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MORPHO-PHYSIOLOGICAL RESPONSE AND YIELD OF SOYBEAN AS INFLUENCED BY NUTRIENT MANAGEMENT

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ABSTRACT

A field experiment was conducted to study the morpho-physiological response and yield of soybean as influenced by nutrient management practices during *kharif* season of 2019-2020 at Agronomy Farm of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra. The experiment was laid out in randomized block design with three replications and seven treatments. The treatments comprised ofControl (T_1), FYM @ 5.0 t ha^{-1} (T_2), 15 kg Nha^{-1} +biofertilizer (T_3), 30 kg Nha^{-1} (T_4), 45 kg Nha^{-1} (T_5), T_2 + 30 kg N ha^{-1} +biofertilizer (T_6) and 50 kg ha^{-1} (T_7). The soil of experimental field was clayey in texture and slightly alkaline in reaction. As regards to 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 growth attributes of soybean *viz*., plant height, number of branches plant^{-1}, number of leaves, leaf area plant^{-1}, and total dry matter accumulation were found significantly maximum with combined application of FYM @ 5.0 t ha^{-1} + 30 kg N ha^{-1} + biofertilizer. Similarly, the physiological characters of soybean *viz*., leaf thickness, leaf angle, canopy temperature, relative leaf water potential, intercepted photosynthetically active radiation and Chlorophyll (a, b and total) content / chlorophyll content index (CCI) were maximum with the application of FYM @ 5.0 t ha^{-1} + 30 kg N ha^{-1} + biofertilizer. Net monetary returns (Rs. 56921) and benefit to cost ratio (2.77) registered their highest values with the treatment of 50 kg Nha^{-1}.

(Key Words: Soybean, morpho-physiological characters, nutrient management, FYM, biofertilizers., yield and economics)

INTRODUCTION

Soybean (*Glycine max* L. Merril) is the world's most important seed legume, which contributes 25 % of the global edible oil, about two-third of the world's protein concentrate for livestock feeding. Soybean is also known as "Golden Bean" or "Miracle Crop", as they contain a complete source of protein and oil. Soybean belongs to the legume family and originated in China. It was introduced to India across the Himalayan Mountain many years ago. Soybean is mainly grown for their seeds and is the second largest oil seed after groundnut in India. Soybean, being full of nutritional value, contains about 40% to 50% high quality protein and 20% to 22% oil. It's also have some essential amino acid (5%), carbohydrates, vitamins, (thiamine and riboflavin) and minerals. Soybean is also called as "Gold of Soil" for its various qualities such as easy in cultivation, fewer requirements of fertilizer and labour etc. It builds up the soil fertility by atmospheric nitrogen fixtion through nodules. Symbiotically soybean fixes 125-150 kg N ha^{-1} and leaves behind at about 30-40 kg N ha^{-1} for succeeding crop. All these qualities have been made it an ideal alternative for crop rotation.

At present, India ranks fifth in the area and production in the world after USA, Brazil, Argentina and China. The contribution of India in the world soybean area is 10 %, but the contribution to total world soybean grain is only 4 % indicating the poor levels of productivity of the crop in India (1.1 t ha^{-1}) as compared to other courtiers (world average 2.2 t ha^{-1}) (Agarwal *et al*., 2013). Madhya Pradesh, Maharashtra and Rajasthan together contributes to about 92-93% of area and production of soybean in India. In recent years, cultivation of soybean is fast expanding in the states of Telangana, Karnataka and Gujarat (Anonymous, 2018). Soybean is grown in Maharashtra in an area of about 38.70 lakh ha and average production is about 48.56 lakh MT,

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with an average productivity of 1012 kg ha^{-1}. The area is increasing rapidly over the years. Thus, it would not be worthwhile to mention that soybean has revolutionized the rural economy and improved socio-economic status of farmers and its cultivation has placed India on the worldmap in recent past (Deshkari *et al*., 2019).

