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Economic and soil chemical impact of nano dap with varied fertilizer levels in soybean production

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Abstract
In the research, we aimed to show that the cultivation of a soybean, with its specific soil profile would perform more positively when it was treated with nano-sized di ammonium phosphate (nano DAP) than a proven conventional fertilizer. In the experiment, it is performed in the Agronomy farm of Department of Agronomy at the School of Agricultural Sciences, G. H. Raisoni University at Saikheda, Pandhurna, Madhya Pradesh and implemented during 2024 kharif season.
It was done on the basis of randomized block Design (RBD) and the 8 treatment combinations were to be repeated 3 times each. In T_1-T_7, the RDF concentration of 30, 45 and 60 DAS doses were applied as two liquid concentrations (4 ml L^{-1} and 2 ml L^{-1}) as foliar spray. The set applications were also done in the same stages of development (30, 45 and 60 DAS) on soybean. Provisional data shows that the treatment T_3 (100% RDF + basal + foliar spray nano DAP 4 ml L-1 @ 30, 45 and 60 DAS) have produced summative returns (Rs 85,610), net returns (Rs 41,492) and B:C ratio 1.94. The lowest values were recorded in all the three of them in absolute control, T_8. In addition, T_3 also maintained high nutrient soil status compared with the control untreated.

Keywords: Nano DAP, RDF, soybean, soil properties, B:C ratio

Introduction
Glycine max L. Soybean is among the top economically valuable crops cultivated in the world and holds a very large proportion of the world production and trade. It supplies about 30% of the processed vegetable oils in the globe and is one of the main sources of the bio-diesel. Soybean is often dubbed as the Golden Bean because it is rich in nutritional value and its utmost versatility. % of oil and protein in each seed are almost 20 and 40 respectively along with essential amino acids, lecithin, starch (approximately 20.5%) and useful vitamins as well as minerals like calcium, iron, B-complex vitamins and other soluble vitamins. This is because it is a leguminous plant and like any other leguminous, soybean also transfers atmospheric nitrogen to soil, enhancing its fertility.
Overall global production of soybean covers an area of about 139.47 million hectares producing an approximate yield of 396.73 million tonnes. The cultivation of soybean in India covers an area of more than 13 million hectares, and it yields approximately 11 million tonnes of crops annually (Anon., 2023) [2]. Soybean oil also serves in this market as a big locally produced vegetable oil that assists India in promoting exports. The remainder of oil after obtaining oil is used in poultry, livestock and fish as well as exported to other countries such as Vietnam, Bangladesh, Japan and Iran. Though the average yield of soybean in India is not as high as in Brazil or the United States, the minimum support price (MSP) is also provided by the national government each year to motivate farmers.
In the meantime, new soybean products are aggressively marketed by the Indian government like soychunks, soymilk and tofu. The demand will definitely go up and production will rise as well. Another new technology is the nano-fertilizers. They are very tiny and have a wide area of coverage, increasing their ability to absorb more nutrients by the plants, which accelerate the photosynthesis and improve crop production. This method has seen the study of using nanoparticle in agriculture with the aim of improving the overall efficiency and worth of agricultural production (Noaema *et al.*, 2020) [10].

2. Materials and Methods

The present field experiment was carried out in Agronomy Farm, Department of Agronomy, School of Agricultural Sciences, G.H. Raisoni University, Saikheda, Pandhurna, Madhya Pradesh in 2024 kharif season. This was done within a Randomized Block Design (RBD) layout that had three replications. A total of eight treatments with eight levels of treatments included; 100% recommended dose of fertilizer (RDF) at 30 and 45 DAS, 100% RDF with 2 sprays of nano-diammonium phosphate (nano-DAP) at 2 ml L^{-1} at 30 and 45 DAS (T_2), 100% RDF with three sprays of 4 ml L^{-1} of nano-DAP each at 30, 45 and 60 DAS (T_3), 75% RDF with two sprays of nano DAP at 2 ml L^{-1} at 30 and 45 DAS (T_4), 50% RDF with three sprays of nano DAP at 4 ml L^{-1} at 30, 45 and 60 DAS (T_5), 50% RDF with two sprays of nano DAP at 2 ml L^{-1} at 30 and 45 DAS (T_6), 25% RDF with three sprays of nano DAP at 4 ml L^{-1} at 30, 45 and 60 DAS (T_7) and Absolute control (T_8). The variety of crops that was planted was the soybean (JS 335) at spacing interval 30 x 10 cm.

