Frost resistance in Indian mustard (*Brassica juncea* L. Czern & Coss.): screening of genotypes

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Abstract

Oilseed *Brassica*s are prone to frost injury. Although, the occurrence of frost is not a regular phenomenon, but if it occurs, it causes heavy losses in seed yield and oil content. The severity of frost damage depends upon the number of frost days and stage of the crop. The yield losses have been reported even up to the tune of 100%. Screening of genotypes for frost resistance can be done both in laboratory and field conditions. The identification of frost resistant genotypes would help in sustaining the fluctuating production in the frost years and developing high yielding frost resistant varieties. Therefore, in the present study efforts have been made to identify promising frost resistant genotypes during the year 2005-2006 under natural frost conditions. Screening under natural frost conditions is most appropriate, but the limitation of availability of frost every year is one of the major constraints. During the crop season of 2005-06 there was natural frost (minimum temperature -2.0, -2.7, -3.5, -2.0°C) for four consecutive days (Jan. 6-9) which gave an opportunity to screen thirty six promising genotypes of *Brassica* contributed by different coordinating centers of the country. Per cent killed seeds/siliqua on main shoot was used as the parameter to screen frost resistant genotypes. It ranged from 3.9% (RM-110) to 78.1 % (NRCHB-303). Higher the per cent killed seeds, more a genotype will be susceptible to frost and vice-*versa*. Genotypes showing less than 20% killed seeds/siliqua were referred as frost resistant genotypes *viz*; RM-110 (3.9%), RRN-598 (13.1%), RH-9902 (16.3%), JGM3-02 (18.0%); the genotypes showing 20 to 30% were categorized as moderately frost resistant genotypes. The genotypes in this group were RH-0202 (22.2%), PRB-2004-06 (23.5%), RK-05-1 (25.0%), RK-05-2 (25.7%), RL-2106 (27.9%), NDR 05-2 (28.3%), JMWR-941-1-2 (28.9%), whereas, the genotypes showing more than 30% were referred as frost susceptible genotypes.

Key words: *Brassica*, Frost injury, Screening.

Introduction

Oilseeds *Brassica*s are the second most important oilseed crops after groundnut in India. The predominantly grown species (*B. rapa* and *B. juncea*) in Indian Sub-continent are susceptible to frost injury (Dhawan, 1985). Although, the frost is not a common phenomenon, if it occurs it causes heavy yield losses and reduction in oil content. Frost damage occurs when ice forms inside the plant tissue and injures the plant cell. The extent of injury caused by frost mainly depends upon the temperature below freezing point, the period of that temperature and the crop stage at which frost occurs. The freezing can be either extra cellular (ice formation outside the cell) or intracellular (ice formation inside the cell). The ice formation inside the cell causes mechanical disruption of protoplasm (Levitt, 1980). The losses due to frost under rainfed conditions are higher than the irrigated conditions. Therefore in dry years, the frost protection is improved by wetting dry soils. During the crop season 2005-06, the temperature touched below zero i.e. -2.0, -2.7, -3.5, -2.0°C for four consecutive days for several hours (Jan. 6-9, 2006) causing heavy yield looses in the entire Haryana State in early sown (first fortnight of October) crop under rainfed conditions. Therefore, benefit of natural frost was taken for screening the for frost resistance. Advanced breeding strains contributed by different research centers of All India Co-ordinated Research Programme were screened

Material and Methods

Thirty six Indian mustard genotypes contributed by different coordinating centers of AICRP programme were screened for their frost resistance /susceptibility under natural field condition. 30 siliquae from the main raceme of randomly taken five plants/genotype from each replication were used for the assessment of freezing injury. Killed seeds/ siliqua were counted seven days after the occurrence of frost. Per cent killed seeds/ siliqua were calculated using following formula :

$$\text{Per cent killed seeds/siliqua} = \frac{\text{Number of killed seeds /siliqua}}{\text{Total number of seeds/siliqua}} \times 100$$

