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Effect of dates of sowing and zinc levels on growth and yield of yellow mustard (*Brassica alba*)

Manchi Satya Sumanth and Shikha Singh

Manchi Satya Sumanth
M.Sc. Scholar, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, India

Shikha Singh
Assistant Professor, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, India

Corresponding Author:
Manchi Satya Sumanth
M.Sc. Scholar, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, India

Abstract
A field experiment was conducted during *Rabi* 2020 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The treatments were different sowing dates of November 20, November 30 and December 10 along with Zinc at 2.5, 4, 5 kg/ha were used. The experiment was laid out in Randomized Block Design with nine treatments each replicated thrice. The results showed that significantly highest plant height (137.0 cm), maximum dry weight (24.8 g), CGR (7.0 g/m^2/day) were recorded in the sowing date of November20 + 5 kg/ha Zinc. The significantly highest Number of siliquae per plant (133.8), seeds per siliquae (33.1), test weight (3.42 g) and test weight (3.5 g), higher seed yield (15.7 q/ha), stover yield (58.0 q/ha) and harvest index (23.2%) were recorded in the treatment three which is with sowing date of November 20 + 5 kg/ha Zinc as compared to all other treatments. However, the maximum gross returns (94200.00 INR/ha), net returns (56430.05 INR/ha) and B:C ratio (1.49) were recorded maximum in the sowing date of November20 + 5 kg/ha Zinc.

Keywords: Economics, growth, mustard, spacing, yield and zinc

Introduction
India is one among the leading oilseed producing countries in the world. Oil seeds from the second largest agricultural commodity after cereals. In India mustard is the second important edible oilseed crop after groundnut. It plays an important role in the oilseed economy of the country. Among the seven edible oilseeds cultivated in India, rapeseed-mustard contributes 28.6% in the total oilseeds production and ranks second after groundnut sharing 27.8% in the India's oilseed economy. Brassicas play an important role in agriculture as oil seeds, vegetables, forage and fodder, green manure and condiments. In world India ranks 2nd and 3rd for area and production, respectively, with 26.5% and 16.6% of total area and production of Rapeseed-Mustard, respectively. In India oilseed crop and Rapeseed-Mustard group of species accounts for 14.1 and 3% of gross cropped area, respectively. Among the seven annual edible oilseeds cultivated in India, rapeseed-mustard contributes nearly 30 present in the total production of oilseeds.

Mustard seed in general, contains 30-33% oil, 17-25% proteins, 8-10% fibres, 6-10% moisture, and 10-12% extractable substances. Demand of edible oil has increased with increasing population and improvement in the living standard of the people, resulting thereby in short supply of edible oils which is being met with imports of edible oil worth 44,000 crores per annum. Major mustard growing states in India are Rajasthan (40.82%), Haryana (13.33%), Madhya Pradesh (11.76%), Uttar Pradesh (11.40%) and West Bengal (8.64%) according to 2018-19 year (Rathi *et al*., 2019) [12]. The seeds are highly nutritive containing 38-57% erucic acid, 5-13% linoleic acid and 27% oleic acid. They are not only rich sources of energy and carriers of fat soluble vitamins A, D, E and K but they form the ingredients of foods and flavours, cosmetics and condiments, soap and detergents, lubricants and laxatives and also known for their medical and therapeutic use (Chauhan *et al*., 2020). In India, it is mainly cultivated in sub-tropical climate, but recent stats prove that it thrives well in dry and cool climate. It requires the temperature from 10^0 to 25^0 C. The crop is highly susceptible to the frost conditions and it requires the rainfall of 625- 1000 mm annual rainfall for its proper growth.

Some of the major constraints behind the low productivity of the mustard are its cultivation in the residual moisture and unavailability of the improved crop husbandry (Singh *et al.*, 2010). Sowing time remains as the constant factor in determining the yield and oilseed content in the mustard seeds. If optimum sowing time is not followed the drastic reduction in the yield remains imminent (Kumar *et al.*, 2012) [5].

Zinc (Zn) deficiency in crops, including rapeseed and mustard, is a widespread nutritional disorder especially in alkaline soils.

