International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; SP6: 49-52

Alka Rajoria
College of Agriculture, Indore, RVSKVV, Madhya Pradesh, India

MP Jain
College of Agriculture, Indore, RVSKVV, Madhya Pradesh, India

Jitendra Singh
CCS, Haryana Agricultural University, Haryana, India

Hirdayram Nagar
RAK College of Agriculture, Sehore, RVSKVV, Madhya Pradesh, India

AK Vishwakarma
ICAR-IISS, Bhopal, Madhya Pradesh, India

Correspondence
Alka Rajoria
College of Agriculture, Indore, RVSKVV, Madhya Pradesh, India

(Special Issue -6)
3rd National Conference
On
PROMOTING & REINVIGORATING AGRI-HORTI, TECHNOLOGICAL INNOVATIONS [PRAGATI-2019]
(14-15 December, 2019)

Effect of nutrient loaded Nano clay polymer composites on growth and yield of soybean

Alka Rajoria, MP Jain, Jitendra Singh, Hirdayram Nagar and AK Vishwakarma

Abstract
An experiment was conducted under "All India Co-ordinated Research Project" (AICRP) for Dry land Agriculture, College of Agriculture, Indore, M.P. during *Kharif*- 2016 with soybean crop variety JS (95-60) in randomized block design (RBD) with three replications each having twelve treatments including control. There were twelve treatments formulated for the experiment which includes control, 75% RDF (15:45:15 kg NPK ha^{-1}), 100% RDF (20:60:20 kg NPK ha^{-1}) and three different doses (5.0, 7.5 and 10.0 kg ha^{-1} of nutrient (S, Zn & Mo) by calcium sulphate, zinc oxide and ammonium molybdate loaded NCPC + 75% of RDF. The application of higher dose of nutrient loaded Nano Clay Polymer Composites (NCPC), recorded higher seed yield T_9– 75% of RDF + NCPC + S @ 10 kg ha^{-1} (1478 kg ha^{-1}) followed by treatment T_{12}–75% of RDF + NCPC + Mo @ 10 kg ha^{-1}(1476 kg ha^{-1}) and T_6-75% of RDF+NCPC+ Zn @ 10 kg ha^{-1}(1472 kg ha^{-1}). The increased% of seed yield due to above treatments were 10.77 10.63 and 10.36% as compared to 100% of RDF. The application of nutrient loaded NCPC recorded significantly higher leaf area index (LAI), plant dry weight, number of branches plant^{-1}, relative water content% (RWC), leaf water loss (LWL), seed index, root weight density and seed yield of soybean.

Keywords: Nano clay polymer composites (NCPC), nutrient loaded NCPC, RWC, LWL and root weight density

Introduction

Oilseeds occupy an important place in the Indian economy and contribute about 6% to the gross national product and 9% of the value of all agricultural commodities. Soybean [*Glycine max* (L.) Merrill] is important oil and protein crop belongs to family Fabaceae. From nutritional point of view, it is called as "miracle bean". It contains high quality protein (40-42%), oil (18-20%) and other nutrients like calcium iron and glycine (Devi *et al*., 2012) [5]. Soybean is known as the "Golden Bean" of the twenty first century. Madhya Pradesh is generally called "The soybean state" contributing more than 70% in terms of area and 64% of the total country's production (Joshi, 2003).

The national area, production and productivity of soybean is 110.65 lakh ha., 83.42 lakh mt and 1.28 mt ha^{-1} respectively, and in Madhya Pradesh, area, production and productivity of soybean is 56.16 lakh ha. 44.0 lakh mt and 1.25 mt ha^{-1} respectively (Anonymous, 2016) [2]. The national and state level of soybean seed productivity is very low in comparison to the world average of 2.9 mt ha^{-1}.

The low productivity is mainly due to deficit and erratic distribution of rainfall and uncertainty in onset of monsoon being experienced on account of global climatic change.

The other main reason is inadequate supply of nutrients like N, P, K, S Zn etc.

As observed that 67 per cent area of Malwa Agro climate Zone of Madhya Pradesh is showing low S and Zn availability in soil. Among modern technologies nanotechnology has a high potential for achieving sustainable agriculture, especially in above foresaid conditions. Polymer has provided solutions to the problems of the present dry land agriculture which is to maximize land and water productivity without threaten the environment and the natural resources. Super absorbent polymer hydrogels potentially influence soil permeability, density, structure, texture, evaporation and infiltration rates of water through the soils. Nano Clay Polymer Composite (NCPC) serves as an important moisture reservoir and slow release fertilizer in rainfed agriculture. These polymers were developed to improve the physical properties of soil in view of increasing water holding capacity, water use efficiency, enhancing soil permeability and infiltration rates, reducing irrigation frequency and compaction tendency, stopping erosion and water run-off, increasing plant performance especially in areas subject to drought.

