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Effect of elevated high temperature stress on seed quality of *Brassica rapa in* ambient storage condition

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Abstract

In view of the current issue of high temperature stress on seed yield and quality, the present investigation was undertaken to assess the effect of high temperature on seed viability of *Brassica rapa* during 2017-18 at Assam Agricultural University, Jorhat. Fifteen entries were grown under temperature gradient tunnel (stress) and in the open field (non stress) conditions in randomized block design with two replications. Seed germination percentage and vigour index were observed on the seeds after nine months of storage. Significant variation was observed among the genotypes for germination percentage in stress but not in non-stress condition. For seed vigour index, the genotypes, parents, crosses and parents vs. crosses significantly differed in both stress and non-stress environments. Germination declined by 12 % and seed vigour index by 223 under high temperature stress. Only in stress condition, significant variations for general combining ability (GCA) and specific combining ability (SCA) were observed for germination percentage. Seed vigour index showed significant variations for GCA and SCA effects in both stress and non-stress conditions. Yellow sarson parents exhibited better combining ability for seed quality after storage than the toria parents under high temperature stress.

Keywords: *Brassica rapa, diallel cross, germination, temperature stress, vigour index*

Introduction

Indian rapeseed (*Brassica rapa* L.) and mustard [*B. juncea* (L) Czern. & Coss.] are major oilseed crops of India. Indian mustard is the predominant oilseed brassica in India. In Assam, rapeseed toria is the most important oilseed crop with some percentage of area under yellow sarson for oil production. There are three agro-morphologically distinct ecotypes of Indian rapeseed, namely brown sarson, yellow sarson and toria (Singh, 1958). Farmers preferably grow rapeseed than mustard because of its shorter life cycle. As it is a cool season crop, people are not aware of increased terminal temperature stress, which may have detrimental effect on seed quality and production. Moreover, climate change is adversely impacting crop production and quality seed production. Among all the environmental factors, temperature and moisture stress during the reproductive stage significantly affects seed quality (Hampton *et al*., 2013; Maity and Pramanik, 2013; Singh *et al.* 2013; Rashid *et al*., 2018). In seed industry, good quality seed includes genetically and physically pure, and physiologically sound seeds without infection by diseases or insect pests. Therefore, it is a challenging task to produce good quality seeds to ensure food security. In view of this, a study was conducted to evaluate the seed quality in response to high temperature stress after nine months of storage.

Materials and Methods

Three Yellow Sarson [*Brassica rapa var Yellow Sarson*] genotypes (B9, YSH 401 and NRCYS 05-03) and two Toria [*Brassica rapa var Toria*] lines (Jeuti and TS 46) were used for study. They were crossed in a diallel fashion without reciprocals. During *Rabi* 2017-18 the fifteen entries comprising five parents and ten F_1s were sown in randomized block design with two replications. The genotypes were grown in stress (high temperature condition) as well as in non-stress (field condition, ambient temperature) conditions to observe the performance of the genotypes. The temperature gradient tunnel (TGT) was filled up with fine tilth soil and other agronomic practices were followed as per package. The flowering period started in the 2nd week of December and the temperature inside the TGT was recorded to be nearly 30°C (+ 4°C) throughout the flowering period and outside the TGT was nearly 25°C. The elevated temperature was maintained through infra-red heater regulated by SCADA software. TGT structure consisted of a rectangular block, fabricated by metallic sheet, covered with polycarbonate sheet (100 ì gauge) and installed in the experimental field. The polycarbonate sheets showed >85% transmission of light. The tunnel was fitted with 4 RTD (remote terminal unit) or data logger**,** temperature sensors, humidity transmitters and infrared heaters. To record ambient data, a temperature sensor and a humidity transmitter were placed outside the chamber. Computer software was used for run and store daily data. The seeds from both the conditions were harvested and kept in ambient storage condition in a cloth bag after proper threshing, cleaning and drying.

Germination percentage and vigour index were calculated by using the following formula:

Germination % = (Number of normal seedling/ Total number of seedlings) × 100

Seed vigour index = Germination % × Average seedling length (cm)

Analysis of variance of each character was done following the standard statistical procedure. Combining ability analysis of the half diallel population was done following model I, method 2 of Griffing (1956).

Results and Discussion

Mean performance

Significant variation was observed among the genotypes and crosses for germination percentage in stress but not in non-stress condition (Table 1). For seed vigour index the genotypes, parents, crosses and parents vs. crosses significantly differed in both stress and non-stress environments.