Higher the % killed seeds / siliqua; more the genotype will be susceptible to frost

Results

During the season, the minimum temperature was below 0°C (-2.0, -2.7, -3.5, -2.0°C) for four consecutive days (Fig. 1), when the crop was at siliqua development stage. Due to frost, there were tremendous seed killing (Fig.2) resulting into heavy yield losses. The higher the per cent killed seeds/ siliqua, more the genotype is susceptible to frost and *vice versa.* Data (Table

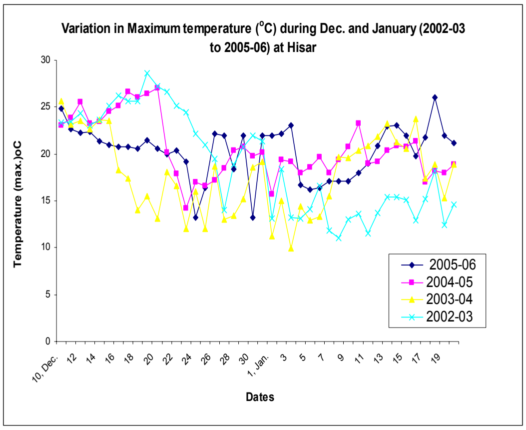
1) reveal that the extent of frost damage ranged from 3.9% (RM-110) to 78.1 % (NRCHB-303). The genotypes showing less than 20% killed seeds/siliqua were termed as frost resistant genotype such as RM-110 (3.9%), RRN 598 (13.1%), RH-9902 (16.3%), JGM3-02 (18.0%) and the genotypes showing damage in the range of 20 to 30% were referred as moderately resistant e.g. RH-0202 (22.2%), PRB-2004-06 (23.5%), RK-05-2 (25.0%), RK-05-1 (25.7%), RL-2106 (27.9%), NDR 05-2 (28.3%), JMWR-941-1-2 (28.9%), whereas, the genotypes showing more than 30% damage were categorized as frost susceptible genotypes. Negative significant correlations were observed between per cent killed seeds / siliqua with seed yield, oil content and days to flower initiation, where as negative non significant association for 1000 seed weight and days to maturity was observed (Table 2).

Discussion

The maximum seed killing was observed when plants were at the developmental stage. Similar results have earlier been reported by Dhawan *et al* 1983, Chhabra and Dhawan, 1992 and Singh *et. al*. 2006, that plants are most susceptible to frost 30-35 days after initiation of flowering. The extent of damage in the present studies has been observed to be more in the early sown (by 15th October) and the rainfed crops than the late sown (in first fortnight of November) and the irrigated plot. The possible explanation could be that the late sown crops were still in vegetative stage and hence escaped frost, whereas early sown crops were at a stage when *Brassica* crop is most sensitive to frost. Irrigated plots due to evaporation energy losses tend to counterbalance the benefit of radiation absorption (Chhabra and Dhawan, 1992) hence such plots escaped frost.

Conclusions

The present study revealed that out of thirty six genotypes, eleven genotypes namely; RM-110, RRN 598, RH-9902, JGM3-02 were tolerant and RH-0202, PRB-2004-06, RK-05-1, RK-05-2, RL-2106, NDR 05-2, JMWR-941-1-2 were moderately tolerant to frost. Keeping in view, the susceptibility of *Brassica* crop to frost, besides growing identified frost tolerant genotypes it is also advocated that frost management strategies viz: irrigation of crop, creating smoke around canopy, spray of Dimethyl sulphoxide @1ml/l before the expected period of frost may also be adopted.



