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Effect of polymers and nutrient management on sesame (*Sesamum indicum*) under custard apple (*Annona squamosa*) based agri-horti system

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ABSTRACT

A field experiment was conducted in 2016–17 to study the effect of polymers and nutrient management on sesame (*Sesamum indicum* L.) under custard apple (*Annona squamosa* L.) based agri-horti system in rainfed conditions of eastern Uttar Pradesh, India. The experiment was laid out in a split-plot design with four replications. Three levels of polymers, viz. Control, NCPC @ 5 kg/ha and Hydrogel @ 5 kg/ha and four level of the nutrient management as Control, 100% RDF, 100% RDF + *Azotobacter* and 100% RDF + PSB were taken in main-plots and sub-plots. Results indicated that the application of NCPC @ 5 kg/ha produced the best results in terms of the sesame seed yield (448.51 kg/ha) and stalk yield (609.97 kg/ha). The nutrient management with 100% RDF + *Azotobacter* gave better results as compared to control (no fertilizers). Their conjoint application can be beneficial to farmers for sustaining the crop productivity in the rainfed condition of eastern Uttar Pradesh.

Key words: Agri-horti system, Hydrogel, Nano Clay Polymer Composite, Nutrient uptake, Sesame

Sesame (*Sesamum indicum* L.) commonly known as til in Hindi is an ancient oilseed crop grown in India, and perhaps the oldest oilseed crop in the world. India is the largest producer of sesame in the world (Kumar *et al.* 2017). Sesame oil has natural antioxidants such as sesamin, sesamolin, and sesamol known as the most stable vegetable oils having a long shelf life. For increased crop production in dryland environments, a greater percentage of the precipitation must be stored in soil and used more efficiently. Superabsorbents have received prominent attention in the last decade due to their numerous applications in many areas. Superabsorbent polymers may have great potential in restoration and reclamation of soil, and storing water available for plant growth and production. Superabsorbent polymer can hold 400-1500 g of water per dry gram of hydrogel (Bowman and Evans 1991). Moreover, the initial humidity after irrigation is substantially higher for soil where the hydrogel has been added. All types of hydrogels, when used correctly and in the ideal situation, will have at least 95% of their stored water available for plant absorption (Johnson and Veltkamp 1985). There are intensive investigations about using superabsorbent as water managing materials in agriculture and horticulture, and encouraging results have been achieved (Yazdani *et al.* 2007). It is cultivated on marginal and sub-marginal lands with poor fertility management. Large scale shedding of flowers, nutrient deficiencies, hormonal imbalances and endogenous level of growth regulators are the main reasons for low grain yield (Meena *et al.* 2015). The main reason for the low productivity of sesame is its cultivation in marginal and submarginal lands under poor management and input starved rainfed conditions (Meena *et al.* 2017). Yield is the manifestation of various physiological processes occurring in plants and these are usually modified by management practices in an environment. Among the management practices, fertilization is the most important factor in determining the yield of sesame (Mahrous *et al.* 2015, Dadhich and Meena 2014). The supplementary and complimentary use of biofertilizers improves soil biological property, fertilizer use efficiency, and plays an important role in the maintenance of soil fertility, and improves the ecological balance of rhizosphere (Ashoka *et al.* 2017). Research information on the conjunctive application of polymer and biofertilizer inoculation under site-specific conditions of growing sesame are not widely available. Therefore, the present study was conducted to assess the impact of applying polymers and biofertilizers on growth, yield and seed quality of sesame under rainfed condition

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of eastern Uttar Pradesh.