Materials and Methods

An experiment was conducted under "All India Co-ordinated Research Project" (AICRP) for Dry land Agriculture, College of Agriculture, Indore, M.P. during *Kharif*- 2016. The field experiment was carried out on soybean crop JS (95-60) in randomized block design (RBD) with three replications each having twelve treatments including control. The total number of experimental plots was 36 having gross plot size 4.5m x 6.0 m, the spacing followed was 45 cm X 10 cm. There were twelve treatments formulated for the experiment which includes control, 75% RDF (15:45:15 kg NPK ha^{-1}), 100% RDF (20:60:20 kg NPK ha^{-1}) and three different doses (5.0, 7.5 and 10.0 kg ha^{-1} of nutrient (S, Zn & Mo) by calcium sulphate, zinc oxide and ammonium molybdate loaded NCPC + 75% of RDF.

The physico-chemical analysis of soil before sowing showed that the soil of experimental site was predominantly clayey in texture. The organic carbon content was (0.41%) and available nitrogen (180 kg ha^{-1}) which was low.

The available phosphorus (13.13 kg ha^{-1}) was medium and the available potash (560 kg ha^{-1}) was high. The soil pH was (7.60) slightly alkaline. EC (0.34 dS m^{-1}) of soil was normal.

The nutrient loaded NCPC was applied as per treatment by basal application at the time of sowing. 75 g of NCPC plot^{-1} i.e. @ 27.7 kg ha^{-1} was applied which were loaded with different doses of nutrients. Customized NCPC material based on the soil and production requirements was received from Department of Soil Science, BHU (Varanasi).

The crop was harvested when plants turned yellow and leave had fallen down on 28th September 2016. Before harvesting, five randomly tagged plants plot^{-1} of the crop were taken out for post-harvest studies. After harvesting, the produce of each plot was tied in bundle, properly labeled and it was allowed to dry in the field for 4-5 days.

The leaf area of five randomly selected plants was recorded and thereafter it was divided by land area to obtain leaf area index (LAI). It was determined plot wise at 25, 50, 75 DAS by using following formula as suggested by Watson (1952).

$$LAI = \frac{\text{Total leaf area } (m^2)}{\text{Land area } (m^2)}$$

The crop growth rate was calculated as an increase in dry matter production per unit ground area per unit time. In this investigation the crop growth rate was worked out with the help of following formula; as proposed by Watson (1952):

$$CGR\ (g\ day^{-1} m^{-2}) = \frac{W_2 - W_1}{P\ (t_2 - t_1)}$$

Where, CGR is Crop growth rate;
P is ground area and
W_1 and W_2 are plant dry weight at time t_1 and t_2, respectively.

Relative water content (RWC) is calculated using the method of Mata and Lamattina (2001).

$$RWC\ (\%) = \frac{(FW - DW)}{(TW - DW)} X100$$

Where, (FW) is fresh weight and (DW) is dry weight which is obtained after drying the sample at 80 ^{0}C for at least 48 hrs. Turgor weight (TW) was determined by subjecting leaves to rehydration for 2 hrs.

LWL was measured according to the method of Xing *et al*. (2004) After their fresh weight (W_1) is recorded when cut from seedlings, the leaves are left to evaporate under room condition for 2 hours and reweighed (W_2).

$$LWL\ (g) = \frac{(W1 - W2)}{W1} X\ 100$$

Root samples were collected in between the rows, using a sample core with 8 cm in diameter and 15 cm long at progressive depths of 15-30 cm depth. The roots were washed and dried in an oven at 65 ◦C and root weight was recorded. The volume of root was calculated by water displacement method. The dry roots are dipped into the measuring cylinder. The blank reading was recorded and water displaced by roots was recorded.

$$RWD\ (g\ cm^{-3}) = \frac{RW}{V}$$

Where, RW is root weight (g), V is the volume of soil core.

Results and Discussions

Results showed that the application of higher dose of nutrient loaded NCPC, recorded higher seed yield T_9– 75% of RDF + NCPC + S @ 10 kg ha^{-1} (1478 kg ha^{-1}) followed by treatment T_{12}–75% of RDF + NCPC + Mo @ 10 kg ha^{-1}(1476 kg ha^{-1}) and T_6-75% of RDF+NCPC+ Zn @ 10 kg ha^{-1} (1472 kg ha^{-1}). The increased% of seed yield due to above treatments were 10.77 10.63 and 10.36% as compared to 100% of RDF.

