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Effect of dates of sowing and chemicals spray to mitigate the effect of increasing temperature on germination and Vigor Index of Indian mustard [*Brassica juncea* (L.) Czern and Coss]

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Abstract
Mustard [*Brassica juncea* (L.) Czern & Coss], belongs to the plant family *Brassiceae* (*Cruciferae*) or the mustard family. In India, *B. juncea* is a predominant species, which accounts for nearly 80% of the production area of the oilseed. The present investigation entitled "Effect of dates of sowing and chemicals spray to mitigate the effect of increasing temperature on seed set, yield and quality of Indian mustard [*Brassica juncea* (L.) Czern and Coss]" field experiment was carried out at Oilseeds Farm, Kalyanpur, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur during *rabi* season 2015-16 & 2016-17. The experiment consisted of two sowing dates [20th October (timely sowing), 5th November (Heat stress) and one varietiy (Mustard "Rohini") with seven treatments likewise Control (T_0), Glycine Betaine - 600 ppm (T_1), Salicylic acid – 800 ppm (T_2), Salicylic acid- 400 ppm (T_3), Ascorbic acid- 10 ppm + Citric acid 1.3% (T_4) Alfa Tocopherol-150 ppm (T_5) KCL - 1% (T_6) there by making forty two treatment combinations. The maximum Germination (%) of 69.76 and 69.61 was noted for first year when crop was shown on first date of sowing. Significantly less Germination (%) of 69.33 in first year and 69.29 in second years was associated with both date of planting. Maximum Germination (%) of 72.52 and 71.12 for first and second years respectively was noted with treatment T_5. The maximum Vigour Index – I of 1402.69 and 1419.80 was noted for both respective years when crop was shown on different date of sowing. Maximum vigor Index – I of 1562.09 and 1580.15 for first and second years respectively was noted with treatment T_5. The maximum vigor Index – II of 3.27 and 4.20 was noted for both respective years when crop was shown on first date of sowing in first year and second date of showing in second year. Maximum vigor Index – II of 3.5 and 4.65 for first and second years respectively was noted with treatment T_6.

Keywords: Mustard, growth parameters**,** glycine betaine, salicylic acid, salicylic acid, ascorbic acidcitric acid and alfa tocopherol

Introduction
Brassica juncea (L.) Czern & Coss., also known as Indian mustard, belongs to the plant family *Brassiceae* (*Cruciferae*) or the mustard family. Indian mustard *Brassica juncea* (L) Czern and coss, 2n=4x=36] is an annual, *rabi* oil seeds crop and an amphidiploid species derived from interspecific cross between *Brassica nigra* (2n=18) and B. rapa (2n=20).Central Asia-Himalaya is a primary centre of diversity for this species with migration to China, India and Caucasus (Hemingway, 1976) [6]. Rapeseed-mustard is the third important oilseed crop in the world after soybean and palm oil. Among the seven edible oilseed crops cultivated in India, rapeseed-mustard (*Brassica spp.*) contributes 28.6% in the total production of oilseeds. In India, it is the second most important edible oilseed after groundnut sharing 27.8% in the India's oilseed economy. The global production of rapeseed-mustard is grown in an area 36.59 m ha and the production is around 72.37 m tonnes with an average productivity of 1980 kg per ha (Anonymous, 2020) [4]. In India, rapeseed and mustard is grown in about 6.5 m ha with total production of about 7.39 mt. and an average productivity of 1840 kg/ha (Anonymous, 2019) [3] next to China (11-12 mt) and EU (10–13 mt) with significant contribution in world rapeseed-mustard industry. It accounts for about 25 per cent of the total oilseed production of the country. In Uttar Pradesh, rapeseed and mustard occupies prime place amongst all the oilseed crops grown in the state, occupying 0.69 m ha area and 0.75 mt. production (Anonymous, 2019) [3]. Rajasthan ranks first both in area and production of rapeseed and mustard in the country.

The rapeseed-mustard group broadly includes Indian mustard, yellow sarson, brown sarson, raya, and toria crops. Indian mustard is predominantly cultivated in Rajasthan, U.P., Haryana, Madhya Pradesh and Gujarat. It is also grown under some nontraditional areas of South India including Karnataka, Tamil Nadu and Andhra Pradesh. The crop can be grown well under both irrigated and rain fed conditions.