This crop is mainly grown in winter season (October- March). The recommended sowing calendar for mustard varies across the major growing regions. Sowing at proper time allows sufficient growth and development of the crop to obtain a satisfactory yield and different sowing dates provide variable environmental conditions within the same location for growth and development of crop and yield stability **(**Pandey *et al.* 1981) [11]. If the mustard sown late, duration is reduced due to the high temperature during the reproductive phase which results in reduction of yield. (Kumari *et al*., 2005) [6]. Some researchers demonstrated that the yield of mustard crop sown at the second fortnight of September was significantly higher than that sown in first fortnight of October (Irradi, 2008). Understanding of physiological and phonological causes of yield reduction with yield reduction with reference to date of sowing can help to develop strategies for improvement of seed yield.

Zinc is one of the first micronutrients recognized as essential for plants that transported to plant root surface through diffusion **(**Maqsood *et al*., 2009) [8]. Zn is a micronutrient and in case of its severe deficiency the symptoms may last throughout the entire crop season (Asad and Rafique, 2000) [3]. Zn is vital for regulating enzymatic activity, the protein and membrane stabilization; it is a component of Zn a major structural motif critical for DNA binding (Tavallali *et al*. 2009) [15]. Zinc is a cofactor of over 300 enzymes and associated proteins involved in carbohydrate metabolism, nucleic acid and protein synthesis, as well as cell division (Osredkar and Sustar 2011) [10]. Moreover, Zn can impart stress tolerance through the formation of Cu/Zn-SOD, a major antioxidant (Ahmad *et al*. 2010) [2]. In the present investigation, we evaluate the effect of dates of Sowing and zinc levels on growth and yield of yellow mustard.

On the basis of the above facts, the present study was undertaken to maximize the seed yield of yellow mustard sown on different dates by using zinc fertilizer in Rabi season (2020).

Materials and Methods

The experiment was conducted during the *rabi* season of 2020-2021 at the Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj. The Crop Research Farm is situated at 25^0 57' N latitude, 87^0 19' E longitude and 98 m altitude from the sea level. This area is situated on the right side of the river *Yamuna* and by the opposite side of Prayagraj city. All the facilities required for crop cultivation are available. The experimentation put down in Randomized Block Design which containing of nine treatments comprised of different sowing dates with November 20 (D_1), November 30 (D_2) and December 10 (D_3) and application of Zinc at 2.5 (Z_1) kg/ha, 4.0 (Z_2) kg/ha and 5.0 (Z_3) kg/ha which are were replicated thrice.

The experimental site was uniform in topography and sandy loam in texture, basal in soil reaction (PH 8.29), low in Organic carbon (0.20%), medium available N (190.6 kg ha^{-1}), higher available P (37 kg ha^{-1}) and medium available K (100 kg ha^{-1}). Nutrient sources were Urea, DAP and Mop to fulfill the requirement of Nitrogen, Phosphorus and potassium. Ten days after the sowing gap filling was done and irrigation given at frequent intervals. In the period from germination to harvest several plant growth parameters were recorded at frequent intervals along with it after harvest several yield parameters were recorded those parameters were plant height (cm), plant dry weight (g/plant), Crop growth rate (g/m^2/day), Relative growth rate (g/g/day), No. of siliquae per plant, No. of grains per siliquae, Test weight (g), Seed yield (q/ha), Stover yield (q/ha) and Harvest index (%) were recorded and statistically analyzed using analysis of variance (ANOVA) as applicable to Randomized Block Design (Gomez K.A. and Gomez A.A. 1984), Economics were recorded and analyzed.

Results and Discussion

Effect of Dates of Sowing and Zinc Levels on Growth parameters of mustard:

Data in Table 1 and 2 were tabulated the plant height (cm), plant dry weight (g/plant), Crop growth rate (g/m^2/day), Relative growth rate (g/g/day) of mustard and there was increasing in crop age growth parameters were improved with the advancement of experimentation.

Plant Height

At the time of harvest, the significantly highest plant height was observed in the sowing at November 20 (D_1) sowing date+ Zinc at 5 kg/ha (137.0 cm) higher over rest of the treatments except treatment and one two with November 20 (D_1) sowing date+ Zinc at 2.5 and 4 kg/ha, which is statistically at par with the November 20 (D_1) sowing date+ Zinc at 5 kg/ha.

The significantly higher height was recorded in the November 20^{th} sowing + zinc at 5 kg/ha, the increase in height may be due the high temperature during the November 20 compared to other sowings and due to increase in the zinc level. These findings were found to be similar with Singh *et al*. (2001) and Mina (2000) [9].

