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Response of maize hybrids from heterotrophic to autotrophic phase of development in cold conditions

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ABSTRACT : Maize (*Zea mays* L.) is a crop of a tropical region with sensitivity to low temperature. This study was conducted to evaluate the performance of experimental maize hybrids in winter months of northern India in field conditions. Data were recorded for survival rate, leaf length and width, seedling height and leaf colour. The analysis of pooled data from 3-leaf stage to 6-leaf stage showed hybrids131023 x 131026 and NS76B x EL-CML-1 as best performers. Hybrids with relatively high leaf appearance rate, less cold injury symptoms showed good level of cold tolerance in terms early seedling growth under cold stress. These secondary traits could be used in selection index for improvement of tropical maize for low temperature adaptation.

KEY **W**ORDS : Maize, Hybrid, SPAD, Cold, Survival

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Growing demand of maize as animal feed, raw material in industrial sectors and interest of the consumers in nutritionally enriched products are the factors behind the emerging importance of maize crop in India. In 2013-14, India produced 24 million tonnes of maize, highest production till now in India. This growth has been achieved largely by adoption of single cross hybrids and continuous demand in domestic and export market. Single-cross hybrids in maize are a viable solution for food security in changing climate scenario. It has high productivity but low cost of production. Besides, they have a better capability to withstand biotic and abiotic stresses such as drought, extreme temperatures, pests and diseases. With the cultivation of single cross hybrid, maize has become more remunerative to the farmer and the area under maize cultivation is continuously increasing in many states of India. The step towards increasing production of maize is to invade into non-traditional areas in non-traditional season *i.e.*, winter maize in northern India (Singh *et al*., 2011). For this we need cold tolerance in maize hybrids in early growth stages. Improvement of cold tolerance leads to a higher growth rate and thus to a more rapid development of ground cover, enabling maize plants to be more competitive with weeds and reducing unfavourable environmental side effects of maize cultivation such as soil erosion, nitrate leaching and the need for the intensive use of herbicides (Riva-Roveda and Perilleux, 2015 and Verheul *et al*., 1996). Heterotrophic growth (*i.e.* germination and growth relying partly on seed reserves) and autotrophic growth (*i.e.* photosynthesis-based growth after the exhaustion of seed reserves) appear to require different minimum limiting temperatures, which may be attributable to different genetic control (Brandolini *et al*., 2000). In agreement with this hypothesis, Hodges *et al.* (1997) and Revilla *et al.* (2000) reported low associations between chilling tolerance at heterotrophic and autotrophic growth stages. In contrast, Janowiak and Markowski (1987) observed a high correlation between the two stages, suggesting a similar genetic control. Hence, further studies comparing heterotrophic and autotrophic plant growth for chilling tolerance in maize are needed. A limited number of reports for cold tolerance studies on hybrids or maize inbred lines and populations in India are available. The present investigation was carried out to evaluate the experimental hybrids in heterotrophic and autotrophic phase of their development in in winter conditions of northern India.

RESEARCH PROCEDURE

To investigate seedling growth and development under field conditions, seventeen experimental hybrids, including three checks *viz.*, Buland, Seed Tech2324 and Bio9681 were studied. Seeds were sown in third week of November of 2013-14 and 2014-15. The experiment was laid out in Randomized Blocks in two replications with 75 cm distance between rows and 25 cm between plants. All other agronomic practices were followed as per recommendation.

The observations were recorded in two stages *viz.*, three leaf stage and six leaf stage. Leaf stages are defined by the number of fully expanded leaves. The observations *viz.*, number of plants germinated, number of fully expanded leaves, SPAD value, seedling height, leaf width and length to compute leaf area, is recorded fortnightly. SPAD values recorded with handheld portable SPAD-502 chlorophyll meter (Minolta Corporation, Ramsey, NJ, USA)and leaf area as leaf width x leaf length x 0.75 (Montgomery, 1911). All the observations on growth parameters were taken on five plants per genotype per replication. All the statistical analysis being done by SAS software.

RESEARCH ANALYSIS AND REASONING

The overall mean performance of experimental hybrids from three to six leaf stage *i.e.*, 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. Mean