During physiological maturity the plants were cut close to the ground level and left to complete the process of sun drying using wooden sticks in the process of threshing. The seeds harvested were then logged, dried and weighed fully. After the harvest, characters like seed yield, number of pods and height of plants (cm) were taken. Following crop harvest, soil pH was measured through the pH meter (with the electrometric pH meter Sorensen), electrical conductivity EC (with the conductivity meter 1:2:5 soil: water), organic carbon of the soil (SOC) (on the Walkley-Black titration method), available Nitrogen (on the alkaline KMnO4 method Subbiah and Asija), phosphorus (on Olsen method), and Potassium (K) (on the flame photometry method M.L. Jackson).

3. Results and Discussion

3.1 Effect of different levels of fertilizers and Nano DAP on economics of soybean

We wanted to understand how the various foliar sprays used in soybean production would have impacted on the production and so we closely monitored the cost of operations as well as the cost of production of each of the treatments. The cost of cultivation during the planting season, net seasonal income, Gross income, ratio of B:C and net extra income over control of soybean can be checked in table 1. When the numbers are seen, treatment T_3 (100% RDF + 3 FS of nano DAP @ 4 ml L^{-1} at 30, 45 and 60 DAS) was the best with the highest seasonal cost of cultivation (Rs 44118), gross returns (Rs 85610), net returns (Rs 41492) and B:C ratio (1.94) compared to the absolute control treatment T_8. These results align well with the ones provided by Roy *et al.* (2021) [20].

Table 1: Economics of soybean as influenced by different treatments

Treatment details	Cost of Cultivation	Gross Income Rs ha^{-1}	Net Income Rs ha^{-1}	B:C ratio
T_1-100% RDF (25 N:60 P2O5: 40K2O :20 S) kg/ha at 30 and 45 DAS	36630	57872	21242	1.57
T_2-100% RDF + 2 foliar sprays of nano DAP 2 ml L^{-1} at 30 and 45 DAS	39126	74163	35037	1.89
T_3-100% RDF + 3 Foliar sprays of nano DAP 4 ml L^{-1} at 30, 45 and 60 DAS	44118	85610	41492	1.94
T_4-75% RDF + 2 foliar sprays of nano DAP 2 ml L^{-1} at 30 and 45 DAS	37760	68488	30728	1.81
T_5-50% RDF + 3 foliar sprays of nano DAP 4 ml L^{-1} at 30, 45 and 60 DAS	41400	75826	34426	1.83
T_6-50% RDF + 2 foliar sprays of nano DAP 2 ml L^{-1} at 30 and 45 DAS	36408	66825	30417	1.83
T_7-25% RDF + 3 foliar sprays of nano DAP 4 ml L^{-1} at 30, 45 and 60 DAS	40046	63596	23550	1.58
T_8-Absolute Control	31196	47256	16060	1.51

3.2 Effect of different levels of fertilizers and Nano DAP on soil chemical properties of soybean

The result of our experiment sought to reveal the effect of traditional and Nano fertilizer on organic carbon in the soil, PH, electrical conductivity, available N, P and K. To a significant extent, any variations were rather small, except the electrical conductivity, which was very responsive against Nano fertilizers.

