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EFFECT OF NUTRIENT MANAGEMENT ON NUTRIENT UPTAKE, YIELD AND ECONOMICS OF SOYBEAN

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ABSTRACT

To study the effect of nutrient management practices on nutrient uptake, yield and economics of soybean, a field experiment was conducted during *kharif* season of 2019-2020 at Agronomy Farm of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra. This experiment was laid out in randomized block design with three replications and seven treatments. The nitrogen management treatments comprised of Absolute Control (No fertilizers) (T_1), FYM @ 5.0 t ha^{-1} (T_2), 15 kg ha^{-1} +biofertilizer (T_3), 30 kg N ha^{-1} (T_4), 45 kg N ha^{-1} (T_5), T_2 + 30 kg N ha^{-1} +biofertilizer (T_6) and 50 kg N ha^{-1} (T_7). The soil of experimental field was clayey in texture and slightly alkaline in reaction. Regarding fertility status, the soil was medium in available nitrogen (210.50 kg ha^{-1}), low in available phosphorus (14.87 kg ha^{-1}), fairly high in available potassium (310.45 kg ha^{-1}), and moderate in organic carbon (0.5 %). The soybean variety (JS-335) was sown on 1st July 2019 at 45 cm x 5 cm spacing and harvested on 17th October 2019. The results showed that total nitrogen, phosphorus and potassium uptake was significantly increased with an application of FYM @ 5.0 t ha^{-1} + 30 kg N ha^{-1} + biofertilizer. Similarly, the yield potential of soybean was also improved with this treatment. As far as economics is concerned, gross monetary returns were also found to be maximum with the INM treatment of FYM @ 5.0 t ha^{-1} + 30 kg N ha^{-1} + biofertilizer, however, the highest net monetary returns and benefit to cost ratio of 2.77 was noted with treatment of 50 kg N ha^{-1}.

(Key words: Soybean, nutrient management, FYM, biofertilizers, NPK uptake, yield and economics)

INTRODUCTION

India has the fifth largest vegetable oil economy in the world. After cereals, oilseeds are the second largest agricultural commodity, accounting for the 14% of the gross cropped area in the country. However, country meets its edible oil demand through imports, which accounts for almost 50% of requirement. The capita^{-1} consumption of the vegetable oil is increasing very rapidly due to increase in population and improved economic status of the population. The demand has increased to about 12.6 kg year^{-1} compared to 4 kg year^{-1} in 1961 and the projected demand for the year 2020 and 2050 is 16.45 and 19.16 kg year^{-1} respectively. To meet this demand, the country will require nearly 25.26 and 35.90 million tons of edible oil. In this scenario, soybean has played and will play a pivotal role in the future, as soybean is considered a major crop because it is an important source of protein for animal feed and oil for human consumption. Production of soybean in India is dominated by Maharashtra and Madhya Pradesh, which contribute 89 per cent of the total production. Rajasthan, Andhra Pradesh, Karnataka, Chhattisgarh and Gujarat contribute the remaining 11 per cent production. (Agarwal *et al.,* 2013). Moreover, during last few years, area under soybean in Vidarbha region is increasing due to reduction in area of cotton (Potbhare *et al.,* 2020).

However, low productivity of the soybean in most of the parts of the country is primarily because of uncontrollable climatic factors like destructive rainfall, distribution pattern and controllable edaphic factor low organic matter status owing to imbalanced use of both macro and micro nutrient through high analysis inorganic fertilizers. Replacement of a part of chemical fertilizers by organic manure through a simple technique of using minimum effective dose of sufficient and balanced quantities of organic and inorganic fertilizers in combination with specific micro nutrients, called integrated nutrient management (INM), has a bright solution in this area. Recently, several investigators reported that integrated use of chemical fertilizers with organic manure is becoming a quite promising