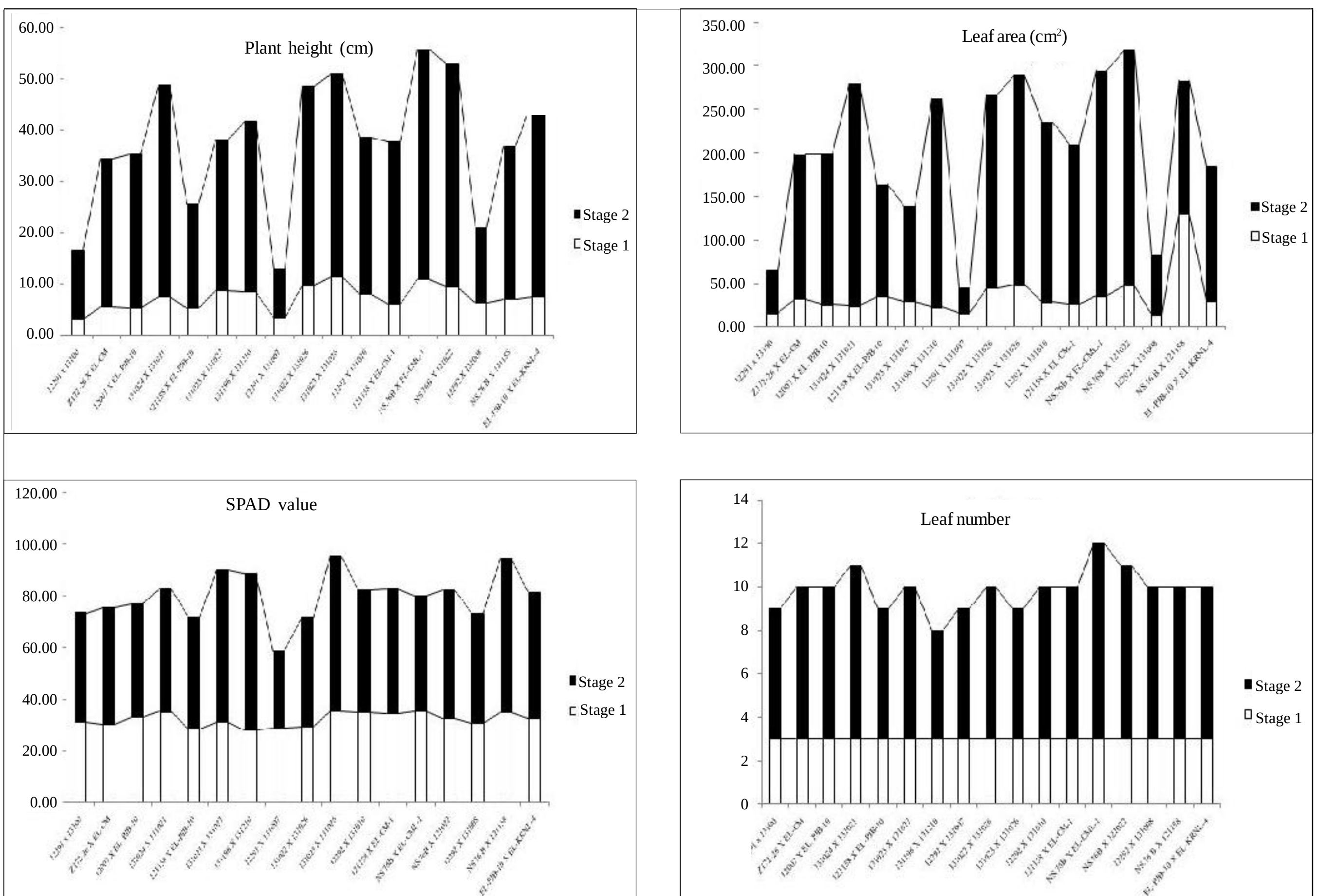
Table 1 : Mean values and standard errors for survival per cent, plant height, SPAD, leaf area and leaf number as affected by cold stress treatment at three leaf stage and six leaf stage

Trait	Three leaf stage						Six leaf stage					
	Mean	S.E.	Max.	Min.	Best	Worst	Mean	S.E.	Max.	Min.	Best	Worst
Survival %	64.8	2.74	83.3	40.0	Z172-26 x EL-CM	12291 x 13100	-	-	-	-	-	-
Plant height	7.4	0.49	11.4	3.3	131023 x131026	12291 x 13100	30.9	2.2	44.8	9.4	NS76B x EL-CML-1	12291 x131007
SPAD	31.8	0.59	35.5	27.9	131023 x 131026	131196 x 131210	49.1	2.3	78.6	30.2	BIO 9681	12291 x 131007
Leaf area	35.1	5.41	130.1	14.1	Buland	12292 x 131008	176.7	15.7	271.0	29.3	12291 x131007	12291 x 131007
Leaf number	3	0	3	3	-	-	6.8	0.9	9.0	5.0	NS.76B x EL-CML-1	131196 x131210

performance of seedling height from three leaf to six leaf stage has increased from 7.4 to 30.9 cm with lot of variation among the hybrids at both the stages (Table 1). Similar results were observed in leaf colour (SPAD value) and leaf area. 131023 x 131026 showed best performance at three leaf stage for plant height and SPAD value. While at six leaf stage NS76B X EL-CML-1 hybrid was better in plant height and leaf number. Reduced chlorophyll content in maize leaves under cold stress has also been reported by others (Leipner *et al*., 1999 and Lee *et al*., 2002).

In Fig. 1 the comparison between three leaf and six leaf stage among the hybrids is shown. In hybrids, time taken for achieving three leaf stage was 20-25 days. But with the onset of cold period the early vigour/height took more than 40 days to achieve six leaf stage. The figure shows the genetic variability among hybrids which can be exploited. Good growth vigor of our experimental hybrids is in line during stage 1 is in line with observations of a fast transformation from kernel reserves into seedling organs in Mexican tropical highland germplasm under cool conditions (Eagles, 1979).