The mean values are presented in Table 2. In stress, TS 46 showed the highest germination percentage (89%) followed by Jeuti (84%), YSH 401 (80.50%), B9 (79%) and NRCYS 05-03 (77%). Among the crosses, B9 x YSH401 (100%), B9 x NRCYS 05-03 (88%), B9 x TS46 (88%), YSH401 x TS46 (97%) and NRCYS05-03 x Jeuti (98%) showed the high germination percentage. In non stress condition, germination percentage was above 85%. In case of vigour index, Jeuti showed high seed vigour index in stress condition. Among the crosses, high seed vigour index was exhibited by B9 x YSH401, B9 x NRCYS05-03, B9 x TS46, YSH401 x TS46 and NRCYS05-03 x Jeuti. In non stress condition, all the lines showed good vigour index except TS46. There was decline in germination and vigour index under stress condition. Germination declined by 12 percent and seed vigour index decreased by 223 under high temperature stress (Table 3). In stress condition, germination percentage showed moderate level of genotypic coefficient of variation with high heritability and genetic advance. Seed vigour index showed high genotypic coefficient of variation, heritability and genetic advance.

Table 1: Analysis of variance (mean squares) for seed quality parameters of stored seeds produced in stress and non stress conditions

Source	df	Germination %		Seed vigour index	
		Stress	Non-stress	Stress	Non-stress
Replications	1	11	0	662	2908
Genotypes	14	374**	20	51212**	52117**
Parents (P)	4	42	3	49202**	83007**
Crosses (C)	9	561**	25	47715**	25549**
P vs. C	1	10	42	90729**	167672**
Error	14	21	13	3032	3599
CV%		6	4	8	7

*Significant at p=0.05 and ** Significant at p=0.01

Germination percentage and seed vigour index was found lower in stress condition than in the normal situation. As the seed longevity was tested after nine months of storage, viability was lost in terms of development of abnormal seedlings. Most of the seedlings showed stunted primary root development. Similar results were reported by Rashid *et al*. (2018). In earlier studies, it was reported that abnormal seedlings may be a result of either mechanical injury to the embryo, plant pathogen attack or deficiencies in the physiological make-up of the seed and embryo (Egli *et al.*, 2005; Gillen *et al.*, 2012; Rashid *et al.*, 2018). In the present study, low germination might be a result of physiological hindrance during seed filling in stress condition as there was no incidence of disease or pest infection. As the seeds were hand podded and handled with care, mechanical injury should not be the

Table 2: Mean performance of the plant materials under stress and non stress environment

Line	Germination (%)		Seed vigour index	
	Stress	Non stress	Stress	Non stress
B9	79	96	565	719
YSH 401	80	98	598	855
NRCY S05-03	78	97	536	814
Jeuti	84	96	888	1113
TS 46	89	95	494	558
B9 x YSH 401	100	89	845	766
B9 x NRCYS 05-03	88	94	870	1010
B9 x Jeuti	75	94	639	932
B9 x TS 46	88	87	916	903
YSH 401 x NRCYS 05-03	84	96	726	1056
YSH 401 x Jeuti	79	99	610	821
YSH 401 x TS 46	97	96	779	1031
NRCYS 05-03 x Jeuti	98	96	818	1064
NRCYS 05-03 x TS 46	81	94	735	1120
Jeuti x TS 46	42	95	391	999
Mean	83	95	694	917
CD (p = 0.05)	10	8	118	129

Table 3: Estimates of genetic parameters for seed quality characters in Indian rapeseed under stress environment

Character	Mean		GCV (%)		Heritability$_{bs}$ (%)		Genetic advance (%)	
	S	(S - NS)	S	NS	S	NS	S	NS
Germination%	83	-12**	16	2 (ns)	89	19	31	2
Vigour index	694	-223**	22	17	89	87	43	33

** Significant at p=0.01 S: Stress NS: Non-stress

reason. During flowering time, temperature was recorded as 30°C (+4°C) which is beyond the threshold temperature for healthy seed development, seed weight and yield as reported by Morrison and Stewart (2002). Heat stress has profound effect on seed mass (Gan *et al.*, 2004; Yu *et al.*, 2014). This may be also a reason of low germination and vigour. Islam *et al.* (2013) reported similar results for germination and seedling vigour index in jatropha, an oilseed plant for bio fuel. Environmental factors, particularly high temperature during seed development, were reported to have considerable influence on seed vigour (Dornbos, 1995; Wilson *et al.*, 2004). Rashid *et al.* (2018) reported 20 to 24 percent loss in seed vigour in high temperature stress.

