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Performance of Integrated Nutrient Management in Soybean (*Glycine max* L.) under Rainfed Conditions

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***Abstract*:** Field experiment was conducted during *Kharif*-2020 at Division of Agronomy, Faculty of Agriculture, SKUAST-K, Wadura to study the performance of soybean (*Glycine max* L.) to integrated nutrient management under rainfed conditions of Kashmir. The experiment comprised of 14 treatments *viz.*, Control (T_1), 100% RDF (T_2), FYM @ 10 t/ha (T_3), Vermicompost @ 2.5 t/ha(T_4), Poultry manure @ 2.5 t/ha(T_5), Vermiwash @ 10% (T_6), *Rhizobium* + PSB + VAM + KSB + ZnSB + *Trichoderma* (T_7), 100% RDF + *Rhizobium* + PSB + VAM + KSB + ZnSB + *Trichoderma* (T_8), *Rhizobium* + PSB + VAM + KSB + ZnSB + *Trichoderma* + Vermiwash @ 10% + 50% RDF (T_9), Vermicompost @ 2.5 t/ha + Vermiwash @ 10% + 50% RDF (T_{10}), Poultry manure @ 2.5 t/ha + Vermiwash @ 10% + 50% RDF (T_{11}), FYM @ 10 t/ha + Vermiwash @ 10% + 50% RDF (T_{12}),75% RDF + FYM @ 5 t/ha(T_{13}) and 50% RDF + FYM @ 5 t/ha(T_{14}). It was revealed that the treatment T_{11} produced significantly greater seed yield (27.35 q/ha) than other treatments, however, T_{10}, T_{12} and T_8 were at par with T_{11}. Moreover, T_{11} was found superior to rest of the treatments in growth parameters, plant height (124.78 cm), leaf area index (3.16), dry matter accumulation (55.97 g/plant), as well as the yield attributing character, number of pods/ plant (88.65). The highest net returns ((₹93,214) were recorded in T_{11} while as the highest B:C ratio (2.81) was observed in T_{14}, which was comparable to T_{11}(2.01). Therefore, under rainfed conditions, it is recommended to apply Poultry manure @ 2.5 t/ha + Vermiwash @ 10% + 50% RDF (T_{11}) for realising higher growth and seed yield.

***Keywords*:** Growth, Integrated nutrient management, Seed yield, Soybean

Soybean (*Glycine max* L.) is an important pulse, contains 20% oil rich in vital unsaturated fatty acids and 40% good-quality protein (Layek et al 2014). With 11.13 million ha under cultivation for soybean and a production of 13.27 mt, has emerged as one of the major oilseed crops in India (FAO 2020). However, only 2.75% of the global production is contributed by India due to low productivity of 0.98 t/ha (USDA 2020). Among the factors responsible for low productivity, inadequate fertilizer use, the establishment of numerous nutritional deficits due to poor recycling of organic resources, and an imbalanced application of fertilisers are significant contributors to low production (Chaturvedi et al 2010). INM has all-around potential for the improvement of plant performance and resource efficiency while also enabling the protection of the environment and resource quality. It may consist of organic manures *viz*. poultry manure, vermicompost, vermiwash, farmyard manure and other sources for sustainable agriculture. Poultry manure enhances the physical, chemical and biological fertility of soils (McGrath et al 2009). Vermicompost has been proved effective to enhance growth and yield of soybean and other crops when used with other organic fertilizers (Javed and Panwar 2013). Vermiwash has been supplemented with elements that help plants develop well (Gorakh et al 2009). FYM plays an important role in making the nutrients available to crop. The use of biofertilizers like *Rhizobium*, PSB, VAM, KSB, and ZnSB in combination with organic manures reduces the amount of inorganic fertilizer needed, lowering cultivation costs and enhancing soil health. To improve plant growth and yield, *Trichoderma* spp. may be applied in combination with other microbial species (Rudresh et al 2005). The integrated nutrient management is the most promising concept for managing long term soil fertility and productivity (Ramesh et al 2010). In Kashmir, although soybean is cultivated as an intercrop, but not grown on a commercial scale. However, the *kharif* season in Kashmir offers a suitable choice for this crop to be grown, which can go a long way in supplementing the dietary oil and protein requirement of the valley. Thus, present study aims to explore the influence of integrated nutrient management on growth, yield and economics of soybean under rainfed conditions of Kashmir valley.