Plant dry weight

At the time of harvest, the significantly highest plant dry weight was observed in the sowing at November 20 (D_1) sowing date+ Zinc at 5 kg/ha (24.4 g) higher over rest of the treatments except treatment one with November 20 (D_1)+ Zinc at 2.5 kg/ha, treatment two with November 20 (D_1) sowing date+ Zinc at 4 kg/ha, treatment six with November 30 (D_2) sowing date+ Zinc at 5 kg/ha, which were statistically at par with the November 20 (D_1) sowing date+ Zinc at 5 kg/ha.

The significantly higher dry weight recorded in November 20 sowing and application of zinc at 5 kg/ha might be due to the higher biomass accumulation because of higher exposure to the sunlight and heat of November 20 sowing compared to other sowings, similar results were observed Pavlista *et al*. (2011).

Crop Growth Rate (g/m^2/day)

At 80-Harveest, the Crop growth rate (g/m^2/day) was highest observed in the treatment four with November 20 sowing date+ Zinc at 2.5 kg/ha and treatment nine with December 10 + Zinc at 5 kg/ha simultaneously (3.5 g/m^2/day) in both treatments, and treatment three with November 10 + Zinc at 5 kg/ha recorded lowest value (3.2 g/m^2/day).

Relative Growth Rate (g/g/day)

At 80-Harvest, the Relative growth rate (g/g/day) was recorded (0.01 g/g/day) value in all the treatment from treatment one to treatment nine.

Effect of Dates of Sowing and Zinc Levels on yield and yield attributes of mustard

Data in Table 3 tabulated the No. of siliquae per plant, No. of grains per siliquae, Test weight (g), Seed yield (q/ha), Stover yield (q/ha) and Harvest index (%) of mustard and there was increasing in yield parameters at harvest of experimentation.

No. of Siliquae per plant

From the observations Siliquae per plant (133.8) was more and significant in treatment with treatment three with sowing date with November 10 (D_1) + Zinc at 5 kg/ha was recorded significantly higher from treatments expect treatment one with sowing date of November 10 (D_1) + Zinc at 2.5 kg/ha, treatment two with sowing date of November 10 (D_1) + Zinc at 4 kg/ha and treatment nine with sowing date of December 10 (D_3) + Zinc at 5 kg/ha were statistically at par with the November 10 (D_1) + Zinc at 5 kg/ha.

No. of seeds per Siliquae

From the observations Seeds per Siliquae (33.1) was more and significant in treatment with treatment three with sowing date with November 10 + Zinc at 5 kg/ha was recorded significantly higher from treatments expect treatment one with sowing date of November 10 + Zinc at 2.5 kg/ha, treatment two with sowing date of November 10 + Zinc at 4 kg/ha and treatment six with sowing date of November 20 + Zinc at 5 kg/ha were statistically at par with sowing date of November 10 + Zinc at 5 kg/ha.

Test weight (g)

From the observations Test weight (3.5 g) was more and significant in treatment with treatment three with sowing date with November 10 + Zinc at 5 kg/ha was recorded significantly higher from treatments expect treatment one with sowing date of November 10 + Zinc at 2.5 kg/ha, treatment two with sowing date of November 10 + Zinc at 4 kg/ha and treatment six with sowing date of November 20 + Zinc at 5 kg/ha were statistically at par with sowing date of November 10 + Zinc at 5 kg/ha.

Seed yield (q/ha)

From the observations Seed yield (15.7 q/ha) was more and significant in treatment with treatment three with sowing date with November 10+ Zinc at 5 kg/ha was recorded significantly higher from treatments expect treatment two with sowing date of November 10 + Zinc at 4 kg/ha and treatment six with sowing date of November 20 + Zinc at 5 kg/ha were statistically at par with of November 10 + Zinc at 5 kg/ha.

Early sowing resulted in the early flowering which helps in early siliqua development and increase in reproductive phase and ultimately the seed yield, thus the November 10 sowing obtained the higher yield attributes and yield, Kumari *et al*., (2012) [7] obtained the similar results in the early sown crop.

Stover yield (q/ha)

From the observations Stover yield (58.0 q/ha) was more and significant in treatment with treatment three with sowing date with November 10 + Zinc at 5 kg/ha was recorded significantly higher from treatments expect treatment two with sowing date of November 10 + Zinc at 4 kg/ha and treatment six with sowing date of November 20 + Zinc at 5 kg/ha were statistically at par with sowing date of November 10 + Zinc at 5 kg/ha.

November 20^{th} sowing helped the plants to encounter higher amount of sunlight and heat which resulted in the higher bio mass accumulation, higher plant height and higher number of branches and more over higher dose of zinc application 5 kg/ha resulted in the higher stover yield.