Very recently, aberrant rainfall pattern and intermittent dry spells were observed in almost all major soybean growing states, which either delayed the sowing or forced for re-sowing of soybean that continue from 2nd week of June to mid-July. There were also reports of sporadic biotic stresses in some soybean growing areas. About 34 districts in Madhya Pradesh, 14 districts in Maharashtra and 14 districts in Rajasthan states received deficit rainfall from June to mid-September period. Rainfall was deficit in major soybean growing regions during 28, 32-34 and 36-37 meteorological weeks (during 30-33 MW in Marathwada and Vidarbha), coinciding with the pod formation and grain filing stage of the crop. Therefore, the crop productivity and production is expected to decline marginally. Due to aberrant weather situation from 2013 onwards led to high fluctuation in crop productivity. The major constraint in its production are rainfed cropping with vulnerability to vagaries of monsoon, non-availability of quality seeds and other agrochemicals in adequate quantity and at right time, lack of awareness on integrated approaches for nutrient and water management as well as pest and disease management. Integrated nutrient management (INM) is a tool that can offer good options and economic choices to supply plants with a sufficient amount of nutrients is need 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.

MATERIALS AND METHODS

Field experiment was carried out during *kharif* season of 2019-2020 at the Plot No. 98-99 of 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 and the climate is semi-arid. The soil of experimental plot was clay in texture and slightly alkaline in reaction. As regards to fertility status, the soil was medium in available nitrogen, low in available phosphorus, fairly high in available potassium, and moderate in organic carbon. Soybean variety (JS-335) was sown on 1st July 2019; and harvested at 17th 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 *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}. However, the integrated dose of organic and inorganic nutrient sources for nitrogen was applied to specified treatments. Phosphorous and potassium was applied as per recommended dose at the time of sowing to all the treatments, except that of absolute control.

Growth attributes *viz*., plant height, number of branches $plant^{-1}$, number of leaves $plant^{-1}$, leaf area $plant^{-1}$ and dry matter accumulation and physiological characters *viz*., leaf thickness, leaf angle, relative leaf water potential, intercepted photosynthetically active radiation and chlorophyll content index (CCI) were recorded periodically. Table 1 and Table 2 represents the growth attributes and plant physiological characters, respectively at specified days after sowing (as mentioned in the Table).

RESULTS AND DISCUSSION

Growth parameters of soybean crop

It is obvious from the data presented in Table1 that all the growth attributes of soybean *viz*., plant height (at 80DAS), number of branches (at 80DAS), number of leaves (at 60DAS), leaf area (at 80DAS) and dry matter accumulation (at harvest) were significantly improved with the INM treatment of FYM @ 5.0 t ha^{-1} + 30 kg N ha^{-1} + biofertilizer (T_6) which was at par with 50 kg N ha^{-1} (T_7) and 45 kg N ha^{-1} (T_5).

Significant increase in plant height at 80 DAS due to the treatment of FYM @ 5 t ha^{-1} + 30 kg N ha^{-1} + biofertilizer along with recommended dose of P and K might have resulted in providing all the growth promoting nutrients through integrated supply in adequate amount without having any antagonistic effect during the early growth stages of the crop which boosted the plant height proportionately.Similarly, at 80 DAS, significant increase in number of branches $plant^{-1}$ might be due to accelerated rate of metabolic processes by plant due to presence of easily available all the major nutrients in balanced amount which promoted the cell division and cell elongation adequately. Increase in number of leaves $plant^{-1}$ might be due to the availability of proportionate quantity of nutrients, improvement in the physical status of soil and increased activity of microbes with combined application of FYM @ 5.0 t ha^{-1} + 30 kg N ha^{-1} + biofertilizer. The increase in leaf area with the same treatment may be due to application of adequate quantity of nutrients through organic and inorganic sources to crop, which increased the number of functional leaves and further increased the cell division reflecting in greater leaf area plant^{-1}.

