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ORIGINAL ARTICLE

Efficacy of Organic and Inorganic Fertilizers on Growth and Yield of Soybean (*Glycine Max*L. Merrill)

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ABSTRACT
Soybean (Glycine max L. Merril) has become the most important oilseed crop in India. Increase soybean production can play a significant role in increasing national food security. A field experiment was conducted at Crop Research Centre of School of Agricultural Sciences, S. G. R. R. University, Dehradun, Uttarakhand to evaluate the efficacy of organic and inorganic fertilizers on growth and yield of soybean variety Pant 1024. The experiment was laid out in a Randomized Complete Block Design (RCBD) consisting ten treatments viz., T_1 (Control) (Recommended dose of fertilizers), T_2 (50% NPK + Vermicompost), T_3 50% NPK + Farm yard manure), T_4 (50% NPK + Rhizobium japonicum), T_5 (50% NPK + PSB) (phosphate solubilizing bacteria), T_6 (50% NPK + Mycorrhiza), T_7 (50% NPK + Vermicompost Farm yard manure), T_8 (50% NPK + Rhizobium japonicum + PSB + Mycorrhiza), T_9 (25% NPK + Vermicompost + Farm yard manure + Rhizobium japonicum), T_{10} (Chicken manure +Farm yard manure + Rhizobium japonicum + PSB + Mycorrhiza). Application of T_2(50% NPK + Vermicompost) resulted in significantly higher germination % (87.17%). The maximum values of plant height (57.61cm), number of branches / plant (10.43), dry matter yield / plant (14.98 g), leaf area index (4.84), pods/ plant (41.0), Fresh weight of plant (45.43 gm), Fresh weight of leaf (20.12 g), Dry weight of plant (24.93 gm), Dry weight of leaf (8.37 mg), Number of nodules (57.60), Root biomass (333.25), Number of pod per plant (33.34), Number of seed per pod (2.41), Seed Index (10.57), seed yield per plant (8.52gm), seed yield per plot (8.54kg), seed yield per /ha. (2843.95kg), Stover Yield /Plot (11.07kg), Stover Yield /ha (3684.81kg). Significantly higher biological yield (6528.76kg) and harvesting index (43.55%) were recorded with T_2(50% NPK + Vermicompost).
Key words: *Soybean, Organic, Inorganic, growth, Seed yield*

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INTRODUCTION

Soybean (*Glycine max* L. Merril) is the world's most important leguminous crop it belongs to the family Leguminosae, which contributes to 25 % of the global edible oil, about two-thirds of the world's protein concentrate for livestock feeding [1]. Soybean has a very good adaptability towards a wide range of soils and climate. Soybean is a short-day plant which requires an optimum temperature of 26º C to 30º C and sandy loam soil with a normal pH of 7 [24]. It contains 35–40% protein on a dry-weight basis, of which, 90% is comprised of two storage globulins, glycinin and β-conglycinin. It also contains 18- 20% oil, which is rich with poly unsaturated fatty acids specially omega 6 and omega 3 fatty acids, 6-7 per cent total mineral, 5-6 per cent crude fibre, 17-19 per cent carbohydrates and triglycerides. It is a better source of vitamins (A and D), minerals (K, P, Ca, Mg, and Fe) [7]. It is effective against cardio-vascular diseases, diabetes and obesity, cancer, osteoporosis, menopausal syndrome, and anemia etc. It is also called, golden beans, miracle bean as well as wonder crop.

Nitrogen and phosphorus play a crucial role in the growth and the development of soybean plants [18]. Inorganic fertilizer is well known for quick nutrient release and uptake by plants, for a consistent yield but the cost of inorganic fertilizers and associated transportation costs has proven to be prohibitive for

many limited resource farmers. The repeated use of Organic fertilizers increases soil organic matter levels, improves water infiltration and aeration of the soil, and enhances soil biological activity as organic materials decompose [2]. Vermicompost helps to attain higher production by adding organic matter, organic carbon, macro and micronutrients and also increase microbial and enzyme activities of soil [25]. Soybean can build a symbiotic association with rhizobium, and produce root nodules that is able to meet the needs of 80% N and increase 10-25% of soybean production. Furthermore, rhizobium requires P to drive energy for atmospheric N fixation and nodule formation. Mycorrhizae and PSB solubilizes the organic phosphorus by secreting various organic acids and enzymes that result plant growth stimulation [27]. Moreover, Chicken manure has been recognized as the most desirable natural fertilizers because of its high nitrogen content. Taking into account the various facts, present investigation was planned to assess the influence of combine use of organic and inorganic fertilizer on growth and yield of soyabean.

