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Krishna Kumar
Department of Agronomy, Raja Balwant Singh College (Dr. B.R. Ambedkar University) Bichpuri, Agra, Utter Pradesh, India

Yogesh Kumar
Department of Soil Conservation Janta Mahavidyalaya, Ajitmal, Auraiya, Utter Pradesh, India

Nirmal Kumar Katiyar
Regional Pesticides Testing Laboratory, Kanpur, Utter Pradesh, India

Correspondence
Krishna Kumar
Department of Agronomy, Raja Balwant Singh College (Dr.B.R. Ambedkar University) Bichpuri, Agra, Utter Pradesh, India

Effect of plant geometry, nitrogen level and antitranspirants on physiological growth, yield attributes, WUE and economics of mustard (*Brassica juncea*) under semi-arid conditions of western Uttar Pradesh

Krishna Kumar, Yogesh Kumar and Nirmal Kumar Katiyar

Abstract
A field experiment was conducted during the winter (*rabi*) season of two consecutive years sandy loam soil using three type crop geometry (45 x 10 cm, 30+60x10 cm and 45x20 cm) three nitrogen levels (0, 40 and 80 kgha^{-1}) and four antitranspirants treatments (Control, Phenyl mercuric acetate (PMA) @ 250 PPM, Kaoline (6%) and PMA + Kaoline) revealed that plant height, protein content, biological yield, seed yield, stover yield, net returns, benefit: cost ratio significantly higher in paired row spacing of 30+60x10 cm crop geometry but primary and secondary branches plant^{-1}, dry weight plant^{-1}, number of siliquae plant^{-1}, weight of siliquae plant^{-1}, grain yield plant^{-1}, 1000-seed weight higher in 45x20 cm plant geometry, WUE and oil content were not affected by different plant geometry. Physiological growth and yield component, quality and quantity of mustard were higher in maximum nitrogen. Application of PMA + Kaoline received higher crop attributes, yields, returns, and quality of Indian mustard but percent of oil content, protein content and soil moisture had not affected by using of different antitranspirants. The higher dose of nitrogen @ 80 kgha^{-1} at paired row spacing of 30+60x10 cm with application of combined spray of PMA+Kaoline at 45 and 90 days after sowing increased grain and stover yields maximum economic returns and higher content is Indian mustard.

Keywords: Physiological growth, yield attributes, oil content, protein content, WUE, economics

1. Introduction

Indian mustard (*Brassica juncea* L. Czern & Coss) is an important *rabi* oil seed crop of India. Because of acute shortage of oilseed in the country we are importing lot of oil from different parts of the world. Rapeseed and mustard are the second major oilseed crops after the groundnut. The estimated area, production and yield of rapeseed-mustard in the world was 30.74 million hectares (Mha), 59.93 million tonnes (Mt) and 1,950 kgha^{-1}, respectively, during 2009-10. Globally, India accounted for 21.7% and 10.7% of the total area and production in 2010.

Although India has 20.8 per cent of the world's area under oilseed crops, it accounts for less than 10 per cent of global production. This is because of low productivity of oilseed crops and year to year fluctuations in production in India. Oilseeds are energy-rich crops but they are grown under energy-starved conditions and about 85 per cent of the area under oilseeds is rain fed comprising mostly marginal and sub marginal lands with soils of poor fertility. Pests and diseases also cause substantial production losses. The Indian mustard responds to nitrogen (Joshi *et al*. 1998) [4]. Effective management natural resources, integrated approach to plant-water nutrient, weed and pest management and extension of rapeseed-mustard cultivation to new area under different cropping systems will pay key role in further increasing and stabilizing the productivity and production of rapeseed-mustard (Shekhawat *et al*. 2012) [13]. Among different agronomic manipulations, the optimum number of plants unit^{-1} area is one of the important non-monetary parameters in increasing the productivity (Bali *et al*. 2000) [2]. In addition to optimum plant density, proper geometry of planting is another important non-monetary input in increasing the productivity per unit area. Chemical that decrease or inhibit transpiration have been studied primarily during the past decade, early work emphasized the use of film-forming compounds to prevent desiccation of plants during transpiration (Marshal and Maki, 1946) [10] and film forming materials reduce transpiration by physically impeding the flow of water vapour away from plant leaves. Such compound should be non-toxic resistant to weathering and impermeable to water vapour yet permeable to CO_2 and O_2 (Gale 1961) [3].

