The Pharma Innovation Journal 2023; 12(6): 1601-1605

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(6): 1601-1605

www.thepharmajournal.com
Received: 01-03-2023
Accepted: 02-04-2023

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Effect of organic and bio fertilizer on growth and yield of soyabean (*Glycine max*) in doon valley of Uttarakhand

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Abstract
A field experiment was conducted in summer season of 2022-23 at crop research centre Shri Guru Ram Rai University, School of Agricultural Sciences, Dehradun, Uttarakhand to evaluate the "Effect of organic and bio fertilizer on growth and yield of soyabean in Doon Valley of Uttarakhand". The experiment was laid out in randomized block design with three replications and 12 treatments. The treatments comprised following levels of different organic and bio fertilizer *viz*. T_1 control, T_2 control + FYM (10 kg/hc) 6kg, T_3 control + FYM (20kg/hc) 12kg, T_4 control + FYM (30kg/hc) 18 kg, T_5 rhizobium + control, T_6 rhizobium + FYM (10kg/hc), 6kg T_7 rhizobium + FYM (20kg/hc) 12kg T8 rhizobium + FYM (30kg/hc) 18kg, T_9 VAM + Control, T_{10} VAM+FYM (10kg/hc) 6kg, T_{11} VAM + FYM (20kg/hc) 12kg, T_{12} VAM + FYM (30 kg/hc) 18kg soyabean (pant soya 26) was done in 25 June 2022. Kg/hc). The growth parameter like plant height (92.52cm), no. of branches/plant (16.767), dry weight of root nodules (28.167 mg) were recorded highest with application of T_{12} VAM + FYM (30 kg/hc) 18kg followed by VAM+ FYM (20kg/hc) 12 kg. The yield parameters *viz*, Straw yield (38.997 kg/ha), Seed yield (27.689 kg/ha) were also recorded highest with VAM inoculation and FYM application which was at par with FYM @18 kg/per hectare.

Keywords: Plant height, treatments comprised

Introduction

In India, Soybean (*Glycine max*) is a significant oilseed crop. Soybean is sometimes known as "golden bean." India is fourth in terms of area and fifth in the world for soybean production. Because of the efforts of the players in the production system, soybean is now an important oilseed crop in India. Area and production have increased at previously unheard-of rates during the past 40 years. The horizontal growth of soybean in India from just 30000 ha in 1970 to a projected 9.3 million ha in 2010 shows the crop's success. It has developed into a significant commercial oilseed crop in Madhya Pradesh and has excellent potential as a kharif oilseed. One of the major factors limiting North Plains' low soybean productivity is unbalanced nutrition. Incorporating bio-fertilizers into the soil combined with inorganic fertilizers increases crop productivity and maintains soil health for a longer period of time (Manna *et al*., 2007) [7]. For generations, soybean has been associated with meat, milk, cheese, bread, and oil by the people of China, Japan, Korea, Manchuria, the Philippines, and Indonesia. This may be the cause of its receiving nicknames like "Cow of the Field" or "Gold from Soil" in these nations. The economic condition of farmers has improved significantly thanks to soy in several regions of the nation. Acc to Ficcii Due to the vast export market for soybean de-oiled cake, it typically brings in better income for the farmers. Despite the fact that India's soy production expanded at a CAGR of 9.60% from 6.87 million tonnes in 2004-05 to 15.68 million tonnes in 2012-13. The majority of soy protein is a heat-stable storage protein. This thermal stability makes it possible to produce soy food products that need to be cooked at high temperatures, such tofu, soy milk, and textured vegetable protein (soy flour). The protein in other legume seeds and pulses and soy protein are virtually comparable. Large rises in global demand for meat products, particularly in developing nations like China, which alone accounts for more than 60% of imports, have been a major driver of the industry's explosive growth. Through the process of biological nitrogen fixation (BNF), biofertilizers can fix atmospheric nitrogen and solubilize plant nutrients like phosphates and potash. Additionally, they can stimulate plant growth by synthesizing various growth-promoting compounds, and their C: N ratio of 20:1 indicates their stability. (Wani *et al*., 2013; Borkar, 2015) [12, 2].

