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EFFICIENCY OF UTILIZATION OF ASELECTION INDEX IN ASSESSMENT OF DRYDOWN OF CORN GENOTYPES (*Zea mays* L.)

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Abstract

Utilization of a reliable, large scale, fast, non-destructive methods for assessing the speed of corn grain dry-down rate (DDR) (speed of loosing water from grain between physiological maturity and harvest) in early stages of the breeding program, to identify real differences among genotypes, is proposed. Non-destructive determinations of the grain moisture of individual plants with a wooden moisture (Voltcraft FM-200 Humidity meter) were performed for a large number of genotypes, hybrids and inbred lines from Romanian Pioneer corn breeding program, during 2010-2012. Calibration curves (issued on the basis of successive determinations of the grain moisture by using in parallel the wooden moisture and standard gravimetric method) were used to transform the wooden moisture readings in estimated% grain moistures (EPGM). A synthetic selection index (DDIND), represented by the slopes of the linear regression line between EPGM and measurement timing were computed. DDIND computed as describe above was used to compute ANOVA analysis. Preliminary results showed that DDIND had a large degree of precision; a significant part of the DDIND variation was due to genotypic variations in all analyzed experiments, suggesting that real differences in genotype with regard to DDIND could be detected by this method. Additional studies are necessary to determine if selection on the basis of DDIND would results in releasing of superior commercial hybrids with fast DDR.

Key words: *corn, dry-down, selection index, Zea mays L.*

INTRODUCTION

Corn dry-down rate (DDR) (speed of loosing water from grain between physiological maturity and harvest) has become an important trait in the last several decades. Farmers appreciate hybrids with fast DDR from economical reasons: saving of drying costs and fossil fuel consumption, preventing mold deterioration during the storage as well as earlier harvest with fewer losses (Boute et al., 2002; Cross, 1985; Eckert, 1978; Hellevang and Reef, 1987; Hellevang, 2004; Lackey, 2008; Ragai and Loomis, 1954; Stere et al., 1995). Numerous studies revealed that corn genotypes differed in DDR and that the differences are heritable (Crane et al. 1959; Cross, 1985; Cross and Kabir, 1989; De-Jager et al., 2004; Hallauer and Russsell, 1961, 1962; Hillson and Penny, 1965; Kondapi et al., 1993; Nass and Crane, 1970; Newton and Eagles, 1991; Purdy and Crane, 1967a; Stere et al., 1995; Troyer and Ambrose, 1971; Zhang et al., 1996). DDR is a physical-biological process, influenced by the weather conditions and genotype. Relationship of DDR with other plant, kernel and husk traits have been reported (Baron and Daynard, 1984; Cavalieri and Smith, 1985; Crane et al., 1959; Hiks et al., 1976; Kang et al., 1975; Nass and Crane, 1970; Purdy and Crane, 1967; Stere et al., 1995; Sweeney et al., 1994; Tollenar and Daynard, 1978; Troyer and Ambrose, 1971) as well as meteorological data (Aldrich et al., 1975; Kang et al., 1983, 1986; Schmidt and Hallauer, 1966). Thus, improving of this trait has become an essential objective of any modern corn breeding program. One difficulty of the breeding programs is the lack of a reliable, large scale, fast, non-destructive methods to asses DDR speed. Such a method would allow breeders to asses DDR in early stages of the breeding program, to identify real differences among genotypes.

Kang et al., 1978 proposed utilization of an electronic device, DC-10 moisture meter, measuring moistures between 6 and 70%, for non-destructive trough husks assessment of kernel moisture content of corn plants grown in the field. A similar approach using an adapted version of an Electrophysics moisture meter (model MT 808 produced by Electrophysics, London, ON, Canada) was proposed by Reid et al., 2010. Khang and Zuber, 1987, 1989 and Kondapi et al., 1993 reported positive results of the utilization of such electronic probes in non-destructive field grain moisture measuring. Data of grain moisture were used by breeders for selection of genotypes with fast DDR. Area under the dry down curve (AUDDC), an index representing the dynamic progress of field dry down, was proposed by Yang et al., 2010 with the objective to test the efficiency of a simple and reliable procedure to select genotypes with fast DDR in corn. Stere et al., 1995 proposed for the first time a DDR selection index based on the slope of linear regression line between successive measurements of the moisture and dates of measurements, but using a destructive electronic probe methods to determine the grain moisture. The present study proposes a similar synthetic selection index (DDIND) for DDR, represented by the slope of the linear regression line between successive grain moisture measurements and timing. Non-destructive determinations of the grain moisture of individual plants with an wooden moisture (Voltcraft FM-200 Humidity meter) were used to estimate of DDR (DDIND).