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practice not only for maintaining higher productivity but also for greater stability to crop production. In addition, INM acts as a source of energy, organic carbon, and available nitrogen for the growth of soil microbes and improvement of physical properties of soil, and also have great residual effect on subsequent crops. So, the key component of the INM goal is to reach the eco-friendly practice through the harmonious properties of both sources by making a combination that can be used for decreasing the enormous use of chemical fertilizers and accreting a balance between fertilizer inputs and crop nutrient requirement, maintaining the soil fertility, optimizing the level of yield, maximizing the profitability, and subsequently reducing the environmental pollution. INM is a tool that can offer good options and economic choices to supply plants with a sufficient amount of nutrients and can also reduce total cost, create favourable soil physio-chemical conditions and healthy environment, eliminate the constraints, safeguard the soil nutrient balance, and find safety methods to get rid of agriculture wastes.

Recently, farmers and agricultural specialists recognize that further application of inorganic fertilizers does not mean that an increase must be induced, and then they realize the importance of soil fertility through the application of organic fertilizers, that are available and inexpensive and can be used solely or in combination with other available organic or inorganic resources to enhance the soil fertility and bring about higher crop production, without having any undesirable impacts on the environment (Selim, 2020). Similarly, Khamparia *et al.* (2018) also emphasized that integration of inorganic fertilizers with organic manures will not only sustain the crop production but will be effective in improving soil health and enhancing the nutrient use efficiency.

Considering all above points, and to identify the cause of stress in soybean crop and to improve the crop productivity, it has been thought worthwhile to conduct the said experiment.

MATERIALS AND METHODS

In semi-arid climate of India, a field experiment was conducted during *kharif* season of 2019-2020 at Agronomy Farm, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, situated at the latitude of 20°70' North and longitude of 77°03' East. The altitude of the place is 307.41 meter above mean sea level. The soil of experimental plot was clay in texture and slightly alkaline in reaction. The soil was medium in available nitrogen (210.50 kg ha^{-1}), low in available phosphorus (14.87 kg ha^{-1}), fairly high in available potassium (310.45 kg ha^{-1}), and moderate in organic carbon (0.5 %). Soybean variety (JS-335) was sown on 1^{st} July 2019; and harvested at 17^{th} October 2019. The gross plot size was 8.00 m x 6.30 m. The experiment was laid out in randomized block design with seven treatments and three replications.

Treatments consisted of application of nitrogen with suitable doses *viz*., Absolute Control (no fertilizers) (T_1), FYM @ 5.0 t ha^{-1} (T_2), 15 kg N ha^{-1} + biofertilizer (T_3), 30 kg N ha^{-1} (T_4), 45 kg N ha^{-1} (T_5), T_2 + 30 kg N ha^{-1} + biofertilizer (T_6) and 50 kg N ha^{-1} (T_7). Seed of soybean was inoculated with *Rhizobium* and *PSB* @ 250 g 10 kg^{-1} of seed. The recommended dose of fertilizers was 30:75:30 kg NPK ha^{-1}. Integrated dose of organic and inorganic nutrient sources for nitrogen was applied to specified treatments. The recommended dose of nitrogen @ 30 kg N ha^{-1} was applied through urea, phosphorus @ 75 kg ha^{-1} was applied through single super phosphate and potassium @ 30 kg ha^{-1} was applied through muriate of potash at the time of sowing. Phosphorus and potassium was applied to all the treatments, except that of absolute control. In order to know the chemical composition of soil, soil samples were collected at 0-30 cm depth from randomly selected spots spread over the experimental area before sowing. A composite soil sample was analysed for the fertility status of soil. Total rainfall received (22^{th} MW 2019 to 1^{st} MW 2020) at Akola centre was 929 mm in 57 rainy days during the *kharif* season of 2019.

The available nitrogen from soil was estimated by alkaline permanganate method (Subbiah and Asija, 1956). The Olsen's method (Jackson, 1967) was used for determining available phosphorus in soil in which phosphorus was extracted from the soil using 0.5 M sodium bicarbonate ($NaHCO_3$), pH 8.5 as an extractant. Available potassium was determined by extracting soil with neutral (1N) ammonium acetate (pH 7) solution and readings were recorded using Flame photometer (Jackson, 1967).