Spraying of antitranspirants like phenyl mercuric acetate water suspension, which reduces transpiration losses from vegetative parts of the plant, go a long way in economizing water and making more water available to the plant for productive purpose. Hence the present investigation was planned to study the optimum plant density, nitrogen requirement and anti-transpirants of Indian mustard under dryland and semi-arid conditions of western Uttar Pradesh resulted in significant increase of all biometric parameters studied (Table-1).

2. Material and Methods

A field experiment was conduct during winter (*rabi*) seasons of two consecutive years at agricultural research farm of Raja Balwant Singh College, Bichpuri Agra (77.9°E, 27.2°N, with mean sea level 168m). The soil was sandy loam in texture, low in available nitrogen (198 kgha^{-1} piper, 1950), medium in available phosphorus (26 kgha^{-1} Olsen *et al.* 1954) and high in available potassium (296 kgha^{-1} Jackson, 1973) and slightly alkaline in pH (7.5). The experiment was laid out in split-plot design with 3 replications consisting of 3 crop geometries, 45 x 10 cm (222,222 plants ha^{-1}), 30 + 60 x 10 cm paired row (222,222 plants/ha) and 45 x 20 cm (111,111 plants ha^{-1}) as main treatments, 3 nitrogen levels (0, 40 and 80 plants ha^{-1}) and 4 anti-transpirants (control, phenyl mercuric acetate (PMA) @ 250 ppm at 45 and 90 days after sowing @ 600 and 1000 L ha^{-1} and kaoline (6%) at 45 and 90 DAS and PMA @ 250 PPM + kaoline (6%) at 45 and 90 DAS @ 600 and 1000 Lha^{-1}, respectively as sub-treatments. Full dose of N through urea applied before sowing. Required plant population was maintained by thinning out extra plants at 20 DAS. Cultivar "Rohini" was planned on 01 october and was harvested on 04 March during both the years, respectively. Rest of the package of practices was same as for Indian mustard.

3. Results and Discussion

3.1 Physiological growth and yield attributes

The mean values of plant height is highest in paired row spacing (30+60x10 cm) over other, through term primary and secondary branches plant^{-1}, Dry weight plant^{-1}, Number of siliquae plant^{-1}, weight of siliquae plant^{-1} grain weight plant^{-1}, 1000-seed weight is wider raw spacing (45 x 20 cm) treatment were significantly higher over other treatment (Table 1). As a result of better partitioning of photosynthates from source to sink and less competition for resources, development of yield attributes was better under wide row spacing (45x20 cm). Application of 80 kg N ha^{-1} recorded significantly higher in plant height, primary and secondary branches plant^{-1}, Dry weight plant^{-1}, number of siliquae plant^{-1}, grain weight plant^{-1}, 1000 seed weight over 40 kg N ha^{-1} and control (Table-1) nitrogen application significantly effect of growth and yield attributes of mustard was also reported by Mishra *et al.* (1999) [11] and Singh and Meena, (2004) [8]. Application of different anti-transpirants (PMA and Kaoline) alone or combined through foliar spray.

