability.

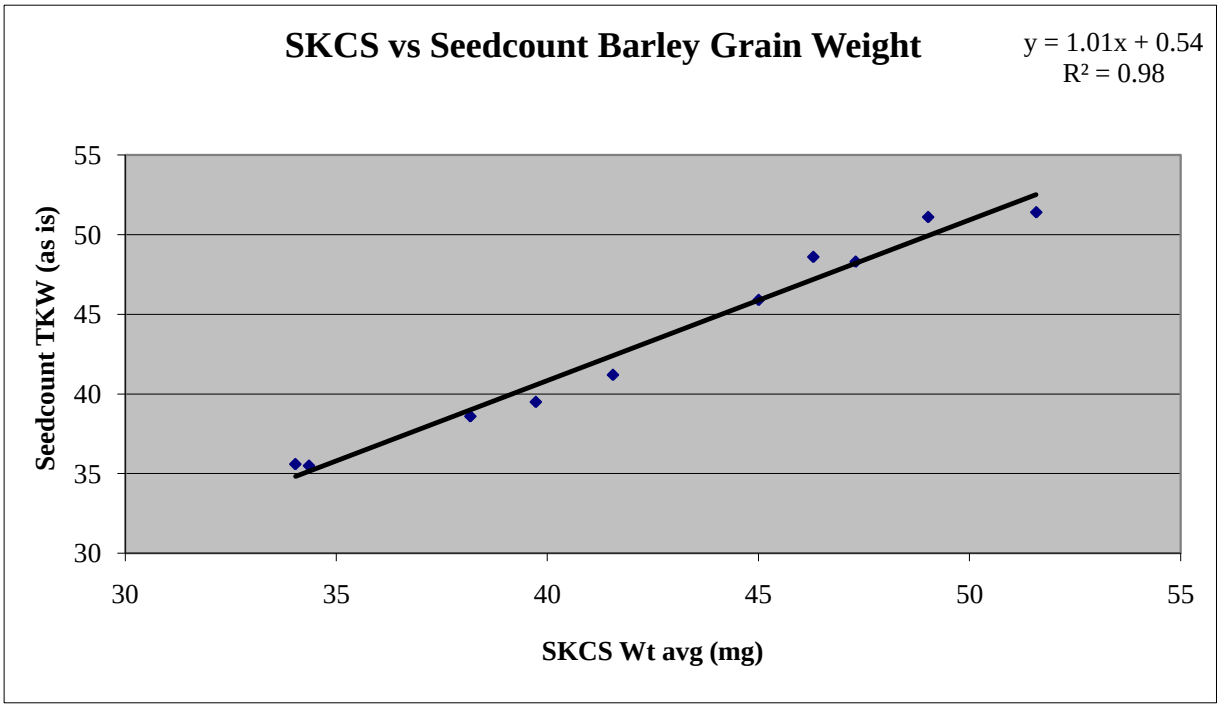

Figure 1. Correlation between SKCS and SeedCount grain weight.

Comments

Distribution of the grain sample on the indent tray is very important (Figure 2). Excessive amounts of doubles affect a number of estimates including grain weight. Some doubles are not detected by the software and have the effect of increasing apparent grain weight. The time taken to analyse a sample is on average between two and five minutes depending on the amount of manual sorting required.

2. Pearled barley evaluation

Pearled barley was evaluated using the wheat indent tray c/f barley indent tray as the pearled barley grain more closely resembled the dimensions of wheat kernels. The smaller 26.2 mL sample cup was also used to prevent overfilling the indent tray with a larger number of smaller kernels. The 20% broken pearl sample scan (hand sorted) was analysed with the three available grain settings in the software (Table 4) to determine the effect on predictions.

Setting	Dockage %	KW	Whole grains	HLWT (kg/100L)
Barley	16.5	29.8	578	81.2
Wheat	16.2	29.8	581	81.2
Malt barley	16.5	29.8	578	81.2

Table 4. Pearled barley parameters with different grain settings.

There appeared to be very little difference in predicted parameters when analysing under the three grain program settings.

The 30% broken pearl sample was analysed both unsorted and sorted (manually sorting pearls and broken fragments into individual indent wells) to determine the effect on predicted parameters (Table 5).

