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Effect of dates of sowing and chemicals spray to mitigate the effect of increasing temperature on growth parameters 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 *Brassicaceae (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 variety (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 Number of Primary Branches 5.12 and 5.36 were noted for both respective years when crop were shown on first date of sowing. Maximum Number of Primary Branches 5.63 and 6.11 for first and second years respectively were noted with treatment T_2. The maximum Number of Secondary Branches of 16.78 and 16.37 were noted for both respective years when crop were shown on first date of sowing. Maximum Number of Secondary Branches 19.26 and 18.53 for first and second years respectively were noted with treatment T_2. The maximum days to 50% flowering of 67.95 and 68.55 were noted for both respective years when crop were shown on first date of sowing. Maximum days to 50% flowering of 65.33 and 65.50 for first and second years respectively were noted with treatment T_5.

Keywords: Mustard, growth parameters**,** glycine betaine, salicylic acid, salicylic acid, ascorbic acid citric acid and alpha 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) [4].

In India, *B. juncea* is a predominant species, which accounts for nearly 80% of the production area of the oilseed. The crop is economically important for its oil, which is largely used for cooking. The oil of mustard possesses a sizable amount of erucic acid (38-57%). Protein content in rapeseed and mustard normally ranges between 24-30% on the basis of whole seed and between 35-40% on the meal basis. But the presence of toxic glucosinolates in the mustard cake render it unsuitable as a source of human protein and is at present as a manure and as a cattle feed. Several medicinal uses of *Brassica* species have also been reported (Kurian, 1995). 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) [2].

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) [1] 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) [1]. 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) [5]. 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.

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.

Number of primary branches per plant

The total number of primary branches per plant on five randomly selected plants from each line were counted and averaged out at the time of maturity.

Number of secondary branches per plant

The total number of secondary branches per plant from the five randomly selected plants in each plot were counted at maturity and averaged out at the time of maturity.

Days to 50 percent flowering

The plants were observed daily to see the appearance of first flowering. When the 50 percent flowers appeared in the plot, the date was recorded and number of days from the date of planting was calculated.

Results and Discussion

Number of Primary Branches

An examination of data presented in above table-1 reveals that maximum Number of Primary Branches of 5.12 and 5.36 was noted for both respective years when crop was shown on first date of sowing. Significantly less Number of Primary Branches of 4.53 in first year and 5.25 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 Number of Primary Branches of mustard during second year of study. Maximum Number of Primary Branches of 5.63 and 6.11 for first and second years respectively was noted with treatment T_2. During second year performance of T_2 was at par with T_5 (5.55) and T_6 (4.83) and it was significantly superior to the rest treatments. Least Number of Primary Branches of 4.13 and 4.35 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 Number of Primary Branches 5.63 was associated with T_5 x D_1 combinations followed by rest of combinations. Similar work done by Singh *et al*. (2001) [13] evaluated the effect of sowing time on growth and yield of Indian mustard. The significantly superior plant height, branches/plant, siliqua/plant, seeds/siliqua.

Number of Secondary Branches

Effect of dates of sowing and chemicals spray on Number of Secondary Branches of Indian mustard [*Brassica juncea* (L.) Czern and Coss] the observations made with consequent influence different planting dates, chemical spray and their interactions on Number of Secondary Branches in leaves of mustard have been presented in table-2.

An examination of data presented in above table reveals that maximum Number of Secondary Branches of 16.78 and 16.37 was noted for both respective years when crop was shown on first date of sowing. Significantly less Number of Secondary Branches of 15.74 in first year and 16.26 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 Number of Secondary Branches of mustard during second year of study. Maximum Number of Secondary Branches of 19.26 and 18.53 for first and second years respectively was noted with treatment T_2. During second year performance of T_2 was at par with T_5 (18.38) and T_6 (18.53) and it was significantly superior to the rest treatments. Least Number of Secondary Branches of 13.23 and 13.31 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 Number of Secondary Branches 18.53 was associated with T_5 x D_1 combinations followed by rest of combinations. Similarly, Muhal and Solanki (2015) [10], Gurjar and Chauhan (1997) [7] reported the effect of two varieties at two spacings on Indian mustard. Pusa bold and Kranti were found more height of plant, number of leaves and primary and secondary branches, siliqua/plant were significantly higher. Mehrotra *et al.* (1976) [9] noted that there was considerable variation in branching, number of siliquae. Gawariya *et al.* (2015) [3] result revealed that sowing during 1st October recorded significantly higher crop yield attributing characters *viz*. no. of primary, secondary and tertiary branches as compared to 31st October and 15th November.