The nutrient uptake (kg ha^{-1}) was determined according to the NPK content in the seed and straw of soybean samples as per standard methods by using the following formula.

$$\text{N/P/K uptake in seed} = \frac{\text{N/P/K content in seed (\%) x seed yield (kg ha}^{-1})}{100}$$

$$\text{N/P/K uptake in straw} = \frac{\text{N/P/K content in straw (\%) x straw yield (kg ha}^{-1})}{100}$$

Total N/P/K uptake = N/P/K uptake in seed + N/P/K uptake in straw

The statistical analysis of the data was performed as per method described by Panse and Sukhatme (1985). Table 1 represents the data regarding NPK uptake by the crop along with crop yield and economics.

RESULTS AND DISCUSSION

Nutrient (NPK) uptake by soybean crop

It is obvious from the data presented in Table 1 that the uptake of nitrogen, phosphorus and potassium was influenced significantly due to various nitrogen management treatments.

As far as nitrogen uptake by the crop is concerned, it was noted that significantly highest total nitrogen uptake (123.95 kg ha^{-1}) was recorded with an application of FYM @ 5.0 t ha^{-1} + 30 kg N ha^{-1} + biofertilizer (T_6) which was found at par with highly fertilized treatments of 50 kg N ha^{-1} (T_7) (120.92 kg ha^{-1}) and 45 kg N ha^{-1} (T_5) (116.16 kg ha^{-1}). Conversely, the lowest nitrogen uptake (97.73 kg ha^{-1}) was recorded in the treatment of absolute control (T_1).

It is observed in general that, the demand for nutrients depends on the soybean growth stage. Since the soybean seed has high levels of protein, demand for nitrogen is extremely high during seed formation. Throughout the growing season, nutrients are provided from the soil and through nitrogen fixation; however, late in the season many of the nutrients are remobilized from the older tissue to support seed development. High nitrogen levels in the soil limit the number of nodules formed increasing soybean's dependence on the soil for nitrogen. In these conditions,nitrogen deficiency can occur later in the season and nitrogen application may be necessary. However, in number of experiments it was noted that nitrogen application at planting does not improve yield and only decreases nodulation while, increasing the plant's dependency on the soil for nitrogen. Moreover, it is also observed that the placement of fertilizer very close to the soybean seed does not improve yield. With these background theories, it is very interesting to observe the results obtained from the present investigation, where the beneficial effect of combined use of organic, inorganic and microbial sources of nutrients might have supplied the nutrients for a longer period and improved the physical, chemical and biological status of soil. Nitrogen being an essential constituent of chlorophyll, protoplasm and various enzymes, it governs the utilization of P and K. Thus, ample availability of N in the treatment involving organic and inorganic fertilizer with inoculation might have resulted in increase in N uptake by crop.Rathod *et al.* (2012) during their experimentation reported that the seed inoculation provided favourable conditions for the multiplication of nodule bacteria, which in turn produced more number of nodules and thereby more N was fixed for use by the plants. All this enabled crop plants to utilize sufficient N during its growth and development that resulted in better fruiting (pods plant^{-1}) and higher seed yield. They further reported that N, P and K uptake by soybean increased significantly with the increasing levels of N as the entire N levels recorded significantly higher N uptake over control.

While considering the phosphorus uptake, it was noted that the treatment comprising of FYM @ 5.0 t ha^{-1} + 30 kg N ha^{-1} + biofertilizer (T_6) (22.93 kg ha^{-1}) being at par with 50 kg N ha^{-1} (T_7) (21.48 kg ha^{-1}) and 45 kg N ha^{-1} (T_5) (20.60 kg ha^{-1}), recorded significantly highest phosphorus uptake. While, the lowest phosphorus uptake (15.57 kg ha^{-1}) was registered in control (T_1) treatment. The most probable reason for highest uptake with INM treatment may be the slow and timely release of phosphorus into the rhizosphere providing the appropriate conditions for plant uptake of exchangeable P in readily available forms.Panneerselvam *et al.* (2000) reported that conjunctive application of organic manures and inorganic fertilizers favourably increased the soil available phosphorus. This might be due to addition of bio-digested slurry or sheep manure which not only acted as a source of nutrients but also influenced the availability of applied inorganic fertilizers, which in turn favoured the crop growth and greater accumulation of biomass leading to higher P uptake at all stages of crop growth. Thus, in present investigation, the increased release of native soil P might be due to the fact that the organic anions compete with phosphate ions for the binding sites on the soil particles and the complex organic anions chelate *viz.*, AI^{3+}, Fe^{3+} and Ca^{2+}; and thereby decrease the phosphate precipitating power of these cations and increase the soluble P and P desorption.

