https://doi.org/10.56093/ijas.v90i4.102220

Indian Journal of Agricultural Sciences **90**(4): 767–70, April 2020/Article

Response of polymers and biofertilizers on soybean (*Glycine max*) yield under rainfed condition

ANKESH KUMAR, RAM SWAROOP MEENA*, NIRMAL D E, D S GURJAR, AJEET SINGH, GULAB SINGH YADAV and GOURISANKAR PRADHAN

Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh 221 005, India

Received: 11 January 2019; Accepted: 30 August 2019

ABSTRACT

A field experiment was conducted to find out the response of polymers and biofertilizers on yield and quality of soybean (*Glycine max* L. Merrill) under rainfed condition at the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India during 2015-16. The experiment was laid-out in split-plot design consisting three levels of polymer (Control, 5 kg/ha Nano clay-polymer composite (NCPC) and 5 kg/ha Hydrogel) in the main-plots and four levels of biofertilizer inoculation (Control, *Rhizobium japonicum*, Phosphate Solubilising Bacteria (PSB) and *Mycorrhiza*) were taken in sub-plots with three replications. Results indicated that the application of polymer @ 5 kg NCPC/ha improved growth parameters, yield attributes, yields, nutrient content, uptake, quality of seed in terms of protein and oil content. However, the application of 5 kg/ha Hydrogel was statically at par on all the parameters. Moreover, amongst the biofertilizers response was found significant on the growth parameters, yield attributes, yield quality parameters, nutrient content and their uptake. Their conjoint application is beneficial to farmers for sustaining the crop productivity in the rainfed condition of eastern Uttar Pradesh, India.

Key words: Hydrogel, Nano Clay Polymer Composite, Soybean, Yield

Enhancing and sustaining the productivity of oilseed crops is important to advancing food and nutritional security (Meena *et al.* 2015a, Lal 2016). The per capita annual consumption of vegetable oil in India is 14.1 kg, which is far below the global average of 23.60 kg (GOI 2015). Soybean (*Glycine max* L. Merrill) is one of the important oilseed crops of India. From a nutritional point of view, it is called a miracle bean. It contains about 40% protein, well-balanced amino acids, 20% oil rich with polyunsaturated fatty acids especially Omega 6 and Omega 3 fatty acids, 6-7% total mineral, 5-6% crude fiber and 17-19% carbohydrates (Meena *et al.* 2018). Soybean cultivation improves soil health because of its atmospheric nitrogen (N)-fixing ability and deep root system. Symbiotically soybean fixes 125-150 kg N/ha and leaves about 30-40 kg N/ha for succeeding crop (MOA 2015). For an increased crop production in rainfed environments, a greater percentage of the precipitation must be stored in soil and used more efficiently. Super absorbent hydrogels are hydrophilic networks with a high capacity for water uptake (Ashoka *et al.* 2017, Meena *et al.* 2015c). This allows the irrigated water not to be wasted after irrigation, but stored in the soil and released under a mechanism controlled by diffusion and driven by roots absorption and evaporation (Basavaraja *et al.* 2014). The use of biofertilizers improve soil physicochemical and biological property, fertilizer use efficiency, mitigate short supply of micronutrients, stimulate the proliferation of diverse group of soil micro-organism and plays an important role to enhance the soil fertility (Meena *et al.* 2014, Meena *et al.* 2020). Research information on the conjunctive application of polymer and biofertilizer inoculation under site-specific conditions of growing soybean are not widely available, Therefore, the present study was conducted to assess the polymer and biofertilizers impacts on growth, yield and seed quality of soybean under rainfed condition of eastern UP of India.