The application of nutrient loaded NCPC recorded significantly higher LAI, plant dry weight, number of branches plant^{-1}, number of pods plant^{-1}, RWC%, LWL, seed index, root weight density and seed yield of soybean under good rainfall year. The growth parameter *viz*., plant population number of branches plant^{-1}, leaf area, dry weight plant height, LAI, CGR, and RWC significantly increased with application of NCPC over control.

The maximum values of all these growth parameters were recorded with T_9 - 75% RDF + NCPC + S @ 10.0 kg ha^{-1} at 25, 50, 75 DAS and at harvest followed by T_{12} - 75% RDF + NCPC + M @ 10.0 kg ha^{-1} at 25, 50, 75 DAS and at harvest T_6 - 75% RDF + NCPC + Zn @ 10 kg ha^{-1} at 25, 50, 75 DAS and at harvest. All these treatments were found significantly at par in most of the cases.

The highest RWC% at flowering stage was recorded under T_9- 75% of RDF + NCPC + S @ 10 kg ha^{-1} (51.47%) followed by T_{12} - 75% of RDF + NCPC + Mo @ 10 kg ha^{-1} (50.02%). The highest amount of LWL was recorded under T_9 - 75% of RDF + NCPC + S @ 10 kg ha^{-1} (1.40 mg) followed by T_{12} - 75% of RDF + NCPC + Mo @ 10 kg ha^{-1} (1.24).

Table 1: Effect of different doses of nutrient loaded NCPC on RWC%, LWL (mg), and RWD (g cm^{-3}) at 45 DAS

	Treatments	RWC	LWL	RWD
T_1	Control	28.28	0.40	1.19
T_2	75% of RDF(15:45:15 kg NPK ha^{-1})	35.33	0.56	1.20
T_3	100% of RDF(20:60:20 kg NPK ha^{-1})	37.02	0.57	1.21
T_4	75% of RDF + NCPC + Zn @ 5.0 kg ha^{-1}	37.04	0.70	1.22
T_5	75% of RDF + NCPC + Zn @ 7.5 kg ha^{-1}	46.48	1.14	1.28
T_6	75% of RDF + NCPC + Zn @ 10 kg ha^{-1}	49.91	1.17	1.29
T_7	75% of RDF + NCPC + S @ 5.0 kg ha^{-1}	40.89	1.03	1.24
T_8	75% of RDF + NCPC + S @ 7.5 kg ha^{-1}	45.07	1.11	1.27
T_9	75% of RDF + NCPC + S @ 10 kg ha^{-1}	51.47	1.40	1.33
T_{10}	75% of RDF + NCPC + Mo @ 5.0 kg ha^{-1}	38.97	0.91	1.23
T_{11}	75% of RDF + NCPC + Mo@ 7.5 kg ha^{-1}	46.71	1.05	1.25
T_{12}	75% of RDF + NCPC + Mo @ 10 kg ha^{-1}	50.02	1.24	1.32
	SEm(±)	3.54	0.07	0.02
	C.D. (at 5%)	10.40	0.20	0.05

RWC- Relative water content, LWL – Leaf water loss, RWD - Root weight density

It was found that the highest root weight density was recorded in treatment T_9 - 75% of RDF + NCPC + S @ 10 kg ha^{-1} (1.33 g cm^{-3}) which was followed by T_{12} - 75% of RDF + NCPC + Mo @ 10 kg ha^{-1} (1.32 g cm^{-3}) and T_6 -75% of RDF + NCPC + Zn@ 10 kg ha^{-1} (1.29 g cm^{-3}) these are found to be at par to each as there is no critical difference between them.

Table 2: Effect of different doses of nutrient loaded NCPC on CGR at successive crop growth stage