High temperature stress directly or indirectly affects plant photosynthetic functions by changing the structural organization and Physico-chemical properties of thylakoid membranes (Lichtenthaler *et al.*, 2005) [7]. The rate of photorespiration increases with increasing temperature which reduces net photosynthesis (Sage and Sharkey, 1987) [11] and probably the seed yield of the crop. Mustard and rapeseed are grown under diverse agro ecological situations such as timely/late sown, rain fed / irrigated, sole and/or mixed crop with cereals (wheat, barley, chickpea, lentil etc.). The inter/mixed cropping with wheat as well as late sowing after rice and cotton exposes this crop to high temperature stress during reproductive stage. Due to tropical environment of India, the effect of heat stress is very much harmful. Brassica being a *rabi* crop of arid and semi-arid regions, its sowing depends upon rain. Heat stress prevailing during sowing time reduces seed germination and causes seedling mortality. Therefore, crop is to be re-sown many a times before a final successful crop is taken. High temperature stress negatively affects plant growth development and crop yield (Boyer, 1982) [5]. According to recent study (Lobel and Asner, 2003) [10] each degree centigrade increasing in average growing season temperature reduce crop yield 17%. High temperature stress directly or indirectly affects plant photosynthetic rate by changing the structural organization and physio-chemical properties of thylakoid membrane (Lichtenthaler *et al.*, 2005) [7]. The rate of photorespiration increases with increase temperature which reduces net photosynthesis (Sage and Sharkey, 1987) [11] and probably the seed yield of the crop.

The sarson crop need cool temperature for better vegetative growth, moderate for flowering and high temperature for maturity to get better yield and quality of seed. It is not possible every time in nature to get favorable temperature, therefore, it needs some manipulation either in sowing time or to use some chemicals or both to get proper growth, yield and seed quality. Keeping in view the above, two dates of sowing (at 15 days interval) and six different chemicals along with a control have been used to see their effect on growth, yield and seed quality and to minimize the adverse effect of increasing temperature on crop performance of mustard crop in this global warming era.

Materials and Methods

The experiment was conducted on Oil seeds Farm, Kalyanpur, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. Geographically, Kanpur is situated 84 km west of Lucknow at 26^0 44‟ North latitude, 80^0 33‟ East longitude and at an altitude of 126 metres above mean sea level. The area falls in agro climatic zone-III (Central Plain Zone) of Uttar Pradesh.

Germination %

Seed germination percentage under lab condition was estimated on the basis of germinated seed from 100 randomly selected seed kept for germination in seed germinator at 20 ^{0}C for 7 day**.**

$$\text{Germination (\%)} = \frac{\text{Number of germinated seed}}{\text{Number of total seeds tested}} \times 100$$

Seedling length (cm)

At the end of germination test period randomly ten normal seedlings were carefully removed from each replication. The distance between the collar and tip of the primary root as shoot length and between the collar and tip of primary root as the length of root was measured in centimeter and the mean values were calculated.

Seedling Dry Weight (g)

Separate the root from the top (cut at soil line). Separately weigh and record the root and top for each plant. (Dry weight for roots/dry weight for top of plant = root/shoot ratio) The root/shoot ratio can be calculated for each treatment.

Vigour index (Abdul Baki and Anderson 1973) [14] I and II

The vigour index was calculated as per the method prescribe by Abdul-Baki and Anderson 1973 [14] expressed in whole number:

Vigour Index-II = Germination (%) x Seedling length (cm).

Vigour Index-II = Germination (%) x Seedling Dry weight (g).

Results and Discussion

Germination (%)

An examination of data presented in above table-1 reveals that maximum Germination (%) of 69.76 and 69.61 was noted for first year when crop was shown on first date of sowing. Significantly less Germination (%) of 69.33 in first year and 69.29 in second years was associated with both date of planting.

A perusal of data also indicated that there was significant impact of different treatments on Germination (%) of mustard during second year of study. Maximum Germination (%) of 72.52 and 71.12 for first and second years respectively was noted with treatment T_5. Least Germination (%) of 68.24 and 68.48 was observed with control treatment T_1.

Interaction due to date of sowing and treatments was found significant during second year of investigation and maximum Germination (%) 73.85 was associated with T_5 x D_2 combinations followed by rest of combinations. Similar work done by Singh and Saxena (1963) [12], Kurmi and Kalita (1991) [8].

Seedling Length (cm)

An examination of data presented in above table-2 reveals that maximum Seedling Length (cm) of 15.09 and 15.57 was noted for both respective years when crop was shown on first date of sowing. Significantly less Seedling Length (cm) of 15.03 in first year and 15.49 in second years was associated with second date of planting.