MATERIALS AND METHODS

The experiment was conducted during the *kharif* season 2016–17 at the Agricultural Research Farm, Rajiv Gandhi South Campus, Department of Agronomy, Banaras Hindu University, Barkachha, Mirzapur (UP), which is situated at 25º 10' North latitude and 82º 37' East longitude and an altitude of 427 m amsl. This region comes under semi-arid and sub-humid climate agro-climatic zone III A (Semi-Arid Eastern Plain Zone), the average annual temperature in Mirzapur is 26ºC. The rainfall here averages around 975 mm. The summer is hot and dry. May is the hottest month with mean maximum temperature ranging from 23.8–41.8ºC, January with a mean minimum temperature varying from 9.3–28.5ºC is the coldest month. The experiment was laid out in a split plot design with four replications. Three levels of polymers, viz. Control, NCPC (Nano clay-polymer composite) @ 5 kg/ha, Hydrogel @ 5 kg/ha, and four levels of the nutrient management, viz. Control, NPKS: 30, 60, 30, 40 kg/ha (100% RDF: Recommended Dose of Fertilizer), 100% RDF + *Azotobacter*, and 100% RDF + PSB (Phosphate Solubilizing Bacteria) were taken in main-plots and sub-plots. Sesame was planted between the custard apple trees (8 years old). Sesame was sown in a seedbed prepared by an indigenous plough on 6 August 2016. The gross and net plot size was 5.0 × 4.80 m, 4.0 × 3.90 m respectively. The distance between plot and replication was 1 m from each side. The variety Shekhar was selected for the experimental work. The soil of the experimental site was clay loam in texture, non-saline and slightly alkaline in reaction. NPKS: 30, 60, 30 and 40 kg/ha was applied as a basal application. Nitrogen and phosphorus were applied through diammonium phosphate, and urea, potash and sulphur through muriate of potash and elemental sulphur respectively. The fertilizer was drilled in furrows 5 cm below the seedling depth before sowing. The nano clay-polymer composite and hydrogel were applied as per treatment by the basal application at the time of sowing. The NCPC and hydrogel were applied @ 5 kg/ha each. Culture (@ 60 g/10 kg seed) was mixed with 10% sugar solution to form slurry. The culture of PSB and *Azotobacter* (200 g/12 kg fine soil) was well mixed separately and then applied as per treatment details. The sesame was seeded at the recommended seed rate of 4 kg/ha at 2.5 cm soil depth. At 15 days after sowing (DAS), thinning was done to maintain the desired plant population. Periodic hand weeding was done as and when needed. The sesame was harvested on 2 October 2016 from each plot. The Microsoft Excel was used as a statistical software package for analyzing the data for the analysis of variance and other statistical parameters. Critical difference (CD) values at P =0.05 were used to determine the significance of differences between mean values of treatments (Draper and Smith 1998).

RESULTS AND DISCUSSION

Effect of polymers: Significantly higher values of growth parameters were obtained with the application of NCPC @ 5 kg/ha in comparison to control. The following growth parameters were included: plant height (cm) at 60 DAS and at harvest, number of branches/plant at 60 DAS and at harvest, leaf area index at 60 DAS and at harvest, number of leaves/plant at 60 DAS and at harvest and dry matter accumulation (g/plant) at 60 DAS and at harvest. The detailed results are presented in Table 1. Similar results were recorded on yield parameters and yield, viz. capsule length (cm), number of capsules/plant, seed weight/capsule (g), seed weight/plant (g), test weight (g), seed yield and stalk yield, biological yield and harvest index (%). Likewise, the quality parameters were recorded, viz. protein yield, oil yield, protein, and oil contents presented in Table 2. In comparison, significantly lower values of growth and yield parameters were recorded in the control plots. Furthermore, the application of NCPC @ 5 kg/ha recorded higher value of nutrient content (%) in grain and stover the sesame and total uptake of the nutrient by the plant (kg/ha) in comparison to control (Table 3). The hydrogel @ 5 kg/ha was statistically at par to that of NCPC @ 5 kg/ha. Singh *et al.* (2011) reported that superabsorbents prevent any tension resulting from fluctuations in the humidity of soil and the gradual release of nutrition in the soil. They also increase the number of pods in the plant and the function of peas by preventing washing them quickly. Rafiei *et al.* (2013) reported that using super absorption polymers at three levels (100, 0, and 200 kg/ha) for corn plant significantly increases the function and the number of seeds in the maize. Superabsorbent polymers and hydrogels will enhance chemical and physical features of soil through water absorption, and partly absorption of mineral fertilizers and alternate expansion and contraction. The main objective of adding superabsorbents to soil is enhancing and increasing the water-holding capacity of soil so the water restored in these substances releases at the time of water shortage and the roots of the plant use it (Khadem *et al.* 2011).

