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Effect of integrated nutrient management and mulching practices on growth attribute and yield of Mustard (*Brassica juncea* L.)

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Abstract
An experiment on "Effect of integrated nutrient management and mulching on yield and quality of Mustard (*Brassica juncea* L.) and soil quality in partially reclaimed Sodic Soil.'' was carried out during *Rabi* session 2018-19 and 2019-20 at Agronomy Research Farm, A.N.D.U.A. & T. Kumarganj, Ayodhya (U.P.). The experiment consists of fourteen treatments were laid out in Randomized Block Design (RBD) with three replications. As per experiment the results revealed that the growth attributes and yield parameters were affected by different INM and mulching practices. The values was recorded with the treatment T_{13} at all growth stages. The values of plant height (cm), number of branches plant^{-1} and dry matter accumulation plant^{-1} gradually in in and up to harvest under all the treatments. While maximum rate of increase was found from 30 DAS to 60 DAS under the all treatments. The maximum growth attributes (at 60DAS) like plant height (83.63 and 83.70 cm), number of branches plant^{-1} (19.01 and 19.60) dry matter accumulation plant^{-1} (23.15 and 23.31) and maximum growth attributes (at harvest) plant height (184.67 and 191.19 cm), number of branches plant^{-1} (23.65 and 24.53) dry matter accumulation plant-1 (56.72 and 57.60) recorded where apply 75% NPK+ N-25% (FYM) +S @40 kg + Mulching @5 t/ha^{-1} (T_{13}) respectively. Similarly highest seed yield (21.05 and 22.08 kg ha^{-1}) and stover yield (49.42 and 49.42 kg ha^{-1}) of mustard crop was recorded under the treatment T_{13} -75% NPK+ N-25% (FYM) +S @40 kg + Mulching @5 t/ha^{-1} during respective years 2018-19 and 2019-20. Which was significantly higher over the treatment T_{13} -75% NPK+ N-25% (FYM) +S @40 kg + Mulching @5 t/ha^{-1} while at par with treatment T_{14} -75% NPK+ N-25% (FYM) + $ZnSO_4$ @25kg + Mulching @5 t/ha^{-1}.

Keywords: INM, mulching, growth attribute, yield and mustard

Introduction
Mustard [*Brassica juncea* (L.)] is important *Rabi* oilseed crop which belongs to family "Cruciferae". The oil content in mustard seeds varies from 37-49 percent the seeds are highly nutritive containing 38-57% eruric acid, and 27% oleic acid (Bhowmik *et al*., 2014) [1]. The oil cake left after extraction is utilized as cattle feed and manure containing 5.1% N, 1.8% P_2O_5 and 1.1% K_2O. This is a potential crop in winter season due to its wider adaptability and suitability to exploit residual moisture (Mukherjee, 2010) [9]. India is one of the largest oilseeds producing country that covers one fifth of the entire area under this group of crops and also yields one-fifth of the total oilseed production in the world. Globally, rapeseed mustard is grown by more than sixty nations including India. In terms of average yield, India (1128 kg/ha) is about 63% below the world average yield (1840 kg/ha) of rapeseed and mustard. In India, it is cultivated by more than 26 states (including Union Territories) with Rajasthan, Madhya Pradesh, Uttar Pradesh, Haryana and West Bengal being that major players in terms of area and production of rapeseed–mustard (DRMR (2020) [3] and DOD (2020) [2]. With the adoption of intensive farming the farmers have shifted from organic to inorganic high analysis S-free fertilizer leading to more widespread and more intense S deficiency in Indian soil in early 1990's estimated to occur in about 130 District and recently about 45% districts of our country so more than 40% S deficiency (Tandon, 1991) [3]. Generally, pulse and oilseed crops are raised under rainfed conditions with low input and poor management practices leading to lower productivity level (Lal *et al.*, 2015) [7]. Yield potentials of the crop, can be realized by balanced and efficient use of organic and inorganic sources of nutrient (Meena *et al.*, 2016) [8] and also use of suitable agronomic package practices to crop. Imbalanced nutrition is one of the important constraints towards higher mustard productivity, oil content and other quality parameters (Lal *et al.*, 2016) [6].