Analysis of combining ability

In stress condition, significant variations for general combining ability and specific combining ability were observed for germination percentage. However, in non-stress condition no significant GCA and SCA effects were observed for germination percentage. Seed vigour index showed significant variations for GCA and SCA effects in both stress and non-stress conditions. The predictability ratio was high for the two seed quality characters in non-

Table 4: Analysis of variance (mean square) for combining ability for seed quality traits of stored seeds grown in stress and non stress conditions

Source	Germination (%)		Seed vigour index	
	Stress	Non-Stress	Stress	Non-Stress
GCA	76**	13	6786**	27347*
SCA	231**	9	33134**	25543**
Error	11	7	1516	1799
G:S variance ratio		0.37	0.85	0.25 0.68

* Significant at p=0.05; ** Significant at p=0.01

stress condition only. This indicated that the progeny performance of the characters could be predicted from the GCA effects in non-stress condition only (Table 4).

The general combining ability effects of the parental lines are presented in Table 5. Positive GCA effect was observed in the parent YSH401 and negative effect in Jeuti for germination percentage. B9 exhibited positive GCA effect and TS46 exhibited negative effect. The specific combining ability effects of the crosses are presented in Table 6. Significant positive SCA effects for germination percentage were exhibited by B9 x YSH401, B9 x TS46, YSH401 x TS46 and NRCYS-05-03 x Jeuti. These crosses including NRCYS05-03 x TS46 showed positive SCA effects for vigour index.

Table 5: Mean values and general combining ability effects in a diallel cross of Indian rapeseed tested in stored seeds after exposure to stress

Parent genotype	Germination (%)		Seed vigour index	
	Mean	GCA effect	Mean	GCA effect
B9	79	2	565.	34*
YSH401	81	3**	598	-1
NRCYS 05-03	77	1	536	8
Jeuti	84	-5**	888	10
TS46	89	-2	494	-51**
	CD 5% = 10	SE (gi) = 1	CD 5% = 118	SE (gi) = 13
	CD 1% = 14	SE (gi-gj) = 2	CD 1% = 163	SE (gi-gj) = 20

* Significant at p=0.05; ** Significant at p=0.01

Table 6: Mean values and SCA effects of diallel cross populations for seed quality parameters of stored seeds grown in high temperature stress

Population	Germination (%)		Seed vigour index	
	Mean	SCA effect	Mean	SCA effect
B9 x YSH 401	100	12**	845	119**
B9 x NRCYS 05-03	88	2	870	134**
B9 x Jeuti	75	-5	639	-99**
B9 x TS 46	88	5**	916	239**
YSH401 x NRCYS 05-03	84	-4	726	25
YSH401 x Jeuti	79	-2	610	-93**
YSH401 x TS 46	97	12**	779	137**
NRCYS05-03 x Jeuti	98	19**	818	106**
NRCYS 05-03 x TS 46	81	-2	735	84**
Jeuti x TS 46	42	-34**	391	-262**
	CD 5% = 10	SE (sij) = 2	CD 5% = 118	SE (sij) = 27
	CD 1% = 14	SE (sij-sik) = 4	CD 1% = 164	SE (sij-sik) = 51
		SE (sij-skl) = 4		SE (sij-skl) = 47

* Significant at P=0.05; ** Significant at P=0.01

In the present study, the crosses involving yellow sarson parents exhibited high SCA effects, under high temperature stress condition even after storage of seeds. The SCA effects denote the high progeny performance of specific crosses and signify the role of non-additive gene action in the expression of the characters. From the present materials, yellow sarson parents viz. B9 and YSH 401 showed good seed longevity.

Conclusion

The study showed that high temperature stress during terminal stage had detrimental effect on seed viability and vigour. However, crosses B9 x YSH 401, YSH 401 x TS 46 and NRCYS 05-03 x Jeuti showed higher germination percentage than the parents including B9 x TS 46 for vigour index. This indicates that the breeding materials have the capacity to respond under stress condition. For increasing higher productivity under high temperature stress condition these materials can be used for future breeding programmes to get quality seeds. More research with a greater number of breeding materials is needed for more investigation in relation to other quality parameters.

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