MATERIALS AND METHODS

The experiment was conducted at the dryland block of Agricultural Research Farm, Banaras Hindu University, Varanasi, Uttar Pradesh during *kharif* 2015-16. Experiment field is situated at $20^{0}18'$ North Latitude and $83^{0}03'$ East Longitude and at altitude of 76.5 meters from msl. This region comes under agro-climatic zone III A (Semi-Arid Eastern Plain Zone), and crops are generally grown under rainfed condition. The average annual rainfall and potential evapotranspiration of this region are about 1100 mm and 1500 mm, respectively. The annual distribution of rainfall as percentages of total rainfall is 86% from June to September

*Corresponding author e-mail: meenars@bhu.ac.in

(*kharif*), 5.78% from December to February. Post-monsoon season is 3.3% from January to February (winter) and 3% from March to May (summer). The mean relative humidity is about 39% which rises up to 94% from July to September and falls down to 17% during the end of April to early June. The field experiment was laid out according to a split-plot design with three replications. The experiment comprised of 12 treatment combinations consisting three levels of polymer (control, 5 kg/ha NCPC and 5 kg/ha hydrogel) and four levels of biofertilizer inoculation (control, *Rhizobium*, PSB, and *Mycorrhiza*). Soybean was sown on 30 cm between the rows and 10 cm spacing within the plants. Soybean, variety Pratap Raj (RKS-24), was sown @ 70 kg/ha in a prepared seedbed by an indigenous plough on 30th July, 2015. The soil of the experimental site was clay loam in texture, non-saline and slightly alkaline in reaction. N, phosphorus (P), potash (K), and sulphur (S) were applied as 30, 60, 20 and 20 kg/ha through urea, diammonium phosphate, muriate of potash and elemental S, respectively by the basal application. The fertilizer was drilled in furrows at 5 cm below the seedling depths before sowing. The nano clay-polymer composite and hydrogel were applied as per treatment by the basal application at the time of sowing. The nano clay-polymer composite and hydrogel applied @ 5 kg/ha each. The required quantity of the cultures, i.e. @ 200 g culture/10 kg seed was mixed to 10% sugar solution to form the slurry. The slurry was sprinkled on seeds and mixed with hand to make a uniform coating over the seeds and then the seeds were spread on a polyethylene sheet in shade to avoid direct sunlight. The culture of PSB and AMF 200 g/12 kg of fine soil were well mixed separately with the help of hand and then applies as per treatment details. Agronomic practices were done as per the requirement. Two gram of dried soybean seeds from each treatment were used for estimation of oil content by soxhlet apparatus using petroleum ether (60-80°C) as an extractant (AOAC 1960). Protein content in seed was estimated by multiplying the N content in seed with the factor 6.25 as suggested by (AOAC 1990). Protein and Oil yields were calculated by multiplying the estimated protein and oil percent with the seed yield. The Microsoft Excel was used as a statistical software package for analyzing the data for the analysis of variance and other statistical parameters (McCullough and Wilson 2005). Critical difference (CD) values at P=0.05 were used to determine the significance of differences between mean values of treatments. The standard level of significance used to justify a claim of a statistically significant effect is 0.05 (Draper and Smith 1998).

RESULTS AND DISCUSSION

Response on growth parameters of soybean: It is revealed (Table 1) that growth parameters, viz. plant height (43.67 cm) at 90 days after sowing (DAS), number of branches/plant (3.83) at harvest, leaf area index (LAI) (3.83) at 60 DAS were significantly higher under the NCPC @ 5 kg/ha as polymer and found statistically at par with hydrogel @ 5 kg/ha. Furthermore, the application of biofertilizer as *Rhizobium* treatments gave higher value of growth parameters, viz. plant height (33.07 cm) at 90 DAS, number of branches/plant (3.18) at harvest, leaf area index (LAI) (2.97) at 60 DAS and the application of PSB and mycorrhiza found statistically at par with each other. Dry matter accumulation (g/plant) in soybean was observed as increased from 30 DAS to at harvest under both the treatments of polymers and biofertilizers (Fig 1). Maximum dry matter accumulation was observed in the treatments of NCPC @ 5 kg/ha in polymer and *Rhizobium* biofertilizer in all the growth stages except at 30 DAS where almost uniform growth was observed. Similar research on the use of superabsorbent polymers as water managing materials for

Table 1 Effect of polymers and biofertilizers on growth parameters of soybean at different stages under rainfed condition