A perusal of data also indicated that there was significant impact of different treatments on Seedling Length (cm) of mustard during second year of study. Maximum Seedling Length (cm) of 17.61and 17.37 for first and second years respectively was noted with treatment T_6. During second year performance of T_6 was at par with T_5 (16.75) and T_2 (15.45) and it was significantly superior to the rest treatments. Least Seedling Length (cm) of 13.51 and 13.78 was observed with control treatment T_1.

Interaction due to date of sowing and treatments was found non-significant during second year of investigation and

maximum Seedling Length (cm) 18.00 was associated with T_6 x D_1 combinations followed by rest of combinations. Similar findings reported by Prasad *et al.* (1989) [13].

Vigour Index - I

An examination of data presented in above table-3 reveals that maximum Vigour Index – I of 1402.69 and 1419.80 was noted for both respective years when crop was shown on different date of sowing. Significantly less Vigour Index – I of 1356.86 in first year and 1402.26 in second years was associated with second date of planting.

A perusal of data also indicated that there was significant impact of different treatments on Vigour Index – I of mustard during second year of study. Maximum Vigour Index – I of 1562.09 and 1580.15 for first and second years respectively was noted with treatment T_5. During second year performance of T_5 was at par with T_6 (1543.35) and T_2 (1370.70) and it was significantly superior to the rest treatments.

Interaction due to date of sowing and treatments was found non-significant during second year of investigation and maximum Vigour Index – I 1610.10 was associated with T_5 x D_2 combinations followed by rest of combinations. Similar results was recorded by Bisnoi and Singh (1979).

Vigour Index - II

An examination of data presented in above table-4 reveals that maximum Vigour Index – II of 3.27 and 4.20 was noted for both respective years when crop was shown on first date of sowing in first year and second date of showing in second year. Significantly less Vigour Index – II of 2.71 in first year and 3.97 in second years was associated with first date of planting.

A perusal of data also indicated that there was significant impact of different treatments on Vigour Index – II of mustard during second year of study. Maximum Vigour Index – II of 3.5 and 4.65 for first and second years respectively was noted with treatment T6. During second year performance of T_5 was at par with T_4 (4.17) and T_7 (4.42) and it was significantly superior to the rest treatments.

Interaction due to date of sowing and treatments was found non-significant during second year of investigation and maximum Vigour Index – II 4.90 was associated with T_5 x D_2 followed by rest of combinations. Similar work done by Bisnoi and Singh (1979) [1], Mudhalkar and Ahlawat (1979) [9].

Seedling Dry weight (g) 10 Seedling

It is revealed in table-5 that maximum Seedling dry weight (g) 10 Seedlings of 0.10 and 0.098 was noted for both respective years when crop was shown on first date of sowing in first year and second date of showing in second year.

A perusal of data also indicated that there was significant impact of different treatments on Seedling dry weight (g) 10 Seedlings of mustard during second year of study. Maximum Seedling dry weight (g) 10 Seedlings of 0.116 and 0.115 for first and second years respectively was noted with treatment T_5. During second year performance of T_5 was at par with T_4 (0.102) and T_7 (0.113) and it was significantly superior to the rest treatments.

Interaction due to date of sowing and treatments was found non-significant during second year of investigation and maximum Seedling dry weight (g) 10 Seedlings 0.117 was associated with T_5 x D_2 combinations followed by rest of combinations. Similar result were also revealed by some earlier scientist *viz.* Bisnoi and Singh (1979) [1], Mudhalkar and Ahlawat (1979) [9], Gawariya *et al.* (2015) [2]. It is revealed from the result that sowing during 1st October recorded significantly higher seedling dry weight.

