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Effect of plant density, N levels and moisture conservation practices on the performance of Indian mustard (*Brassica juncea*) and available N status of soil

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ABSTRACT

A field experiment was conducted in the winter (rabi) seasons of 2007-08 and 2008-09, to study the effect of plant geometries, nitrogen levels and application of anti-transpirants on the growth, yields, economics, N-uptake soil N-status and N-balance of Indian mustard (Brassica juncea L. Czernj & Cosson), Indian mustard sowing in paired row of 30 + 60 × 10 cm spacing gave 0.17 t/ha extra seed yield of mustard without reducing growth attributes, yield components, economics, WUE, oil content and soil N-status. Growth and yield attributes and maximum increment in seed and stalk yields of mustard were recorded with 80 kg N/ha and it were 8.54% and 14.26% higher over the control, respectively. The spraying of PMA + kaolin (6%) at 45 and 90 DAS increased the seed and stalk yields by 9.41 and 15.17% respectively over rest of treatments. The highest dose of nitrogen @ 80 kg/ha with paired row spacing of 30 + 60 × 10 cm planting along with combined spray of PMA @ 250 ppm + kaolin (6%) at 45 and 90 days after sowing increased production and quality of mustard and improved N status of soil.

Key wards : Available soil N, Anti-transpirant, Indian mustard, Kaolin, Nitrogen-use-efficiency, PMA Plant, Water-use-efficiency.

Indian mustard is a important winter (*rabi*) seasons oilseed crop of India, because of acute shortage of edible oil in the country we are importing it from different parts of the world. Rapeseed-mustard are the second major oilseed crops after the groundnut. Indian mustard responds to nitrogen. Among different agronomic manipulations, the optimum number of plants/unit area is one of the important non-monetary input in increasing the productivity. In addition to optimum plant density, the proper geometry of planting is another important non-monetary input in increasing the productivity per unit area. Spraying of anti-transpirants like phenyl mercuric acetate can go a way in economizing water and making it more available to the plant for growth and seed production. The present investigation was planned to study the optimum plant density, nitrogen requirement and spray of anti-transpirant in Indian mustard.

MATERIALS AND METHODS

A field experiment was conducted during the winter (*rabi*) seasons of 2007-08 and 2008-09 at the farm of Krishi Vigyan Kendra, Hazratpur, District Firozabad (Uttar Pradesh). The soil was sandy loam in texture, low in available N (168 kg/ha), medium in available P (22 kg/ ha), medium in available K (196 kg/ha) and with pH 7.8. The experiment was laid out in split-plot design with three replications, consisting of three crop geometries viz. 45 × 10 cm (2,22,222 plants/ha), 30 + 60 × 10 cm (2,22,222 plants/ha) and 45 × 20 cm (1,11,111 plants/ha), three nitrogen levels of 0, 40 and 80 kg/ha and four anti-transpirants practices of control, phenyl mercuric acetate (PMA) @ 250 ppm at 45 and 90 days after sowing in 600 to 1,000 l water/ha, Kaolin (6%) at 45 and 90 DAS in 600 to 1000 l water/ha and PMA @ 250 ppm + Kaolin (6%) at 45 and 90 DAS in 600 to 1000 water l/ha. The combinations of plant geometry and N levels were placed in main-plots, while the anti-transpirants treatments were in sub-plots. The experiment was conducted in a field kept vacant during the previous kharif to have uniform fertility gradient. Indian mustard 'Rohini' was used as test variety. The mustard was sown using a seed rate of 5 kg/ha on 01 October and was harvested on 04 March during both the years, respectively. The crop was raised as per the recommended package of practices accept the treatments.

RESULTS AND DISCUSSION

Growth and yield attributes

Since the variance for yield and growth attributes, economics, WUE, NUE and oil content were homogenous

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during both the years so the pooling of the results was done. Interaction between plant geometry, nitrogen levels and anti-transpirants in mustard were non-significant.