Treatment	Plant height (cm)				No. of branches/plant				LAI		
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS
Polymers											
Control	11.51	29.68	37.24	35.95	1.37	3.15	3.26	3.37	1.86	3.17	2.28
NCPC	12.53	33.03	43.67	41.24	1.54	3.59	3.74	3.83	2.25	3.83	2.76
Hydrogel	11.94	31.82	41.35	41.11	1.48	3.49	3.63	3.72	2.15	3.66	2.66
SEm±	0.47	0.42	0.56	0.48	0.04	0.06	0.07	0.08	0.06	0.10	0.07
CD (P=0.05)	NS	1.17	1.55	1.33	NS	0.17	0.18	0.22	0.15	0.27	0.20
Biofertilizers											
Control	8.72	22.39	25.86	26.82	0.96	2.20	2.27	2.35	1.34	2.29	1.65
Rhizobium	9.40	25.18	33.07	32.18	1.25	3.00	3.12	3.18	1.75	2.97	2.16
PSB	9.02	23.67	31.06	30.67	1.10	2.53	2.63	2.70	1.60	2.71	1.95
Mycorrhiza	8.84	23.29	30.74	30.15	1.09	2.51	2.61	2.69	1.59	2.70	1.94
SEm±	0.36	0.45	0.68	0.43	0.04	0.08	0.08	0.12	0.04	0.07	0.06
CD (P=0.05)	NS	0.95	1.42	0.91	NS	0.18	0.16	0.25	0.08	0.14	0.2

NCPC, Nano clay-polymer composite; PSB, Phosphorus Solubilizing Bacteria; DAS, Days after sowing; LAI, Leaf area index.

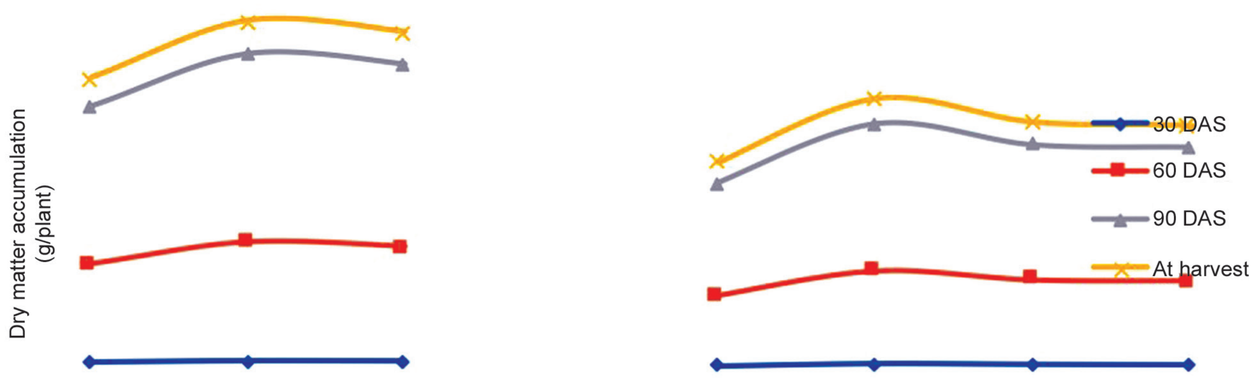

Fig 1 Effect of polymers and biofertilizers on dry marrer accumulation of soybean.

the renewal of arid, semi-arid and rain-fed environment has attracted great attention, and encouraging results have been observed as they can reduce irrigation water consumption, improve fertilizer retention in soil and increase plant growth (Meena and Yadav 2015, Mahrous *et al.* 2015, Meena *et al.* 2020a).

