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Influence of biochar and farmyard manure on growth performance and economic returns of soybean (*Glycine max* L. Merrill)

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Abstract
The field experiment was conducted during *kharif* season of the year 2024-2025 at Central Farm, College of Agriculture, VNMKV, Parbhani to assess the influence of Biochar and Farmyard Manure on growth performance and economic returns of soybean (*Glycine max* L. Merrill). The experiment was laid out in Randomized Block Design with three replications and ten treatments. The treatments were T_1: Control, T_2: 100% RDF, T_3: 75% RDF + 2 t ha-^{1} Biochar, T_4: 75% RDF + 1 t ha-^{1} Biochar, T_5: 75% RDF + 2 t ha^{-1} Biochar + 5 t ha^{-1} FYM, T_6: 75% RDF + 1 t ha^{-1} Biochar + 2.5 t ha^{-1} FYM, T_7: 100% RDF + 2 t ha^{-1} Biochar, T_8: 100% RDF + 1 t ha^{-1} Biochar, T_9: 100% RDF + 2 t ha^{-1} Biochar + 5 t ha^{-1} FYM, T_{10}: 100% RDF + 1 t ha^{-1} Biochar + 2.5 t ha^{-1} FYM. On the basis of present investigation, the results revealed that the application of 100% RDF + 2 t ha^{-1} Biochar + 5 t ha^{-1} FYM (T_9) improved crop growth performance with higher gross and net monetary returns and it was at par with the application of 100% RDF + 1 t ha^{-1} Biochar + 2.5 t ha^{-1} FYM (T_{10}) and 75% RDF + 2 t ha^{-1} Biochar + 5 t ha^{-1} FYM (T_5) and found significantly superior over rest of the treatments.

Keywords: Soybean, biochar, FYM, growth, economics

Introduction

Soybean (*Glycine max* L. Merrill), often referred to as the "golden bean," is a versatile leguminous crop of global significance, primarily cultivated for its high protein and oil content. Originating in China, soybean is recognized not only for its nutritional value, comprising 38-42% protein, 20-22% edible oil, crude fiber, lysine, and essential vitamins and minerals but also for its agronomic role in enhancing soil fertility through symbiotic nitrogen fixation, contributing approximately 60-115 kg N ha^{-1} to the soil.

However, despite its importance, the sustainability of soybean production is increasingly threatened by soil degradation and nutrient depletion, primarily resulting from the overuse of chemical fertilizers. To address the decline in soil fertility and mitigate the negative impacts of excessive chemical fertilizer use, attention has turned toward sustainable soil amendments. Biochar is fine-grained, carbon rich porous product remaining after plant biomass has been subjected to thermo-chemical conversion process (pyrolysis) at low temperature (~350-600 °C) in an environment with little or no oxygen (Amonette and Joseph, 2009) [1] has emerged as a promising soil amendment. Its origin is linked to the fertile "terra preta" soils of the Amazon basin. Biochar is characterized by high porosity, cation exchange capacity, and nutrient-retention properties, making it effective in improving soil structure, microbial activity, and nutrient availability while also sequestering carbon and reducing greenhouse gas emissions (Bonanomi *et al.* 2017) [3].

In conjunction with biochar, Farmyard Manure (FYM), a traditional organic amendment derived from decomposed animal dung and plant residues has long been utilized for its beneficial effects on soil structure, microbial activity, and nutrient availability. Rich in essential macronutrients such as nitrogen (N), phosphorus (P), and potassium (K), FYM serves as a potent soil conditioner and complements biochar in enhancing crop performance and soil health.

Materials and Methods

The experiment was conducted during *kharif* season of the year 2024-2025 at Central Farm, College of Agriculture, VNMKV, Parbhani to study the Influence of Biochar and Farmyard Manure on Growth Performance and Economic Returns of Soybean (*Glycine max* L. Merrill). The experiment was laid out in randomized block design with three replications of ten treatments. The treatments were T_1: Control, T_2: 100% RDF, T_3: 75% RDF + 2 t ha-^{1} Biochar, T_4: 75% RDF + 1 t ha^{-1} Biochar, T_5: 75% RDF + 2 t ha^{-1} Biochar + 5 t ha^{-1} FYM, T_6: 75% RDF + 1 t ha^{-1} Biochar + 2.5 t ha^{-1} FYM, T_7: 100% RDF + 2 t ha^{-1} Biochar, T_8: 100% RDF + 1 t ha^{-1} Biochar, T_9: 100% RDF + 2 t ha^{-1} Biochar + 5 t ha^{-1} FYM, T_{10}: 100% RDF + 1 t ha^{-1} Biochar + 2.5 t ha^{-1} FYM. The soil of experimental site was clayey in texture and well drained. Initial soil characterization of experimental site indicated that soil had a pH of 8.2, EC of 0.26 dSm^{-1} with the organic carbon content of 0.57 %. The soil was low in available nitrogen (131.71 kg ha^{-1}), medium in available phosphorus status (17.8 kg ha^{-1}) and high in available potassium status (551.84 kg ha^{-1}). The recommended dose of fertilizer was 30:60:30 kg N, P_2O_5 and K_2O kg ha^{-1}. Each experimental unit had a gross plot size of 5.4 m x 4.8 m and net plot size of 4.5 m x 3.5 m. Biochar and FYM were mixed and applied to respective plots as per the treatments before sowing of the crop. Observations on growth parameters were recorded on randomly selected five plants from each net plot and tagged for recording the observations.