The growth and yield attributes of Indian mustard varied significantly due to different planting densities (Table 1). The lower plant population of 1,11,111 plants/ha (Crop geometry of 45 × 20 cm) registered significantly higher number of siliquae/plant, number of seeds/siliqua and 1,000-seed weight. However, taller plants, more branches and higher percentage of harvest index were received in paired row spacing of 30 + 60 × 10 cm. The more severe competition for light and higher intra-row competition for nutrients and water due to over crowding of plants might be responsible for increasing the growth parameters and declining the values of yield attributes respectively at higher planting densities. Singh *et al*, (2006) also reported similar results in African mustard. Application of nitrogen @ 40 to 80 kg/ha gave taller plants of mustard with more primary and secondary branches/plant and yield attributes of mustard viz. siliquae/plant, siliqua length, 1,000-seed weight and higher percentage of harvest index. The findings are in close conformity with those of Singh and Meena (2004). The PMA + kaolin spray at 45 and 90 DAS recorded significantly higher plant height, branches per plant (growth components) and siliquae per plant, siliqua length, seeds per siliqua and 1000-seed weight (yield attributes) and also gave higher harvest index of Indian mustard followed by other anti-transpirants and control (Table 1). It may be due to better plant water status during crop growth. Singh and Rana (2006) also reported that FYM + organic mulch + kaolin improved the soil moisture status of upper soil layer.

Seed and stalk yields

Paired row spacing of 30 + 60 × 10 cm gave significantly higher seed and stalk yields than wider spaced of 45 × 20 cm and closer spacing of 45 × 10 cm (Table 2). The paired row spacing of 30 + 60 × 10 cm (2,22,222 plants/ha) recorded 5.21 and 8.54% higher seed and 6.24 and 14.26% higher stalk yields followed by wider spacing of 45 × 20 cm (1,11,111 plants/ha) and closer spacing of 45 × 10 cm (2,22,222 plants/ha). The improvement in both seed and stalk yields of mustard with an increase in planting densities from 1,11,111 to 2,22,222 plants/ ha was significant. This indicated that higher plant population in closer crop geometry gave higher seed and stalk yield even though yields/plant was less. Similar results were reported from studies conducted by AICRP-RM (2000).

Significant improvement in seed yield as well as in stalk yield was observed with successive increase in level of nitrogen from 0 to 80 kg/ha during both the years (Table 2). Application of 80 kg N/ha recorded significantly higher seed of 2.22 t/ha and stalk of 6,56 t/ha yields over its proceeding lower levels. It was increased seed of 14.4 and 41.4% and stalk of 30.9 and 49.4% yields over applied of 40 kg N/ha and control The significant increase in seed and stalk yields of mustard were largely a function of improved growth and the consequent increase in different

Table 1. Influence of plant geometry, nitrogen level and anti-transpirants on growth and yield attributes of mustard (Mean data of 2 years)

Treatment	Plant height (cm)	Branches/plant		Siliquae/ plant	Siliqua Length	Seeds/ Siliqua	1,000 Seed wt/g	Harvest Index (%)
		Primary	Secondary					
Plant geometry								
45 × 10 cm	173.6	6.2	13.4	265.7	5.70	12.20	4.80	21.6
30+60 × 10 cm	182.2	6.7	13.9	291.0	6.20	12.40	5.00	24.3
45 × 20 cm	179.3	5.3	10.1	293.6	6.40	15.00	5.60	24.0
SEm+	0.9	0.1	0.3	1.9	0.07	0.07	0.03	-
CD (P=0.05)	2.6	0.4	0.9	5.3	0.20	0.20	0.10	-
Nitrogen Level (kg/ha)								
0	173.7	5.1	10.6	264.4	5.30	11.90	4.50	20.3
40	179.0	6.2	12.8	318.0	6.20	13.10	5.20	23.8
80	186.5	6.9	14.0	331.1	6.80	14.60	5.60	25.8
SEm±	0.9	0.1	0.3	1.9	0.07	0.07	0.03	-
CD (P=0.05)	2.6	0.4	0.9	5.3	0.20	0.20	0.10	-
Anti-transpirant								
Control	171.8	5.3	10.3	298.6	4.9	12.7	4.80	20.7
PMA	177.2	6.4	12.6	311.7	5.9	12.8	5.20	23.2
Kaolin	181.3	6.8	12.9	322.2	6.3	13.3	5.20	23.2
PMA+kaolin	183.0	6.9	13.5	334.6	6.7	13.8	5.30	24.8
SEm+	1.1	0,1	0.2	2.6	0.1	0.1	0.02	-
CD (P=0.05)	2.8	0.3	0.5	7.2	0.4	0.3	0.10	-

yield components due to adequate supply of nitrogen plant nutrient under successive increase nitrogen dose which finally resulted in higher seed yield. Several workers have reported the positive response of nitrogen application on seed and stalk yields of mustard (Singh and Meena 2004 and Reager et al., 2006).