Response on yield attributes, yields and quality of soybean: It is revealed that (Table 2) yield attributes, viz. number of pod/plant (31.31), number of seeds/pod (2.82), harvest index (38.96%), production efficiency (15.03%) and yields, viz. grain yield (13.92 q/ha), stover yield (20.91 q/ha) and quality parameters, viz. protein yield (6.47 q/ha), oil yield (3.29 q/ha) were significantly higher under the NCPC @ 5 kg/ha as polymer and found statistically at par with hydrogel @ 5 kg/ha. Furthermore, the application of biofertilizer as *Rhizobium* treatments gave higher value of yield attributes, viz. number of pod/plant (24.45), number of seeds/pod (2.18), harvest index (29.84%), production efficiency (12.01%) and, viz. grain yield (10.87 q/ha), stover yield (16.38 q/ha) and quality parameters, viz. protein yield (4.97 q/ha), oil yield (2.53 q/ha) and the application of PSB and mycorrhiza found statistically at par with each other. As per the other findings, viz. Tripathi *et al.* (1997) noticed that the polymer (10 kg/ha) increased seed yield of Indian mustard cv. Varuna (2.23 t/ha) as compared to control (1.24 t/ha). Highest tuber yield in potato; bulb diameter, bulb weight and yield in onion were reported when the polymer was applied with potassium fertilizers into the soil (Liang and Liu 2007). Yazdani *et al.* (2007) reported significantly increased (5495 kg/ha) soybean seed yield by the application of superabsorbent polymer (225 kg/ha) as compared to control plants (4172 kg/ha). Soybean crop responds to fertilizers and biofertilizers application remarkably depending on soil type and source of its use. The functions of biofertilizers within the plant are closely related to plant growth and development (Meena *et al.* 2015b, Meena *et al.* 2017).

The experimentation suggested that the application of polymer @ 5 kg NCPC/ha+ *Rhizobium* improved growth parameters, yield attributes, yields, nutrient content, uptake, quality of seed in terms of protein and oil content. However, these results are only indicative and require further experimentation to arrive at a more consistent and final conclusion to be passed on the farmers.

Table 2 Effect of polymers and biofertilizers on yield attributes yields and quality of soybean under rainfed condition

Treatment	No of pod / plant	No of seeds/ pod	100 seeds weight (g)	Harvest index (%)	Production efficiency (%)	Grain yield (q/ha)	Stover yield (q/ ha)	Protein yield (q/ha)	Oil yield (q/ha)
Polymers									
Control	26.19	2.19	16.01	32.84	13.08	11.64	17.57	5.32	2.73
NCPC	31.31	2.82	16.80	38.96	15.03	13.92	20.91	6.47	3.29
Hydrogel	30.25	2.69	16.48	37.15	14.92	13.45	20.31	6.16	3.16
SEm±	0.75	0.05	0.40	0.76	0.42	0.33	0.50	0.14	0.09
CD (P=0.05)	2.08	0.13	NS	2.10	1.18	0.92	1.39	0.39	0.25
Biofertilizers									
Control	18.75	1.65	12.00	23.66	9.44	8.33	12.56	3.80	1.97
Rhizobium	24.45	2.18	12.72	29.84	12.01	10.87	16.38	4.97	2.53
PSB	22.36	2.00	12.54	27.82	10.91	9.94	14.98	4.57	2.36
Mycorrhiza	22.19	1.95	12.10	27.62	10.67	9.86	14.88	4.61	2.33
SEm±	0.55	0.07	0.97	0.85	0.32	0.25	0.37	0.11	0.07
CD (P=0.05)	1.16	0.16	NS	1.78	0.67	0.52	0.78	0.22	0.14

REFERENCES

AOAC. 1960. *Official Methods of Analysis,* 18th Edition. Association of Official Agriculture Chemists (AOOAC), Washington.

AOAC. 1990. *Official Methods of Analysis*, edn. 12. Association of Analytical Chemists (AOAC), Washington DC.

Ashoka P, Meena R S, Kumar S, Yadav G S and Layek J. 2017. Green nanotechnology is a key for eco–friendly agriculture. *Journal of Cleaner Production* **142**: 4440–1.

Basavaraja M, Srikantaiah S, Umesha K S, Prasanna and Lakshmipathi R N. 2014. Growth and dry matter production of soybean as influenced by beneficial microorganisms under field condition. *Current agriculture research* **2**(1): 33–6.

Draper N R and Smith H. 1998. *Applied Regression Analysis*, 3rd edn., John Wiley, New York.

