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Response of polymers and nutrient management on growth, yield, and quality of Indian mustard (*Brassica juncea*)

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The demand for oilseeds is increased due to high population pressure (Bharose *et al*. 2011). Based on the minimum requirement for oils and fats, it should be 5.5 million tonnes, against the present production of only 2.9 million tonnes, leaving a gap of 2.6 million tonnes (DES, 2018). This demand has been increasing at the rate of six percent per annum in the last 13 years (Ashoka *et al*. 2017). This would only show that there is an urgent need to step up oilseed production principally through an increase in productivity on a sustainable basis (Banerjee *et al.* 2010). India occupies a premier position in the global oilseeds scenario with 15 percent of oilseeds area. The oilseeds are the key player in the agricultural economy of India after food production (Meena and Yadav 2015). Rapeseed-mustard [*Brassica juncea* (L.) Czern. and Coss.] is a winter (*rabi*) season crop that requires a fair supply of soil moisture during the growing season and a dry harvest period. Indian mustard seed has 28-36% protein content with a high nutritive value. Also, it is one of the most important sources of oil production in India (Kumar *et al*. 1997). The major area of Indian mustard is cultivating under rainfed situations, it has not only low but quite unstable production system due to initial poor crop stand under deficient profile moisture. Hence, need to improper the fertilizers and water use efficiency under rainfed condition (Meena *et al.* 2015).

In dry land condition the productivity can increase by the use of polymer. Polymer has provided the solutions to the problems of the present dry land agriculture which is to maximize land and water productivity without threatening the environment and the natural resources (Hedrick and Mowry 2002). These polymers were developed to improve the physical properties of soil in view of increasing water-holding capacity (WHC), water use efficiency (WUE), enhancing soil permeability and infiltration rates, reducing irrigation frequency and compaction tendency, stopping erosion and water run-off, increasing plant performance especially in structure less soils in areas subject to drought (Ekebafe *et al*. 2011). All the major nutrients, *viz*. nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) play an important role to increase the yield and quality of Indian mustard. N is known to activate most of metabolic activities and transformation of energy (Verma *et al*. 2015). P is essential for cell division and meristematic growth of tissue. It also helps in seed and fruit development and it stimulates flowering as well (Meena *et al.* 2017). P is the third major nutrient for mustard crop after N and P in the fertilization process. S application greatly influences chlorophyll synthesis, carbohydrate as well as protein metabolism and finally results in improvement in growth characters, contributing to higher dry matter accumulation (DMA) in plants (Ramarethinam and Chandra 2005). These aspects led agronomists to concern and look for use of biofertilizer like KSB (Meena *et al.* 2017a). This is a promising strategy for the improvement of plant absorption of potassium and so reducing the use of chemical fertilizer. Therefore, the inoculations of KSB with polymers in the soil become mandatory to restore and maintain the effective microbial populations for solubilization of chemically fixed K and availability of other macro and micronutrients to harvest good sustainable yield of various crops (Archana *et al*. 2008; Meena *et al.* 2020).

A field experiment was conducted during winter (*rabi*) season of 2015-16 at the Agricultural Research Farm,

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Department of Agronomy, Institute of Agricultural Sciences (IAS), Banaras Hindu University (BHU), Varanasi, Uttar Pradesh (India), situated under North East Plain Zone of the country. The pattern of rainfall distribution was not normal during the experimental period. The experiment was laid out in the split-plot design. The main plot treatment consisted three polymer levels, *viz*. (i) control, (ii) NCPC@5 kg/ha and (iii) hydrogel @ 5 kg/ha and four levels of nutrient management, *viz*. (i) control, (ii) 100% RDF, (iii) 75% RDF+KSB, (iv) 100% RDF+KSB /ha were allocated to sub-plots. The treatments were replicated four times to avoid any effect of heterogeneity. The soil of the experimental site was clay loam in texture, non-saline and slightly alkaline in reaction. The plow layer contains available N (238.48 kg/ha), P (23.48 kg/ha), K (172.10 kg/ha), S (20.73 kg/ha), organic carbon (0.38%), soil pH (7.8) and electrical conductivity (EC) (0.18 dS/m). The NCPC and hydrogel were applied by basal application at the time of sowing. RDF was applied @ 120-60-60-40 kg/ha NPKS, respectively and KSB applied as the seed treatment at the time of sowing. The cultivar Ashirwad was sown at the rate of 5 kg/ha at a spacing of 30 cm ×15 cm. The standard level of significance was used to justify a claim of a statistically significant effect is 0.05 (Draper and Smith 1998).

