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RESPONSE OF SOYBEAN (*Glycine max* L. Merrill) TO DIFFERENT SOURCES OF FERTILIZERS ON GROWTH, YIELD AND QUALITY

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ABSTRACT

A field experiment was conducted in the experimental Research Farm of School of Agricultural sciences (SAS), Nagaland University, Medziphema, Nagaland during the period of June to November, 2019 to study on "Response of soybean (*Glycine max* L. Merrill) to different sources of fertilizers on growth, yield and quality". The experiment was laid out in Randomized Block Design (RBD) with 12 treatments and 3 replications. The study revealed that the incorporation of different sources of fertilizers significantly influenced the plant growth, yield attributes and quality parameters such as oil and protein content, nutrient uptake and available nutrients in soil after harvest. The crop growth attributes such as plant height, number of leaves plant^{-1} and number of nodules plant^{-1} were significantly influenced by its application. The highest seed yield of 2426.82 kg ha^{-1} and stover yield of 2989.10 kg ha^{-1} were recorded with the treatment of 100% RDF+MB+FYM and it was found significantly superior over all other treatments. The quality of soybean was improved by 100% RDF+MB+FYM in the presence of different sources of fertilizers. The available soil nutrient, nutrient content and uptake by soybean were recorded to be maximum with the treatment of 100% RDF+MB+FYM.

INTRODUCTION

Soybean (*Glycine max* L. Merrill) is a kharif crop belonging to Leguminosae family. It can be grown in a wide range of climates and soils varying from sandy loam to clay soil. An average temperature of 26 - 30°C is required for growing soybean. It is one of the major oilseed crops of the world accounting for nearly 50% of the world area and production of oilseeds. It contains 40% of high quality protein and 20 % of oil. It is a rich source of amino acids like arginine, lysine, vitamin C, minerals, salts (thiamine and riboflavin) (Singh *et al*., 2003). It is called the "Golden Bean" and "Wonder crop" of the twentieth century and "Miracle crop" of the 21st century because of its high nutritional value and myriad forms of uses. Soybean oil serves as a raw material for antibiotics, paints, varnishes, lubricants etc and food products such as textured vegetable protein (TVP), soybean curd, fried and roasted soynut. Soybean helps in preventing heart diseases, diabetes, obesity etc (Kim, 2021). The global soybean production in the world is estimated at 333.67 million tonnes from an area of 120.50 million hectares and ranks fourth in area and fifth in production (Agricultural Market Intelligence Centre, PJTSAU Soybean Outlook, 2021). In India, the area and production of soybean are 12.81 million hectares and 12.90 million tonnes (DES, MoA and FW, 2020). Among the various oilseed crops of the world, soybean stood first in contributing approximately 23% of vegetable oil production. In India, Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, Andhra Pradesh, Chhattisgarh are the major soybean cultivating states.

The amount of nitrogen fixed through symbiotic nitrogen fixation of *Rhizobium i.e* 125-150 kg N ha^{-1} is utilized (chandel *et al*.,1989) and leaves about 30-40 kg ha^{-1} for the succeeding crop (Saxena and Chandel, 1992). It ameliorates soil fertility by fixing atmospheric N_2 upto 50-300kg ha^{-1} (Keyser and Fudi, 1992).

Vesicular – Arbuscular Mycorrhizae (VAM) plays a prominent role in phosphate availability by improving absorption of available nutrients from soil as the fungus alters the root morphology. VAM fungi increased plant growth enhances soil fertility.

FYM is the most easily available organic manure in the soil that enhances carbon sequestration, protects soil from erosion, supplies essential plant nutrients through decomposition process (Abiven *et al*.,2009) thereby enhancing yield attributes and total seed yield (Rudresh *et al*.,2005). The total nitrogen content in seed and stover was also affected significantly. Use of FYM combined with mycorrhizal biofertilizer results in positive effects on the soybean growth and yield characters.