There existed a certain decreasing trend in that parameter as the dosage of Nano fertilizers increased. The control as recorded in Plot T_8 had the most EC (0.26). On the other hand, with the lowest value relating to T_3 (100% RDF + 3 FS of nano DAP @ 4 ml L-1 at 30, 45 and 60 DAS) and T_5 (50% RDF + 3 FS of nano DAP @ 4 ml L-1 at 30, 45 and 60 DAS) which implies that the higher concentration of Nano DAP was employed.

Low EC values mean less leaching and salt accumulation and this provides healthier physiochemical conditions of the soil. Other important parameters of soil that responded to the fertilizer application were soil pH. The mean measure of all the treatment was found to be 7.74-7.81 which was strong because of traditional and Nano fertilizers. The control had the maximum pH of 7.81 and only T_3 (100% RDF + 3 FS of nano DAP @ 4 ml L-1 at 30, 45 and 60 DAS) showed a low (marginal acidic) pH of 7.74.

Table 2: Measure of pH, electrical conductivity, and organic carbon of the soil under different use of fertilizers and nano DAP which summarized in this table

Treatments	Soil pH	Electrical conductivity dS m^{-1}	Organic Carbon
T_1-100% RDF (25 N:60 P2O5: 40K2O :20 S) kg/ha at 30 and 45 DAS	7.46	0.24	0.36
T_2-100% RDF + 2 foliar sprays of nano DAP 2 ml L^{-1} at 30 and 45 DAS	7.48	0.25	0.40
T_3-100% RDF + 3 Foliar sprays of nano DAP 4 ml L^{-1} at 30, 45 and 60 DAS	7.44	0.20	0.40
T_4-75% RDF + 2 foliar sprays of nano DAP 2 ml L^{-1} at 30 and 45 DAS	7.46	0.22	0.38
T_5-50% RDF + 3 foliar sprays of nano DAP 4 ml L^{-1} at 30, 45 and 60 DAS	7.45	0.21	0.39
T_6-50% RDF + 2 foliar sprays of nano DAP 2 ml L^{-1} at 30 and 45 DAS	7.49	0.25	0.34
T_7-25% RDF + 3 foliar sprays of nano DAP 4 ml L^{-1} at 30, 45 and 60 DAS	7.45	0.21	0.35
T_8-Absolute Control	7.51	0.26	0.33
Sem	0.028	0.009	0.007
CD at 5%	0.087	0.027	0.023

As we investigated the concentration of N, P, and K in the different tissues of soybeans, a pattern was achieved whereby, all of the fertilizers used led to drastic rise of N, P, and K, regardless of the tissue being used. The highest had been recorded in T_3-the regime that mixed the 100% recommended dose fertilizer (RDF) with three 4 mL/liter doses of nano DAP at 30, 45 and 60 days duration of putting seeds in the ground; second-highest had been recorded in T_2 where 100% RDF was paired with two applications of nano DAP at 30 and 45 days after sowing, and the lowest values were registered in the control regime.

Table 3: Effect of different fertilizier treatments with Nano DAP spray on available N, P and K in soil.

Treatments	Available Nitrogen	Available phosphorus	Available Potassium
T_1-100% RDF (25 N:60 P2O5: 40K2O :20 S) kg/ha at 30 and 45 DAS	199.40	15.28	397.43
T_2-100% RDF + 2 foliar sprays of nano DAP 2 ml L^{-1} at 30 and 45 DAS	200.23	15.32	398.12
T_3-100% RDF + 3 Foliar sprays of nano DAP 4 ml L^{-1} at 30, 45 and 60 DAS	200.81	15.46	398.73
T_4-75% RDF + 2 foliar sprays of nano DAP 2 ml L^{-1} at 30 and 45 DAS	198.92	14.63	395.51
T_5-50% RDF + 3 foliar sprays of nano DAP 4 ml L^{-1} at 30, 45 and 60 DAS	197.39	14.41	392.39
T_6-50% RDF + 2 foliar sprays of nano DAP 2 ml L^{-1} at 30 and 45 DAS	196.75	14.30	392.65
T_7-25% RDF + 3 foliar sprays of nano DAP 4 ml L^{-1} at 30, 45 and 60 DAS	196.73	14.19	390.14
T_8-Absolute Control	191.48	12.82	376.33
Sem	0.57	0.23	0.73
CD at 5%	1.75	0.70	2.23

