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Influence of different levels of inorganic fertilizers and biochar on soil health parameters and yield of cluster bean (*Cyamopsis tetragonoloba* L.) Var. Kohinoor

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Abstract

A trial was during *Kharif* season (July 2023 – September 2023) on central research farm of Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. The experiment was laid out in randomized block design with three levels of NPK (0%, 50% and 100%) and three levels of Biochar (0%, 50% and 100%) on the topic “Influence of different levels of Inorganic fertilizers and biochar on soil health parameters and yield of cluster bean (*Cyamopsis tetragonoloba* L.) var. Kohinoor”. The result shows that application of different levels combination of NPK and Biochar increased growth, yield of cluster bean and improved soil physical and chemical properties. It was recorded from the application of NPK and Biochar in treatment T₉ - [NPK @ 100% + Biochar @ 100%] shows minimum bulk density 1.184 Mg m⁻³ and 1.207 Mg m⁻³, particle density 2.127 Mg m⁻³ and 2.145 Mg m⁻³, pH 6.72 and 6.76 and maximum percent pore space 44.34% and 43.73%, water holding capacity 48.26% and 47.71%, EC 0.264 dS m⁻¹ and 0.232 dS m⁻¹, organic carbon 0.62% and 0.60%, available nitrogen 309.76 kg ha⁻¹ and 305.56 kg ha⁻¹, available phosphorus 25.55 kg ha⁻¹ and 24.82 kg ha⁻¹, available potassium 197.89 kg ha⁻¹ and 194.03 kg ha⁻¹ at 0-15 cm and 15-30 cm respectively in all treatments. It was observed that for post-harvest T₉ was best in terms of growth, yield and economic parameters with maximum plant height, number of leaves plant⁻¹, number of branch plant⁻¹, pod yield and maximum cost benefit ratio of 1:2.31.

Keywords: Soil properties, inorganic fertilizers, biochar, cluster bean, yield, etc.

Introduction

India with a contribution of about 90% to the global production ranks first in the world in cluster bean production. It is an important feed, fodder, food and industrial crop grown in arid and semiarid regions of West and North-West India specifically, Rajasthan, accounted for about 87.7% of the production and 91.5% of the acreage during 2020–21. India is also the major exporter of guar gum or derivatives in the international market and during 2022–23, earned valuable foreign exchange worth US \$617.14 million by exporting 0.41 million tonnes (mt) of guar gum. There is big demand for Indian guar gum products, food additives, food thickener (Kumar *et al.*, 2019) [33]. Guar is a drought-tolerant, multi-purpose legume crop cultivated mainly in the *Kharif* season in arid environments and is used as animal feed and fodder, green manure and for extraction of gum for various industrial uses. It is from the endosperm that guar gum is derived, which is the prime marketable product of the plant. The spherical endosperm contains significant amount of galactomannan gum (19-43% of the whole seed), which forms a viscous gel in cold water (Chavan *et al.*, 2015) [7].

Application of organic matter in the soils has been undoubtedly credited for better soil health and plant growth response all over the world, particularly in the tropical soils having comparatively lower organic matter content. However, the stability of applied organic residues or compost highly varies with the soil it is applied on, molecular structure it has and the environmental and biological condition of the soil. Biochar, a highly stable and recalcitrant form of organic matter produced by heating biomass in an oxygen limited condition and high temperature (pyrolysis) usually above 250 °C has been emerged as an option. Increased yield of crops has been reported by many studies (Lehmann and Joseph, 2015) [41] since biochar has been introduced as an agronomic tool.

Biochar liming effect, high water holding capacity and capability to increase crop nutrient availability might be the main factors behind the positive effects. However, the idea of incorporating biochar in soil has an historical background. Modern day's objective to use biochar in soils are mainly for the carbon sequestration purpose. Biochar can effectively sequester in soil for hundreds to thousands of years. Biochar, a carbon-rich solid material and legumes having numerous benefits to the soil-plant system gaining a keen interest as an innovative sustainable approach among the agriculture research community in many parts of the world especially in developing countries in order to enhance soil quality and ensure food security. Thus, with the same approach, we have carried out a field experiment to examine the effect of biochar application in field crops. In the present study, we investigated the effects of co-application of inorganic fertilisers and a biochar produced from coconut tree waste on growth and yield attributes as well concentration and uptake of nutrients in cluster bean.