As regards to potassium uptake, it was observed that significantly highest total potassium uptake was recorded with an application of FYM @ 5.0 t ha^{-1} + 30 kg N ha^{-1} + biofertilizer (T_6) (87.33 kg ha^{-1}) which was at par with 50 kg N ha^{-1} (T_7) (84.52 kg ha^{-1}) and 45 kg N ha^{-1} (T_5) (82.86 kg ha^{-1}). Significantly lowest potassium uptake (70.37 kg ha^{-1}) was recorded in control (T_1) treatment. Again, the role of slow release of K came into force, when the INM treatment comprising of inorganic, organic and biofertilizers was involved in crop growth and development processes. Potassium being the constituent of cell wall plays a great role in conjunction with adequately available N and P. It is well known that potassium is taken up by plants in large amounts and performs functions in plant metabolism, assimilates translocation and storage and is required for turgor maintenance. Because it is not metabolized by the plants; and forms easily reversible bonds with organic molecules, it get accumulated in the crop remains at the end of the crop cycle. Lyngkhoi *et al.* (2020) also pointed out that higher levels of phosphorus application significantly enhanced the content of N,P,K and S in both seed and stover of soybean crop. They also observed 13% decrease in K translocation to the seed, causing internal imbalance of K. This decrease may be related to K replacement by another ion, such as Na. As the soil K concentrations were within the adequate range, luxury consumption could have occurred, especially when associated with high biomass production and nutrient uptake, which cause an internal imbalance in plants. Sikka *et al.* (2013) during their experimentation on influence of integrated nutrient and agronomic management on growth, yield and nutrient uptake by soybean and on soil health, observed that application of FYM with NP or NPK improved the yield of soybean over NP or NPK alone treatment. The inclusion of FYM in the fertilizer treatment resulted in maximum increase in the uptake of NPK nutrients. Later on, it is also pointed out that the high percentage of nutrient accumulation after the full pod stage indicates good nutrient supply during seed filling stages, which are crucial to sustain high yields.

Soybean crop yield and economic studies

The data regarding soybean seed and straw yield are presented in Table 1, which reveals that an application of FYM @ 5.0 t ha^{-1} + 30 kg N ha^{-1} + biofertilizer (T_6) (2391 kg ha^{-1}) recorded significantly highest seed yield being at par with 50 kg N ha^{-1} (T_7) (2327 kg ha^{-1}) and 45 kg N ha^{-1} (T_5)

Table 1. Nitrogen, phosphorus,potassium uptake, crop yield and economics of soybean as influenced by various treatments

Treatments		N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})			Crop yield		Economics	
		Seed	Straw	Total	Seed	Straw	Total	Seed	Straw	Total	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	NMR (Rs ha^{-1})	B:C ratio
T_1	Absolute control	88.34	9.39	97.73	9.7	5.87	15.57	9.87	60.50	70.37	1630	1894	35626	2.31
T_2	FYM @ 5.0 t ha^{-1}	96.57	10.08	109.65	11.27	6.50	17.77	10.47	65.38	75,85	1957	2191	31379	1.71
T_3	15 kg N ha^{-1} + biofertilizer	93.76	9.69	103.45	10.82	6.08	16.90	10.13	62.50	72.63	1823	2065	37848	2.17
T_4	30 kg N ha^{-1}	102.23	10.47	112.70	11.74	7.13	18.87	11.37	67.39	78.76	2117	2270	49414	2.55
T_5	45 kg N ha^{-1}	105.23	10.93	116.16	12.84	7.76	20.60	12.34	70.52	82.86	2229	2469	53619	2.67
T_6	T_2 + 30 kg N ha^{-1} + biofertilizer	111.87	12.08	123.95	14.1	8.83	22.93	14.10	73.23	87.33	2391	2625	47401	2.06
T_7	50 kg N ha^{-1}	109.54	11.38	120.92	13.4	8.08	21.48	13.22	71.30	84.52	2327	2552	56921	2.77
SE (m) ±		2.22	0.39	4.18	0.43	0.37	1.05	0.60	0.94	3. 33	90	90	2196	-
CD (P=0.05)		6.66	1.17	12.91	1.29	1.12	3.25	1.79	2.81	10.26	269	271	6586	-