	Treatments	CGR (g $day^{-1}m^{-2}$)		
		25-50 DAS	50-75 DAS	75-harvest
T_1	Control	0.45	0.07	0.138
T_2	75% of RDF(15:45:15 kg NPK ha^{-1})	0.48	0.09	0.142
T_3	100% of RDF(20:60:20 kg NPK ha^{-1})	0.50	0.10	0.150
T_4	75% of RDF + NCPC + Zn @ 5.0 kg ha^{-1}	0.57	0.12	0.154
T_5	75% of RDF + NCPC + Zn @ 7.5 kg ha^{-1}	0.82	0.28	0.209
T_6	75% of RDF + NCPC + Zn @ 10 kg ha^{-1}	0.92	0.29	0.218
T_7	75% of RDF + NCPC + S @ 5.0 kg ha^{-1}	0.72	0.23	0.182
T_8	75% of RDF + NCPC + S @ 7.5 kg ha^{-1}	0.77	0.27	0.201
T_9	75% of RDF + NCPC + S @ 10 kg ha^{-1}	1.01	0.32	0.288
T_{10}	75% of RDF + NCPC + Mo @ 5.0 kg ha^{-1}	0.67	0.22	0.159
T_{11}	75% of RDF + NCPC + Mo @ 7.5 kg ha^{-1}	0.75	0.24	0.193
T_{12}	75% of RDF + NCPC + Mo @ 10 kg ha^{-1}	0.93	0.31	0.239
	SEm(±)	0.05	0.05	0.04
	C.D. (at 5%)	0.15	0.14	0.12

At 25-50 DAS stage the maximum CGR (1.01 g day^{-1} m^{-2}) was recorded with T_9 - 75% of RDF + NCPC + S @ 10 kg ha^{-1} followed by T_{12} - 75% of RDF + NCPC + Mo @ 10 kg ha^{-1} (0.93 g $day^{-1}m^{-2}$).

At 50-75 DAS CGR stage of crop, T_9 - 75% of RDF + NCPC + S @ 10 kg ha^{-1} (0.32 g day^{-1} m^{-2}) having maximum CGR but statistically at par with the following treatments- T_{12} - 75% of RDF + NCPC + Mo @ 10 kg ha^{-1} (0.31 g day^{-1} m^{-2}).

At 75 DAS - harvest stage the highest value CGR was noted under T_9 - 75% of RDF + NCPC + S @ 10 kg ha^{-1} (0.288 g $day^{-1}m^{-2}$) which was followed by T_{12} - 75% of RDF + NCPC + Mo @ 10 kg ha^{-1} (0.239g $day^{-1}m^{-2}$),

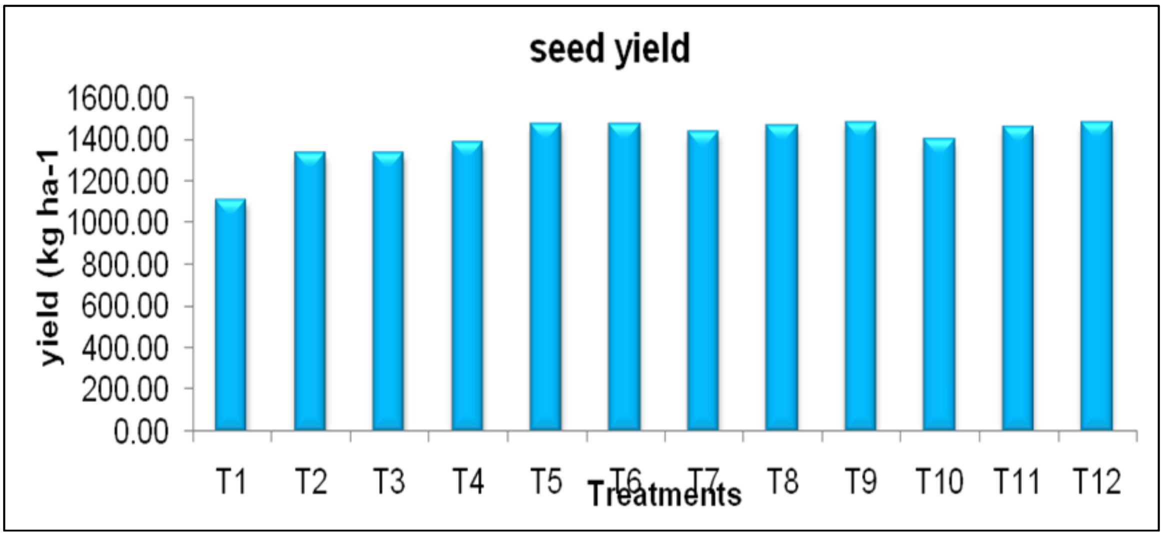

Fig 1: Effect of different doses of nutrient loaded NCPC on seed and straw yield kg ha^{-1} at harvest.