A critical examination of data indicates that application of NCPC @ 5 kg/ha significantly increased the growth parameters (Table 1), *viz.* plant height (174.39 cm), number of branches/plant (8.00) and DMA(40.14g) at harvest, leaf area index (LAI)(5.12) at 90 DAS and yield attributes and yield (Table 2), *viz.* number of siliqua (315.91), siliqua length (4.96 cm), number of seeds/siliqua (12.90), 1000 seed weight (4.94g), seed yield (1770 kg/ha), stover yield (5616 kg/ha), biological yield (7387 kg/ha) harvest index (23.64) and quality parameters and economics (Table 3), *viz.* protein content (22.24%), protein yield (405 kg/ha), oil content (37.50 %), oil yield (683 kg/ha), net return (83443 ₹/ha) and B: C ratio (2.62) of Indian mustard and found at par with application hydrogel @ 5 kg/ha. While, the minimum growth, yield, quality parameters and economics were observed in control plot. Implementing proper management practices in agriculture to maintain soil moisture and increase WHC is considered as one of the ways to save water. The use of super absorbent Polymers resulted in increased performance level, WUE and some growth indices of some crop (Meena *et al.* 2020a,b).The overall improvement in crop growth under the influence of polymers application could be attributed to better environment for growth and development that might be due to increased availability of N to the growing plants. The increased availability of available nutrient due to presence of polymers to plant might have enhanced early root growth and cell multiplication leading to more absorption of other nutrients from deeper layers of soil ultimately resulting in increased plant growth in terms of plant height, DMA and LAI (Hasanvandi *et al.* 2014, Meena *et al.* 2018). The optimized combination of super absorbents and slow release fertilizers may improve fertilizer use efficiency by 50 per cent and mitigate the

Table 1 Effect of polymers and nutrient management on growth parameters of Indian mustard at different stage

Treatment	Plant height (cm)				Number of branches/plant			LAI			DMA (g/ plant)			
	30 DAS	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
Polymers														
Control	23.62	78.17	152.59	157.38	4.13	6.05	7.46	0.59	4.75	3.66	2.29	15.51	35.38	37.45
Hydrogel@ 5 kg/ha	24.68	87.04	168.19	171.73	4.41	6.43	7.91	0.62	5.05	3.91	2.48	16.67	37.85	39.72
NCPC@ 5 kg/ha	25.17	88.68	171.08	174.39	4.46	6.50	8.00	0.63	5.12	3.98	2.52	16.89	38.31	40.14
SEm±	0.65	1.26	2.21	2.04	0.04	0.05	0.06	0.00	0.03	0.02	0.03	0.17	0.35	0.32
CD (*P*=0.05)	NS	3.49	6.14	5.65	0.11	0.15	0.16	0.01	0.08	0.07	0.08	0.46	0.97	0.90
Nutrient management														
Control	17.55	56.33	110.39	114.31	3.03	4.44	5.48	0.42	3.45	2.65	1.67	11.33	25.89	27.49
100% RDF	18.64	65.29	126.16	128.82	3.31	4.82	5.93	0.47	3.80	2.95	1.86	12.51	28.39	29.79
75% RDF+ KSB	18.58	64.32	124.46	127.25	3.28	4.78	5.88	0.46	3.74	2.90	1.84	12.38	28.12	29.54
100% RDF+KSB	18.71	67.96	130.85	133.13	3.39	4.94	6.07	0.49	3.93	3.05	1.92	12.86	29.13	30.48
SEm±	0.61	1.15	2.03	1.87	0.04	0.05	0.06	0.01	0.04	0.03	0.02	0.15	0.32	0.30
CD (*P*=0.05)	NS	2.42	4.26	3.92	0.07	0.10	0.12	0.01	0.09	0.07	0.05	0.32	0.68	0.62

NCPC: Nano Clay Polymer Composite; RDF: Recommended Dose of Fertilizers; KSB: Potassium Solubilizing Bacteria

Table 2 Effect of polymers and nutrient management on yield attributes and yields of Indian mustard

