International Journal of Agriculture and Food Science Technology.
ISSN 2249-3050, Volume 4, Number 6 (2013), pp. 589-594
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http://www.ripublication.com/ ijafst.htm

A Study on the Thermo-tolerance at Germination and Seedling Stage in Indian Mustard [*Brassica Juncea* (L.) Czern & Coss]

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Abstract

High temperature at germination and seedling stage is becoming a major problem affecting production and productivity of Indian mustard in the major mustard growing states like Rajasthan and Haryana. In an experiment conducted to study whether the thermo-tolerance at germination and seedling stage are correlated in Indian mustard, fifty varieties were screened for their thermo-tolerance at these two stages. A screening protocol which simulates the temperature fluctuations experienced in the field during the germination and seedling stage of the crop was used in the study. Both the experiments were carried out in the controlled growth chamber of the National Phytotron Facility, New Delhi. In the first experiment, the ability of a genotype to germinate under high temperature was assessed in terms of germination per cent. In the second experiment five-days old seedlings were screened under high temperature conditions and seedling thermo-tolerance index was taken as the parameter to assess thermo-tolerance at seedling stage. The correlation between per cent germination under high temperature condition and seedling thermo-tolerance index was not significant. The varieties showing thermo-tolerance at these two stages were also different. This result indicates that thermo-tolerance at germination and seedling stages are not correlated in Indian mustard, and the genotypes tolerant at one stage need not be thermo-tolerant at another stage. So there is a need for separate breeding programmes for thermo-tolerance at these two stages.

Keywords: Germination; Indian mustard; seedling thermo-tolerance index; thermo-tolerance.

1. Introduction

Oilseed *Brassicas* are an important oilseed crop of winter season and is the second most important edible oil seed of India after soybean in terms of the area sown and the acreage. More than 90% of the area under oilseed *Brassicas* in India is occupied by the Indian mustard (*Brassica juncea*) because of its relative tolerance to biotic and abiotic stresses in comparison with other oilseed *Brassica* species. Heat stress due to high ambient temperatures is a serious threat to crop production worldwide (Hall, 2001). Most of the world crops are exposed to heat stress during some stages of their life cycle (Stone, 2001). Cool-season annual species like Indian mustard are more sensitive to hot weather than warm-season annuals. The maximum threshold temperatures for germination and emergence are lower for cool-season than for warm-season annuals.

Lallu and Dixit (2008) reported that an optimum average temperature around 25^{o}C is required for the proper germination and establishment of seedlings in Indian mustard. This optimum temperature could be ensured in the past by sowing the crop during the recommended sowing time of rapeseed-mustard in the north Indian states i.e., in the first three weeks of October. But due to the changing climate, temperatures during the last 15 years except 2010, was above this limit in the major rapeseed-mustard growing states of the country. The soil temperature reaches up to 40-42^{0}C in the afternoon and remains at the same level for about 2-3 hours in the north-west plane zone, especially in Rajasthan, Madhya Pradesh and Haryana, affecting the seed germination and resulting in poor plant stand in the field. The reduction in maximal emergence of Indian mustard due to hot soils can be so pronounced that yield of the economic product is reduced substantially. High temperature during the germination stage and the resultant reduction in the plant emergence also prevents early sowing of Indian mustard, which is a highly recommended practice because of the various advantages it offers as enlisted by Kaur *et al.* (2009).

Though there are many studies (Morrison, 1993; Angadi *et al.*, 2000; Morrison and Stewart, 2002; Young *et al.*, 2004) related with thermo-tolerance in oilseed *Brassicas* at the flowering stage, there are not even a single study to understand the effect of high temperature on seed germination and seedling survival. Since heat tolerance in crop plants is a developmentally regulated, stage-specific phenomenon, tolerance at one stage of plant development may not be correlated with tolerance at other developmental stages (Wahid *et al.*, 2007). So, individual stages throughout the ontogeny of the plant should be evaluated separately for the assessment of tolerance and for the identification, characterization and genetic manipulation of tolerance traits. Moreover the highest temperatures in a crop season are observed during the germination and seedling stages of the crop and these are the stages affected most by high temperature. On the basis of these observations, the present study was proposed with an objective to find out the effect of supra-optimal temperature on seed

germination and seedling survival in the Indian mustard genotypes and also to find out whether these two traits are correlated or not.