Material and Methods

A field experiment was carried out during *Rabi* season of 2018-19 and 2019-20 at the experimental farm (26º47' N latitude and 82º12' E longitude) of A.N.D. University of Agriculture and Technology Kumarganj located at an altitude of 113 m above the mean sea level in Ayodhya district of Uttar Pradesh. The experimental site is characterized by sub-tropical climate with extreme temperature during summer (up to 46^0C) and winter (as low 3^0C) and rainfall (1000mm and most which is received in rainy season). The soil is silty loam, well drained, having pH (8.20), EC (0.25 dS/m), organic carbon (0.33%) available N (137 kg ha^{-1}), available P (15.35 kg ha^{-1}), available K (249.25 kg ha^{-1}), available sulphur (15.35 ppm) at commencement of the experiment. The present investigation entitled that "Effect of integrated nutrient management and mulching on yield and quality of Mustard (*Brassica juncea* L.) and soil quality in partially reclaimed Sodic Soil.'' The experiment was consists of fourteen treatments i.e. T_1- Control (NO NPK + NO Mulching), T_2- 100% NPK + NO Mulching, T_3- 75% NPK + N-25% (FYM) + NO Mulching, T_4- 100% NPK+ S @40 kg + NO Mulching, T_5 -100% NPK+ $ZnSO_4$ @25 kg + NO Mulching, T_6 - 75% NPK+ N-25% (FYM) +S @40 kg + NO Mulching, T_7 -75% NPK+ N-25% (FYM) + $ZnSO_4$ @25kg + NO Mulching, T_8- Control + mulching @5 t/ha^{-1}, 100% NPK + Mulching @5t/ha^{-1}, T_{10} - 75% NPK + N-25% (FYM) Mulching @5 t/ha^{-1}, T_{11} - 100% NPK+ S @40 kg + Mulching @5 t/ha^{-1}, T_{12} - 100% NPK+ $ZnSO_4$ @25 kg + Mulching @5 t/ha^{-1}, T_{13}-75% NPK+ N-25% (FYM) +S @40 kg + Mulching @5 t/ha^{-1} and T_{14} -75% NPK+ N-25% (FYM) + $ZnSO_4$ @25kg + Mulching @5 t/ha^{-1} treatments were laid out in Randomized Block Design (RBD) with three replications. The variety Varuna was shown proper moisture stage on 20 oct., 2018-19 and 27 oct., 2019-20. Mustard seeds were sown in line at the distance of 45 cm row to row and plant to plant 15 cm with the help of *kudal*. The seed rate was used @5 kg ha^{-1}. Fertilizer Nitrogen, phosphorus and potassium were applied in the forms of Urea, SSP and Muriatic of potash @ 80, 40 and 20 kg ha^{-1}, respectively. Full dose of phosphorus, potassium and half dose of nitrogen were applied as Basel dressing at the time of sowing and rest half dose of nitrogen was applied as two split doses at the time of first irrigation and second irrigation.

Harvest index is an economic yield expressed as percentage of biological yield and calculated as formula given by Donald and Hamblin (1976)

$$\text{Index Harvest (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Results and Discussion

Plant height increased progressively with increase in duration of Mustard crop (Table 1). Crop growth rate was maximum up to 60 DAS and thereafter, a slow increase in growth was obtained up to harvest. The plant height was significantly influenced by the various INM and mulching practices. The taller plants were recorded with the treatment T_{13}-T_6 + Mulching @5 t/ha^{-1} it was found significantly superior with T_8 while statistically at par with rest over the treatments at all the successive growth stages of crop. Whereas the shortest plant height was recorded with the treatment T_1- Control (NO NPK + NO Mulching) due to lack of nutrient available in the soil. This might be due to increment of additional nutrient applied as the form of different component of integrated nutrient management and mulching. The increase component seems to have been broad about by increase nitrogen supply. Probably the increase in auxin, cell division in the plant height. (Upadhyay *et al.* 2012, Gupta *et al.* 2019) [4].

The number of branches plant^{-1} was significantly influenced by various INM and mulching practices at all the growth stages except 30 DAS during both the years (Table 2). The maximum numbers of branches plant^{-1}at 60DAS was recorded under the treatment T_{13}-T_6 + Mulching @5 t/ha^{-1}. It was found statistically at par with T_{14}, T_{11}, T_{12} and T_4 however significantly superior to rest of the treatments during 2018-19. The treatment T_{13} statistically superior with T_{10}, T_9, T_3 T_2 and T_8 and significantly at par to over rest the treatment in the year of 2019-20. The minimum number of branches was recorded in the control (No NPK and No mulching) treatment at all the stages. INM and mulching practices increased the yield and growth attributes which had possibly contributed to more vegetative growth. The favorable synthesis of growth promoting constituents in plant system owing to better supply of nutrients resulted in higher number of branches. The results are in conformity with (Tetarwal *et al.* 2013 and Gupta *et al.* 2019) [14, 4].