MATERIAL AND METHODS

The field experiment was carried out at Division of Agronomy, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura, Sopore, during *Kharif* 2020, located in the northern part of the Jammu and Kashmir. The treatments included, Control (T_1),

100% RD: (NPK:40:100:40) (T_2), FYM @ 10 t/ha (T_3), Vermicompost @ 2.5 t/ha (T_4), Poultry manure @ 2.5 t/ha (T_5), Vermiwash @ 10% (T_6), *Rhizobium* + PSB + VAM + KSB + ZnSB + *Trichoderma* (T_7), 100% RDF + *Rhizobium* + PSB + VAM + KSB + ZnSB + *Trichoderma* (T_8), *Rhizobium* + PSB + VAM + KSB + ZnSB + *Trichoderma* + Vermiwash @ 10% + 50% RDF (T_9), Vermicompost @ 2.5 t/ha + Vermiwash @ 10% + 50% RDF (T_{10}), Poultry manure @ 2.5 t/ha + Vermiwash @ 10% + 50% RDF (T_{11}), FYM @ 10 t/ha + Vermiwash @ 10% + 50% RDF (T_{12}), 75% RDF + FYM @ 5 t/ha (T_{13}) and 50% RDF + FYM @ 5 t/ha (T_{14}). The experiment was laid out in randomized complete block design (RCBD) with three replications. The soil of the experimental site was clay loam in texture, neutral in reaction with medium available nitrogen (335 kg/ha), phosphorus (15.5 kg/ha) and potassium (215 kg/ha). Weather data was obtained from a weather station set up at the experimental site during the period of May to October of 2020, indicating that the crop had experienced mean maximum and minimum temperature of 34.5 and 4.54°C, average precipitation of 12.74 mm and mean maximum and minimum relative humidity of 79.05 and 54.73% during the growth period (Fig. 1).

The seeds were sown in lines @ 80 kg/ha maintaining the row-to-row distance of 45 cm. After two weeks of sowing, the plants were thinned and gap filled to maintain a plant-to-plant distance of 10 cm. Amounts of urea, DAP and MOP were calculated and applied as per the different treatments of NPK nutrient. The crop was harvested at maturity and threshed as per schedule. The data on growth parameters (plant height, leaf area index and dry matter accumulation), yield attributes (number of pods/plant, number of seeds/pod and 100-seed weight) and yield parameters were recorded following the standard procedures. The data analysis was done using OPSTAT software package (Sheoran et al 1998).

RESULTS AND DISCUSSION

Growth parameters: The integrated use of organic along with inorganic sources of nutrients significantly influenced the growth parameters of soybean such as plant height, leaf area index and dry matter accumulation (Table 1). Plant height was significantly higher with poultry manure @ 2.5 t/ha + vermiwash @ 10% + 50% RDF (T_{11}) followed by vermicompost @ 2.5 t/ha + vermiwash @ 10% + 50% RDF (T_{10}) and FYM @ 10 t/ha + Vermiwash @ 10% + 50% RDF (T_{12}). The treatment T_{11} recorded significantly highest leaf area index, followed by T_{10} with no significant differences. The maximum dry matter accumulation was recorded in T_{11} followed by T_{10}, T_{12} being at par with T_{11}. It may be due to the absorption of sufficient nutrients through chemical fertilizers at initial stages of growth and later through organic sources, which may have led to more nucleic acid and amino acid synthesis, amide substances in the growing region, ultimately increasing the growth attributes in these treatments. These findings agree with earlier researchers (Jain, 2015, Sheikh et al 2015, Sutrismo, 2017).