Chemical fertilizers like N, P and K are considered as the major contributor to enhancing crop production and maintaining soil fertility. However long term use of chemical fertilizers lead to decline in crop yields and soil fertility in soybean cultivated area. Therefore, integrated approach will enhanced soil fertility and crop production (Koushal and Singh, 2011 and Sikka *et al*., 2013).

The combined application of various nutrient sources have been found to significantly increase the crop growth parameters, yield and yield attributes. Application of 75 % NPK + 25 % N through VC + Rhizobium + PSB significantly increased the pant growth parameters, yield and yield attributes of soybean (Verma *et al*., 2017). The combined application of 100% RDF+PSB+FYM significantly improved the growth parameters, yield and yield attributes of mung bean (Harish *et al*., 2023). Similar observation was also reported by Mangaraj *et al*. (2023) in rice-mungbean growing system with 50% NPK+ 50% RDN" FYM to rice and 75% NPK + Rhizobium+ PSB. Roopashree *et al*., 2020 also observed significant increase in NPK uptake with application of RDF along with FYM in babycorn. The integrated nutrient application of organic manure and chemical fertilizer in maize-wheat cropping sequence have been found to increase crop yield and production thereby enhancing sustainability in crop productivity (Chahal *et al*.,2019).

The North-Eastern region of India is bestowed with favourable agro-climatic condition and soil for growing pulses yet it falls under 82% deficit of its pulses requirement (Das *et al*., 2016). The cultivation of soybean in North-East Region of India has been found to be a good prospects and profitable enterprise as their productivity is high despite the total area under soybean cultivation is low (Singh *et al*., 2001). The area and production of soybean in Nagaland is 6126 ha and 7460 MT (Statistical handbook, 2022). It is utilized as a pulse crop as well as in fermented form locally known as Axone. Though it is found to be growing in all the districts yet it is mostly grown for home consumption only (Mere *et al*., 2015) because its production is low owing to soil nutrient deficiency as well as due to use of imbalance fertilizers (Bhattacharjee *et al*., 2011). The low production of soybean due to nutrient deficiency, lack of recycling of organic sources and imbalance fertilization was also reported by Chaturvedi *et al*. (2010).

Keeping all the above facts in view, the present investigation was undertaken with the objectives to study the "Response of Soybean (*Glycine max* L. Merrill) to Mycorrhizal Biofertilizer and Fertilizers on Growth, Yield and Quality".

MATERIALS AND METHODS

The present investigation entitled "Response of soybean (*Glycine max* L. Merrill) to different sources of fertilizers on growth, yield and quality" was conducted in the experimental Research Farm of School of Agricultural sciences (SAS), Nagaland University, Medziphema, Nagaland in 2019. The site is situated at 25°45'43" N latitude and 93°53'04" E longitude at an elevation of 310 m above mean sea level. The mean temperature ranges from 21°C to 33°C during the growing period with an average rainfall ranging from 2000-2500 mm per annum. The experiment was laid out in randomised block design (RBD) comprising of 12 treatments and 3 replications such as T_1 -Control,T_2 -100% RDF, T_3 -100%RDF+MB, T_4-100%RDF+FYM, T_5-100%RDF+MB+FYM,T_6-75%RDF+MB, T_7 -75%RDF+FYM, T_8 -75%RDF+MB+FYM, T_9 - 50%RDF+MB, T_{10} - 50%RDF+FYM, T_{11} -50% RDF+MB+FYM, T_{12} -125%RDF. Soil samples were collected from the experimental site, processed and analysed using prescribed standard procedure. The experimental soil was sandy loam in texture, acidic in nature having medium organic carbon (%) with low nitrogen, medium in phosphorus and low in sulphur. The recommended dose of NPK and S fertilizers, FYM and mycorrhizal biofertilizer used were 20:60:40:30, 2t ha^{-1} and 12 kg ha^{-1}. Soybean variety used was JS 97-52. Oil content was estimated using soxhlet extraction unit (AOAC 1960) and seed protein content (%) was estimated by multiplying percent N content in seed with the factor 6.25. After harvest, the soil samples were analysed for organic carbon (Walkley and Black, 1934), soil pH (Jackson, 1973) available N using modified kjeldhal method described by Subbiah and Asija (1956), available P by Baruah and Barthakur (1997), available K by Black (1965) and available S by turbidimetric method as given by Tabatabi and Bremer (1970). The dried seeds and stover samples were grounded and kept in polythene bags for chemical analysis of N, P, K and S content which were estimated using modified Kjeldahl method (AOAC,1995), Ammonium molybdate vanadate by Chapman and pratt (1962), Flame Photometer by Hanway and Heidal, (1952) and turbidimetric method by Chesnin and Yien (1950).The experiment datas were recorded and analyzed statistically using analysis of variance (ANOVA) as described by Cochran and Cox (1957).