The dry matter accumulation increased with increasing the rate of photosynthesis (Table 3). The maximum dry matter accumulation was recorded under the treatment T_{13}-T_6 + Mulching @5 t/ha^{-1}, which was statistically at par with T_{14}, T_{11},T_{12}, T_6, T_{10}, T_9 and T_7 and T_6, and T_{14} and significantly superior over rest treatments at 30 DAS and 60 DAS during both years, respectively. The height dry matter accumulation (at harvest) was recorded same treatment it was statistically at par with T_6, T_{14}, T_7, T_{11}, T_4 and T_{12} and significantly superior with T_5, T_{10}, T_3, T_{19} T_3, and T_8 respective years 2018-19 and 2019-20. However, the lowest dry matter accumulation was observed under the treatment T_1 - Control (NO NPK + NO Mulching) in both the years, respectively. Dry matter accumulation plant^{-1} is an ultimate result of all the metabolic processes (physiology and biochemistry) occurring inside the plant. The higher value of total dry matter plant^{-1} under these treatments was due to higher rate of photosynthetic organ i.e. leaves. The higher dry matter accumulation of plant^{-1} in these treatments was due to higher plant height. These results are in tune with (Sharma and Jain 2002, Tetarwal *et al.* 2013, and Pandey *et al.* 2019) [11, 14, 10].

Seed and stover yield of mustard was significantly influenced by the use of integrated nutrient management system and mulching (Table 4). Among the treatments, maximum seed (21.05 and 22.08 q ha^{-1}) and stover yield (49.42 and 51.43 q ha^{-1}) were recorded under treatment T_{13}-75% NPK+ N-25% (FYM) +S @40 kg + Mulching @5 t/ha^{-1} in respective years of 2018-19 and 2019-20. Which was found statistically at par with T_{14} -75% NPK+ N-25% (FYM) + $ZnSO_4$ @25kg + Mulching @5 t/ha^{-1}having yield (19.57 and 21.17 q ha^{-1}) and significantly superior over rest treatments in respective years 2018-19 and 2019-20. The Productivity of crop is collectively determined by vigour of the vegetative growth and yield attributes which resulted in higher seed and straw yields. The increase in yield was further attributed to better translocation of photosynthesis from source to sink due to higher uptake of N, P, K and S. Which was responsible for quick and easy translocation of photosynthesis. Contrary to this, nutrients stress and moisture due to reduced absorption of nutrients in control plots provided minimum seed and straw yields due to poor growth and yield attributing characters. Similar finding has been given by (Singh *et al.* 2020 and Kumar S. T. 2020) [12, 5].

Table 1: Effect of INM and mulching practices on plant height (cm) at different growth stages

Treatments	30 DAS		60 DAS		At harvest	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
T_1- Control (NO NPK + NO Mulching)	23.09	24.15	61.23	63.12	136.10	143.30
T_2- 100% NPK + NO Mulching	25.39	25.67	75.56	76.19	166.42	172.16
T_3- 75% NPK + N-25% (FYM) + NO Mulching	25.53	25.83	76.49	76.45	170.44	175.32
T_4- 100% NPK+ S @40 kg + NO Mulching	25.93	26.03	79.98	80.93	175.46	182.63
T_5 -100% NPK+ $ZnSO_4$ @25 kg + NO Mulching	25.83	25.98	78.40	78.72	175.42	179.32
T_6 - 75% NPK+ N-25% (FYM) +S @40 kg + NO Mulching	26.68	26.34	83.07	82.82	183.76	190.35
T_7 -75% NPK+ N-25% (FYM) + $ZnSO_4$ @25kg + NO Mulching	26.23	26.04	81.11	82.32	176.49	185.52
T_8- T_1 + Mulching @5 t/ha^{-1}	24.40	24.60	63.89	65.71	142.14	146.67
T_9-T_2 + Mulching @5 t/ha^{-1}	25.46	26.43	76.19	77.00	167.33	173.00
T_{10} -T_3 + Mulching @5 t/ha^{-1}	25.60	26.59	77.12	77.26	171.35	176.16
T_{11} - T_4 + Mulching @5 t/ha^{-1}	26.00	26.79	80.61	81.74	176.37	183.47
T_{12} -T_5 + Mulching @5 t/ha^{-1}	25.90	26.74	79.03	79.53	176.33	180.16
T_{13}-T_6 + Mulching @5 t/ha^{-1}	26.75	27.10	83.63	83.70	184.67	191.19
T_{14} -T_7 + Mulching @5 t/ha^{-1}	26.30	26.80	81.74	83.13	177.40	186.36
SE(m)±	1.09	1.02	3.22	3.08	6.38	7.51
CD at 5%	NS	NS	9.55	9.16	18.96	22.41