Harvest Index (%)

From the observations Harvest Index (23.2%) was more and significant in treatment with treatment eight with sowing date of December 10 + Zinc at 4 kg/ha was recorded significantly higher from treatments expect treatment four with sowing date of November 20 + Zinc at 2.5 kg/ha, treatment seven with sowing date of December 10 + Zinc at 2.5 kg/ha and treatment nine with sowing date of December 10 + Zinc at 5 kg/ha were statistically at par with sowing date of November 10 + Zinc at 5 kg/ha.

Effect of Dates of Sowing and Zinc Levels on Economics of mustard:

Data in Table 4 tabulated the Gross returns (INR/ha), Net returns (INR/ha) and Benefit cost ratio (B: C) of mustard were recorded after harvest of experimentation.

Gross returns (INR/ha)

Highest Gross returns (94200.00 INR/ha), Net returns (56430.05 INR/ha) and Benefit Cost ratio (1.49) was found to be highest in treatment with sowing date of November 20 (D_1) + Zinc at 5 kg/ha.

Table 1: Effect of Dates of Sowing and Zinc Levels on growth parameters of mustard

Treatments	Plant Height (cm)					Plant dry weight (g)				
	20 DAS	40 DAS	60 DAS	80 DAS	At Harvest	20 DAS	40 DAS	60 DAS	80 DAS	At Harvest
1. Nov 20 (D_1) + 2.5kg/ha (Zn_1)	14.8	19.8	56.6	94.2	134.8	0.4	3.5	8.1	16.9	23.6
2. Nov 20 (D_1) + 4.0kg/ha (Zn_2)	15.3	20.6	58.5	95.2	136.1	0.4	3.6	8.3	17.3	24.0
3. Nov 20 (D_1) + 5.0kg/ha (Zn_3)	15.7	21.4	60.0	96.8	137.0	0.6	3.9	8.7	17.9	24.4
4. Nov 30 (D_2) + 2.5kg/ha (Zn_1)	14.1	18.4	55.0	84.9	127.2	0.3	3.0	7.6	15.8	22.9
5. Nov 30 (D_2) + 4.0kg/ha (Zn_2)	14.6	19.3	55.8	87.8	128.9	0.4	3.2	7.8	16.4	23.3
6. Nov 30 (D_2) + 5.0kg/ha (Zn_3)	15.2	19.9	57.9	92.8	132.1	0.4	3.5	8.1	16.9	23.8
7. Dec 10 (D_3) + 2.5kg/ha (Zn_1)	13.3	17.5	54.0	82.0	126.2	0.3	2.6	7.2	15.1	22.1
8. Dec 10 (D_3) + 4.0kg/ha (Zn_2)	13.9	17.8	54.7	83.9	127.8	0.3	2.8	7.4	15.5	22.4
9. Dec 10 (D_3) + 5.0kg/ha (Zn_3)	14.5	18.6	56.0	85.8	129.5	0.3	3.3	7.8	16.0	23.1
F test	S	S	S	S	S	S	S	S	S	S
S.Em(+)	0.16	0.75	1.09	0.80	0.74	0.06	0.19	0.27	0.33	0.31
CD (5%)	0.49	2.26	3.26	2.41	2.21	0.17	0.56	0.82	0.98	0.94

Table 2: Effect of Dates of Sowing and Zinc Levels on growth parameters of mustard

Treatments	C.G.R ($g/m^2/day$)				R.G.R (g/g/day)			
	20-40 DAS	40-60 DAS	60-80 DAS	80-Harvest	20-40 DAS	40-60 DAS	60-80 DAS	80-Harvest
1. Nov 20 (D_1) + 2.5kg/ha (Zn_1)	3.2	6.1	5.8	3.3	0.11	0.04	0.04	0.01
2. Nov 20 (D_1) + 4.0kg/ha (Zn_2)	2.1	3.8	7.2	3.3	0.11	0.04	0.04	0.01
3. Nov 20 (D_1) + 5.0kg/ha (Zn_3)	1.6	2.7	5.2	3.2	0.10	0.04	0.04	0.01
4. Nov 30 (D_2) + 2.5kg/ha (Zn_1)	0.9	1.9	3.4	3.5	0.12	0.05	0.04	0.01
5. Nov 30 (D_2) + 4.0kg/ha (Zn_2)	3.2	6.3	4.2	3.4	0.11	0.04	0.04	0.01
6. Nov 30 (D_2) + 5.0kg/ha (Zn_3)	2.0	3.7	7.0	3.4	0.11	0.04	0.04	0.01
7. Dec 10 (D_3) + 2.5kg/ha (Zn_1)	1.4	2.6	4.4	3.4	0.11	0.05	0.04	0.01
8. Dec 10 (D_3) + 4.0kg/ha (Zn_2)	1.0	1.9	3.3	3.4	0.12	0.05	0.04	0.01
9. Dec 10 (D_3) + 5.0kg/ha (Zn_3)	4.6	6.9	5.8	3.5	0.11	0.05	0.02	0.01
F test	S	S	S	NS	NS	NS	NS	NS
S.Em(+)	0.22	0.51	0.27	0.22	0.01	0.00	0.00	0.00
CD (5%)	0.65	1.51	0.80	-	-	-	-	-