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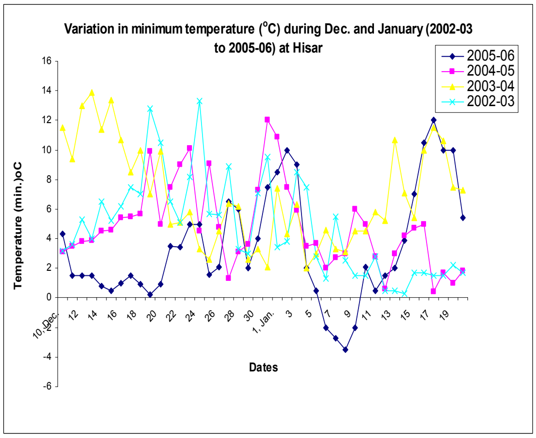

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Fig 1.Variatin in maximum (A) and minimum(B) temperature (°C) during December & January, 2002-03 to 2005-06

Fig. 2 Showing killed seeds due to frost

Table 1: Showing the results of different quantitative characters and % killed seeds due to frost in different genotypes of Indian mustard screened under natural frost and rainfed conditions

Strains	Days to flowering initiation	Days to maturity	Seed yield (kg/ha)	1000 Seed weight (g)	Oil content (%)	% killed seed
RK-05-2	49	137	2246	4.9	34.5	25.0
RB-50	49	139	1832	4.9	35.1	49.5
SKM-401	49	136	1418	5.2	33.1	68.6
JMWR-13-1	41	138	1241	4.9	35.0	48.5
SKM-425	47	139	1950	5.3	35.5	73.8
NRCHB-303	42	140	1182	4.8	32.8	78.1
NDR 05-1	48	140	2955	5.1	36.4	37.3
JNWR-941-1-2	47	136	1123	4.8	35.3	28.9
RH-0202	48	138	1182	4.8	33.1	22.2
RGN-152	47	138	1359	5.3	34.6	47.7
PRB-2004-06	47	138	1359	7.3	33.3	23.5
RH-9902	47	138	1241	5.3	38.9	16.3
RK-05-1	48	137	2305	6.1	38.8	25.7
RRN-598	46	141	1478	5.5	34.2	13.1
PR-2004-2	50	138	2187	4.5	35.3	69.5
NDR-05-2	47	138	1537	5.2	35.1	28.3
JS-21	45	143	1182	5.7	34.8	78.4
PBG-1188	43	141	1478	5.4	35.4	46.2
RM-110	45	144	1950	4.8	36.4	3.9
NRCDR 507	44	138	1418	5.2	35.7	75.2
JK MS-2	43	136	946	5.7	31.3	74.9
TNM-17	42	137	768	3.7	35.4	63.8
PHJ 02-402	43	140	1832	3.9	36.4	45.9
RL-2106	44	144	1773	5.0	36.6	27.9
PBR-300	47	139	2482	5.2	36.4	33.9
JGM3-02	46	140	1773	4.3	36.9	18.0
Zonal Check	46	142	1891	5.1	37.9	69.0
45J21	39	135	591	5.9	34.0	69.7
PARASMANI-2	44	141	1300	6.0	32.0	49.8
Filler-2	46	143	2069	4.2	37.3	27.2
ORY (M) 15-2-2	45	144	2128	5.7	38.3	64.8
RKM-1	44	141	1182	5.1	33.7	68.8
Filler-1	47	137	1714	4.8	38.4	49.0
Kranti (NC)	47	137	1418	4.3	36.1	43.2
Varuna (NC)	46	137	1478	5.9	32.7	34.9
Radha 8117	42	137	1241	4.7	33.9	42.9
GM	45	139	1589	5.1	35.3	
CD at 5%	4.5	3.0	433	1.1	2.2	
CV %	4.9	1.1	13.4	10.4	3.1	

Table 2 Correlation coefficients between % killed seeds due to frost with Seed yield, 1000 seed weight, oil content, days to flower initiation and days maturity.

% Killed seeds due to frost	Seed yield (kg/ha)	1000 seed weight (g)	Oil content (%)	Days to flowering initiation	Days to maturity
	-0.280*	-0.002	-0.259*	-0.320*	-0.100

Significant at p= 0.05

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