Dry matter accumulation is the prerequisite for higher yields, which is an indication of the biosynthetic process associated with the crop growth and development. Total dry matter accumulation was significantly influenced mainly due to greater availability of nutrients in soil, improved soil environment and higher root penetration leading to better absorption of moisture and nutrient which improved the photosynthesis and translocation assimilates with the treatment where organic and inorganic nutrients were combined. Ritu and Harpreet (2019) showed that the plant growth parameters like plant height, leaf area index (LAI) and dry matter accumulation of soybean increased with the application of the nitrogen from 30-80 kg N ha^{-1}.

Plant physiological parameters of soybean crop

Physiological characters *viz*., leaf thickness, canopy temperature, relative leaf water potential, intercepted photosynthetically active radiation and chlorophyll content index (CCI) were improved to significant extent with the treatment of FYM @ 5.0 t ha^{-1} + 30 kg N ha^{-1} + biofertilizer (T_6) which was at par with 50 kg N ha^{-1} (T_7) and 45 kg N ha^{-1} (T_5). Zhijia *et al.* (2017) showed that starter nitrogen fertilizer had positive effect on the chlorophyll content, and thus promoted the increase of photosynthetic rate at the developmental stage. Results indicated that fertilizer N increased the chlorophyll content and photosynthetic rate of soybean in the pot experiment. They further corroborate the previous studies, which reported that a small amount of starter N at planting could be beneficial to early growth. In their study, N_{50} produced highest leaf area index at the developmental stages. High level of nitrogen treatment (N_{75}) decreased the leaf area index. That is because N_{75} inhibited the root activity and decreased the dry root weight compared to N_{50}, and thus reduced the leaf area index.

Leaf thickness and final area were related to resource supply but not in simple fashion. Both positive and negative correlations between leaf thickness and carbohydrate and nitrogen concentration were obtained depending on the environmental variable responsible for the variation. Both low and high temperature affect plant growth and development at whole plant level, tissue and cell level and even at sub-cellular level. Temperature variation may affect morphology, anatomy, phenology and plant biochemistry at all levels of organization. Direct injuries due to high temperature in plants include protein denaturation and aggregation, and increased fluidity of membrane lipids. Plant nutrients play a greater role in improving the temperature stress tolerance. Extrapolated values of leaf water potential at zero transpiration were within a few tenths bar of measured nutrient-solution potentials. These results indicated that plant resistances to water flow remained constant from near zero transpiration up to the maximum obtained average rate of 1.8-3.0 g dm^{-2} h^{-1}. The magnitude of the resistance varied considerably from plant to plant even within a single cultivar of one species and definite conclusions as to interspecies differences in resistance were not made. As population density increases in a soybean crop, maximum light interception occurs earlier in the season. Earlier canopy closure would be expected to increase the cumulative radiation intercepted. Synthesis of the photosynthetic apparatus requires large amounts of N, the proportion of leaf N allocated to the chloroplast. Availability of N is sufficient to increase chlorophyll biosynthesis, leaf organ formation and assimilation.

Soybean crop yield and economic studies

Maximum seed yield was recorded with an application of FYM @ 5.0 t ha^{-1} + 30 kg N ha^{-1} + biofertilizer (T_6) (2391 kg ha^{-1}) which was at par with 50 kg N ha^{-1} (T_7) (2327 kg ha^{-1}) and 45 kg N ha^{-1} (T_5) (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. Lyngkhoi *et al.* (2020) reported that favourable effect of better plant nutrients reflects in better yield attributes and finally higher seed yield. Javaid and Mahmood (2010) concluded that soybean yield can be significantly enhanced by the application of *B. japonicum* and farm yard manure amendment.Rathod *et al.* (2012) revealed that both seed and straw yield were significantly increased with the increase in 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.