GOI. 2015. Government of India, Economic Survey of India, Ministry of Finance (Economic Division) GOI, New Delhi. pp 17–22.

Lal R. 2016. Global food security and nexus thinking. *Journal of Soil and Water Conservation* **71**(4): 85A–90A.

Liang C J and Liu. 2007. Studies on the relationship between the nitrogen fixing activity of *Rhizobium* and the yield of different soybean cultivars. *Journal of Agricultural Research of China* **32**(3): 253–8.

Mahrous N M, Abu-Hagaza M, Abotaleb H H and Fakhry M K. 2015. Enhancement of growth and yield productivity of sesame plants by application of some biological treatments. *Journal of Agriculture and Environment Sci*ences **15**(5): 903–12.

McCullough B D and Wilson B. 2005. Computational Statistics and Data Analysis **49**: 1244–52.

Meena R S , Lal R and Yadav GS. 2020. Long-term impacts of topsoil depth and amendments on soil physical and hydrological properties of an Alfisol in central Ohio, USA. *Geoderma* 363:1141164 https://doi.org/10.1016/j.geoderma.2019.114164

Meena R S and Yadav R S. 2015. Yield and profitability of groundnut *(Arachis hypogaea* L) as influenced by sowing dates and nutrient levels with different varieties. *Legume Research* **38**(6): 791–7.

Meena R S, Dhakal Y, Bohra J S, Singh S P, Singh M K and Sanodiya P. 2015a. Influence of bioinorganic combinations on yield, quality and economics of mungbean. *American Journal of Experimental Agriculture* **8**(3): 159–66.

Meena R S, Kumar S, Datta R, Lal R, Vijayakumar V, Britnicky M, Sharma M P, Singh G S, Jahariya M K, Jangir C K, Pathan S I, Dokulilova, Pecina V and Marfo T D. 2020a. Impact of agrochemicals on soil microbiota and management: A review. *Land* 9:34. doi:10.3390/land9020034

Meena R S, Kumar V, Yadav G S and Mitran T. 2018. Response and interaction of *Bradyrhizobium japonicum* and *Arbuscular mycorrhizal* fungi in the soybean rhizosphere: A review. *Plant Growth Regulation* **84**: 207–23.

Meena R S, Meena P D, Yadav G S and Yadav S S. 2017b. Phosphate solubilizing microorganisms, principles and application of microphos technology. *Journal of Cleaner Production* **145**: 157–8.

Meena R S, Yadav R S, Meena H, Kumar S, Meena Y K and Singh A. 2015c. Towards the current need to enhance legume productivity and soil sustainability worldwide: A book review. *Journal of Cleaner Production* **104**: 513–5.

Meena R S, Yadav R S and Meena V S. 2014. Response of groundnut (*Arachis hypogaea* L.) varieties to sowing dates and NP fertilizers under Western Dry Zone of India. *Bangladesh Journal of Botany* **43**(2): 169–73.

Meena R S, Yadav R S, Reager M L, De N, Meena V S, Verma J P, Verma S K and Kansotia B C. 2015b. Temperature use efficiency and yield of groundnut varieties in response to sowing dates and fertility levels in western dry zone of India. *American Journal of Experimental Agriculture* **7**(3): 170–7.

MOA. 2015. Ministry of Agriculture (MOA), Government of India, *http://eands.dacnet.nic.in/Advance_Estimate/2ndAd18022015HINDI.pdf*

Tripathi M L, Kumavasahi S M and Namdeo K N. 1997. Effect of starch polymer and ntriacontanol on growth and yield of Indian mustard *cv.*Varuna. *Indian Journal of Agronomy* **42**(1): 194–5.

Woodhouse J M and Johnson M S. 1991. Effect of soluble salts and fertilizers on water storage by gel forming soil conditioners. *Acta Horticulture* **294**: 261–9.

Yazdani F, Allahadadi I and Akbari G A. 2007. Impact of superabsorbent polymer on yield and growth analysis of soybean (*Glycine max* L.) under drought stress condition. *Pakistan Journal of Biology Science* **10**(23): 4190–6.