(2229 kg ha^{-1}). The lowest seed yield (1630 kg ha^{-1}) was recorded in control (T_1) treatment. Whereas, maximum straw yield was recorded with an application of FYM @ 5.0 t ha^{-1} + 30 kg N ha^{-1} + biofertilizer (T_6) (2625 kg ha^{-1}) which was at par with 50 kg N ha^{-1} (T_7) (2552 kg ha^{-1}) and 45 kg N ha^{-1} (T_5) (2469 kg ha^{-1}). The lowest straw yield (1894 kg ha^{-1}) was recorded in control (T_1) treatment. Thus, in present investigation, the maximum seed yield due to INM might be due to marked improvement in dry matter accumulation, yield attributes and greater nutrients content and their uptake by soybean. Rathod *et al*. (2012) revealed that both seed and straw yield of soybean was significantly increased with increase in the N dose with declining yield response at higher level. Farid *et al*. (2013) also showed that the balanced and timely nutrient management practices applied for soybean contributes to sustainable growth, yield and quality, influences plant health and reduces environmental risks. Further, Singh *et al*. (2007) reported that sole or dual inoculation of soybean with biofertilizers, application of FYM and recommended dose of fertilizer (RDF) significantly increased the plant growth, nodulation, seed and straw yields as well as N and K uptake over the control.Abbas *et al*. (2011) also revealed that different combinations of organic and inorganic fertilizers significantly improved the grain yield of mungbean.

As far as economics is concerned, the net monetary returns provide the true value of income to the producer. During present investigation, it was noted that treatment of 50 kg N ha^{-1} (T_7) (56921 Rs ha^{-1}) recorded maximum net monetary returns while, the lowest net monetary returns were found in FYM @ 5.0 t ha^{-1} (T_2) (31379 Rs ha^{-1}). This might be due to improvement in growth and yield attributes. Ultimate increase in seed yield could be the reason for enhanced economic returns in the treatment of 50 kg N ha^{-1} (T_7).

The ratio of Benefit to Cost (B:C) provides net gain over the monetary investment. The highest B:C ratio was registered with an application of 50 kg N ha^{-1} (2.77) (T_7) which was however higher among various organic and inorganic sources.Farid *et al*. (2013) showed that balanced fertilization generates higher profits for the farmers, not necessarily through reduced inputs in soybean.Bachhav *et al*. (2012) revealed that higher net returns and benefit:cost ratio was obtained due to application of 50 kg N ha^{-1} than control in soybean crop. They also revealed that the FYM applied @ 5 t ha^{-1} recorded maximum seed yield (1,908 kg ha^{-1}), straw yield (3,588 kg ha^{-1}), gross realization, net realization with benefit:cost ratio than remaining treatments. Selim (2020) revealed that INM is a tool that can offer good options and economic choices to supply plants with a sufficient amount of nutrients in need and can also reduce total costs, create favourable soil physiochemical conditions and healthy environment, eliminate the constraints, safeguard the soil nutrient balance, and find safety methods to get rid of agriculture wastes.

Thus, in nutshell, it can be concluded that highest nutrient uptake and crop productivity along with higher monetary returns are possible if the inorganic fertilization is coupled with organic nutrient sources and biofertilizers in case of soybean cultivation.

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