Materials and Methods

A field experiment conducted at the Soil Science Research Farm, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, during the *Kharif* season of (July 2023- September 2023) growing cluster bean var. *kohinoor* applied 3 levels of NPK and Biochar respectively NPK and Biochar (0%, 50% and 100%) experiment is lead to observe the physical and chemical parameters.

In physical parameters

Bulk density, particle density, pore space and water holding capacity through method by 100 ml graduated measuring cylinder and process by Muthuvel *et al.*, 1992 [20].

In chemical parameters through method by

Soil pH: Method given by M. L. Jackson, 1958 [13] using digital pH meter

Soil EC (dSm⁻¹): Method given by Wilcox, 1950 [38] using digital EC meter

Organic Carbon (%): Wet oxidation method given by Walkley and Black, 1947 [37].

Available Nitrogen (kg ha⁻¹): Kjeldhal Method (Subbiah and Asija, 1956) [34]

Available Phosphorus (kg ha⁻¹): Colorimetric method by using Jasper single beam, U.V. Spectrophotometer at 660 nm wavelength given by Olsen *et al.*, 1954 [21]

Available Potassium (kg ha): Flame photometric method by using Metzer Flame Photometer given by Toth and Prince, 1949 [36].

Result and Discussion

Physical Properties of Soil

The response bulk density of soil was found to be non-significant in levels of organic and inorganic fertilizer. The maximum bulk density of soil 1.191 Mg m⁻³ and 1.403 Mg m⁻³ at 0-15 cm and 15-30 cm was recorded in treatment T₁ (NPK @ 0% + Biochar @ 0%) and minimum 1.177 Mg m⁻³ and 1.385 Mg m⁻³ at 0-15 cm and 15-30 cm was recorded in

treatment T₉ (NPK @ 100% + Biochar @ 100%) respectively. Similar result has been recorded by (Leigh *et al.*, 2016; Sheng-Gao *et al.*, 2013) [42, 43]. The maximum particle density of soil 2.161 Mg m⁻³ and 2.424 Mg m⁻³ at 0-15 cm and 15-30 cm was recorded in treatment T₁ (NPK @ 0% + Biochar @ 0%) and minimum 2.145 Mg m⁻³ and 2.409 Mg m⁻³ at 0-15 cm and 15-30 cm was recorded in treatment T₉ (NPK @ 100% + Biochar @ 100%) respectively. Similar result has been recorded by (Leigh, *et al.*, 2016) [42] The response pore space of soil was found to be significant in levels of NPK and biochar. The maximum pore space of soil 45.18% and 42.41% at 0-15 cm and 15-30 cm was recorded in treatment T₉ (NPK @ 100% + Biochar @ 100%) and minimum 44.89% and 42.13% at 0-15 cm and 15-30 cm was recorded in treatment T₁ (NPK @ 0% + Biochar @ 0%) respectively. Similar result has been recorded by (Leigh *et al.*, 2016; Sheng-Gao *et al.*, 2013) [42, 43]. The response water holding capacity of soil was found to be significant in levels of organic and inorganic fertilizers. The maximum water holding capacity of soil 48.26% and 47.71% at 0-15 cm and 15-30 cm was recorded in treatment T₉ (NPK @ 100% + Biochar @ 100%) and minimum 35.55% and 31.48% at 0-15 cm and 15-30 cm was recorded in treatment T₁ (NPK @ 0% + Biochar @ 0%) respectively. Similar result has been recorded by (Leigh *et al.*, 2016; Sheng-Gao *et al.*, 2013) [42, 43].

