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Evaluation of experimental hybrids in early growth stages for cold tolerance in maize

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ABSTRACT : To evaluate fifteen experimental hybrids at early seedling stages in winter season of northern India, a study was conducted during *Rabi* seasons of 2013-14 and 2014-15 with three checks. The experiment was laid out in Randomized Block Design with two replications and observations were recorded fortnightly from third week of December to last week of February. Cold stress significantly reduced the survival rate, seedling height, leaf appearance rate and leaf area in genotypes. Experimental hybrids, 12007x EL-KRNL-7, 12007 x A-89 and 131026 x131023 out-performed the superior check under cold conditions. Cold tolerant hybrids for early growth stages identified may be recommended for northern India in winter season after undergoing multi location yield trials. Further these hybrids can be utilized in breeding programmes.

KEY **W**ORDS : Maize, Cold stress, SPAD, Emergence, Leaf area, Survival

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Maize (*Zea mays* L.) is traditionally a monsoon crop (June-October) in India, but is also extensively cultivated in large parts of northern, eastern and southern India in winter (October- April) season. The current agronomic trend of planting maize in *Rabi* season in northern India especially Bihar and adjoining areas has helped in maximizing production of maize. The advantages of growing *Rabi* maize are better water management, mild and favourable temperature, better response to macronutrients, less incidence of diseases and insect-pests, better plant stand and better weed management (Singh *et al*., 2011). But planting at this time has increased the likelihood that a young maize plant will spend early stages of its development in suboptimal temperature conditions (Zaidi *et al*., 2010). In Northern India, during December and January the average temperature falls below 15°C and at times in night it goes subzero. Substantial efforts worldwide being dedicated to understand cold tolerance in early growth stages of maize *i.e.*, from germination to 3-leaf stage when the plant relies on seed reserves for its assimilates (Revilla *et al.*, 2016). Being cold sensitive, maize is prone to physiological damages during non-freezing suboptimal temperatures (Zaidi *et al.*, 2010). Cold stress induces damages in seedling such as reduced growth rate (Sowinski *et al*., 2005 and Verheul *et al*., 1996) water uptake disturbance (Aroca *et al*., 2003) photosynthesis efficiency (Foyer *et al*., 2002 and Haldimann, 1998), increase in reactive oxygen species (ROS) (Foyer *et al*., 2002) as well as enzymatic and non-enzymatic antioxidants (Leipner *et al*., 1999). Leaves developed under cold conditions are found to have lower photosynthetic capacity, lower quantum efficiency of CO_2-fixation and lower quantum efficiency of electron transfer at PSII (/PSII) (Nie *et al*., 1992 and Leipner *et al*., 1999). To breed such material genetic improvement for cold tolerance is needed. Several studies have been conducted on cold tolerance in temperate and highland maize growing areas, largely focusing on germination and early growth stages (Ying *et al*., 2002). However, limited information is available on cold tolerance in maize grown during winter season in tropical/sub-tropical environment. The objective of this study was to evaluate hybrids according to their aboveground appearance based on growth, early vigour and leaf parameters.

RESEARCH PROCEDURE

A set of 15 experimental hybrids developed by crossing diverse inbred lines along with three checks *viz*., Seed Tech 2324, Bio9681 and Buland were studied. The parental lines used in these hybrids are derived from HEY (Highland Early yellow) pool with PFSR resistance and sturdy stem and few lines derived CIMMYT - DTPY populations .

Experiments were conducted during the *Rabi* season of 2013-14 and 2014-15 at the research farm of Indian Institute of Maize Research, New Delhi, India. In both the years planting was done in third week of November. All the genotypes were sown in two row plot, each 3.0 m long, with 25 cm spacing within and 75 cm between rows in RBD. Experiments were kept free from insect, weeds and diseases using recommended post-emergence chemical measures and managed under optimal agronomic practices.

To study the cold tolerance of maize genotypes five traits were observed: (1) days to emergence, (2) seedling height (3) number of fully expanded leaves (4) leaf length and maximum width of the each fully expanded leaf was recorded on three plants in each plot; leaf area per leaf was calculated using the formula: length x maximum width x 0.75 (Montgomery, 1911) (5) chlorophyll concentration in fully expanded leaf was estimated with a handheld portable SPAD-502 chlorophyll meter (Minolta Corporation, Ramsey, NJ, USA). All the observations except days to emergence were recorded in 15 days interval from second fortnight of December to second fortnight of February. Survival percentage was computed from number of plants survived in last interval of observation. All the analysis was done using SAS software.