Effect of nutrient management: The data showed significantly higher values of growth parameters (Table 1), yield attributes and yield (Table 2), with the application of 100% RDF + *Azotobacter* in comparison to control. However, the application of 100% RDF +*Azotobacter* significantly increased the quality parameters, i.e. protein and oil contents (%) and their yield (kg/ha) and nutrient content (%) and their uptake (kg/ha) were presented in (Table 2 and 3). While, the nutrient management with 100% RDF + PSB was found statistically at par with 100% RDF +*Azotobacter* and the application of 100% RDF was statistically at par with 100% RDF + PSB. The significant response of yield and quality attributing characters to fertilizer application is an indication of the role of nitrogen in plant nutrition. Nitrogen is the limiting nutrient in soils of eastern Uttar Pradesh, and plays an important role in yield attributing characters. Phosphorus has an important role in root development which in turn plays an important role in the uptake of moisture and nutrients as well as providing anchorage. The present finding of growth attributes is in

Table 1 Effect of polymers and nutrient management on growth parameters of sesame at different stages under custard apple based agri-horti system system

Treatment	Plant height (cm)			No. of branches /plant		Leaf area index (cm)		No. of leaves /plant			Dry matter accumulation (g/plant)		
	30 DAS	60 DAS	At harvest	60 DAS	At harvest	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
Polymer													
Control	49.67	98.45	104.43	1.58	2.58	2.20	1.72	60.67	247.25	182.58	0.309	34.11	60.40
NCPC @5 kg/ha	51.39	112.44	118.84	1.72	2.91	2.58	2.08	62.39	290.33	218.08	0.310	45.02	71.31
Hydrogel @5 kg/ha	50.09	110.99	117.39	1.71	2.91	2.56	2.06	61.09	284.17	211.17	0.309	43.49	69.49
SEm±	1.08	1.25	1.04	0.01	0.01	0.03	0.02	1.08	4.98	2.59	0.001	1.52	1.67
CD (P =0.05)	NS	3.46	2.88	0.03	0.04	0.08	0.06	NS	13.82	7.20	NS	4.21	4.63
Nutrient management													
Control	37.05	66.06	70.96	1.11	1.92	1.63	1.32	45.30	157.96	103.21	0.231	25.39	45.48
100% RDF	37.67	79.51	84.00	1.25	2.11	1.86	1.49	45.92	194.13	147.71	0.232	30.13	49.63
100% RDF + *Azotobacter*	38.26	90.13	94.61	1.35	2.20	1.95	1.53	46.51	244.20	189.45	0.233	33.95	53.45
100% RDF + PSB	38.16	86.18	91.08	1.31	2.16	1.90	1.53	46.41	225.46	171.46	0.232	33.15	52.65
SEm±	0.78	4.87	4.89	0.05	0.04	0.05	0.05	0.78	14.63	14.13	0.001	0.77	0.68
CD (P =0.05)	NS	10.23	10.28	0.10	0.07	0.11	0.12	NS	30.74	29.69	NS	1.62	1.43

NCPC, Nano composite polymer; RDF, Recommended dose of fertilizers; PSB, Phosphorus solubilizing bacteria; DAS, Days after sowing.

Table 2 Effect of polymers and nutrient management on yield attributes, yield and quality parameters of sesame under custard apple based agri-horti system

Treatment	Capsule length (cm)	No. of capsule/ plant	Seed weight/ capsule (g)	Seed weight/ plant (g)	Test weight (g)	Seed yield (kg /ha)	Stalk yield (kg/ha)	Biological yield (kg/ ha)	Harvest index (%)	Protein content (%)	Protein yield (kg/ ha)	Oil content (%)	Oil yield (kg/ha)
Polymer													
Control	1.71	107.92	0.166	2.45	3.22	338.61	468.85	796.88	40.64	21.59	73.42	38.01	890.12
NCPC @5 kg/ha	1.82	140.67	0.207	2.57	3.70	448.51	609.97	1059.31	42.64	24.58	112.52	43.56	1027.00
Hydrogel @5 kg/ha	1.81	130.42	0.194	2.53	3.64	434.93	591.51	1026.44	42.37	24.16	106.63	42.25	1026.93
SEm±	0.02	2.49	0.011	0.03	0.03	13.84	18.46	33.25	0.36	0.16	3.89	1.33	1.38
CD (P =0.05)	0.04	6.91	0.031	0.07	0.07	38.41	51.25	92.30	1.00	0.44	10.81	3.69	3.82
Nutrient management													
Control	1.21	66.05	0.105	1.74	2.15	251.41	350.26	591.09	30.83	14.49	48.52	26.89	702.05
100% RDF	1.32	87.21	0.127	1.86	2.59	301.28	409.74	711.02	31.32	17.25	69.91	30.17	746.04
100% RDF + *Azotobacter*	1.43	117.28	0.177	2.01	2.99	339.55	461.78	801.33	32.08	19.77	90.75	33.85	748.33
100% RDF + PSB	1.39	108.46	0.158	1.94	2.84	329.81	448.55	779.19	31.43	18.83	83.39	32.91	747.63
SEm±	0.04	8.78	0.016	0.05	0.17	7.39	14.39	17.07	0.40	1.07	3.98	0.71	1.59
CD (P =0.05)	0.09	18.44	0.034	0.10	0.36	15.52	30.24	35.85	0.85	2.24	8.37	1.49	3.34