The anti-transpirants PMA and kaolin alone and in combination through foliar spray resulted in significant increased of all biometric parameters. The increase in seed yield of 3.96, 6.93 and 9.41% and the stalk yield of 5.67, 10.17 and 15.17% was recorded with PMA + kaolin combined foliar spray, followed by PMA, kaolin, respectively (Table 2). The results confirm the finding of Singh and Rana (2006) and Regar et al, (2007).

Economics

The net returns of ₹17,439/ha and benefit: cost ratio of 1.32 were highest in paired row planting of 30 + 60 × 10 cm (2,22,222 plants/ha) (Table 2) Highest net returns (₹20416/ha) and B:C ratio (1.46) were realized with application of 80 kg N/ha. Further, the maximum returns of (₹17,436/ha) and B:C ratio (1.28) were recorded in foliar spray of PMA @ 250 ppm and kaolin (6%) at 45 and 90 DAS. This might be due to higher productivity in these treatments. Parihar *et al.,* (2010) reported that 60 + 17.6 kg N + P//ha to mustard fetched highest net returns and Awasthi *et al.,* (2007) reported beneficial effects of mulches on monetary returns.

WUE, NUE and Oil content

The effect of different crop geometries, N- levels and spray of anti-transpirants on water efficiency and nitrogen use efficiency were found significant (Table 2). The maximum water use efficiency (12.3 kg/ha-cm) was achieved in the crop geometry of 30 + 60 × 10 cm, which was significantly higher than 45 × 10 cm and 45 × 20 cm spacing.

The successive increase in nitrogen in level from 0 to 80 kg/ha significantly improved the WUE and NUE. Highest WUE (42.2 kg/ha-cm) and NUE (16.58%) were seen with 80 kg N/ha. The superiority of this treatment over rest of the treatments might be ascribed to higher seed yield due higher availability of nitrogen to crop under 80 kg N/ha and improved transpiration efficiency. Regar et al, (2006) reported similar results.

The maximum WUE (13.0 kg/ha-cm) and NUE (16.87%) were noted with PMA @ 250 ppm + kaolin (6%) foliar spraying with 600 to 1000 water l/ha at 45 and 90 DAS (Table 2). The approximately 99% of the water taken up by the plant root is transpired to the atmosphere through stomata. An anti-transpirant is a substance that is applied to transpiring plant surface with the aim of reducing water loss due to transpiration. The other benefit of anti-transpirations are increasing the water use efficiency, maintaining of turgor pressure etc. Anti-transpirants viz., PMA @ 250 ppm reduce the transpiration by closing the stomata for 2-3 days when sprayed on the leaves. Firm forming anti-transpirants produce an external physical

Table 2. Yield, economics, WUE, NUE and oil content (%) as influenced by plant geometry, nitrogen level and anti-transpirants of mustard (Mean data of 2 years)

Treatment	Seed Yield (t/ha)	Stalk Yield (t/ha)	Net returns (₹/ha)	B:C ratio	WUE (kg/ha - cm)	NUE (%)	Oil Content (%)
Plant geometry							
45 × 10 cm	1.82	5.11	14860	1.13	12.0	19.01	38.7
30+60 × 10 cm	1.99	5.96	17439	1.32	12.3	16.37	38.8
45 × 20 cm	1.92	5.45	16537	1.24	12.0	16.39	38.6
SEm+	0.01	0.06	-	-	0.87	0.32	0.45
CD (P=0.05)	0.04	0.15	-	-	NS	0.87	NS
Nitrogen Level (kg/ha)							
0	1.57	4.39	11631	0.93	09.8	-	39.2
40	1.94	5.01	16789	1.27	12.3	17.21	38.7
80	2.22	6.56	20416	1.46	14.2	16.58	38.2
SEm+	0.01	0.06	-	-	0.87	0.32	0.45
CD (P=0.05)	0.04	0.15	-	-	NS	0.87	NS
Anti-transpirant							
Control	1.83	5.09	15184	1.17	11.2	20.55	38.5
PMA	1.88	5.39	15863	1.21	11.9	18.18	38.6
Kaolin	1.94	5.66	16632	1.28	12.3	16.44	38.7
PMA+kaolin	2.02	6.00	17436	1.28	13.0	16.57	38.8
SEm+	0.02	0.07	-	-	0.76	0.59	0.03
CD (P=0.05)	0.05	0.20	-	-	1.70	1.54	NS

barrier to retard the escape of water vapour. Another approach to reduce the transpiration rate is by coating the leaf surface with white reflecting materials and kaolin at 6% helps to lower the leaf temperature and reduce the transpiration when applied on foliage. Water use efficiency and nitrogen use efficiency in terms of seed yield were highest in PMA + kaolin spraying as under such conditions plants would use available soil moisture most economically and therefore PMA @ 250 ppm + kaolin(6%) foliar spray with 600 to 1,000 water l/ha at 45 and 90 DAS followed by kaolin, PMA alone and control but there was not affected of oil content % on plant geometry, N level and anti-transpirants treatments. These results confirm those of Singh and Rana (2006).