MATERIALS AND METHODS

Non-destructive successive grain moisture measurements were made with a wood moisture meter (Voltcraft FM-200 Humidity meter) in Pioneer yield trials with hybrids (2 and 4 rows plots) and inbred lines (1 row plots), in 1-2 locations, during 2010-2012, with the purpose of DDR estimation. Same tagged contiguous competitive 5-10 plants were used for successive measurements in each plot (Table 1). Measurements started at physiological maturity (about 30-35% grain moisture), estimated when completely yellowish husks of 50% of the plants from a plot occurred.

Voltcraft FM-200 Humidity meter is a robust and precise measuring device for determining the moisture in wood and construction material like plaster, floor etc. (Pictures 1 and 2) Technical Details & Specifications of the device are presented in Table 2.

Table 1. Experimental parameters of the trials used for DDIND estimation, 2010-2012

Year	Exp.	Loc.	Type of entries	No. of entries	Type of plot	No. of plants per plot
2010	10R3H	1	Hybrids	36	4 rows/plot	6
2010	10DPI	2	Inbreds	185	1 row/plot	5
2011	11TCNSH	2	Hybrids	197	2 rows/plot	6
2011	11TCSSH	2	Hybrids	250	2 rows/plot	6
2011	11R3H	2	Hybrids	121	4 rows/plot	10
2011	11DPI	2	Inbreds	467	1 row/plot	5
2012	12R3H	1	Hybrids	94	4 rows/plot	6
2012	12R1H	1	Hybrids	416	2 rows/plot	6
2012	12DPI	1	Inbreds	530	1 row/plot	5

Table 2. Specifications of the device

Calibration possible to	ISO / DKD
Measurement type	Invasive, two pins
Measurement accuracy wood moisture	± 1%
Measurement range-wood moisture	6-44
Dimensions	47 x 139 x 25 mm
Power supply	3 batteries CR2032
Measurement range-temperature	-
Weight	100 g

In a separate experiment, successive determinations of the grain moisture were performed by using in parallel the wood moisture meter and standard gravimetric method (recommended by seed quality laboratories), averaged over 3 plants for each measurement, were collected and used to compute calibration curves (for each of the three utilized devices) for transforming the wood moisture meter readings in estimated% grain moistures (EPGM). A synthetic selection index (DDIND), represented by the slope of the linear regression line between successive grain moisture measurements and dates of measurements, was computed from EPGM to estimate the DDR expressed as lost% of moisture/day. ANOVA analysis was computed to separate the effects of genotype, environment and genotype x environment on DDR.

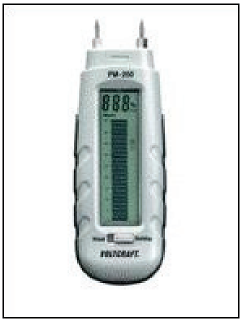

Figure 1. Voltcraft FM-200 Humidity meter, produced by Volcraft, UK

Figure 2. Measuring grain moisture with Voltcraft FM-200 Humidity meter, trough the husks

RESULTS AND DISCUSSIONS

Means, amplitudes of variation and coefficients of variation (CV) of DDIND, obtained in all experiments during 2010-2012 are shown in Table 3. Relative large amplitudes of variation were registered, roughly indicating the existence of significant differences among tested genotypes. Relative low values of the coefficients of variation presented in Table 3 suggest a good quality and uniformity of the data used. In Table 4, p main variance components and their F values and probabilities of DDIND are presented. Data showed that DDIND computed with EPGM had a large degree of precision and that a significant part of the DDIND variation was due to genotypic variations in all analyzed experiments, suggesting that real differences in genotype could be detected by utilization of DDIND to estimate the DDR. The differences in DDR expressed as DDIND were used for a better characterization and selection of the experimental genotypes.