NCPC, Nano composite polymer; RDF, Recommended dose of fertilizers; PSB, Phosphorus solubilizing bacteria.

Table 3 Effect of polymers and nutrient management on nutrient content and uptake of sesame under custard apple based agri-horti system

Treatment	NPKS content (%)								NPKS uptake (kg/ha)							
	Seed				Stalk				Seed				Stalk			
	N	P	K	S	N	P	K	S	N	P	K	S	N	P	K	S
Polymer																
Control	3.45	0.529	0.610	0.984	1.43	0.331	1.684	0.185	11.75	1.80	2.07	3.35	6.70	1.54	7.89	0.86
NCPC @5 kg/ha	3.93	0.602	0.695	1.124	1.63	0.390	1.835	0.283	18.00	2.75	3.18	5.14	10.14	2.44	11.27	1.82
Hydrogel @5 kg/ha	3.86	0.595	0.686	1.110	1.61	0.384	1.824	0.273	17.06	2.62	3.02	4.90	9.64	2.31	10.92	1.68
SEm±	0.02	0.003	0.003	0.012	0.008	0.002	0.016	0.009	0.62	0.08	0.10	0.20	0.30	0.07	0.32	0.10
CD (P =0.05)	0.07	0.008	0.009	0.035	0.022	0.007	0.043	0.024	1.73	0.24	0.28	0.58	0.85	0.20	0.90	0.28
Nutrient management																
Control	2.32	0.358	0.413	0.661	0.97	0.216	1.211	0.085	7.76	1.19	1.38	2.21	4.49	1.00	5.63	0.38
100% RDF	2.76	0.422	0.488	0.795	1.14	0.269	1.320	0.178	11.15	1.71	1.97	3.22	6.29	1.48	7.25	1.00
100% RDF + *Azotobacter*	3.16	0.484	0.558	0.901	1.31	0.319	1.426	0.252	14.50	2.22	2.56	4.13	8.17	2.08	8.86	1.60
100% RDF + PSB	3.01	0.461	0.532	0.862	1.25	0.300	1.387	0.225	13.34	2.04	2.35	3.81	7.51	1.81	8.33	1.37
SEm±	0.17	0.026	0.030	0.049	0.07	0.021	0.053	0.034	0.63	0.10	0.11	0.18	0.35	0.10	0.34	0.15
CD (P =0.05)	0.36	0.055	0.063	0.102	0.14	0.045	0.110	0.071	1.33	0.21	0.24	0.38	0.74	0.21	0.71	0.32

NCPC, Nano composite polymer; RDF, Recommended dose of fertilizers; PSB, Phosphorus solubilizing bacteria.

conformity with the results obtained by Babaji *et al.* (2006) and Shehu *et al.* (2010). Biofertilizers play a major role in sesame crop production in which *Azotobacter* has the ability to fix atmospheric nitrogen into the soil and PSB converts unavailable form of phosphorus into available one, hence indirectly helps in increasing yield attributing characters of sesame. The present findings are conformity with Mondal *et al.* (1992), Wayase *et al.* (2014) and Kumar *et al.* (2018).

This field experiment suggests that application of polymer NCPC @ 5 kg/ha + 100% RDF + *Azotobacter* improved growth parameters, yield and its attributes, nutrient content and uptake, quality of seed in terms of protein and oil content. As per interaction effects of treatment, synergistic behaviour was noted between NCPC @ 5 kg/ha + 100% RDF + *Azotobacter* on yields of sesame under rainfed conditions of eastern Uttar Pradesh, India. However, these results are only indicative and require further experimentation to arrive at a more consistent and final conclusion to be passed on to the farmers.

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