Plants can access nutrients that are naturally abundant in soil and the environment thanks to biofertilizers. These have been proven to be inexpensive, efficient inputs that pose no environmental risks in many field experiments. (Ghosh, 2004; Sahoo *et al.*, 2014; Borkar, 2015) [4, 2]. Soybeans account for 10% of India's domestic oil production, and the country exports soy meal, which generates substantial foreign revenue (Joshi 2003). Soybean seed is one of the key sources of nourishment for both people and animals. Palmitic acid (16:0), stearic acid (18:0), oleic acid (18:1), linoleic acid (18:2), and linolenic acid (18:3) are the five fatty acids that make up soybean oil. These five fatty acids make up an average of 10%, 4%, 18%, 55% and 13% of soybean oil, respectively. Low oxidative stability brought on by this fatty acid composition restricts the usage of soybean oil in both food goods and industrial applications. According to oxidative degradation of soybean oil, for instance, causes rancidity and off flavors in food products as well as the formation of sticky polymers in soybean-derived biodiesel that clogs oil filters. It is important to note that numerous researches on crop germplasm collections have found significant variability in the levels of saturated and unsaturated fatty acids (Rebetzke GJ, Burton and Fernandez-Martinez J, et all). Such differences might present opportunities for creating improved combinations with premium edible and specialized industrial oils. Undoubtedly, genetic and environmental factors. (Goffman FD and Mourtzinis Set all) play a role in the diversity of fatty acid composition, which in turn affects the fatty acids' processing properties and nutritional value. In the tropics, subtropics, and temperate climes, the crop is grown in warm temperatures. Although soybeans may grow in both very high and very low temperatures, their growth rates are slower at 35 °C and below 18 °C. At temperatures below 24 °C, flowering may be postponed in some cultivars. For crop production, minimum temperatures should be at 15 °C and 10 °C, respectively, for growth. Soyabean can grow and yield with as little as 180mm of in-crop rain but could expect a 40-60 percent yield decline compared to optimal conditions. The ideal rainfall range is between 500 and 1000mm. Depending on soil type and stored soil moisture, crop failure would be expected if less than 180mm of rain were received in crop. ‘Biofertilizers can fix atmospheric nitrogen through the process of biological nitrogen fixation (BNF) and solubilize plant nutrients like phosphates, potash; in addition, it also stimulates plant growth through synthesis of different growth promoting substances and has C: N ratio 20:1 indicating its stability (Wani *et al.,* 2013 Borkar, 2015) [12, 2]. The main sources of biofertilizers are bacteria, fungi, and cyanobacteria (bluegreen algae) (Chittora *et al*., 2020). The most striking relationship that these have with plants is symbiosis, in which the partners derive benefits from each other (Al Abboud *et al*., 2014) [1]. Biofertilizers are products applied on the surface of a plant, seeds or in soil and contain live microorganisms that promote plant growth and development. These products may include bacterial species such as Rhizobium, Azotobacter, VAM and Azospirilium as well as blue green algae (BGA) (Machhar, Rg & C, SADHU & Patel, Sanjay & Hitesh, Kacha. (2016) [8]. In 1987, the National Research Centre for Soybeans was founded. In the XI Plan, the NRC for Soybean has been upgraded to a status of Directorate of Soybean Research to provide adequate support to R&D in soybean to capitalise on the benefits. This is due to the crop's spectacular growth, its role in the oil and national economy, improvement in the socioeconomic status of farmers, as well as its potential to alleviate the widely prevalent energy protein malnutrition and to provide functional and health benefits. Two programmers’, the Directorate of Soybean Research (DSR*)* and the All India Coordinated Research Project on Soybean (AICRP on Soybean), are now in operation for soybean R&D. Hence, the study was undertaken to evaluate the co-inoculation of VAM, FYM and *Rhizobium*, with NPK fertilizers on growth parameters, yield, nutrient uptake of soybean.