RESULTS AND DISCUSSION

Effect on growth parameters

The growth parameters were found to be increased significantly. The maximum plant height, number of leaves plant^{-1} and number of nodules at flowering stage recorded were 77.75 cm, 35.53 and 47.60 at T_5 (100%RDF+MB+FYM) and the lowest was recorded at T_1 (control) as shown in table.1. The increase in uptake of plant nutrients due to enhance metabolic activities and root growth leads to increase in growth parameters (Jaga *et al*., 2015 and Cirak *et al*., 2006). Moreover, the increased in nodulation might be due to abundant supply of organic matter which increased the microbial activity and further improved soil aeration and soil environment for nodulation (Prakash *et al*., 2001). The growth parameters were found to be increased significantly with the application of 100 % RDF + FYM + PSB + Azotobacter in chilli by Sikarwar *et al*. (2023). Similar observation was reported by Kalita *et al*. (2019) in growth parameters of toria with Azotobacter + PSB + 75 % of recommended NPK + FYM treatment. Devi *et al*. (2013) also observed that nodulation in soybean were significantly improved with the use of 75% RDF + VC @ 1t ha^{-1} + PSB.

Effect on quality

It is observed that increasing levels of RDF+MB+FYM significantly increased the number of pods, filled pods plant^{-1} and number of seeds pod^{-1} in soybean (Table. 2). The maximum number of pods plant^{-1}, filled pods plant^{-1} and number of seeds pod^{-1} recorded were 82.27, 69.67 and 2.92 at T_5 (100%RDF+MB+FYM) and the lowest were observed at T_1 (control). There were also significant increase in seed and stover yield with increasing levels of RDF+MB+FYM (Table. 2). The highest seed and stover yield recorded were 2426.82 and 2989.10 kg ha^{-1} at treatment T_5 (100%RDF+MB+FYM) while the lowest were recorded at T_1 (control) as shown in table. 2. The seed oil and protein content were also increase with maximum oil content of 20.07 % and protein content of

Table 1: Effect of different sources of fertilizers on growth attributes of soybean

Treatment	Plant height (cm)	Number of leaves plant^{-1}	Number of nodules at flowering stage
T1 – Control	57.32	23.73	26.47
T2 - 100% RDF	68.55	29.93	39.4
T3 - 100%RDF+MB	70.4	31.27	41.73
T4 - 100%RDF+FYM	72.42	32.53	43.47
T5 - 100%RDF+MB+FYM	77.75	35.53	47.6
T6 - 75%RDF+MB	63.2	25.93	32.4
T7 - 75%RDF+FYM	65.32	26.87	35.73
T8 - 75%RDF+MB+FYM	67.3	28.07	37.27
T9 - 50%RDF+MB	58.55	24.27	27.87
T10 - 50%RDF+FYM	60.46	24.93	28.57
T11 - 50% RDF+MB+FYM	61.88	25.13	30.53
T12 - 125%RDF	74.97	34.87	45.33
SEm±	1.71	0.87	1.07
CD (p=0.05)	5.02	2.56	3.14

Table 2: Effect of different sources of fertilizers on yield attributes and quality of soybean