Table 3. Means, amplitudes of variation and coefficients of variation (CV) of DDIND, 2010-2012

Exp.	Mean	Amplitude	CV %
10R3H	-1.049	-0.2208 _-1.5529	17.50
10DPI	-1.105	-0.4324 _-1.6044	12.20
11TCNSH	-1.182	-0.7427 _-2.0457	4.37
11TCSSH	-1.149	-0.736 _-2.0808	5.70
11R3H	-1.066	-0.4917 _-2.2612	5.41
11DPI	-1.852	-0.9019 _-2.7486	6.27
12R3H	-1.215	-0.7401 _-1.6126	5.60
12R1H	-1.189	-0.4877 _-1.9199	6.12
12DPI	-1.215	-0.7401 _-1.6126	9.6

Table 4. ANOVA results: main variance components and their F values and probabilities of DDIND, 2010-2012

Exp.	Location			Genotype			Loc X Genotype			Error
	Mean Sq.	*F Value*	*Prob*	*Mean Sq.*	*F Value*	*Prob*	*Mean Sq.*	*F Value*	*Prob*	*Mean Sq.*
10R3H				0.234	6.956	0.000				0.034
10DPI	5.854	31.679	0.001	0.144	7.958	0.000	0.071	3.895	0.000	0.018
11TCNSH	7.013	871.930	0.000	0.145	54.406	0.000	0.106	39.723	0.000	0.003
11TCSSH	21.340	1583.654	0.000	0.395	91.827	0.000	0.349	81.209	0.000	0.004
11R3H	0.237	69.73	0.000	0.794	326.999	0.000	0.541	161.667	0.000	0.003
11DPI	51.014	3605.133	0.000	0.022	16.600	0.000	0.158	11.707	0.000	0.013
12R3H				0.142	30.564	0.000				0.005
12R1H				0.171	32.176	0.000				0.005
12DPI				0.299	118.617	0.000				0.003

CONCLUSIONS

Utilization of Voltcraft FM-200 Humidity meter and of the calibration curves represented a reliable and efficient method to assess non-destructively the grain moisture on field corn plants.

DDIND, the selection index for measuring DDR was efficient in detecting significant real differences among genotypes.

A strong interaction genotype x environment has been estimate, as expected.

Addition future studies are necessary to to see the extend in which DDIND is efficient in selecting hybrids with early generation superior commercial hybrids, with a fast DDR.

REFERENCES

Aldrich S.R., Scott W.O., Leng E.R., 1975. Modern corn production. A and L Publication, Champaign, IL.

Baron V.S., Daynard T.B., 1984. Factors affecting grain dry-down in early-maturing European and Canadian corn hybrids. Ca J. Plant Sci. 64, p. 465-747.

Baute T., Hayes A., McDonald I., Reid K., 2002. Agronomy guide for field crops. Publication 811. The Ontario Ministry of Agriculture, Food and Rural Affairs.

Cavalieri A.J., Smith O.S., 1985 Grain filling and field drying of a set of maize hybrids released from 1930-1982. Crop Sci. 25, p. 856-860.

Crane P.L., Miles S.R., Newman J.E., 1959. Factors associated with varietal differences in rate of field drying in corn. Agron. J. 51, p. 318-320.

Cross H.Z., 1985. A selection procedure for ear drying rates in maize (*Zea mays* L.). Euphytica 34:409-418.

Cross H.Z., Kabir K.M., 1989. Evaluation of field dry-down rates in early maize. Crop Sci. 29, p. 54-58.

De-Jager B., Roux C.Z., Kuhn H.C., 2004. An evaluation of two collections of South African maize (*Zea mays* L.) germplasm:2. The genetic basis of dry-down rate. South African J. Plant Soil 21, p. 120-122.

Eckert D.J., 1978. Growing drier corn for the conservation of energy. Cooperative Extension Service, The Ohio State University, Bul. 645.