Days to 50% flowering

An examination of data presented in above table-3 reveals that maximum days to 50% flowering of 67.95 and 68.55 was noted for both respective years when crop was shown on first date of sowing. Significantly less days to 50% flowering of 60.85 in first year and 61.23 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 days to 50% flowering of mustard during second year of study. Maximum days to 50% flowering of 65.33 and 65.50 for first and second years respectively was noted with treatment T_2. During second year performance of T_2 was at par with T_5 (65.33) and T_6 (65.16) and it was significantly superior to the rest treatments. Least days to 50% flowering of 63.33 and 65.50 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 days to 50% flowering 61.66 was associated with T_5 x D_1 combinations followed by rest of combinations. Similar work was done by Saini *et al.* (1985) [12] they analysed that yellow sarson (*B napus*) Cv Basant has flowers in 32 days days. Alam, *et al.* (2014) [6] reported that the growth and yield of mustard genotypes under late sown condition when the crop faced high temperature. Days to flowering and maturity were different at different planting times.

Table 1: Effect of dates of sowing and chemicals on Number of Primary Branches

Treatments	Number of Primary Branches					
	2015-16			2016-17		
	D1	D2	Mean	D1	D2	Mean
(T_1)	4.73	4.33	4.53	4.46	4.23	4.35
(T_2)	5.40	4.93	5.16	5.26	5.23	5.25
(T_3)	6.20	5.06	5.63	6.3	5.93	6.11
(T_4)	5.33	4.80	5.06	5.93	5.4	5.66
(T_5)	5.46	4.06	4.76	5.63	5.46	5.55
(T_6)	3.86	4.40	4.13	4.53	5.13	4.83
(T_7)	4.86	4.13	4.50	5.43	5.36	5.40
Average	5.12	4.53		5.36	5.25	
	D	T	D×T	D	T	D×T
SE (d)	0.21	0.39	0.55	0.237	0.443	0.627
CD (p=0.05)	0.43	0.81	N.S.	N.S.	0.911	N.S.

Table 2: Effect of dates of sowing and chemicals on Number of Secondary Branches

Treatments	Number of Secondary Branches					
	2015-16			2016-17		
	D1	D2	Mean	D1	D2	Mean
(T_1)	13.46	13.00	13.23	13.03	13.6	13.31
(T_2)	15.00	14.46	14.73	14.8	15.16	14.98
(T_3)	18.40	16.26	17.33	17.13	17.53	17.33
(T_4)	14.93	14.40	14.66	15.33	15.16	15.25
(T_5)	20.10	18.43	19.26	18.53	18.23	18.38
(T_6)	18.10	17.33	17.71	18.93	18.13	18.53
(T_7)	17.46	16.33	16.90	16.1	16.76	16.43
Average	16.78	15.74		16.26	16.37	
	D	T	D×T	D	T	D×T
SE (d)	0.33	0.62	0.87	0.302	0.565	0.80
CD (p=0.05)	0.68	1.27	N.S.	N.S.	1.162	N.S.

Table 3: Effect of dates of sowing and chemicals on Days to 50% flowering

Treatments	Days to 50% flowering					
	2015-16			2016-17		
	D1	D2	Mean	D1	D2	Mean
(T_1)	56.66	70.00	63.33	60.33	70.66	65.5
(T_2)	62.33	66.33	64.33	61.66	68.5	65.33
(T_3)	60.33	67.00	63.66	60.33	67	63.66
(T_4)	63.33	67.33	65.33	62.00	68	65.00
(T_5)	61.00	69.00	65.00	61.66	69	65.33
(T_6)	60.66	67.66	64.16	62.00	68.33	65.16
(T_7)	61.66	68.33	65.00	60.66	68.33	64.5
Average	60.85	67.95		61.23	68.55	
	D	T	D×T	D	T	D×T
SE (d)	0.64	1.19	1.69	0.438	0.189	1.159
CD (p=0.05)	1.31	N.S.	3.48	0.90	N.S.	N.S.

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