3.2 Yield

Application of crop geometry (45 x 20 cm) lower plant population on growth and yield component of individual plant was observed the seed and stover yield did not improve mainly because of lower number of plant ha^{-1}, seed and straw yield (19.88 and 59.60 q ha^{-1}) with higher plant population of 222, 222 plant ha^{-1} (paired row spacing 30 + 60 x 10 cm) was significantly higher than that of wider spacing (45 x 20 cm) and narrow spacing (45 x 10 cm) which was higher seed and straw yield increase 3.65% and 9.36% over wider spacing of 45 x 20 cm and 9.34% and 16.63% over narrow spacing of 45 x 10 cm, respectively. The result clearly indicated that for *Brassica juncea*, wider spacing of 45 x 20 cm adversely affected the seed and straw yields. Similar results were reported from studies conducted at Ludhiana, Bhatinda and Kangra (AICRP- RM. 2000), Saren *et al.* (2009) [12], Mishra *et al.* (2001) [9] and Kazemeini *et al.* (2010) [5]. Application 80 Kg N ha^{-1} recorded significantly higher seed (22.19 q ha^{-1}) and stover (65.60 q ha^{-1}) yields over its preceding lower Levels. It was increase seed 14.43% and 41.40% and straw 30.34% and 49.43% yields over 40 kg N ha^{-1} and control (Table-2). Nitrogen Application significantly improved growth and yield components. Which resulted in significantly higher seed and stover yield. Mishra *et al.* (1999) [11], Singh and Meena (2004) [8] and Yadav *et al.* (2010) [14]. Application of different antitranspirants (PMA and Kaoline) alone or combined through foliar spray resulted in significant increase of all biometric parameter studied (Table -2). The significantly increase in seed yield was 10.38% 6.01% and 2.73% by PMA + Kaoline, Kaoline and PMA over the control. The stover yield was found in similar trends.

The oil and protein content (%) higher in (Paired row spacing 30+60×10 cm) and nitrogen level of increasing decreased the oil content and increased protein content. Application of antitranspirants (PMA+Kaoline) spraying resulted in highest oil and protein (%) than other antitranspirants. Raskar and Bhoi (2003) [15] also reported that application plastic film + Kaoline (8%) increased significantly oil and protein (%) content under mulching than the control.

Economics returns: Plant geometry 30+60×10 cm to mustard recorded in significantly higher net return (Rs 17439 ha^{-1}) and benefit:cost ratio (1.32) than rest of plant geometry treatments. The application of nitrogen level 80 kg ha^{-1} gave significantly higher net return (Rs 20416 ha^{-1}) and benefit:cost ratio (1.24) than rest of treatment. Use of antitranspirants PMA+Kaoline spray gave significantly higher net return (Rs 17436 ha^{-1}) and benefit:cost ratio (1.28) than other antitranspirants treatment and control. Patel and Patel (1999) [7] and Baskar and Bhoi (2003) [15] also reported that use of plastic film mulch with kaoline spray gave significantly higher net returns and benefit: cost ratio than rest of treatment.

Water-use efficiency: The highest value of water-use efficiency was obtained (12.34 kgha^{-1} mm) under plant geometry (30+60×10 cm) paired row treatment. Wider spacing facilitated to evaporate more water from filed and hence water used by the crop was found also higher than other spacing treatment. Increase in fertilizer levels increased water use efficiency due to increase in grain yield in higher proportions than the corresponding increase in water use. The water-use efficiency highest obtained (13.03 kgha^{-1} mm), PMA+Kaoline spraying than other treatments. These indicate than minimized loss of stored soil moisture as evaporation from the soil surface and transpiration through weeds because water was most efficiently utilized under the (PMA + Kaoline) antitranspirants. Katole and Sharma (1999) [6] and Hembran and Saren (2015) [15] also reported similar finding.

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Table 1: Effect of plant geometry, nitrogen level and antitranspirants on physiological growth and yield attributes of mustard (2 year pooled data).