Hallauer A.R., Russell W.A., 1962. Estimates of maturity and its inheritance in maize. Crop Sci. 2, p. 289–294.

Hellevang K.J., Reff T., 1987. Calculating grain drying cost. AE-923. NDSU Extension Service, North Dakota StateUniversity. http://www.ag.ndsu.nodak.edu/abeng/pdffiles/ae923.pdf.

Hellevang K.J., 2004. Post-harvest tips for late maturing corn. NDSU Extension Service, North DakotaStateUniversity http://www.ext.nodak.edu/county/griggs/agriculture/2004agalerts/08-18-04.htm.

Hiks D.R., Geadelmann J.L., Peterson R.H., 1976. Drying rates of frosted maturing maize. Agron. J. 68, p. 452-455.

Hillson, M.T., and L.H. Penny. 1965. Dry matter accumulation and moisture loss during maturation of corn grain (*Zea mays*). Agron. J. 57, p. 150–153.

Kang M.S., Colbert T.R., Zuber M.S., Horrocks R.D., 1975. Grain moisture loss as related to drydown rates in corn. p. 57. In Agronomy Abstracts. ASA, Madison, WI.

Kang M.S., Zuber M.S., Krause G.F., 1983. Path coefficient analyses of grain yield and harvest grain moisture in maize. trop. Agric. (Trinidad) 60, p. 253-256.

Kang M.S., Zuber M.S., Colbert T.R., Horrocks R.D., 1986. Effects of certain agronomic traits on and relationship between rates of grain-moisture reduction and grain fill during the filling period in maize. field Crops Res. 14, p. 339-347.

Kondapi N., Kang M.S., Zhang Y., Deng X., 1993. Genetics of grain dry down rate in corn. p. 91-92. In Agronomy Abstracts. ASA, Madison, WI.

Lackey R., 2008. Corn energy value-A comparison of harvesting corn as shelled dried corn, high moisture corn, high moisture cob corn (cob meal) and corn silage. Ministry of Agriculture Food and Rural Affairs. http://www.omafra.gov.on.ca/english/livestock/beef/news/vbn1108a2.htm.

Nass H.G., Crane P.L., 1970. Effects of endosperm mutants on drying rates in corn. Crop Sci. 10, p. 141-144.

Newton S.D., Eagles H.A., 1991. Development traits affecting time to low ear moisture in maize. Plant Breed. 106, p. 58-67.

Purdy J.L., Crane P.L., 1967. Inheritance of drying rate in mature corn (*Zea mays* L.). Crop Sci. 7, p. 294-297.

Purdy J.L., Crane P.L., 1967. Influence of pericarp on differential drying rate in mature corn (*Zea mays* L.). Crop Sci. 7, p. 379-381.

Ragai H., Loomis W.E., 1954. Respiration of maize grain. Plant Physiol. 29, p. 49-55.

Reid L.M., Zhu X., Morrison M.J., Woldemariam T., Voloaca C., Wu J., Xiang K., 2010. A non-destructive method for measuring maize kernel moisture in a breeding program. Maydica 55, p. 163-171.

Schmidt J.L., Hallauer A.R., 1966. Estimating harvest date of corn in the field. Crop Sci. 6, p. 227-231.

Stere I., Stere Ioana, Ciocazanu I., Sarca Tr., Stefu E., 1995. Combining ability for grain dry-down rate in maize. Romanian Agricultural Research 4, p. 25-30.

Sweeney P.M., Martin S.K. St., Clucas C.P., 1994. Indirect inbred selection to reduce grain moisture in maize hybrids. Crop Sci. 34, p. 391-396.

Tollenaar M., Daynard T.B., 1978. Effect of defoliation on kernel development in maize. Can. J. Plant Sci. 58, p. 207-212.

Troyer A.F., Ambrose W.B., 1971. Plant characteristics affecting field drying rate of ear corn. Crop Sci. 11, p. 529–531.

Zhang Y., Kang M.S., Magari R., 1996. A diallel analysis of ear moisture loss rate in maize. Crop Sci. 36, p. 1140–1144.