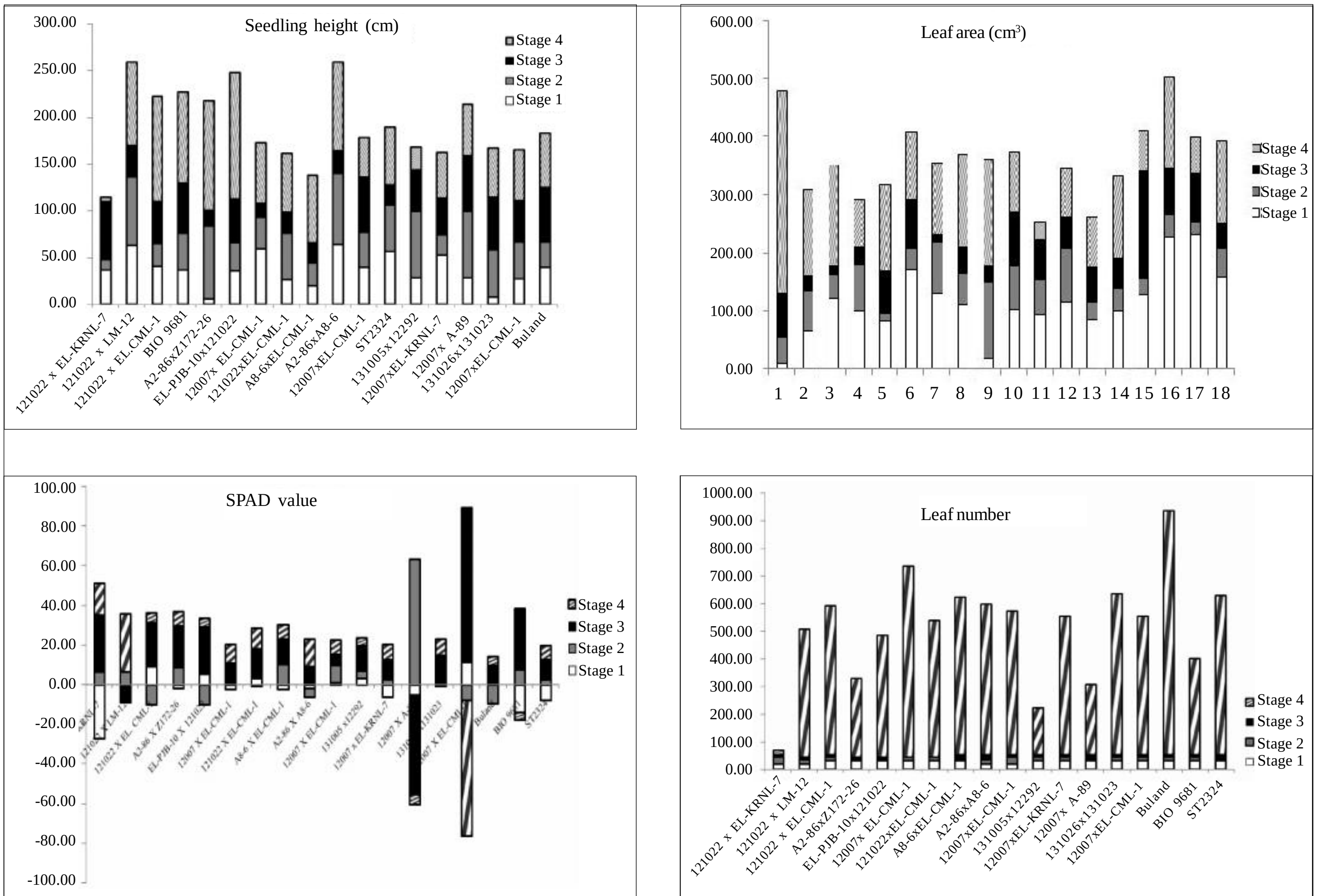
RESEARCH ANALYSIS AND REASONING

The overall mean performance of experimental hybrids in early growth stages in comparison to checks from December to February for survival rate, plant height, SPAD value and leaf appearance is shown in Table 1. The variability among the genotypes was high for SPAD, leaf area and survival rate, depicting the influence on traits by cold stress. Reduced chlorophyll content in maize leaves under cold stress has also been reported by others