Results and Discussion

Growth Parameters

The growth parameters in soybean crop shows a higher plant height (cm), maximum number of branches, maximum number of functional leaves plant^{-1}, leaf area plant^{-1} (dm^2) and dry matter accumulation plant^{-1} (g) with application of 100% RDF + 2 t ha^{-1} Biochar + 5 t ha^{-1} FYM (T_9) and it was found at par with 100% RDF + 1 t ha^{-1} Biochar + 2.5 t ha^{-1} FYM (T_{10}), 75% RDF + 2 t ha^{-1} Biochar + 5 t ha^{-1} FYM (T_5) and 75% RDF + 1 t ha^{-1} Biochar + 2.5 t ha^{-1} FYM (T_6) and found significantly superior over rest of the treatments.

Plant height and other growth parameters were significantly increased by the application of biochar and FYM at all stages of crop growth. The observed response may be attributed to the effect of biochar in conjunction with FYM which enhances soil structure, nutrient availability, and microbial activity, thereby ensuring a continuous nutrient release that supports optimal soybean growth. The results of the present investigation are in accordance with the findings of Arunkumar and Tippeshappa (2020) [2], Surya P. R. (2020) [7] and Sodah *et al.* (2022) [6].

Table 1: Influence of Biochar and FYM on plant growth parameters at different growth stages of Soybean

Tr. No.	Treatments	Plant height (cm) at harvest	No. of branches at harvest	Functional leaves plant^{-1} at 60 DAS	Leaf area plant^{-1} (dm^2) at 60 DAS	Dry matter accumulation plant^{-1} (g) at harvest
T_1	Control	50.50	4.73	17.89	13.47	12.82
T_2	100% RDF	62.50	5.54	19.35	16.69	14.25
T_3	75% RDF + 2 t ha^{-1} Biochar	56.40	5.34	18.79	16.19	13.78
T_4	75% RDF + 1 t ha^{-1} Biochar	52.40	5.24	18.34	15.38	13.39
T_5	75% RDF + 2 t ha^{-1} Biochar + 5 t ha^{-1} FYM	67.10	6.23	22.24	17.57	15.03
T_6	75% RDF + 1 t ha^{-1} Biochar + 2.5 t ha^{-1} FYM	65.47	5.98	21.78	17.30	14.58
T_7	100% RDF + 2 t ha^{-1} Biochar	63.80	5.77	20.65	17.10	14.37
T_8	100% RDF + 1 t ha^{-1} Biochar	60.10	5.42	19.12	16.39	14.13
T_9	100% RDF + 2 t ha^{-1} Biochar +5 t ha^{-1} FYM	72.10	6.65	23.64	19.10	16.31
T_{10}	100% RDF + 1 t ha^{-1} Biochar + 2.5 t ha^{-1} FYM	69.90	6.32	23.21	18.55	15.42
SE (m ±)		2.51	0.29	0.88	0.67	0.58
CD @ 5%		7.46	0.87	2.61	1.98	1.73
G.M.		62.03	5.72	20.50	16.77	14.41

Economics

The data pertaining to economics of each treatment viz., gross monetary returns (₹ ha^{-1}) and net monetary returns (₹ ha^{-1}) is presented in table 2. The data in table shows that higher gross monetary returns (₹ ha^{-1}) and net monetary returns (₹ ha^{-1}) were recorded with the application of 100% RDF + 2 t ha^{-1} Biochar +5 t ha^{-1} FYM (T_9) which was at par with the application of 100% RDF + 1 t ha^{-1} Biochar + 2.5 t ha^{-1} FYM (T_{10}), 75% RDF + 2 t ha^{-1} Biochar + 5 t ha^{-1} FYM (T_5) and 75% RDF + 1 t ha^{-1} Biochar + 2.5 t ha^{-1} FYM (T_6) and found significantly superior over rest of the treatments. These results are in conformity with Das *et al.* (2024) [5] and Chaddha (2019) [4].

Table 2: Gross monetary returns (₹ ha^{-1}) and Net monetary returns (₹ ha^{-1}) of soybean as influenced by different treatments

Tr. No.	Treatments	Gross monetary returns (₹ ha^{-1})	Net monetary returns (₹ ha^{-1})
T_1	Control	69276	33130
T_2	100% RDF	93359	51703
T_3	75% RDF + 2 t ha^{-1} Biochar	90085	37314
T_4	75% RDF + 1 t ha^{-1} Biochar	80261	31490
T_5	75% RDF + 2 t ha^{-1} Biochar + 5 t ha^{-1} FYM	120554	52783
T_6	75% RDF + 1 t ha^{-1} Biochar + 2.5 t ha^{-1} FYM	111612	55341
T_7	100% RDF + 2 t ha^{-1} Biochar	105250	51094
T_8	100% RDF + 1 t ha^{-1} Biochar	91139	40983
T_9	100% RDF + 2 t ha^{-1} Biochar +5 t ha^{-1} FYM	136165	67009
T_{10}	100% RDF + 1 t ha^{-1} Biochar + 2.5 t ha^{-1} FYM	121665	64007
SE (m ±)		5976.70	5976.7
CD @ 5%		17758.40	17758.4
G.M.		99745	48486

Conclusion

It is concluded from the present investigation that the combined application of 100% RDF + 2 t ha^{-1} Biochar + 5 t ha^{-1} FYM (T_9) markedly improved crop growth performance which may be due to enhanced soil aeration, moisture retention, and nutrient availability which promoted better root development and vegetative vigor. These improvements in growth parameters contributed to higher gross and net monetary returns demonstrating the economic advantage of integrating biochar with FYM over sole reliance on inorganic fertilizers.

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