Table 2: Effect of INM and mulching practices on number of branches plant^{-1} at different growth stages

Treatments	30 DAS		60DAS		At harvest	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
T_1- Control (NO NPK + NO Mulching)	1.41	1.56	12.59	13.19	16.78	16.94
T_2- 100% NPK + NO Mulching	1.62	1.66	15.80	16.65	20.20	20.93
T_3- 75% NPK + N-25% (FYM) + NO Mulching	1.66	1.75	14.79	16.86	20.27	20.99
T_4- 100% NPK+ S @40 kg + NO Mulching	1.80	1.89	17.37	17.67	21.40	22.19
T_5 -100% NPK+ $ZnSO_4$ @25 kg + NO Mulching	1.69	1.78	16.40	17.65	21.28	22.14
T_6 - 75% NPK+ N-25% (FYM) +S @40 kg + NO Mulching	2.12	2.21	15.81	19.26	23.26	24.12
T_7 -75% NPK+ N-25% (FYM) + $ZnSO_4$ @25kg + NO Mulching	1.82	1.95	14.99	18.35	22.42	23.03
T_8- T_1 + Mulching @5 t/ha^{-1}	1.49	1.63	13.19	13.76	17.08	17.11
T_9-T_2 + Mulching @5 t/ha^{-1}	1.85	1.89	16.58	16.99	20.59	21.34
T_{10} -T_3 + Mulching @5 t/ha^{-1}	1.89	1.98	16.63	17.20	20.66	21.40
T_{11} - T_4 + Mulching @5 t/ha^{-1}	2.03	2.12	17.62	18.01	21.79	22.60
T_{12} -T_5 + Mulching @5 t/ha^{-1}	1.92	2.01	17.40	17.99	21.67	22.55
T_{13}-T_6 + Mulching @5 t/ha^{-1}	2.35	2.44	19.01	19.60	23.65	24.53
T_{14} -T_7 + Mulching @5 t/ha^{-1}	2.05	2.18	18.20	18.69	22.81	23.44
SE(m)±	0.15	0.11	0.59	0.77	0.82	0.91
CD at 5%	NS	NS	1.67	2.28	2.39	2.65

Table 3: Effect of INM and mulching practices on dry matter accumulation plant^{-1}(g) at different growth stages of mustard

Treatments	30 DAS		60DAS		At harvest	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
T_1- Control (NO NPK + NO Mulching)	1.22	1.23	12.09	13.03	27.12	28.32
T_2- 100% NPK + NO Mulching	1.43	1.48	16.82	18.27	42.02	47.98
T_3- 75% NPK + N-25% (FYM) + NO Mulching	1.49	1.49	17.07	19.14	43.36	50.32
T_4- 100% NPK+ S @40 kg + NO Mulching	1.54	1.54	19.06	20.03	49.25	53.07
T_5 -100% NPK+ $ZnSO_4$ @25 kg + NO Mulching	1.53	1.52	18.63	19.85	47.77	51.67
T_6 - 75% NPK+ N-25% (FYM) +S @40 kg + NO Mulching	1.88	2.01	21.95	22.34	55.52	56.40
T_7 -75% NPK+ N-25% (FYM) + $ZnSO_4$ @25kg + NO Mulching	1.56	1.75	19.66	20.92	51.84	54.72
T_8- T_1 + Mulching @5 t/ha^{-1}	1.33	1.32	12.52	13.30	28.78	29.02
T_9-T_2 + Mulching @5 t/ha^{-1}	1.78	1.87	18.02	19.24	43.22	49.18
T_{10} -T_3 + Mulching @5 t/ha^{-1}	1.84	1.88	18.27	20.11	44.56	51.52
T_{11} - T_4 + Mulching @5 t/ha^{-1}	1.89	1.93	20.26	21.00	50.45	54.27
T_{12} -T_5 + Mulching @5 t/ha^{-1}	1.88	1.91	19.83	20.82	48.97	52.87
T_{13}-T_6 + Mulching @5 t/ha^{-1}	2.23	2.40	23.15	23.31	56.72	57.60
T_{14} -T_7 + Mulching @5 t/ha^{-1}	1.91	2.14	20.86	21.89	53.04	55.92
SE(m)±	0.13	0.14	0.82	0.86	2.01	1.91
CD at 5%	0.34	0.41	2.41	2.50	5.59	5.63