Treatments	Number of pods plant^{-1}	Number of filled pods plant^{-1}	Number of seeds pod^{-1}	Seed yield (kg ha-1)	Stover yield (kg ha^{-1})	Oil content (%)	Protein content (%)
T1 – Control	60.27	46.87	2.2	1814.92	2496.92	15.87	36.93
T2 - 100% RDF	73.6	61.13	2.72	2191.27	2716.37	17.97	39.7
T3 - 100%RDF+MB	75.87	62.8	2.73	2225.6	2773.45	18.73	39.85
T4 - 100%RDF+FYM	78.67	65.67	2.83	2254.85	2826.12	19.27	39.72
T5 - 100%RDF+MB+FYM	82.27	69.67	2.92	2426.82	2989.1	20.07	39.9
T6 - 75%RDF+MB	67.73	54.87	2.52	1967	2596.52	16.93	39.69
T7 - 75%RDF+FYM	70.67	56.87	2.63	2004.67	2618.33	17.13	39.58
T8 - 75%RDF+MB+FYM	72.2	58.67	2.65	2089.8	2642.4	17.33	39.69
T9 - 50%RDF+MB	61.17	47.27	2.23	1852.67	2512.54	16.13	37.8
T10 - 50%RDF+FYM	63.07	49.4	2.3	1893.25	2525.2	16.37	37.62
T11 - 50% RDF+MB+FYM	65.93	51.93	2.45	1928.67	2546.55	16.67	38.1
T12 - 125%RDF	80.6	68.07	2.84	2419.9	2945.77	19.47	39.87
SEm±	1.38	1.37	0.06	39.2	41.89	0.45	0.69
CD (p=0.05)	4.05	4.02	0.19	114.97	122.86	1.31	2.01

39.90 % recorded at T_5 (100%RDF+MB+FYM) and T_1 (control) recorded the lowest value (Table. 2). This increase in yield attributes and quality might be attributed to enhance nutrient availability and uptake which leads to increase vegetative and reproductive growth in plants (Dekhane *et al.*, 2011 and Raj *et al.*, 2017). Singh *et al.* (2016) reported significant increase in grain and stover yield with 125% recommended dose of NPK + Azotobacter + PSB in wheat. The protein and oil content in mustard was also improved significantly with the application of chemical fertilizers, FYM and biofertilizers (Kumar and Singh. 2019)

Effect on Nutrient content and uptake

There was a significant variation of N content in seed and non-significant N content in stover (Table 3). The maximum N content in seed recorded was 6.94 at T_5 (100% RDF+MB+FYM) and the lowest was recorded in T_1 (control). The maximium N content in stover recorded was 1.76 at T_5 (100% RDF+MB+FYM) and the lowest was observed at T_1 (control). The P content in seed was observed to be non-significant, however in stover it was significant with maximum P content in seed was 0.62 % and in stover was 0.48 % at T_5 (100% RDF+MB+FYM) and their lowest were recorded at T_1 (control). There was a non -significant variation in K content in seed and stover among various treatment. The maximum K content in seed and stover were observed at T_5 (100% RDF+MB+FYM) *i.e.*, 2.29 and 0.90 % and lowest were recorded in T_1 (control). The S content in seed and stover were found to be significant with maximum S content in seed and stover observed at T_5 (100% RDF+MB+FYM) *i.e.*, 0.34 and 0.40 % and lowest were recorded in T_1 (control) as shown in table. 3. It was observed that NPK&S uptake by seed and stover significantly increased as shown in table. 4. The maximum N uptake recorded was 219.42 kg ha^{-1} at T_5 - 100% RDF+MB+FYM which was followed by 214.30 kg ha^{-1} at 125% RDF. The lowest was recorded in T_1 (control). The maximum P uptake recorded at T_5 -100% RDF+MB+FYM was 29.72 kg ha^{-1} followed by 28.15 kg ha^{-1} at T_{12} - 125% RDF and the lowest was recorded in T_1 (control). The maximum K uptake observed at T_5 - 100% RDF+MB+FYM was 82.72 kg ha^{-1} followed by 79.93 kg ha^{-1} at T_{12} -125% RDF and the lowest was recorded in T_1 (control). The maximum S uptake recorded in treatment (T_5) 100% RDF+MB+FYM was 20.42 kg ha^{-1} followed by 19.05 kg ha^{-1} at T_{12} - 125% RDF and lowest was recorded in T_1 (control). This might be due to enhance nutrient availability in the soil because of greater solubilisation of phosphate and nitrogen fixation by the incorporation of microbial biofertilizer thereby enhancing nutrient uptake by plants (Ponmurugan and Gopi, 2006). Organic manure also enhances nutrient uptake through root stimulation and better metabolic balance enhancing development growth thereby increasing nutrient uptake by plants (Singh and Yadav 2008).