30% Broken pearls	Dockage %	KW	Whole grains	HLWT (kg/100L)
Unsorted	20.3	28.4	588	81.4
Sorted	32.3	29.1	483	81.4

Table 5. Comparison of parameters with and without manual sorting.

There was a large variation in predicted parameters (except HLWT) between sorted and unsorted samples. The prediction on sorted samples more closely reflects the actual percentage of broken pearls in the sample.

Comments

Pearled barley analysis is best achieved using the wheat indent tray. Best prediction of broken pearls (SeedCount Dockage %) is achieved by manually sorting the sample components into individual wells. Multiple pearled grains or fragments can commonly be misinterpreted by software recognition as whole grains. Manually sorting the 30% broken pearl sample took approximately 15 minutes.

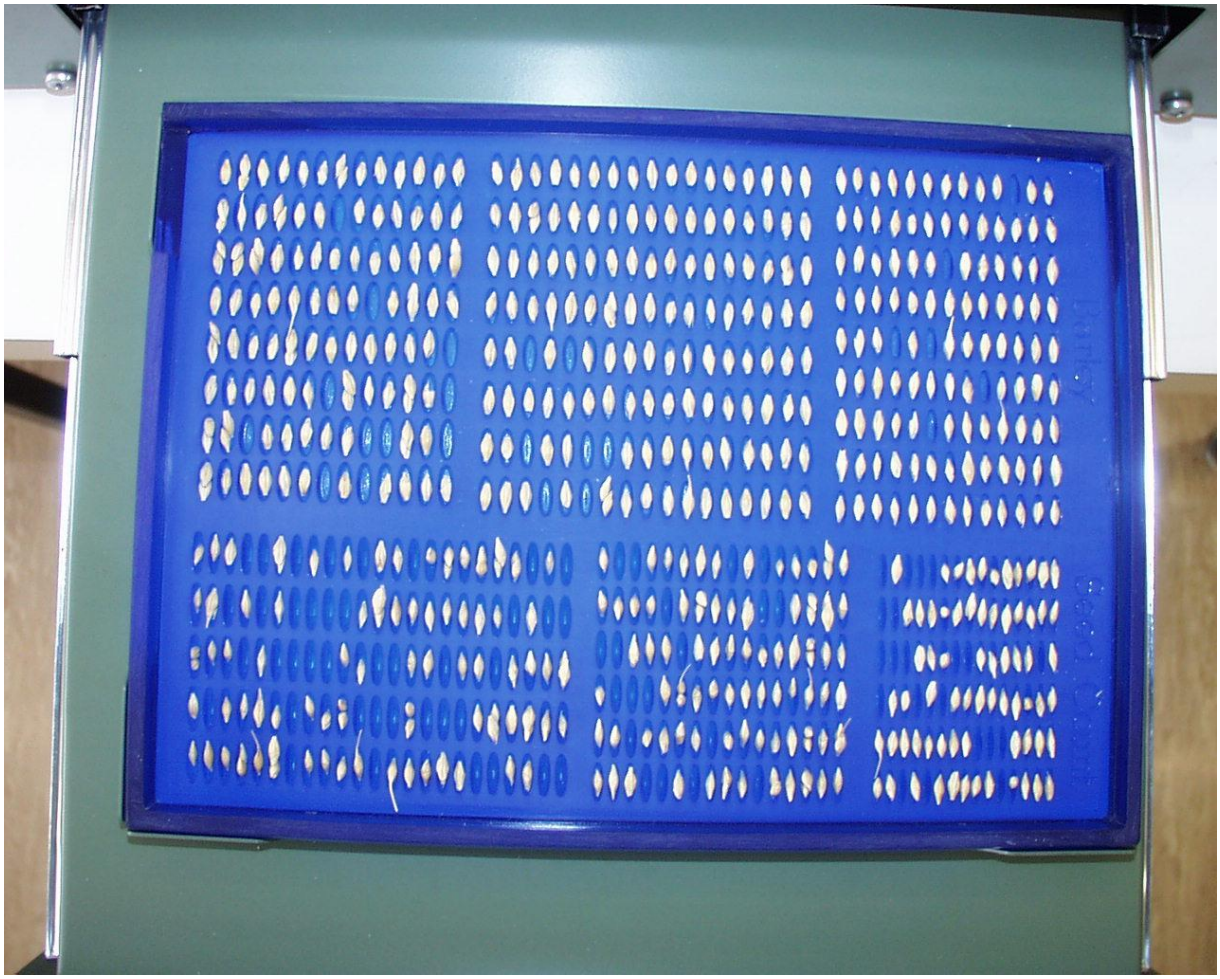

Figure 2. Barley sample tray with sample loaded without manual sorting.