MATERIAL AND METHODS

The experiment was conducted during Kharif season of year 2019 and 2020at the Crop Research Centre block, School of Agricultural Sciences, S. G. R. R. University, Dehradun, Uttarakhand. The region falls under the semi-arid to semi-humid climate. The annual distribution of rainfall as percentages of total rainfall is 86 percent from June to September (Kharif season). Soybean variety Pant 1024 was sown on 5 July 2019 and 7 July of 2020 with a seed rate 70 kg seed ha^{-1}in row spacing of 40 cm. The recommended dose of fertilizer N: P_2O_5: K_2O was applied @ 30:60:30 kg ha-1 for soybean crop.

The experiment was included 10 treatments and the design used was Randomized Block Design (RBD) with 3 replicas. Ten treatments in soybean *viz*., T_1(Control) (Recommended dose of fertilizers), T_2(50% NPK + Vermicompost), $T_3$50% NPK + Farm yard manure), T_4 (50% NPK + *Rhizobium japonicum*), T_5(50% NPK + PSB) (phosphate solubilizing bacteria), T_6 (50% NPK + Mycorrhiza), T_7(50% NPK + Vermicompost Farm yard manure), T_8(50% NPK + *Rhizobium japonicum* + PSB + Mycorrhiza), T_9(25% NPK + Vermicompost + Farm yard manure + *Rhizobium japonicum*), T_{10}(Chicken manure +Farm yard manure + *Rhizobium japonicum* + PSB + Mycorrhiza). Nitrogen, Phosphorus and Potassium was applied through chemical fertilizer urea, SSP and muriate of potash. Seeds were treated before sowing with rhizobium and PSB as per treatments whereas FYM, VAM and Chicken manure was applied in furrows before sowing. Pre sowing operation like ploughing, weeding, leveling, layout application of fertilizer, sowing of seeds were carried out manually. After the sowing, first irrigation done immediately after sowing while subsequently irrigation was provided at regular interval.

Pre-harvest observations i.e., germination % was recorded at 20 DAS. Whereas Plant height, leaf area index, number of branches were recorded at interval of 30, 45 60 DAS. The post- harvest observations i.e., Fresh weight of plant, fresh weight of leaf, dry weight of plant, dry weight of leaf, number of nodules, root biomass, number of pods per plant, number of seeds per pod, seed index, seed yield, per plant, seed yield per plot, seed yield per hectare, stover yield per plot, stover yield per hectare, biological yield and harvest index (%) were recorded after harvesting. The data were statistically analyzed using standard procedures of ANOVA at 5% level of significance [11].

RESULTS AND DISCUSSION

Pre-harvest Growth and Yield Attributes Studies

The data highlighted in table 1 as regards with the treatments effect in pre-harvest growth attributes of soybean plants. Application of 50% NPK + Vermicompost (T2) showed maximum seed germination percentage87.17 (Pooled)]% over all other treatments during both the years of study as well as pooled analysis whereas T7 (50% NPK + Vermicompost + Farm yard manure) which was found 2nd best with 86.46 % (Pooled) germination followed by others The optimum use of Nitrogen, Phosphorous and Potassium led to increased production of different amino acids which may have led to a rise in seed protein content, increases cell division ultimately led to increase in seed weight, size and per cent germination. Similar results were also reported [22] and [12]. The bioactive principles present in vermicompost are believed to have a positive impact germination rate [6];[30].

Pooled data for both 2019 and 2020 year, showed significantly taller plants recorded 21.98cm, 40.16cm and 57.61cm in the plot treated with T2 (50% NPK + Vermicompost) at 30, 45 and 60 DAS respectively followed by T7. Vermicompost exhibits notable characteristics such as elevated porosity, aeration, drainage, and water retention capacity and has positive effect on presence of micro biota, specifically fungi, bacteria, and actinomycetes [13]. It also contains nutrients in available forms, including nitrates, phosphates, exchangeable calcium, and soluble potassium [19]. The cumulative favorable effect of NPK and Vermicompost may have led to increased growth of plant. The treatment T7 containing (50% NPK +

Vermicompost+ FYM) was statistically at par with T2. This may be due to the similar soil conditioning properties of FYM as of Vermicompost [15]; [4].

The pooled data recorded for leaf area index was 2.52cm, 3.68cm and 4.84cm) for 30, 45 and 60 DAS respectively which was found maximum in T2 (50% NPK + Vermicompost) among all other treatments. The Macro nutrients play a vital role in production of optimum vital enzymes and proteins which lead to increase in cell division and elongation of the leaf mesophyll cells. This might have led to the increase of the leaf area [10].