Materials and Methods

Field experiment was conducted in Dehradun on Effect of organic and bio fertilizer on growth and yield of Soyabean in Dehradun valley of Uttarakhand”. The experiment was carried out in kharif season of 2022-2023 at crop research centre at SGRR University, School of Agricultural Sciences, Pathri Bagh, Dehradun, Uttarakhand, India. The elevation of the city of Dehradun, which is predominantly situated in the Doon Valley, varies from 410 metres in Clement Town to more than 700 metres in Malsi. However, the average height is 450 metres above sea level. Dehradun is situated between latitude 30°18' N and longitude 78°18' E on a geographical scale. A humid subtropical climate prevails in Dehradun. It can be anything from balmy to quite frigid depending on altitude. For a few days in the summer, temperatures can get as high as 44 °C, and North India frequently experiences hot winds called loo. Typically, the wintertime ranges from 1 to 20 °C. The location receives average 2,073.3 mm (81.63 in) of yearly rainfall. The city experiences the most rainfall between the months of July and August, which also happen to be the wettest months. Throughout the monsoon season, extended periods of heavy rain are frequent. The subtropical climate of Dehradun is humid. For a few days in the summer, temperatures in North India can reach 44 °C, and a sweltering wind known as Loo blows through the region. The normal wintertime temperature is between 10 and 20 degrees Celsius, and winters in plains regions are frequently foggy. Although below-freezing temperatures can occasionally occur in Dehradun during particularly cold spells, this is unusual. Throughout the monsoon season, there are frequently extended periods of heavy rainfall. The average annual rainfall is 2074 millimeters. Dehradun and the surrounding plain regions of Uttarakhand receive more rain than Assam and almost the same amount as coastal Maharashtra. Agriculture benefits from fertile alluvial soil, excellent drainage, and a lot of rain. The experiment consisted of seven treatments namely T_1 control, T_2 control + FYM(10 kg/hc) 6kg, T_3 control + FYM (20kg/hc) 12kg, T_4 control + FYM (30kg/hc) 18 kg, T_5 rhizobium +control, T_6 rhizobium +FYM (10kg/hc), 6kg T_7 rhizobium +FYM (20kg/hc)12kg T8 rhizobium +FYM (30kg/hc)18kg, T_9 VAM + CONTROL, T_{10} VAM+FYM (10kg/hc) 6kg, T_{11} VAM +FYM (20kg/hc)12kg, T_{12} VAM + FYM (30kg/hc)18kg soyabean (pant soya 26) was done in 25 june, 2022. VAM and rhizobium was applied in the field at the time of sowing sprayed at the soil subsurface and soaked the seed before 1 hr from sowing. Treatments were tested in RBD with twelve replications. The recommended dose of *Rhizobium* and VAM as per treatments. VAM culture after mixing with air dried soil was applied into the field at the time of sowing at the seeding depth. The pre-inoculated seeds were sown as per the treatment. The seed was inoculated with *Rhizobium* with slurry method, whereas the soil was inoculated with VAM inoculums.

Results and Discussion

Plant Height and No. of Branches

The co-inoculation of *Rhizobium, VAM along with different quantities of FYM* enhanced the growth significantly than the control. Application of FYM at different doses (10-30Kg/hc) 6kg,12kg and 18 kg respectively produced tallest plant at different growth stages (27.33, 57.937,79.317, 91.853 and 92.52 at 30 DAS, 60 DAS, 90 DAS, 120 DAS and at maturity respectively.) The lowest plant height (24.4, 55.43,76.353, 85 and 86.5 respectively) was recorded in control Which is shown in (Table 1). The increase in plant height might be due to the increased metabolic activities, stimulation of root growth resulting in enhanced uptake of nutrients. The findings are in accordance with P.K Jaga (2015) [9].