As far as net monetary returns is concerned, it is depend on gross returns and cost of cultivation. Application of 50 kg ha^{-1} (T_7) (56921 Rs.ha^{-1}) recorded maximum net monetary returns and lowest net monetary returns was 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 above treatments. Desai *et al.* (2019) revealed that the highest seed yield (1760 kg ha^{-1}, 1809 kg ha^{-1} and 1843 kg ha^{-1}) of soybean was found with the application of vermicompost @ 2.5 t ha^{-1}, 60 kg P_2O_5 and seed treatment of *Rhizobium* + PSB, respectively.

Singh (2012) concluded that Integrated use of chemical fertilizers (100 % NPK) with FYM @ 5 tonnes ha^{-1} recorded significantly higher nodules $plant^{-1}$, yield attributes namely, number of pods $plant^{-1}$, number of seeds pod^{-1}, seed index and seed yield (2,470 and 2,547 kg ha^{-1}), straw yield (2,408 and 2,658 kg ha^{-1}) and harvest index.

In the present investigation, the highest benefit:cost 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.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. Khaim *et al*. (2013) also indicated that organic manure in combination with the recommended dose of chemical fertilizers can be applied to achieve better yield and quality of soybean as well as to improve soil fertility status.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.

Overall, from the present investigation it is obvious that apart from improving the morpho-qualitative traits, yield maximization can be achieved by integrating the organic and inorganic sources of nutrients in soybean.

Table 1. Growth parameters of soybean as influenced by various treatments

Treatments	Plant height (cm) (80 DAS)	No. of branches $plant^{-1}$ (80 DAS)	No. of leaves $plant^{-1}$ (60 DAS)	Leaf area $plant^{-1}$ (dm^2) (60 DAS)	Total dry matter (g $plant^{-1}$) (at harvest)
T_1 Absolute control	45.1	4.46	16.47	7.37	21.32
T_2 FYM @ 5.0 t ha^{-1}	51.5	6.18	18.46	6.85	23.31
T_3 15 kg N ha^{-1} + biofertilizer	53.2	5.89	18.11	7.61	23.19
T_4 30 kg N ha^{-1}	53.4	6.35	18.93	8.12	24.28
T_5 45 kg N ha^{-1}	54.4	7.79	19.83	9.41	26.15
T_6 T_2 + 30 kg N ha^{-1} + biofertilizer	55.8	8.65	22.48	11.76	32.18
T_7 50 kg N ha^{-1}	54.8	8.31	21.13	10.93	26.17
SE (m) ±	0.75	0.56	1.12	1.07	1.43
CD (P=0.05)	2.34	1.76	3.37	3.22	4.29

Table 2. Plant physiological parameters of soybean as influenced by various treatments

Treatments	Leaf thickness (mg cm^{-2}) (60 DAS)	Canopy temperature (^{0}C) (60 DAS)	Leaf water potential (MPa) (60 DAS)	PAR (J $^{m-2}$) (60 DAS)	Chlorophyll content Index (60 DAS)
T_1 Absolute control	15.82	29.10	5.23	0.71	38.23
T_2 FYM @ 5.0 t ha^{-1}	15.98	29.53	5.50	0.73	38.74
T_3 15 kg N ha^{-1} + biofertilizer	15.62	29.10	5.29	0.71	38.57
T_4 30 kg N ha^{-1}	15.21	29.63	5.32	0.74	38.98
T_5 45 kg N ha^{-1}	16.23	29.67	5.44	0.75	39.11
T_6 T_2 + 30 kg N ha^{-1} + biofertilizer	17.33	30.27	5.52	0.76	40.16
T_7 50 kg N ha^{-1}	17.13	29.77	5.46	0.75	39.92
SE (m) ±	0.31	0.21	0.11	0.01	0.35
CD (P=0.05)	0.92	0.62	-	0.03	1.06

Table 3. Seed yield, straw yield, net monetary returns and benefit : cost ratio of soybean as influenced by different treatments