Table 4: Effect of INM and mulching practices on seed yield (q ha^{-1}), stover yield (q ha^{-1}) and harvest index (%) of mustard

Treatments	Seed yield (q ha^{-1})		Stover yield (q ha^{-1})		Harvest index (%)	
	2018-19	2019-20	2018-20	2018-19	2018-20	2019-20
T_1- Control (NO NPK + NO Mulching)	10.05	10.41	31.59	32.23	24.13	24.41
T_2- 100% NPK + NO Mulching	14.72	15.96	37.93	40.75	27.95	28.14
T_3- 75% NPK + N-25% (FYM) + NO Mulching	15.17	16.42	40.66	41.25	27.31	28.47

T_4- 100% NPK+ S @40 kg + NO Mulching	16.22	18.42	42.30	43.23	27.71	29.87
T_5 -100% NPK+ $ZnSO_4$ @25 kg + NO Mulching	15.22	17.02	41.31	42.76	26.92	28.47
T_6 - 75% NPK+ N-25% (FYM) +S @40 kg + NO Mulching	18.89	19.77	47.17	49.08	28.59	28.71
T_7 -75% NPK+ N-25% (FYM) + $ZnSO_4$ @25kg + NO Mulching	17.41	18.86	43.61	46.58	28.53	26.82
T_8- T_1 + Mulching @5 t/ha^{-1}	11.78	12.30	34.23	35.48	25.60	25.74
T_9-T_2 + Mulching @5 t/ha^{-1}	16.88	18.27	40.18	43.19	29.58	29.72
T_{10} -T_3 + Mulching @5 t/ha^{-1}	17.33	18.73	42.91	44.11	28.76	29.80
T_{11} - T_4 + Mulching @5 t/ha^{-1}	18.38	20.53	44.55	45.58	29.20	29.99
T_{12} -T_5 + Mulching @5 t/ha^{-1}	17.38	19.13	43.56	45.11	28.51	29.77
T_{13}-T_6 + Mulching @5 t/ha^{-1}	21.05	22.08	49.42	51.43	29.90	30.87
T_{14} -T_7 + Mulching @5 t/ha^{-1}	19.57	21.17	45.86	48.93	29.87	30.19
SE(m)±	0.73	0.76	2.04	2.07	_	_
CD at 5%	2.14	2.22	6.01	6.15	_	_

Summary and Conclusion

As par the data presented in table 1, 2, 3 and 4 the results may be concluded that, among the INM system and mulching practices. The Plant height, number of branches plant^{-1}, dry matter accumulation plant^{-1}, varied significantly due to various INM and mulching treatments as compared to treatment T_1- control (NO NPK+NO mulching) at all growth stages. However, at 30 DAS, plant height and number of branches plant^{-1} did not increase significantly by INM and mulching practices during both the years. The maximum plant height, number of branches plant^{-1} and dry matter accumulation plant^{-1} was recorded under the treatment T_{13}-75% NPK+ N-25% (FYM) +S @40 kg + Mulching @5 t/ha^{-1} as compared to other treatments at 30 DAS during both years, respectively. At 60 DAS and at harvest, the plant height, number of branches plant^{-1} and dry matter accumulation plant^{-1} was recorded under the treatment T_{13}-75% NPK+ N-25% (FYM) +S @40 kg + Mulching @5 t/ha^{-1} followed by the application of T_7 -75% NPK+N-25% (FYM)+ 25 kg ZnSO4+ NO Mulching during the years of 2018-19 and 2019-2020 respectively. The highest yield of mustard was found where applied 75% NPK+ N-25% (FYM) +S @40 kg + Mulching @5 t/ha^{-1} (T_{13}).

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