Number of root nodules per plant and Fresh and dry weight of nodules

From each plot, five plants were chosen at random for nodule counting. With the aid of a khurpi, plants were dug up, and the soil that had attached to them was washed off. Nodules were counted, and the average number per plant for five plants was determined. After seeding for 30, 45, 60, 75, and 90 days, observations were mad**.** Nodules' fresh and dry weights were measured and represented in mg. Nodules were dried in an oven at 60 °C for two days to determine their dry weight, which was then calculated as a percentage of each plant (mean of five plants per plot). On the same specified stage as the number of nodules, the observations on the fresh and dried weight of nodules were also noted Which shown in (Table 2). These findings agree with those of P.K Jaga (2015) [9].

Yield and yield components

Higher seed yield of soybean (27.693 q ha^{-1}) was obtained with the treatment combination of dual inoculation of VAM +FYM (18kg/per hc). Compared to control (18.15 q ha^{-1}). The higher seed yield was mainly due to positive association between yield attributing characters *viz.*, Such as higher number of pods $plant^{-1}$, number of seeds $plant^{-1}$ and 100 seed weight. Significantly higher number of pods $plant^{-1}$ (28.01 g $plant^{-1}$) were also recorded by inoculation of FYM+ VAM compared to control (21.79 pod $plant^{-1}$ 23.173 and 23.547 g $plant^{-1}$, respectively) which is shown in (Table No 3). This might be due to better nodulation of soybean roots owing to increased availability of nutrients. Biofertilizers play a key role in enhancing the efficiency of utilization of native as well as applied nutrients. The greater yield response due to dual inoculation of VAM fungus and FYM than with Rhizobium alone can be attributed to the activity of the VAM fungus in transporting extra phosphorus solubilized by PSB from and beyond the root zone into the plant roots which in the absence of VAM hyphae gets refixed by soil constituents during the course of slower diffusion towards plant roots. These results are in accordance with the findings of P.K Jaga and Satish Sharma (2015) [9] in soybean. They reported that higher seed yield of soybean was due to inoculation of VAM than inoculation of either rhizobium alone. effect of combined applications of mineral nutrients and humic acid substances. The results obtained in this study revealed that the single inoculation of VAM fungus is better than the other single inoculation in soybean.

Physiological Parameters

Application of VAM, Rhizobium and FYM on soyabean in which vam recorded maximum total chlorophyll content (2.487 mg g^{-1}). These results might be due to physiological influence of VAM *and* FYM on the activity of number of enzymes along with the inorganic nutrients. The dual inoculated plots showed significant increase in quality parameters than the single inoculants which is shown in (Table 4). However, VAM treated plot had significant increase in the protein content over the plot treated with either *Rhizobium*, but less than the dual inoculums. These findings agree with Shi H, Guo J, An J, Tang Z, Wang X, Li W, Zhao X, Jin L, Xiang Y, Li Z, Zhang F. (2023) [11].

Table 1: The increase in plant height might be due to the increased metabolic activities

Treatments	Plant height at 30 DAS	Plant height at 60 DAS	Plant height at 90 DAS	Plant height at 30 DAS	At Maturity	Number of branches At 30 DAS	Number of branches at 60 DAS	Number of branches at 90 DAS	Number of branches at 120 DAS	At maturity
T_1 Control	24.4	55.43	76.353	85	86.5	2.437	15.13	15.4	15.587	15.587
T^2 Control + FYM (10kg/per hectare) 6 kg per plot	25.037	55.903	77.3333	85.967	87.333	2.5	15.297	15.33	15.92	15.92
T_3 Control + FYM (20kg/per hectare) 12 kg per plot	25.433	55.553	77.51	85.614	86.611	2.52	15.503	15.67	15.613	15.613
T_4 Control + FYM (30kg/per hectare) 18kg per plot	25.2	55.97	75.937	85.59	87.667	2.517	15.797	15.557	15.697	15.679
T_5 Rhizobium+ Control	25.5	55.683	76.573	86.717	87.063	2.597	15.537	15.703	15.657	15.657
T_6 Rhizobium + FYM (10Kg/hc) 6 kg per plot	25.067	55.433	76.52	86.318	87.6	2.55	15.663	15.687	15.933	15.933
T_7 Rhizobium+ FYM (10Kg/hc) 6 kg per plot	24.73	55.587	76.573	86.956	88.0	2.583	15.517	15.567	16.2	16.2
T_8 Rhizobium+ FYM (10Kg/hc) 6 kg per plot	25.037	56.563	75.45	86.321	87.867	2.8	15.163	15.687	15.92	15.92
T_9 VAM+ Control	25.167	56.83	76.353	88	88.167	2.607	15.097	15.6	15.933	15.933
T_{10} VAM+ FYM (10Kg/hc) 6 kg per plot	26.133	57.167	76.55	89.744	89.744	2.737	15.697	16.03	16.133	16.3
T_{11} VAM+ FYM (20Kg/hc) 12 kg per plot	26.667	57.083	78.797	90.922	90.922	2.913	15.963	16.3	16.01	16.143
T_{12} VAM+ FYM (30Kg/hc) 18 kg per plot	27.33	57.937	79.317	91.852	92.52	3.263	16.533	16.9	16.733	16.767
C.V	1.013	1.395	1.61	1.095	1.57	0.369	0.437	0.487	0.613	0.65