	Treatments	Crop yield and economics			
		Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	NMR (Rs. ha^{-1})	B:C ratio
T_1	Absolute control	1630	1894	35626	2.31
T_2	FYM @ 5.0 t ha^{-1}	1957	2191	31379	1.71
T_3	15 kg N ha^{-1} + biofertilizer	1823	2065	37848	2.17
T_4	30 kg N ha^{-1}	2117	2270	49414	2.55
T_5	45 kg N ha^{-1}	2229	2469	53619	2.67
T_6	T_2 + 30 kg N ha^{-1} +biofertilizer	2391	2625	47401	2.06
T_7	50 kg N ha^{-1}	2327	2552	56921	2.77
SE (m) ±		90	90	2196	-
CD (P=0.05)		269	269	6586	-

REFERENCES

Abbas, G., Z.Abbas, M.Aslam, A.U.Malik, M.Ishaqueand F.Hussain, 2011. Effects of organic and inorganic fertilizers on mungbean (*Vigna radiata* L.) yield under arid climate. Intl. Res. J.Pl. Sci.**2**(4):094-098.

Agarwal, D.K., S.D.Billore, A.N.Sharma, B.U.Dupare and S.K. Srivastava, 2013. Soybean: Introduction, Improvement, and Utilization in India-Problems and Prospects. Agric. Res. 2:293–300.

Anonymous, 2018. ICAR- Indian Institute of Soybean Research, Indore. Soybean Monitor/Market Watch. https://iisrindore.icar. gov.in/pdfdoc/soybeanmonitorsept2019.pdf

Bachhav, S.D., S.H. Patel, and P.K. Suryawansi, 2012. Yield and economics of soybean influenced by integrated nutrient management practices. Intl. J. Forestry and Crop Improv.**3**(2):140-143.

Desai, C.K., G.J. Patel, and K.N. Rana, 2019. Effect of organic manures, bio-fertilizers, levels of nitrogen and phosphorus on growth and yield of soybean. J.Pharmacogn. Phytochem.**8**(2):966-969.

Deshkari, S.M, P.C.Pagar, S.T.Dangore, V.S.Khawale and H.S. Mendhe, 2019. Effect of Imazethapyr + Imazamox on weed control in soybean, J. Soils and Crops.**29** (2) : 280-284.

Farid, A.H., T. Magdi, and Abdelhamid, 2013. Nutrient Management Practices for Enhancing Soybean (*Glycine max* L.) Production. Acta Biologica Colombiana.**18**(2):3-14.

Javaid, A., and N. Mahmood, 2010. Growth, nodulation and yield response of soybean to biofertilizers and organic manures. Pak. J. Bot.**42**(2): 863-871.

Khaim, K., M.H.A. Chowdhury and B.K. Saha, 2013. Organic and inorganic fertilization on the yield and quality of soybean. J. Bangladesh Agril. Univ. **11**(1): 23–28.

Lyngkhoi, F.N., Sentimenla and A,K, Singh, 2020. Response of soybean to different levels of phosphorus and sulphur on growth, yield and quality. J. Soils and Crops.**30** (1) :49-55.

Rathod, K.S., R. Pannu and S.S. Dahiya, 2012. Effect of nitrogen management on soil fertility and NPK uptake in soybean. J. Food Legumes. **25:** 153-55.

Ritu, B., and K.V. Harpreet, 2019. Nitrogen management in Soybean: A Review. Agril. Reviews.**40**(2):129-135.

Selim, M.M. 2020. Introduction to the Integrated Nutrient Management Strategies and Their Contribution to Yield and Soil Properties: A Review Article. Intl. J. Agron. **2020**:01-04.

Singh, S.R., G.R. Najar and U. Singh, 2007. Productivity and nutrient uptake of soybean (*Glycine max*) as influenced by bio-inoculants and farmyard manure under rainfed conditions. Indian J.Agron.**52**(4): 325-329.

Zhijia, G., J. Zhang, and L. Caifeng, 2017. Effects of starter nitrogen fertilizer on soybean root activity, leaf photosynthesis and grain yield. PLoS One. **12**(4): e0174841.

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