Nutrient uptake and balance

The lowest plant population 45 × 20 cm (1,11,111 plants/ha) recorded significantly higher nitrogen uptake and closer spacing of 45 × 10 cm (2,22,222 plants/ha) and 30 + 60 × 10 cm (2,22,222 plants/ha) during 2007-08 and 2008-09, respectively (Table 3). The increased uptake was due to higher N content in seed and stalk and increased yield attributes. The computed N-balance was increased in similar trend but in negative under all spacing treatments during both the years, respectively.

The uptake of N significantly increased with N application, maximum being at 80 kg/ha (Table 3). Application of N registered increased in N uptake by 22.93% and 23.16% with 40 kg N/ha and 35.09% and 35.547% with 80 kg N/ha during Ist and IInd years, respectively over control. It was owing to received higher yields of Indian mustard. The increase in N uptake with nitrogen application might be because nutrient uptake is correlated with yield which in turn resulted in increase in dry matter and nutrient uptake. The results confirm the findings of Singh and Meena (2004). The available N-status of soil and actual gain/loss over initial status improved with application of N over the control, because of increased supply of nitrogen. As regards rates of N application maximum negative balance in available of -81.0 to -85.4 was kg N/ha was recorded with an application of 40 kg N/ha and lowest -34.0 and -40.0 kg N/ha with control during both the years, respectively.

The PMA @ 250 ppm + kaolin foliar spray (6%) recorded significantly higher N-uptake by crop, soil N-status after harvest of crop and actual gain/loss over initial status over foliar spray of PMA and kaolin alone and control during both the years (Table 3). As regards antitranspirants, the maximum negative N-balance in available N of -80.9 to 91.5 was recorded under spray of PMA + kaolin (6%). Singh and Rana (2006) reported the highest N and P uptake of Indian mustard and lentil was with FYM + organic mulch + kaolin 6% spray.

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Table 3. Balance sheet of N (kg/ha) as influenced by plant geometry, N level and anti-transpirants in mustard.

Treatment	N-added in soil (b)		N-uptake by crop (c)		Soil N-status after harvest (d)		Actual gain/loss over initial (a - d)		Availabe N-balance (kg/ha) (a + b)-(c + d)	
	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
Plant geometry										
45 × 10 cm	40.0	40.0	84.4	85.6	173.9	198.3	7.2	9.0	-68.6	-74.7
30+60 × 10 cm	40.0	40.0	97.3	97.7	174.2	199.1	7.5	9.8	-69.6	-76.0
45 × 20 cm	40.0	40.0	92.8	93.6	172.7	198.6	6.0	9.3	-70.0	-77.2
SEm+	-	-	0.2	0.2	0.1	0.2	0.2	0.1	-	-
CD (P=0.05)	-	-	0.6	0.4	0.3	0.6	0.5	0.4	-	-
Nitrogen (kg/ha)										
0	-	-	71.6	72.0	169.1	197.5	02.4	08.2	-72.0	-80.6
40	40.0	40.0	92.9	93.7	182.4	206.1	15.7	16.8	-81.0	-85.4
80	80.0	80.0	110.3	111.3	197.8	216.3	31.1	27.0	-68.2	-67.4
SEm+	-	-	0.2	0.2	0.1	0.2	0.2	0.1	-	-
CD (P=0.05)	-	-	0.6	0.4	0.3	0.6	0.5	0.4	-	-
Anti-transpirants										
Control	40.0	40.0	84.0	85.0	174.0	196.0	07.3	06.7	-70.5	73.4
PMA	40.0	40.0	88.7	89.1	176.2	199.4	09.5	10.1	-76.3	79.4
Kaolin	40.0	40.0	93.8	94.7	176.7	200.3	10.0	11.0	-78.4	-83.0
PMA+kaolin	40.0	40.0	98.3	99.7	176.9	204.7	10.2	15.4	-80.9	-91.5
SEm+	-	-	0.5	0.8	0.4	0.6	0.6	0.5	-	-
CD (P=0.05)	-	-	1.5	2.7	1.2	1.7	2.1	1.3	-	-

Initial soil N status (kg/ha) = 166.7 (2007-08) and 189.3 (2008-09)

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