Table 3. Effect of different sources of fertilizers on nutrient content of soybean

Treatments	Nutrient content of seed (%)				Nutrient content of stover (%)			
	N	P	K	S	N	P	K	S
T1 – Control	5.9	0.52	1.82	0.26	1.55	0.29	0.65	0.29
T2 - 100% RDF	6.47	0.58	2.23	0.29	1.7	0.42	0.85	0.36
T3 - 100%RDF+MB	6.49	0.6	2.25	0.3	1.71	0.44	0.85	0.37
T4 - 100%RDF+FYM	6.55	0.59	2.26	0.3	1.73	0.43	0.86	0.39
T5 - 100%RDF+MB+FYM	6.94	0.62	2.29	0.34	1.76	0.48	0.9	0.4
T6 - 75%RDF+MB	6.4	0.56	2.18	0.27	1.61	0.4	0.83	0.34
T7 - 75%RDF+FYM	6.45	0.55	2.19	0.28	1.62	0.4	0.84	0.34
T8 - 75%RDF+MB+FYM	6.46	0.58	2.21	0.28	1.65	0.41	0.85	0.35
T9 - 50%RDF+MB	6.02	0.54	2.15	0.24	1.56	0.34	0.67	0.3
T10 - 50%RDF+FYM	6.05	0.54	2.18	0.25	1.57	0.32	0.69	0.31
T11 - 50% RDF+MB+FYM	6.1	0.55	2.18	0.26	1.59	0.37	0.72	0.33
T12 - 125%RDF	6.87	0.6	2.27	0.32	1.75	0.47	0.88	0.39
SEm±	0.1	0.02	0.09	0.01	0.05	0.02	0.06	0.02
CD (p=0.05)	0.29	NS	NS	0.03	NS	0.05	NS	0.06

NS=Non-significant at 5%levelofsignificance

Table 4: Effect of different sources of fertilizers on nutrient uptake of soybean

	Nutrient uptake (seed + stover) (kg ha^{-1})			
Treatments	N	P	K	S
T1 – Control	137.36	14.15	42.2	9.33
T2 - 100% RDF	188.15	23.37	72.02	15.7
T3 - 100%RDF+MB	191.86	25.1	74.12	16.48
T4 - 100%RDF+FYM	198.7	25.03	76.6	17.98
T5 - 100%RDF+MB+FYM	219.42	29.72	82.72	20.42
T6 - 75%RDF+MB	167.17	20.32	63.05	13.1
T7 - 75%RDF+FYM	171.6	19.83	65.28	13.7
T8 - 75%RDF+MB+FYM	179.35	22.1	68.65	14.72
T9 - 50%RDF+MB	149.02	16.75	53.5	10.56
T10 - 50%RDF+FYM	153.47	16.32	57.22	11.63
T11 - 50% RDF+MB+FYM	157.72	18.42	59.3	12.42
T12 - 125%RDF	214.3	28.15	79.93	19.05
SEm±	7.07	0.96	1.78	0.78
CD (p=0.05)	20.75	2.81	5.21	2.3

Table 5: Effect of different sources of fertilizers on soil physicochemical properties