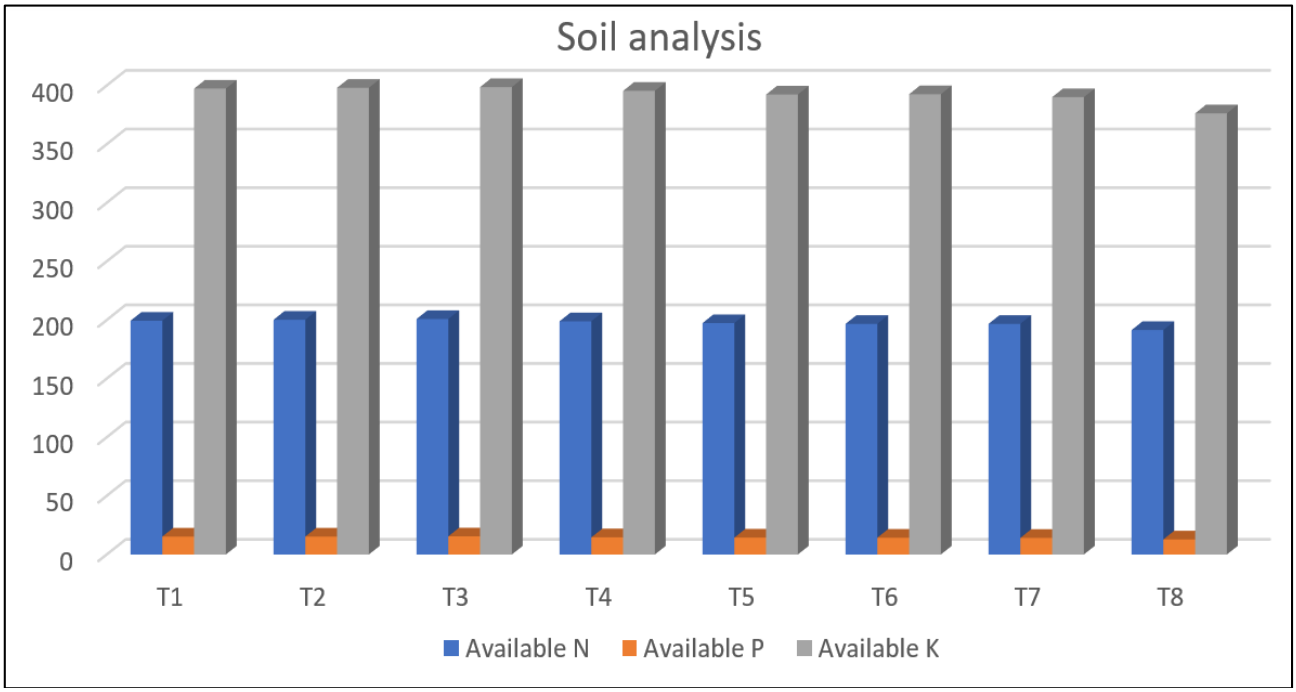

Fig 3.1: Influence of different treatments on available N, P and K in soil.

4. Conclusion

Coming to the conclusion where we used 100% RDF and three foliar sprays of nano DAP the overall economic returns recorded a sharp increase and B:C ratio was improved (1.94). Surprisingly, the 100% RDF + 2 sprays of nano DAP, 50% RDF + 3 sprays of nano DAP and 100% RDF + 3 sprays of Nano DAP at 30, 45 and 60 DAS showed almost the same results. The pH of the soil decreased by a few points in all the treatments, the electrical conductivity reduced by few units, whereas the organic carbon content in the soil increased with additional fertilizer applications and foliar application of Nano DAP. Possible supply of N, P, and K in the soil post-harvest of soybean did not show a lot of change, with the exception of the control group.

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