Table 2: These findings agree with those of P.K Jaga (2015) [9].

Treatments	Number of root nodules per plant 30 DAS	Number of root nodules per plant 60 DAS	Number of root nodules per plant 90 DAS	Number of root nodules per plant 120 DAS	At maturity	Fresh Weight of root nodule at 30 DAS	Fresh Weight of root nodule at 60 DAS	Fresh Weight of root nodule at 90 DAS	Fresh Weight of root nodule at 120 DAS	At maturity	Dry Weight of root nodule at 30 DAS	Dry Weight of root nodule at 30 DAS	Dry Weight of root nodule at 30 DAS	Dry Weight of root nodule at 30 DAS	At maturity
T_1 Control	4.267	16.367	23.5	23.5	23.5	84.567	95.577	104	104.417	104.583	60.5	81.167	95.5	104.167	104.167
T_2 Control + FYM (10kg/per hectare) 6 kg per plot	4.3	16.763	23.967	24.567	24.633	85.417	96.417	106.027	106.027	106.36	62.167	81.417	95.683	104.817	105.15
T_3 Control + FYM (20kg/per hectare) 12 kg per plot	4.643	16.853	23.933	23.933	24.15	87	97.567	105.567	105.733	105.733	62.167	81.817	96.53	104.84	105.173
T_4 Control + FYM (30kg/per hectare) 18kg per plot	4.933	17.32	24.9	24.9	24.9	87	98	105.533	105.533	105.533	61.167	82.053	96.63	105.447	106.03
T_5 Rhizobium+ Control	4.717	17.433	24.31	24.767	24.767	86	98.13	105.837	106.117	106.117	62.833	82.5	96.74	106.563	106.563
T_6 Rhizobium+ FYM (10Kg/hc)6 kg per plot	4.54	17.713	25.417	25.917	26.11	85.167	97	106.503	106.837	107.333	62.167	82.943	96.38	106.32	106.403
T_7 Rhizobium+ FYM (10Kg/hc)6 kg per plot	5.3	17.163	25.887	25.97	26.32	85.167	98.33	105.68	106.593	107.5	62.25	83.483	96.933	106.677	106.817
T_8 Rhizobium+ FYM (10Kg/hc)6 kg per plot	4.85	17.4	26.017	26.133	26.503	83.233	97.333	106.633	107.667	108	63.583	82.883	97.527	106.397	106.627
T_9 VAM+ Control	5.333	17.3	25.597	25.52	25.633	86.067	97.6	105.52	106.333	106.333	64.983	82.96	97.4	106.413	106.38
T_{10} VAM+ FYM (10Kg/hc)6 kg per plot	5.6	17.467	25.887	26.02	26.02	86.233	98.13	108.36	108.733	108.733	65.683	83.6	98.047	107.137	107.137
T_{11} VAM+ FYM (20Kg/hc)12kg per plot	6.03	18.067	27.08	27.33	27.43	86.617	98.73	108.583	108.917	109.25	67.013	84.32	98.83	107.563	107.563
T_{12} VAM+ FYM (30Kg/hc)18kg per plot	6.443	18.38	27.45	27.867	28.167	88.6	98.93	109.417	109.417	110	68.417	86.053	99.213	109.3	109.3
C.V	0.672	0.479	0.729	0.845	0.74	2.063	0.87	1.353	1.541	1.697	1.183	0.983	0.671	1.556	1.514