Table 1: Effect of dates of sowing and chemicals on Germination (%)

Treatments	Germination (%)					
	2015-16			2016-17		
	D1	D2	Mean	D1	D2	Mean
(T_1)	68.52	67.95	68.24	69.00	67.95	68.48
(T_2)	70.20	70.47	70.34	70.24	70.00	70.12
(T_3)	68.56	68.85	68.71	69.56	67.85	68.71
(T_4)	69.35	68.18	68.77	68.35	69.19	68.77
(T_5)	71.18	73.85	72.52	70.18	72.05	71.12
(T_6)	69.90	71.00	70.45	68.90	70.00	69.45
(T_7)	70.58	67.00	68.79	69.08	68.00	68.54
Average	69.76	69.61		69.33	69.29	
SE (d)	0.25	0.66	0.75	0.28	0.53	0.75
CD (p=0.05)	0.62	1.49	1.34	0.67	1.45	1.34

Table 2: Effect of dates of sowing and chemicals on Seedling Length (cm)

Treatments	Seedling Length (cm)					
	2015-16			2016-17		
	D1	D2	Mean	D1	D2	Mean
(T_1)	15.15	12.55	13.85	15.1	13.85	14.47
(T_2)	15.51	14.44	14.975	15.5	15.4	15.45
(T_3)	13	14.57	13.785	15	15.5	15.25
(T_4)	13.79	15.85	14.82	14.9	16.15	15.52
(T_5)	17.5	16.24	16.87	16.5	17	16.75
(T_6)	18	17.22	17.61	17	17.22	17.37
(T_7)	12.25	14.78	13.515	15	15.1	15.05
Average	15.03	15.09		15.57	15.49	
	D	T	D×T	D	T	D×T
SE (d)	0.217	0.507	0.752	0.284	0.532	0.652
CD (p=0.05)	N.S	1.017	N.S	N.S	1.093	N.S

Table 3: Effect of dates of sowing and chemicals on Vigour Index- I

Treatments	Vigour Index – I					
	2015-16			2016-17		
	D1	D2	Mean	D1	D2	Mean
(T_1)	1205.10	1255.20	1230.15	1210.05	1280.8	1245.42
(T_2)	1355.22	1321.54	1338.38	1395.9	1345.5	1370.7
(T_3)	1226.35	1371	1298.68	1350.1	1390.3	1370.5
(T_4)	1353.65	1339.54	1346.6	1360.05	1350.2	1355.25
(T_5)	1522.48	1601.70	1562.09	1550.2	1610.1	1580.15
(T_6)	1480.57	1571.22	1525.9	1495.8	1590.9	1543.35
(T_7)	1354.67	1358.67	1356.67	1330.1	1370.8	1350.45
Average	1356.863	1402.696		1419.8	1402.26	
	D	T	D×T	D	T	D×T
SE (d)	23.54	41.21	61.45	24.231	45.333	64.110
CD (p=0.05)	N.S	92.20	N.S	N.S	93.209	N.S

Table 4: Effect of dates of sowing and chemicals on Vigour Index – II

	Vigour Index – II					
Treatments	**2015-16**			**2016-17**		
	D1	**D2**	**Mean**	**D1**	**D2**	**Mean**
(T_1)	2.60	2.30	2.45	3.58	3.5	3.54
(T_2)	3.30	2.90	3.10	3.9	3.75	3.82
(T_3)	3.50	3.00	3.25	3.5	3.4	3.45
(T_4)	3.00	2.40	2.70	3.85	4.5	4.17
(T_5)	3.60	2.50	3.05	4.1	4.9	4.5
(T_6)	3.80	3.20	3.50	4.5	4.85	4.65
(T_7)	3.10	2.70	2.90	4.35	4.5	4.42
Average	3.27	2.71		3.97	4.20	
	D	T	D×T	D	T	D×T
SE (d)	0.61	1.15	N.S.	3.58	3.5	3.54
CD (p=0.05)	N.S	0.56	N.S	N.S	0.626	N.S

Table 5: Effect of dates of sowing and chemicals on Seedling Dry weight (mg) 10 Seedling

	Seedling Dry weight (g) 10 Seedling					
Treatments	**2015-16**			**2016-17**		
	D1	**D2**	**Mean**	**D1**	**D2**	**Mean**
(T_1)	0.05	0.048	0.049	0.05	0.046	0.048
(T_2)	0.09	0.094	0.092	0.09	0.098	0.094
(T_3)	0.085	0.095	0.09	0.085	0.095	0.09
(T_4)	0.095	0.11	0.102	0.095	0.11	0.102
(T_5)	0.115	0.117	0.116	0.115	0.115	0.115
(T_6)	0.112	0.115	0.113	0.112	0.115	0.113
(T_7)	0.114	0.112	0.113	0.11	0.11	0.11
Average	0.098	0.100		0.094	0.098	
	D	T	D×T	D	T	D×T
SE (d)	0.004	0.005	0.009	0.003	0.006	0.008
CD (p=0.05)	0.054	0.047	0.049	0.05	0.046	0.048

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