Treatment	Plant height (cm)			Primary branches plant^{-1}			Secondary branches plant^{-1}			Dry weight plant^{-1} (g)	Number of Siliquae plant^{-1}	WeightofsiliquaePlant^{-1}	Grain weight plant^{-1} (g)	1000-seed weight (g)
	60DAS	90DAS	120DAS	60DAS	90DAS	120DAS	60DAS	90DAS	120DAS					
Plant geometry														
45 x 10 cm	128.30	168.92	173.59	2.64	5.59	6.60	3.47	5.67	7.73	67.67	265.7	38.00	12.17	4.8
30 + 60 x 10 cm	129.82	176.78	182.21	2.73	5.63	6.73	3.72	5.79	7.87	72.84	291.0	41.50	12.40	5.0
45 x 20 cm	125.40	175.62	179.29	2.74	5.95	7.88	3.97	6.58	8.70	102.94	393.6	55.92	14.99	5.6
CD (P=0.05)	2.36	2.91	3.65	0.07	0.12	0.16	0.08	0.14	0.18	2.32	5.3	1.03	0.34	0.1
Nitrogen level (kg/ha)														
0	125.12	170.82	173.67	2.62	5.53	6.85	3.57	5.75	7.87	67.97	264.4	37.83	11.89	4.5
40	128.24	173.98	178.92	2.70	5.74	6.99	3.70	6.05	8.11	83.33	318.0	46.33	13.09	5.2
80	130.17	176.51	186.50	2.76	5.80	7.37	3.89	6.25	8.33	94.29	367.9	51.75	14.58	5.6
CD (P=0.5)	2.36	2.91	3.65	0.07	0.12	0.16	0.07	0.14	0.19	2.32	5.3	1.03	0.34	0.1
Antitranspirants														
Control	124.49	169.10	172.05	2.60	5.57	6.72	3.51	5.73	7.82	76.60	298.6	42.52	12.61	4.8
PMA	127.35	172.70	177.22	2.69	5.71	7.09	3.65	6.01	7.99	79.65	311.7	44.55	13.07	5.2
Kaoline	129.44	175.81	181.22	2.71	5.74	7.16	3.83	6.11	8.25	82.75	322.2	45.81	13.31	5.2
PMA + Kaoline	130.44	177.50	182.95	2.77	5.88	7.33	3.89	6.20	8.36	85.96	334.6	47.67	13.75	5.3
CD (P=0.5)	2.21	3.76	3.84	0.09	0.13	0.15	0.08	0.16	0.22	3.04	7.2	1.04	0.42	0.1

WUE = Water use efficiency, PMA = Phenyl mercuric acetate & NS = Non-significant.

Table 2: Effect on oil content, protein content, WUE, biological yield and economics as influenced by plant geometry, nitrogen and antitranspirants of mustard (2 year pooled data).

Treatment	Oil content (%)	Protein content (%)	Soil moisture (%)	WUE (kg-ha-mm)	Biological yield (qha^{-1})	Seed yield (q ha^{-1})	Stover yield (q ha^{-1})	Net return	Benefit: costratio
Plant geometry									
45 x 10 cm	38.7	20.2	8.87	11.95	68.91	18.26	51.65	14860	1.13
30 + 60 x 10 cm	38.8	20.6	8.57	12.34	79.12	19.88	59.53	17439	1.32
45 x 20 cm	38.6	20.9	8.51	11.95	72.71	19.15	54.45	16537	1.24
CD (P=0.05)	NS	0.4	0.11	….	2.82	0.47	2.10	---	---
Nitrogen level (kg/ha)									
0	39.2	19.8	8.76	9.84	58.97	15.67	43.90	11631	0.93
40	38.7	20.6	8.63	12.29	74.84	19.41	56.12	16789	1.27
80	38.2	21.3	8.57	14.16	86.93	22.19	65.61	20416	1.46
CD (P=0.5)	0.3	0.4	0.11		2.82	0.47	2.15	---	---
Antitranspirants									
Control	38.5	20.4	8.67	11.15	68.03	18.03	50.38	15184	1.17
PMA	38.6	20.6	8.63	11.92	71.82	18.36	53.86	15863	1.21
Kaoline	38.7	20.7	8.66	12.27	75.18	19.41	56.62	16632	1.27
PMA + Kaoline	38.8	20.7	8.69	13.03	79.29	20.16	60.00	17436	1.28
CD (P=0.5)	NS	NS	NS	NS	3.60	0.67	2.79	---	---

WUE = Water use efficiency, PMA = Phenyl mercuric acetate & NS = Non-significant

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