Table 3: The results obtained in this study revealed that the single inoculation of VAM

Treatments	Pods per plant	Test weight (g)	Harvest index (%)	Grain yield (qha^{-1})	Straw yield (qha^{-1})
T_1 Control	21.79	13.703	45.96	18.15	27.773
T_2 Control + FYM (10kg/per hectare) 6 kg per plot	23.173	14.357	48.43	20.97	32.453
T_3 Control + FYM (20kg/per hectare) 12 kg per plot	23.547	14.31	48.777	21.323	32.573
T_4 Control + FYM (30kg/per hectare) 18kg per plot	23.96	14.357	49.093	21.54	32.653
T_5 Rhizobium+ Control	24.363	14.237	49.097	22.92	32.75
T_6 Rhizobium+ FYM (10Kg/hc) 6 kg per plot	24.93	14.527	49.98	23.38	34.17
T_7 Rhizobium+ FYM (10Kg/hc) 6 kg per plot	25.767	14.57	50.017	23.59	34.21
T_8 Rhizobium+ FYM (10Kg/hc) 6 kg per plot	26.213	14.5	51.373	24.96	35.357
T_9 VAM+ Control	26.773	15.657	51.867	24.84	36.16
T_{10} VAM+ FYM (10Kg/hc) 6 kg per plot	27.25	16.263	52.783	25.163	36.97
T_{11} VAM+ FYM (20Kg/hc)12 kg per plot	27.023	16.907	53.903	25.35	37.777
T_{12} VAM+ FYM (30Kg/hc)18 kg per plot	28.01	17.507	55.777	27.693	38.997
C.V	0.839	0.755	1.017	1.315	1.225

Table 4: However, VAM treated plot had significant increase in the protein

Treatments	Total chlorophyll (mg g^{-1}) 30 das	Total chlorophyll (mg g^{-1}) 60 das	Total chlorophyll (mg g-1) 90 das	Total chlorophyll (mg g-1) 120 das	Nitrogenous activity
T_1 Control	1.167	1.487	1.487	1.487	80.727
T_2 Control + FYM (10kg/per hectare) 6 kg per plot	1.483	1.667	1.727	1.727	82.85
T_3 Control + FYM (20kg/per hectare) 12 kg per plot	1.47	1.66	1.66	1.66	85.667
T_4 Control + FYM (30kg/per hectare) 18kg per plot	1.53	1.733	1.733	1.733	85.333
T_5 Rhizobium+ Control	1.597	1.75	1.75	1.75	83.192
T_6 Rhizobium+ FYM (10Kg/hc)6 kg per plot	1.76	1.76	1.76	1.76	87.107
T_7 Rhizobium+ FYM (10Kg/hc)6 kg per plot	1.8	1.8	1.838	1.838	94.687
T_8 Rhizobium+ FYM (10Kg/hc)6 kg per plot	1.867	1.986	1.996	2	99.36
T_9 VAM+ Control	1.767	1.92	1.928	1.969	104.167
T_{10} VAM+ FYM (10Kg/hc)6 kg per plot	1.943	2.253	2.363	2.403	104.08
T_{11} VAM+ FYM (20Kg/hc)12kg per plot	2.407	2.957	2.963	2.963	109.713
T_{12} VAM+ FYM (30Kg/hc)18 kg per plot	2.847	3.01	3.114	3.114	119.503
C.V	0.368	0.257	0.286	0.231	4.546

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