Treatment	Number of siliquae/ plant	Length of siliqua (cm)	Number of seeds/ siliqua	Test weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
Polymers								
Control	297.29	4.61	11.43	4.22	1243	3607	4851	23.52
Hydrogel@ 5 kg/ha	312.80	4.91	12.77	4.89	1721	5416	7136	24.18
NCPC@ 5 kg/ha	315.91	4.96	12.90	4.94	1770	5616	7387	23.64
CD (*P*=0.05)	5.61	0.09	0.22	0.10	102	348	450	0.74
Nutrient management								
Control	218.97	3.38	8.69	3.15	882	2678	3560	17.05
100% RDF	234.65	3.68	9.43	3.62	1244	3869	5112	18.09
75% RDF+ KSB	232.83	3.65	9.36	3.59	1258	3910	5168	17.80
100% RDF+KSB	239.54	3.76	9.63	3.69	1351	4182	5533	18.41
CD (*P*=0.05)	4.06	0.07	0.16	0.06	55	162	215	1.07

Table 3 Effect of polymers and nutrient management on quality parameters and economics of Indian mustard

Treatment	Protein content (%)	Protein yield (kg/ha)	Oil content (%)	Oil yield (kg/ha)	Net return (₹/ha)	B: C ratio
Polymers						
Control	17.94	227.30	32.23	408	48373	1.66
Hydrogel@ 5 kg/ha	22.04	390.36	37.16	658	78346	2.17
NCPC@ 5 kg/ha	22.24	405.10	37.50	683	83443	2.62
SEm±	0.15	7.55	0.26	13	1669	0.05
CD (*P*=0.05)	0.41	20.97	0.71	36	4634	0.13
Nutrient management						
Control	14.00	184	24.03	315	40774	1.29
100% RDF	16.01	271	27.51	463	52835	1.43
75% RDF+ KSB	15.89	268	27.30	458	53714	1.45
100% RDF+KSB	16.32	300	28.04	514	62839	1.85
SEm±	0.12	7	0.20	13	1687	0.05
CD (*P*=0.05)	0.25	16	0.43	27	3545	0.10

environmental impact. The increased availability of available nutrient due to presence of polymers to plant might have enhanced the absorption of other nutrients from deeper layers of soil ultimately resulting in increased plant yield (Bowman *et al*. 2002).

The data showed that the application of 100% RDF+KSB/ha, significantly increased the growth parameters (Table 1), *viz.* plant height (133.13cm) and number of branches/plant(6.07) at harvest, LAI at 90 DAS (3.93), DMA at harvest (30.48g) and yield attributes and yield (Table 2), *viz.* number of siliqua (239.54), siliqua length (3.76 cm), number of seeds/siliqua (9.63), 1000 seed weight (3.69g), seed yield (1351 kg/ha), stover yield (4182 kg/ha), biological yield (5533 kg/ha), harvest index (18.41) and quality parameters(Table 3), *viz.* protein content (16.32%), protein yield (300 kg/ha), oil content (28.04%), oil yield (514 kg/ha) and economics (Table 3), *viz.* net return (62839 ₹/ha) and B:C ratio was observed 1.85% of Indian mustard. While, the minimum growth, yield, quality parameters and economics were observed in the control plot. The adequate and balanced supply of plant nutrients is of critical importance in improving the growth parameters of oilseeds. Mustard crop respond to fertilizers and biofertilizers application remarkably depending on soil type and source of its use. The functions of nutrients within the plant are closely related to plant growth and development. Most of the nutrients generally deficient in majority of our Indian soils and needs much attention for maintenance of P and S in soils (Archana *et al*. 2013; Meena *et al.* 2020a). In oil seed crops, biofertilizers play significant role on the growth parameters. Therefore, crop of oil seeds require a higher quality of nutrients for proper growth and development of plants (Lynn *et al*. 2013). The adequate and balanced supply of plant nutrients is of critical importance in improving the productivity of oilseeds. The functions of S within the plant are closely related to those of N and the two nutrients are synergistic. The more availability of N increased protein yield (Meena *et al.*2020b). Biofertilizers are also playing major role in mustard oil and nutrient content in which KSB isolates that are able to dissolve K from mineral soils that increase crop plant growth and yield. The increased net returns could be explained on the basis of increased yield and ultimately economics due to better response of polymer and KSB (Meena *et al.* 2018b).

SUMMARY

A field experiment was conducted during winter season of 2015-16 at IAS, BHU, Varanasi, Uttar Pradesh (India) to evaluate the response of polymers and nutrient management on growth, yield and quality of Indian mustard. Result showed that the application of polymer as NCPC @ 5 kg/ha and nutrient management with 100% RDF + KSB improved the growth parameters, yield attributes and yields, quality and net return of the Indian mustard.

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