Table 3: Effect of Dates of Sowing and Zinc Levels on yield and yield attributes of mustard

Treatments	No. of Siliquae per plant	No. of seeds per Siliquae	Test weight (g)	Seed yield (q/ha)	Stover yield (q/ha)	Harvest index (%)
1. Nov 20 (D_1) + 2.5kg/ha (Zn_1)	131.1	31.9	3.3	14.8	55.0	21.1
2. Nov 20 (D_1) + 4.0kg/ha (Zn_2)	132.0	32.5	3.4	15.3	57.2	21.1
3. Nov 20 (D_1) + 5.0kg/ha (Zn_3)	133.8	33.1	3.5	15.7	58.0	21.3
4. Nov 30 (D_2) + 2.5kg/ha (Zn_1)	128.4	30.5	2.9	14.1	49.2	22.2
5. Nov 30 (D_2) + 4.0kg/ha (Zn_2)	129.3	31.2	3.1	14.6	52.9	21.7
6. Nov 30 (D_2) + 5.0kg/ha (Zn_3)	131.5	32.3	3.2	15.2	56.1	21.4
7. Dec 10 (D_3) + 2.5kg/ha (Zn_1)	125.1	29.5	2.9	13.3	44.6	23
8. Dec 10 (D_3) + 4.0kg/ha (Zn_2)	127.0	30.3	2.9	13.9	45.6	23.2
9. Dec 10 (D_3) + 5.0kg/ha (Zn_3)	129.4	30.7	3.0	14.5	50.6	22.3
F test	S	S	S	S	S	S
S.Em(+)	1.61	0.58	0.14	0.16	0.79	0.32
CD (5%)	4.83	1.73	0.42	0.49	2.36	0.95

Table 4: Effect of Dates of Sowing and Zinc levels on economics of mustard

Treatments	Cost of cultivation (*INR*/ha)	Gross returns (*INR*/ha)	Net returns (*INR*/ha)	Benefit cost ratio (B:C)
1. Nov 20 (D_1) + 2.5kg/ha (Zn_1)	37769.95	88800.00	52030.05	1.37
2. Nov 20 (D_1) + 4.0kg/ha (Zn_2)	37769.95	91800.00	54769.95	1.45
3. Nov 20 (D_1) + 5.0kg/ha (Zn_3)	37769.95	94200.00	56430.05	1.49
4. Nov 30 (D_2) + 2.5kg/ha (Zn_1)	39198.52	84600.00	45401.52	1.15
5. Nov 30 (D_2) + 4.0kg/ha (Zn_2)	39198.52	87600.00	48401.48	1.23
6. Nov 30 (D_2) + 5.0kg/ha (Zn_3)	39198.52	91200.00	52001.48	1.32
7. Dec 10 (D_3) + 2.5kg/ha (Zn_1)	40150.90	79800.00	40601.48	1.01
8. Dec 10 (D_3) + 4.0kg/ha (Zn_2)	40150.90	83400.00	44201.48	1.10
9. Dec 10 (D_3) + 5.0kg/ha (Zn_3)	40150.90	87000.00	47801.48	1.00

Conclusion

On the basis of study, Prayagraj region of Uttar Pradesh state conditions are much better suitable for growing mustard due to favourable conditions. Maximum plant height up to (137.0 cm), Plant dry weight (24.4 g), yield of (33.1 q/ha) in and stover yield (58.0 q/ha) as well as maximum gross returns (94200.00 INR/ha) were recorded at Prayagraj Agro-climatic conditions with experimentation of sowing date with November 20 (D_1) + Zinc at 5 (Z_3) kg/ha.

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