Table 1 : Mean performance of experimental hybrids over two seasons

	Mean*	S.E.	Maximum	Minimum
Plant height(cm)				
Experimental hybrids	12.46	0.82	18.49	7.13
Checks	12.66	0.49	13.37	11.95
SPAD value				
Experimental hybrids	35.07	3.42	78.82	22.24
Checks	33.01	0.41	33.90	32.20
Leaf area (cm^2)				
Experimental hybrids	49.77	3.49	68.39	19.85
Checks	51.31	5.84	61.94	41.82
Leaf number (no.)				
Experimental hybrids	4.76	0.06	5	4.2
Checks	4.73	0.07	4.8	4.6
Survival rate (%)				
Experimental hybrids	62.62	4.42	94	36
Checks	59.11	6. 78	72.67	52

*Mean of hybrids calculated across five observation periods over two seasons



***Stage1**: Second fortnight of December to first fortnight of January; **Stage 2:** First fortnight of January to second fortnight of January; **Stage 3:** Second fortnight of January to first fortnight of February; **Stage 4 :** First fortnight of February to second fortnight of February

Fig. 1 : Per cent change in traits of experimental hybrids over period of cold stress

Table 2: Per cent superiority of experimental hybrids over best check

Genotypes	Growth		SPAD		Leaf area	
	December	February	December	February	December	February
121022 x EL-KRNL-7	-51.04	-60.38	-31.20	-15.69	-4.58	-77.98
121022 X LM-12	-28.60	-15.38	-26.86	-3.98	-13.43	-35.09
121022 X EL. CML-1	-21.25	-5.12	-26.14	-5.15	-1.47	-16.22
A2-86 X Z172-26	-38.80	-12.94	-22.52	-5.62	-5.19	-27.74
EL-PJB-10 X 121022	-4.12	35.64	-13.23	-6.32	-7.10	17.32
12007 X EL-CML-1	-11.46	-29.48	-12.92	16.39	-19.47	-24.99
121022 X EL-CML-1	-10.24	-15.51	-29.13	-7.02	-13.14	-8.85
A8-6 X EL-CML-1	-13.09	-28.46	-5.17	0.46	-10.80	-23.12
A2-86 X A8-6	-23.70	13.97	-22.52	-7.96	-17.14	-0.69
12007 X EL-CML-1	-14.32	-16.53	-12.30	6.55	17.68	-30.47
131005 x12292	-38.80	-41.02	-11.78	-19.43	-13.14	-46.23
12007 x EL-KRNL-7*	8.11	-14.74	-10.54	6.55	12.07	-2.46
12007 X A-89*	-8.20	23.33	-10.44	9.13	-1.73	18.21
131026 X131023*	1.99	37.56	-6.20	-22.25	-26.72	31.41
12007 X EL-CML-1	-10.64	-12.56	-4.34	11.00	-12.25	-9.60

*hybrids superior over best check

(Leipner *et al*., 1999 and Lee *et al*., 2002).

In order to study the effect of cold period on growth in terms of plant height, chlorosis and leaf appearance in hybrids the data was recorded fortnightly in five stages from December to February and per cent changes observed in traits is shown in Fig. 1. Effect of cold period on growth parameters (Fig. 1) in December and January leads to limited growth but with rising temperature from February to March hybrids started its recovery. Data indicated that there was a decrease in leaf appearance rate, plant height, SPAD value and leaf growth during cold temperature regime *i.e*., stage 1 and 2 (Fig. 1). The emergence of leaves at the apex is largely governed by temperature in gramineae (Wilhelm and Master,1995 and Van Esbroeck *et al*., 2008). In genotypes with poor cold tolerance leaf growth decreased significantly during first fortnight of January (86.4%) and continued until end of January. Similar effect of cold temperature regime was observed on rate of increase in plant height and leaf chlorophyll.