Data of both the year showed that the highest number of branches per plant was observed from T2 (50% NPK + Vermicompost) i.e. 7.25, 8.86 and 10.33 (30, 45 and 60 DAS respectively),while the minimum number of branches was recorded in T1 Control (Recommended dose of fertilizers) i.e. 6.44, 8.07 and 9.30 (Pooled).Vermicompost in soil may have led to nutrient availability status in soil by microbes-aided mineralization of nitrogen and production of phytohormones like gibberellins and cytokinin which leads to increase in branching number of plants [9].

Table 1: Effect of organic and inorganic fertilizer on pre harvest growth attributes at 30, 45 and 60 DAS (Pooled for 2019-2020 and 2020- 2021 years

Treatments	Growth Attributes									
	Germination %	Plant height (cm)			Leaf Index (cm)			Number of Branches		
	20 DAS	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
T 1	67.02	18.41	29.38	39.78	1.62	2.17	3.77	6.44	8.07	9.30
T 2	87.17	21.98	40.16	57.61	2.52	3.68	4.84	7.25	8.86	10.43
T 3	85.92	21.46	38.76	54.51	2.40	3.50	4.64	7.20	8.74	10.18
T 4	84.38	20.99	37.53	52.82	2.26	3.32	4.42	7.12	8.59	10.05
T 5	79.89	20.01	34.99	49.53	1.97	2.94	4.34	6.90	8.46	9.85
T 6	82.19	20.51	36.25	51.20	2.13	3.12	4.51	6.99	8.57	10.04
T 7	86.46	21.73	39.46	56.21	2.48	3.64	4.77	7.23	8.80	10.33
T 8	74.48	19.09	32.62	46.20	1.74	2.53	4.06	6.60	8.21	9.63
T 9	77.67	19.55	33.88	47.88	1.85	2.72	4.20	6.74	8.32	9.73
T 10	72.01	18.65	31.53	44.49	1.67	2.32	3.94	6.51	8.14	9.50

Post-harvest growth attributes

Post-harvest growth attributes shown in (table 2) were recorded soon after harvest. The increase in fresh weight of leaf per plant and fresh weight of plant was observed to be maximum in treatment T_2 (50% NPK + Vermicompost) i.e. 20.12 mg. and 45.43 mg/ plant respectively. Phyto hormones and macronutrients play a vital roleinproductionofoptimumvitalenzymesandproteinswhichleadtoincreaseincelldivision and elongation of the leaf mesophyll cells. This leads to more biomass accumulation, result increase in fresh weight of leaves. Similar report also emerged while working on soybean [5].

Pooled data analysis for both the years revealed maximum dry weight of roots 24.93 (mg/plant) and leaf 8.37 mg/planting treatment T_2 (50% NPK + Vermicompost). Similar reports were also reported [14]; [20].

The findings of the study indicate a significant increase in the number of nodules observed in T_2 i.e. 57.60 receiving higher rates of NPK application. Researchers found similar results on evaluating organic and inorganic amendments [15]; [9].

Treatment T_2 (50% NPK + Vermicompost) was also recorded with the maximum root biomass (dry weight) 333.25g (Pooled)] over all other treatments whereas T_7 (50% NPK + Vermicompost + Farm yard manure) was found 2nd best. Application of vermicompost may be attributed to the height and availability of mineral sand the presence of diverse bio stimulants, such as organic acids, amino acids, enzymes, and plant hormones [16]. The application of inorganic phosphorous along with Nitrogen and Potassium leads to increased growth of root tips along with increased root proliferation [17].

Table 2: Effect of organic and inorganic fertilizer on growth attributes of soybean at harvest (Pooled for 2019-2020 to 2020- 2021 years)

Treatments	Fresh weight of plant (g)	Fresh weight of leaf (mg)	Dry weight of plant (g)	Dry weight of leaf (mg)	Number of nodules	Root biomass
T 1	29.66	14.25	16.27	5.93	48.77	272.38
T 2	45.43	20.12	24.93	8.37	57.60	333.25
T 3	44.04	19.45	24.16	8.09	56.67	328.61
T 4	42.78	19.13	23.47	7.96	55.73	322.53
T 5	40.36	18.43	22.14	7.66	53.40	307.50
T 6	41.75	18.76	22.91	7.80	54.35	313.86
T 7	44.54	19.77	24.44	8.22	57.19	330.58
T 8	37.58	17.76	20.62	7.39	51.18	284.68
T 9	36.17	18.06	26.25	7.51	52.16	296.57
T 10	36.17	17.48	19.85	7.27	50.20	278.89