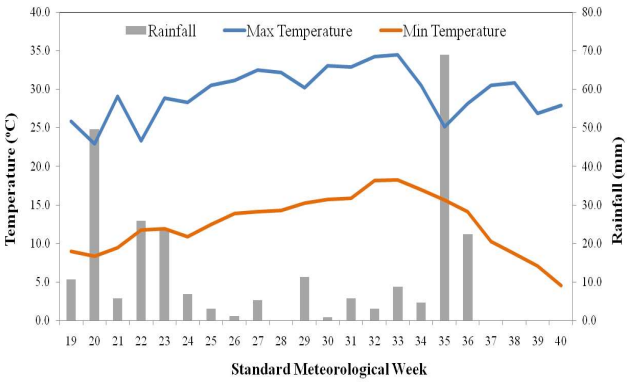

Fig. 1. Weather conditions prevailed during the crop growth period of *Kharif* 2020

Yield attributes: The amount of pods/plant in soybean was significantly influenced by the integration of different organic and inorganic sources of nutrients, however, number of seeds/pod and 100-seed weight were found to be insignificant (Table 1). The highest number of pods/ plants was recorded with poultry manure @ 2.5 t/ha + vermiwash @ 10% + 50% RDF (T_{11}). The treatment with vermicompost @ 2.5 t/ha + vermiwash @ 10% + 50% RDF (T_{10}) followed by FYM @ 10 t/ha + Vermiwash @ 10% + 50% RDF (T_{12}) and 100% RDF + *Rhizobium* + PSB + VAM + KSB + ZnSB + *Trichoderma* (T_8) were at par with (T_{11}). It is possibly due to the improvement in physical and biological properties of soil and increased nutrient supply to crop, which in turn, enhanced the accumulation of carbohydrates, proteins and their translocation. Similar findings were reported by Yagoub et al (2015), Sheikh et al (2015), Nagar et al (2016) and Sutrisno (2017).

Yield: The yield of soybean was significantly influenced by the integration of different sources of nutrients in terms of seed yield, straw yield and harvest index (Table 1). The treatment with poultry manure @ 2.5 t/ha + vermiwash @ 10% + 50% RDF (T_{11}) recorded significantly highest seed yield. However, vermicompost @ 2.5 t/ha + vermiwash @ 10% + 50% RDF (T_{10}) followed by FYM @ 10 t/ha + Vermiwash @ 10% + 50% RDF (T_{12}) and 100% RDF + *Rhizobium* + PSB + VAM + KSB + ZnSB + *Trichoderma* (T_8) were at par with (T_{11}). Similarly, the highest stover yield was recorded in T_{11}. However, the highest harvest index was observed in the treatment with FYM @ 10 t/ha + Vermiwash @ 10% + 50% RDF (T_{12}). It may be due to slow and steady availability of nutrients during entire crop growth besides inorganic forms, which might have induced cell division,

Table 1. Growth, yield, attributes and economics of soybean influenced by different sources of nutrients