Treatments	Soil pH	Organic carbon (%)	Available nutrient (kg ha^{-1})			
			N	P	K	S
T1 - Control	5.15	1.67	227.72	16.9	130.37	18.82
T2 - 100% RDF	5.26	1.83	281.85	27.8	191.56	26.91
T3 - 100%RDF+MB	5.3	1.85	282.12	30.38	191.88	26.93
T4 - 100%RDF+FYM	5.33	1.87	284.52	28.32	192.57	26.95
T5 - 100%RDF+MB+FYM	5.39	1.92	290.85	31.93	193	27.02
T6 - 75%RDF+MB	5.17	1.76	259.32	22.58	183.62	22.44
T7 - 75%RDF+FYM	5.19	1.79	260.45	21.97	183.6	22.47
T8 - 75%RDF+MB+FYM	5.22	1.81	261	23.15	183.78	22.58
T9 - 50%RDF+MB	5.08	1.71	249.25	20.98	156	18.93
T10 - 50%RDF+FYM	5.12	1.72	249.32	20.17	157.92	18.98
T11 - 50% RDF+MB+FYM	5.15	1.75	252.6	21.3	158.02	19.01
T12 - 125%RDF	5.36	1.89	289.32	30.96	192.86	26.98
SEm±	0.07	0.05	5.76	1.02	5.79	0.86
CD (p=0.05)	NS	NS	16.89	3	16.97	2.52

NS=Non-significant at 5% level of significance

Kaur (2016) reported that the application of inorganic fertilizer, fym and biofertilizer significantly increased the N, P and K content in seed and stover of green pea. The integrated use of chemical fertilizer, fym and biofertilizer significantly increased the N, P and K content and uptake by seed and stover of maize (Meena *et al*., 2013). Application of inorganic fertilizers along with biofertilizers significantly increased the nutrient content and uptake of N, P and K in seed and stover of maize (Janardhan *et al*., 2023). Namdeo *et al*. (2021) reported increase in the nutrient content and uptake of N, P, K and S in seed and stover of mustard with combined application of RDF+FYM+Azotobacter. Lakshman *et al*. (2023) also reported significant increase in the N, P and K content and uptake in seed and stover of green gram with the application of 75% N through vermicompost, seed treatment with 5 ml kg seed^{-1} of Rhizobium and Bio NPK consortium 1 L ha^{-1}.

Effect on soil fertility

The application of different levels of RDF+MB+FYM observed non-significant increase in soil pH and organic carbon after harvest (Table 5). The highest soil pH and OC recorded were 5.39 and 1.92 % at T_5 (100% RDF+MB+FYM) while the lowest were recorded at control T_1. Soil available NPK and S after harvest were observed to be significant as shown in table. 5. The highest available NBPK&S recorded were 290.85, 31.93, 193.00 and 27.02 kg ha^{-1} at T_5- 100%RDF+MB+FYM and the lowest were recorded in T_1 (control). This is due to mineralisation aided by the incorporation of FYM and microbial biofertilizer which increased the soil available N and K (Kumar *et al.*, 2019 and Laxminarayan and Patiram 2006). The maximum available P after harvest might be due to the added organic manures which produced organic acids on their decomposition in soil thereby mobilising soil P (Rao, 2003). Parewa *et al.* (2014) also observed that the soil available NPK were increased with the application of 100% NPK fertilizer, FYM @ 10 t ha^{-1} and bioinoculants in inceptisols. Rai *et al.* (2014) reported that combined use of chemical fertilizers, vermicompost, biofertilizers and fym in onion crop enhanced the availability of soil N, P, K and S as compared to use of chemical fertilizer alone.

CONCLUSIONS

On the basis of the above findings, it may be concluded that among the various treatment combinations, the application of 100%RDF+MB+FYM (T_5) exhibited better performance in soybean crop thereby influencing the plant height, number of leaves plant^{-1}, number of nodules plant^{-1}, oil and protein content of soybean. The seed and stover yield, nutrient content and uptake in seed and stover of soybean were increased signicantly at T_5 (100% RDF+MB+FYM). The nutrient availability in soil after harvest were also improved with the increasing level of nutrient sources. So, it can be concluded that the nutrient management in soybean with 100% RDF+MB+FYM (T_5) was found to be most effective in increasing the yield and quality of soybean and residual soil nutrient status under the acidic soil conditions of Nagaland state.

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