2. Materials and Methods

The experimental material consisted of 50 released varieties of Indian mustard. Four varieties [Pusa Mustard 25, Pusa Mustard 27, Pusa Agrani and Pusa Karishma] were utilized as the checks. The genotypes were screened for their ability to germinate under high temperature in the controlled growth chamber of the National Phytotron Facility (NPF), IARI, New Delhi, using the protocol proposed by Naveen Singh *et al* (2012). In the second experiment, five days old seedlings of the same set of genotypes were screened for seedling thermo-tolerance using the same screening protocol in the growth chamber. A control experiment was carried out in the glass house of the NPF where optimum temperature for seed germination and seedling survival was given. All the experiments were carried out in augmented design. The sowing medium was prepared by mixing autoclaved soil and vermi-compost in 3:1 ratio. One hundred seeds of each genotype were sown in different trays and supplement irrigation was given to avoid water stress. The entire experiment was conducted at a constant R.H. of 80%. The germination and seedling survival in the genotypes were recorded on every day from third day after sowing onwards up to 9^{th} day after sowing. Seeds were considered germinated when they exhibited radical extension of >3mm. Counts of germinated seeds were made daily during the course of the experiment to determine the final germination percentage. Final germination percentages were calculated from total number of seeds germinated divided by total number of seeds used. The parameter, seedling thermo-tolerance index (STI) was used to assess a genotype's ability to survive under high temperature stress. Seedling Thermo-tolerance Index (STI) was calculated as the ratio of number of seedling survived to the number of seedling emerged, expressed in percentage. The data obtained from the two screening experiments conducted in the phytotron was compared. To make homogeneity in the variance, the data were transformed by angular transformation. The transformed values were analyzed by the statistical software SPAD (Rathore *et al.*, 2004). The correlation between germination % under high temperature conditions and seedling thermo-tolerance index was calculated using the SPSS software.

3. Results and Discussion

There were no significant differences among the test genotypes for germination (mean = 98.65) and seedling survival (mean = 98.74) under optimum temperature conditions in the control experiment, with almost all the genotypes showing complete germination and complete seedling survival (up to 14 15 days after sowing). Whereas, germination and seedling survival under high temperature condition was reduced drastically (mean = 69.90 and 16.66, respectively). Analysis of variance showed significant differences among the genotypes for germination (%) and STI (%) under supra-optimal conditions

in the controlled growth chamber (data not shown). This indicates that genotypes differ in their ability to germinate and survive under high temperature conditions. Table 1 gives the summary of the screening experiments conducted and the list of selected genotypes showing thermo-tolerance at germination and seedling stage.

To find out whether the ability to germinate under high temperature conditions is correlated with the ability of seedling survival, correlation analysis was carried out between the germination per cent data and seedling thermo-tolerance index obtained from the two experiments. The correlation between the germination percent and the seedling thermo-tolerance index on 9^{th} days after treatment (r=0.050) and 11^{th} days after treatment (r=0.049) were both non-significant. This indicates that, the gene constellations responsible for conferring thermo-tolerance at germination stage are different from those conferring tolerance at seedling stage in the Indian mustard genotypes studied. The genotypes selected for thermo-tolerance at these two stages were also different, except the variety NPJ 147 which showed good germination and seedling survival under high temperature conditions. So simultaneous selection for the improvement of these two traits is not possible and there should be separate breeding programmes for imparting thermo-tolerance at these two stages. This result once again prove that crop plants show different sensitivity to high temperature stress at different developmental stages; hence the results obtained on thermo-tolerance at one developmental stage cannot be extrapolated to other stages. But, for confirming this result the selected Indian mustard genotypes have to be screened in randomized complete block design over different locations and seasons, because, both the traits involved in the study, especially seedling thermo-tolerance, are greatly affected by the environmental variations, and a precise partitioning of variation caused by genetic factors from the environmental variations should be made.

Table 1: Summary of the screening experiments along with the selected genotypes having thermo-tolerance at germination and seedling stage.

Genotypes	**Germination (%)**		**Genotypes**	**STI (%)**	
	Control	**Growth chamber**		**Control**	**Growth chamber**
Kranti	100.00	100.00	NPJ 124	100.00	74.0
Laxmi	100.00	100.00	Pusa Mahak	100.00	73.0
BEC 286	100.00	100.00	NPJ 113	100.00	64.0
PBR 91	100.00	95.24	EJ 22	100.00	63.0
NPJ 147	100.00	90.48	Pusa Bahar	100.00	58.0
EJ 20	95.24	90.48	NPJ 147	100.00	44.00
Minimum	85.71	33.33	Minimum	80.95	0.00
Maximum	100.00	100.00	Maximum	100.00	74.00
Mean	98.65	69.90	Mean	98.74	16.66

LSD1 (P=0.05)	-	7.07	LSD1 (P=0.05)	-	14.68
LSD2 (P=0.05)	-	7.90	LSD2 (P=0.05)	-	16.42
CV (%)	-	7.10	CV (%)	-	16.01

LSD: Least significant difference; $LSD_{1:}$ LSD between two test treatments in the same block, $LSD_{2:}$ LSD between Two Test Treatments (Different Blocks); CV: Coefficient of variation.

4. Conclusion

High temperature drastically reduces germination and seedling survival in the Indian mustard germplasm studied. But the ability to germinate under high temperature and the seedling survival under heat stress are not correlated. So a variety thermo-tolerant at one stage of development may not be thermo-tolerant in the other growth stage hence simultaneous improvement in the two traits is not possible.

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