Treatments	Plant height (cm)	Leaf area index	Dry matter accumulation (g/plant)	Number of pods/plant	Number of seeds/pod	100-seed weight (g)	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)	Net returns (₹/ha)	Benefit-Cost ratio
T_1	104.35	1.47	33.56	45.90	2.17	18.81	9.03	23.21	27.58	24511	1.12
T_2	113.76	2.34	46.80	68.03	2.44	21.21	22.45	48.47	31.69	84393	2.79
T_3	108.85	2.04	39.57	59.09	2.70	20.89	19.95	46.16	30.12	71225	2.31
T_4	111.27	2.06	41.73	60.58	2.72	20.39	22.35	53.42	29.45	61555	1.16
T_5	113.46	2.09	43.38	58.83	2.12	20.41	22.15	48.03	31.52	77785	2.20
T_6	105.28	1.63	34.90	51.23	2.36	19.44	12.43	33.76	26.88	34988	1.21
T_7	106.71	1.84	37.18	53.38	2.42	19.32	15.75	40.10	28.62	52682	1.88
T_8	116.22	2.56	50.49	78.97	2.27	21.19	24.54	51.00	32.49	91130	2.67
T_9	114.60	2.34	45.11	68.09	2.94	21.13	22.38	51.88	30.12	75308	1.92
T_{10}	122.95	3.00	55.23	85.26	2.06	21.29	26.98	58.56	31.53	73871	1.16
T_{11}	124.78	3.16	55.97	88.65	2.09	21.32	27.35	58.75	31.76	93214	2.01
T_{12}	120.98	2.76	52.39	81.68	2.98	21.22	25.53	49.12	34.25	88149	2.10
T_{13}	119.74	2.46	48.82	73.73	2.91	20.68	23.96	50.60	32.12	87837	2.55
T_{14}	118.49	2.41	47.59	72.71	2.87	19.99	23.75	49.54	32.41	89782	2.81
CD (p=0.05)	9.75	0.24	4.98	10.32	NS	NS	3.22	7.08	3.29	16471	0.52

expansion of cell wall, meristematic activity, photosynthetic efficiency, and regulation of water intake into the cells, resulting in the enhancement of yield parameters. Highest grain and stover yield of soybean with INM were also reported by Bandopadhyay et al (2016) and Bonde and Gawande (2017). The highest harvest index with the integrated use of RDF with FYM was reported by Chaturvedi et al (2010). Similar results were reported earlier by Bachhav et al (2012), Aziz et al (2016), and Verma et al (2017).

Economics: The economics of soybean was influenced by the integration of different sources of nutrients, in terms of net returns and benefit-cost ratio (Table 1). The highest net returns (₹93,214) were with poultry manure @ 2.5 t/ha + vermiwash @ 10% + 50% RDF (T_{11}) while as the highest benefit-cost ratio (2.81) was with the application of 50% RDF + FYM @ 5 t/ha (T_{14}), which was comparable to T_{11} (2.01). However, with Vermicompost @ 2.5 t/ha (T_4), followed by vermicompost @ 2.5 t/ha + vermiwash @ 10% + 50% RDF (T_{10}) recorded lower benefit-cost ratio, both being 1.16. Higher values of economic returns were directly associated to higher values of grain and stover production while as the lower benefit-cost ratio could be attributed to the high cost of cultivation due to the use of vermicompost in comparison to other treatments. These results are also reported by Bachhav et al (2012), Bonde and Gawande (2017), Tomar et al (2018) and Dorota et al (2020).

CONCLUSIONS

The integration of organic and inorganic sources of nutrients influenced the growth, yield and economics of soybean. The treatment combination of poultry manure @ 2.5 t/ha along with vermiwash @ 10% and 50% RDF, proved to be the outstanding source of nutrients for the improvement of growth and yield characteristics. Similarly, the highest net returns were recorded in this treatment while as the highest benefit-cost ratio was observed in 50% RDF + FYM @ 5 t/ha, which was comparable to poultry manure @ 2.5 t/ha + vermiwash @ 10% + 50% RDF. Therefore, under rainfed conditions, it is recommended to apply Poultry manure @ 2.5 t/ha + Vermiwash @ 10% + 50% RDF (T_{11}) for realising higher growth and seed yield.

AUTHORS CONTRIBUTION

Sualiya Rashid is PG Scholar and conducted research, Amjad Masood has conceptualized the research idea, Lal Singh, assisted in soil, plant sampling and analysis S. Sheraz Mahdi has assisted in manuscript writing and final editing, Malik Asif Aziz, provided fertilizer inputs and assisted in layout plan of field experiments.

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