Conclusion

The SeedCount analysis system (ca $17,000) provides a low cost alternative to other digital image analysis methods such as the Tecator Graincheck. Prediction accuracy relies on uniform grain distribution on the indent tray which requires manual sorting, increasing the analysis time. For the parameters tested, TKW correlates highly with SKCS average grain weight and dockage percentage correlates well with broken pearl percentage in pearled barley. The repeatability of analysis was good with no significant differences between replicates at the α = 0.05 confidence level. This evaluation did not test the accuracy of sieving predictions nor blacktip predictions, which need to be further evaluated. Future additions of sample trays to suit other grains and refinements to the software will improve the versatility of the system. The SeedCount analysis system could be used in physical grain testing analysis as a rapid means for determining sample uniformity and composition.

Appendix 1. Correlation between SKCS and SeedCount parameters.

	Whole Seeds	*TKW (as-is)*	*Hectoliter wt*	*Dockage pct*	*Blackpoint Orig %*	*Blackpoint Man. %*	*Blackpoint No. Sum*	*Plumpness*	*Roundness*	*Sample Clean wt*	*Sample Volume*	*Avg. Seed Area*	*Total Area sq mm*	*> 2.8 Screening*	*2.5 - 2.8 Screening*	*2.2 - 2.5 Screening*	*2.0 - 2.2 Screening*	*1.6 - 2.0 (< 2.0)*	*<1.6 (<2.5)*	*>2.8 mm count*	*>2.5 mm count*	*>2.2 mm count*	*>2.0 mm count*	*<2.0 mm count*
SKCS Havg	0.47	-0.39	0.42	0.00	-0.33	-0.33	0.54	-0.31	-0.57	0.43	0.00	-0.28	-0.12	-0.67	0.42	0.76	0.75	0.70	0.77	-0.65	0.19	0.73	0.74	0.65
Hsd	0.28	-0.32	0.00	-0.18	0.06	0.06	-0.62	0.40	0.28	0.00	0.00	-0.37	0.29	-0.08	0.10	0.08	-0.07	-0.02	0.04	-0.08	0.23	0.14	-0.05	0.07
SKCS Wavg	-0.99	0.99	-0.46	0.40	0.71	0.71	-0.31	-0.22	0.17	-0.46	0.00	0.85	-0.30	0.87	-0.69	-0.85	-0.72	-0.65	-0.83	0.86	-0.64	-0.87	-0.71	-0.63
Wsd	-0.67	0.67	-0.45	0.17	0.83	0.83	-0.52	-0.13	0.18	-0.45	0.00	0.53	-0.06	0.64	-0.54	-0.58	-0.49	-0.52	-0.57	0.66	-0.46	-0.58	-0.46	-0.46
SKCS Mavg	0.44	-0.48	0.16	-0.08	-0.28	-0.28	-0.28	0.60	0.29	0.17	0.00	-0.61	0.30	-0.17	0.00	0.35	0.19	0.23	0.31	-0.14	0.06	0.39	0.22	0.26
Msd	0.29	-0.25	0.21	-0.09	-0.04	-0.04	-0.12	0.01	-0.25	0.21	0.00	-0.29	0.32	-0.37	0.21	0.50	0.25	0.45	0.45	-0.32	0.14	0.53	0.28	0.43
SKCS Davg	-0.94	0.95	-0.32	0.53	0.76	0.76	-0.26	0.00	0.40	-0.33	0.00	0.72	-0.35	0.93	-0.75	-0.90	-0.80	-0.65	-0.88	0.93	-0.64	-0.90	-0.79	-0.62
Dsd	-0.51	0.50	-0.46	-0.10	0.70	0.70	-0.58	-0.16	0.12	-0.46	0.00	0.45	0.21	0.48	-0.31	-0.53	-0.53	-0.51	-0.54	0.49	-0.20	-0.51	-0.51	-0.47

Correlations greater than 0.7 indicated in red.