The pooled data presented in Table 1. Clearly indicate that the highest number of pod per plant (33.34) was recorded from the treatment T2 (50%NPK+Vermicompost) followed by T_7 (32.60). The lowest number Pods /plant (18.75) was recorded from treatment T_1. Due to optimal availability of plant nutrients, there is always early tendency for reproductive growth of the plant and due to optimal availability of nutrients at plants disposal, the number of pods per plant also increased.

The statistical analysis of the observation regarding the seed yield per pod, per plant, per plot, and per hectare(kg/ha) showed that T_2 (50%NPK+Vermicompost) was the best treatment among all showing yield of 2.41g/pod,8.52 g/plant, 8.54 kg/ plot, 2843.95 kg/ha. [28];[4];[8].

The study for both the year revealed that a maximum stover yield per plot and per hectare of 11.07kg and 3684.8kgwas recorded respectively from treatment T_2 (50%NPK+Vermicompost) followed by T_7 (Table 3). Presence of growth regulators in Vermicompost has been found to contribute to the attainment of the highest straw yield [19]. Similar results were reported by [8]; [23]. The data on biological yield reveals that maximum yield obtained from T_2 (50%NPK+Vermicompost i.e. 6528.76 kg/ha. followed by (50% NPK + Vermicompost + Farm yard manure) with biological yield of 6318.04 kg/ha. The least biological yield 3058.16 kg/ha was obtained in treatment control. Results were similar to the finding of [20]; [9]; [21]. It was observed that the treatment T2 (50% NPK + Vermicompost) recorded the maximum Harvest Index (%) i.e., 43.55% (Pooled) over all other treatments whereas effect of T_7 (50% NPK + Vermicompost + Farm yard manure) was found 2nd best with 43.44% harvest Index (%).

Table 3: Effect on yield and yield attributes of soybean at harvest (Pooled for 2019-2020 to 2020- 2021 years)

Treatments	No. P/P	No. S/Pod	SI (g)	SY/P (g)	SY /Plot (kg)	SY /ha. (kg)	St.Y /Plot (kg)	St.Y /ha. (kg)	BY /ha. (kg)	HI (%)
T 1	18.75	2.10	9.67	3.81	3.82	1272.53	5.36	1785.63	3058.16	41.60
T 2	33.34	2.41	10.57	8.52	8.54	2843.95	11.07	3684.81	6528.76	43.55
T 3	32.05	2.34	10.46	7.86	7.88	2623.77	10.29	3427.76	6051.53	43.34
T 4	29.59	2.32	10.38	7.15	7.16	2384.74	9.44	3142.91	5527.65	43.13
T 5	26.70	2.26	10.03	6.07	6.08	2024.84	8.17	2721.35	4746.19	42.64
T 6	28.07	2.28	10.09	6.48	6.49	2161.73	8.65	2880.88	5042.61	42.85
T 7	32.60	2.39	10.53	8.23	8.25	2745.69	10.73	3572.34	6318.04	43.44
T 8	23.78	2.19	9.86	5.15	5.16	1716.77	7.05	2349.02	4065.78	42.21
T 9	25.13	2.21	9.94	5.53	5.54	1846.07	7.51	2501.87	4347.95	42.44
T 10	22.43	2.16	9.79	4.75	4.76	1585.43	6.57	2186.61	3772.04	42.02

Where: No.P/P = Number of pods per plant, No.S/Pod = Number of seeds per pod, SI = Seed index, SY/P = Seed yield, per plant, SY/Plot = Seed yield per plot, SY/ha. = Seed yield per hectare, St.Y/Plot = Stover yield per plot, St.Y/ha. = Stover yield per hectare, BY = Biological yield per ha., HI = Harvest index (HI).

CONCLUSION

The findings of the two years (2019–20 and 2020–21) of experiment at on soybean concluded that growth and yield attributing characters of soybean can be substantially increased by the integration of organic fertilizer with inorganic fertilizer. Among the various treatments used in the research, application of T_2(50%NPK+Vermicompost) recorded almost significantly higher growth and yield attributes. The

present findings suggest that vermicomposting is not solely focused on enhancing nutrient content, but rather encompasses the participation of a diverse range of microorganisms, enzymatic processes within the soil, and the regulation of plant growth and productivity.

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