Twelve hybrids were superior to best check in SPAD value and three in survival per cent. Only two hybrids out performed best check in plant height. Initially most of the hybrids performed at par with check but with the prolonged cold spell by 6 leaf stage all the experimental hybrids showed more leaf yellowing in comparison to best check. Yellowing of leaves is a better criterion for selection of cold tolerance (Sudipta *et al*., 2005). Significant genotypic differences for low temperature injury in maize and better tolerance of single crosses were also reported by Dhillon *et al*. (1988); Mahajan and Patil (1992) and Giauffret *et al*. (2000). Cold tolerance is genetically



***Stage1**: Three leaf stage; **Stage 2:** Six leaf stage

Fig. 1 : Variation in growth parameters of hybrids from three-leaf stage to six-leaf stage during cold stress

controlled, inherited with maternal effects and is related to germination, early seedling and vegetative growth and physiological maturity of the line (Revilla *et al.*, 2014 and 1999 and Wijewardana *et al.*, 2015).

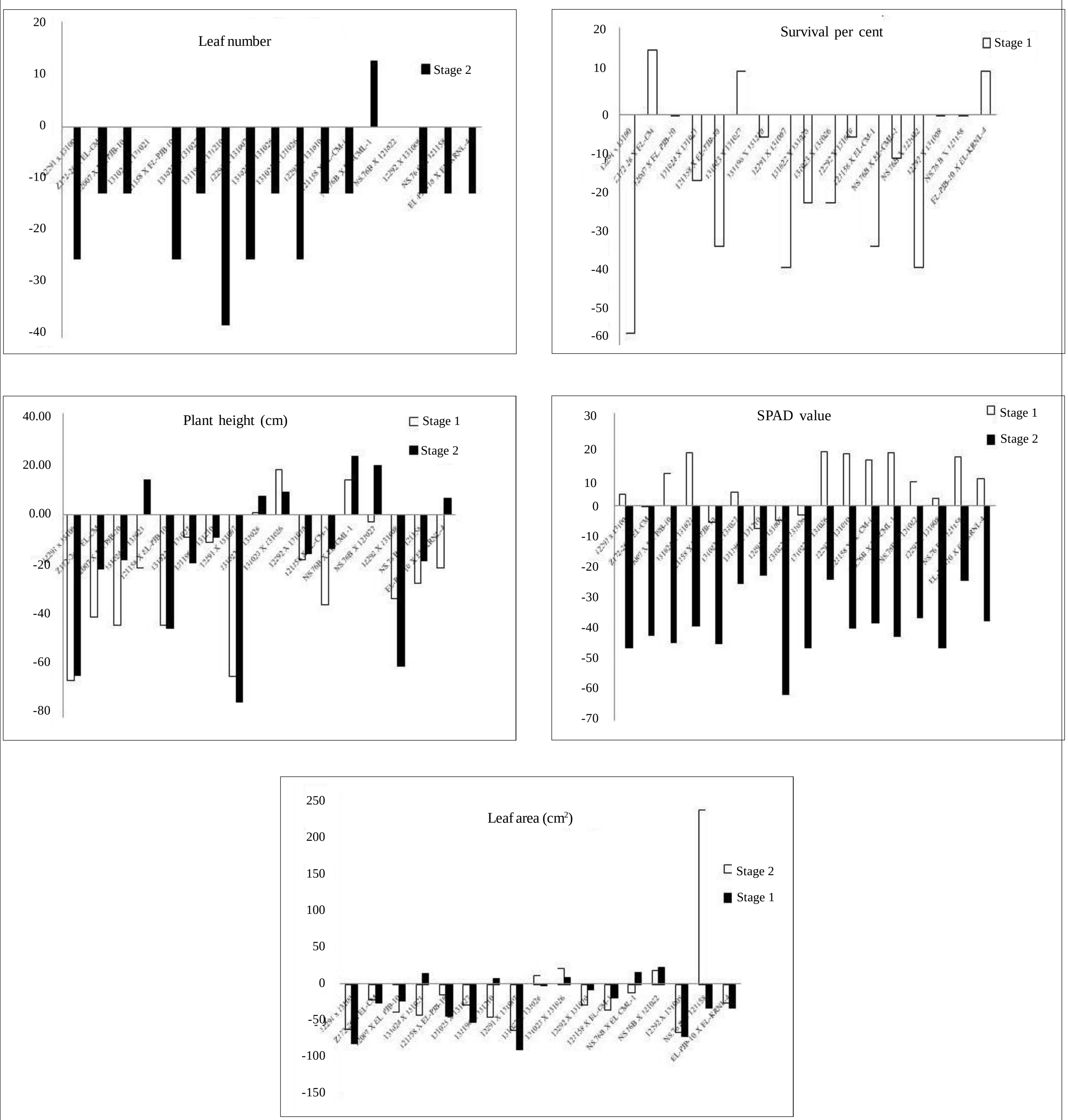


Fig. 2 : Per cent deviation from best check for survival per cent, SPAD value, plant height, leaf number and leaf area in seventeen hybrids

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