Breeding for cold stress requires identification of genotypes with rapid growth, early vigour and less leaf damage. In all traits among hybrids, analyzing the superiority over the best check resulted three hybrids *viz*.,12007 x EL-KRNL-7,12007 x A-89 and 131026 x131023 as best performers (Table 2).

LITERATURE CITED

Aroca, R., Vernieri, P., Irigoyen, J.J., Sanchez-Diaz, M., Tognoni, F. and Pardossi, A. (2003). Involvement of abscisic acid in leaf and root of maize (*Zea mays* L.) in avoiding chilling-induced water stress. *Plant Sci*., **165** : 671-679.

Foyer, C.H., Vanacker, H., Gomez, L.D. and Harbinson J. (2002). Regulation of photosynthesis and antioxidant metabolism in maize leaves at optimal and chilling temperatures: Review. *Plant Physiol. Biochem.,* **40** : 659-668.

Haldimann, P. (1998). Low growth temperature-induced changes to pigment composition and photosynthesis in *Zea mays* genotypes differing in chilling sensitivity. *Plant Cell Environ*., **21**: 200-208.

Lee, E.A., Staebler, M.A. and Tollenaar, M. (2002). Genetic Variation in physiological discriminators for cold tolerance – early autotrophic phase of maize development. *Crop Sci*., **42** : 1919-1929.

Leipner J., Fracheboud Y. and Stamp, P. (1999). Effect of growing season on the photosynthetic apparatus and leaf anti-oxidative defenses in two maize genotypes of different chilling tolerance. *Environ. Exp. Bot.,* **42**: 129-139.

Montgomery, E.G. (1911). Correlation studies in corn. In. 24th Nebraska Agric. Res. Stn. Report, Lincoln, NE. pp. 108-159.

Nie, G.Y., Long, S.P. and Baker, N.R. (1992). The effects of development at sub-optimal growth temperature on photosynthetic capacity and susceptibility to chilling-dependent photoinhibition in *Zea mays*. *Physiologia Plant.,* **85**: 554-560.

Revilla, P., Rodríguez, V.M., Ordás, A., Rincent, R., Charcosset, A., Giauffret, C., Melchinger, A.E., Schön, C.C., Bauer, E., Altmann, T., Dominique, B., Moreno-González, J., Campo, L., Ouzunova, M., de Galarreta, J.I.R., Jacques Laborde, J and Malvar, R.A. (2016). Association mapping for cold tolerance in two large maize inbred panels. *BMC Plant Biol.,* **16**:127 - 137.

Singh, N. and Rajendran, A. (2012). *Rabi* maize : Opportunities and challenges, Directorate of Maize Research, Pusa campus, New Delhi, Technical Bulletin No.9-32 p.

Sowinski, P., Rudzinska-Langwald, A., Adamczyk, J., Kubica, I. and Fronk, J.(2005). Recovery of maize seedling growth, development and photosynthetic efficiency after initial growth at low temperature. *J. Plant Physiol.,* **162**: 67–80.

Van Esbroeck, G.A., Corral, J.A., Gonzalez, J.J.S. and Holland, J.B. (2008). A Comparison of leaf appearance rates among Teosinte, maize land races and modern maize. *Maydica* **53** : 117-123.

Verheul, M.J., Picatto, C. and Stamp, P. (1996). Growth and development of maize (*Zea mays* L.) seedlings under chilling conditions in the field. *European J. Agron.,***5** : 31-43.

Wilhelm, W.W. and McMaster, G.S. (1995). Importance of the phyllochron in studying development and growth in grasses. *Crop Sci*., **35**: 1-3.

Ying, J., Lee, E.A. and Tollenaar, M. (2002). Response of leaf photosynthesis during the grain-filling period of maize to duration of cold exposure, acclimation and incident PPFD. *Crop Sci.,* **42**: 1164-1172.

Zaidi, P.H., Yadav, M., Maniselvan, P., Khan, R., Shadakshari, T.V., Singh, R.P. and Pal, D. (2010). Morpho-physiological traits associated with cold stress tolerance in tropical maize (*Zea mays* L.). *Maydica,* **55**: 201-208.