Table 3: Effect of different doses of nutrient loaded NCPC on seed yield of soybean kg ha^{-1}

	Treatments	Seed yield
T_1	Control	1107
T_2	75% of RDF(15:45:15 kg NPK ha^{-1})	1331
T_3	100% of RDF(20:60:20 kg NPK ha^{-1})	1334
T_4	75% of RDF + NCPC + Zn @ 5.0 kg ha^{-1}	1380
T_5	75% of RDF + NCPC + Zn @ 7.5 kg ha^{-1}	1467
T_6	75% of RDF + NCPC + Zn @ 10 kg ha^{-1}	1472
T_7	75% of RDF + NCPC + S @ 5.0 kg ha^{-1}	1431
T_8	75% of RDF + NCPC + S @ 7.5 kg ha^{-1}	1463
T_9	75% of RDF + NCPC + S @ 10 kg ha^{-1}	1478
T_{10}	75% of RDF + NCPC + Mo @ 5.0 kg ha^{-1}	1394

T_{11}	75% of RDF + NCPC + Mo@ 7.5 kg ha^{-1}	1454
T_{12}	75% of RDF + NCPC + Mo @ 10 kg ha^{-1}	1476
	SEm(±)	67
	C.D. (at 5%)	191

The highest yield was recorded under T_9 - 75% of RDF + NCPC + S @ 10 kg ha^{-1} (1478 kg ha^{-1}) followed by T_{12} – 75% of RDF + NCPC + Mo @ 10 kg ha^{-1} (1476 kg ha^{-1}) and T_6 - 75% of RDF+NCPC+ Zn @ 10 kg ha^{-1} (1472 kg ha^{-1}).The increase in seed yield due to treatments were 10.77 10.63 and 10.36% as compared to 100% RDF.

Conclusions

It is concluded that application of higher dose of nutrient loaded NCPC, 75% of RDF+NCPC+S @ 10 kg ha^{-1} recorded higher seed yield T $_9$ (1478 kg ha^{-1}) followed by treatment T_{12} – 75% of RDF + NCPC + Mo @ 10 kg ha^{-1} (1476 kg ha^{-1}) and T_6 - 75% of RDF+NCPC+ Zn @ 10 kg ha^{-1} (1472 kg ha^{-1}).The increase in seed yield due to treatments were 10.77 10.63 and 10.36% as compared to 100% of RDF. The application of different doses of nutrient loaded NCPC recorded significantly higher plant height, plant dry weight, number of branches $plant^{-1}$, seed index, seed yield as well as net income with maximum benefit cost ratio, under good rainfall year.

Reference

1. Akter F, Islam MN, Shamsuddoha ATM, Bhuiyan MSI, Shilpi S. Effect of Phosphorus and Sulphur on Growth and Yield of Soybean (*Glycine max* L.) Int. J of Bio-resource and Stress Management. 2013; 4(4):555-560.
2. Anonymous. Soybean processors association of India, 2016.
3. Bouyoucos GJ. Hydrometer method improved for making particle size analysis of soils. Agron. J l. 1962; 54:464-465.
4. Chouhan S, Parvender S, Singh M, Kumar M. Nutrient uptake and yield of soybean as influenced by N and P fertilization. Haryana. J of Agron. 2012; 21:190-191.
5. Devi KN, Singh LNK, Singh MS, Singh SB, Singh KK. Influence of Sulphur and Boron Fertilization on Yield, Quality, Nutrient Uptake and Economics of Soybean under Upland Conditions. J. of Agric. Sci. 2012; 4(4):1-10.
6. Jatav JK, Mukhopadhyay R, De N. Characterization of swelling behaviour of nano clay composite. Int. J of Innovative Res. in Sci., Eng. and Tech. 2013; 2(5).
7. Panse VG, Sukhatme PV. Statistical methods for Agricultural workers. (3rd Edition). ICAR, New Delhi, 1978.
8. Subbarao CHV, Kartheek G, Sirisha D. Slow Release of Potash Fertilizer Through Polymer Coating. Int. J. of Applied Sci. and Eng. 2013; 11(1):25-30.
9. Sivapalan S. Some benefits of treating a sandy soil with a cross-linked type polyacrylamide. Aus. J of Exp. Agric. 2006; 46:579-584.
10. Thenua OVS, Singh K, Raj V, Singh J. Effect of sulphur and zinc application on growth and productivity of soybean [*Glycine max*. (L.) Merrill] in northern plain zone of India. Ann. Agric. Res. New series 2014; 32(5):183-187.
11. Walkely AL, Black JA. An estimation of titrimetric method for determination soil. Organic matter and proposed modification of chromic acid titration method. Soil Sci. 1934, 37-39.
12. Wasmatkar RP, Ingole GL, Raut PD. Effect of different levels of sulphur and zinc on quality and uptake of nutrient of soybean. J. 2002
13. Yadav BL. Effect of varying fertility levels with and without of FYM, sulphur and zinc sulphate on growth and yield of soybean. M.Sc. (Ag.). Thesis, JNKVV, Jabalpur, 2003.