Chemical Properties of Soil

The response pH of soil was found to be non-significant in levels of organic and inorganic fertilizer. The maximum pH of soil 7.25 and 7.34 at 0-15 cm and 15-30 cm was recorded in treatment T₁ (NPK @ 0% + Biochar @ 0%) and minimum 6.72 and 6.76 at 0-15 cm and 15-30 cm was recorded in treatment T₉ (NPK @ 100% + Biochar @ 100%) respectively. Similar result has been recorded by (Akhtar *et al.*, 2015; Chongloi and Sharma, 2019) [1, 8]. The response EC of soil was found to be non-significant in levels of organic and inorganic fertilizer. The maximum EC of soil 0.264 dSm⁻¹ and 0.232 dSm⁻¹ at 0-15 cm and 15-30 cm was recorded in treatment T₉ (NPK @ 100% + Biochar @ 100%) and minimum 0.246 dSm⁻¹ and 0.214 dSm⁻¹ at 0-15 cm and 15-30 cm was recorded in treatment T₁ (NPK @ 0% + Biochar @ 0%) respectively. Similar result has been recorded by (Akhtar *et al.*, 2015, Chongloi and Sharma, 2019) [1, 8]. The response organic carbon of soil was found to be non-significant in levels of organic and inorganic fertilizer. The maximum OC of soil 0.62% and 0.60% at 0-15 cm and 15-30 cm was recorded in treatment T₉ (NPK @ 100% + Biochar @ 100%) and minimum 0.52% and 0.46% at 0-15 cm and 15-30 cm was recorded in treatment T₁ (NPK @ 0% + Biochar @ 0%) respectively. Similar revealed has been recorded (Akhtar *et al.*, 2015, Chongloi 2019) [1, 8]. The response available nitrogen of soil was found to be significant in levels of organic and inorganic fertilizer. The maximum available nitrogen of soil 309.76 kg ha⁻¹ and 305.56 kg ha⁻¹ at 0-15 cm and 15-30 cm was recorded in treatment T₉ (NPK @ 100% + Biochar @ 100%) and minimum 291.61 kg ha⁻¹ and 287.34 kg ha⁻¹ at 0-15 cm and 15-30 cm was recorded in treatment T₁ (NPK @ 0% + Biochar @ 0%) respectively. Similar result has been recorded by (Ramesh *et al.* 2006, Sharma *et al.* 2019 and Chaturvedi *et al.* 2020) [27, 33, 6]. The response available phosphorus of soil was found to be significant in levels of organic and inorganic fertilizer. The maximum available

phosphorus of soil 25.55 kg ha⁻¹ and 24.82 kg ha⁻¹ at 0-15 cm and 15-30 cm was recorded in treatment T₉ (NPK @ 100% + Biochar @ 100%) and minimum 18.20 kg ha⁻¹ and 16.38 kg ha⁻¹ at 0-15 cm and 15-30 cm was recorded in treatment T₁ (NPK @ 0% + Biochar @ 0%) respectively. Similar result has been recorded by (Ramesh *et al.* 2006, Sharma *et al.* 2019 and Chaturvedi *et al.* 2020) [27, 33, 6]. The response available potassium of soil was found to be significant in levels of organic and inorganic fertilizer The

maximum available potassium of soil 197.89 kg ha⁻¹ and 194.03 kg ha⁻¹ at 0-15 cm and 15-30 cm was recorded in treatment T₉ (NPK @ 100% + Biochar @ 100%) and minimum 183.43 kg ha⁻¹ and 181.05 kg ha⁻¹ at 0-15 cm and 15-30 cm was recorded in treatment T₁ (NPK @ 0% + Biochar @ 0%) respectively. Similar result has been recorded by (Ramesh *et al.* 2006, Sharma *et al.* 2019 and Chaturvedi *et al.* 2020) [27, 33, 6].

Table 1: Effect of NPK and Biochar on soil physical properties

Treatment	BD (Mg m ⁻³)		PD (Mg m ⁻³)		Pore space (%)		Water holding capacity (%)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	15-30 cm	15-30 cm
NPK @ 0% + Biochar @ 0%	1.191	1.403	2.161	2.424	44.89	42.13	35.55	31.48
NPK @ 0% + Biochar @ 50%	1.187	1.398	2.160	2.421	45.05	42.26	37.07	32.60
NPK @ 0% + Biochar @ 100%	1.185	1.397	2.158	2.419	45.09	42.28	38.76	34.18
NPK @ 50% + Biochar @ 0%	1.184	1.395	2.157	2.418	45.11	42.31	39.04	37.26
NPK @ 50% + Biochar @ 50%	1.183	1.393	2.155	2.416	45.11	42.35	41.61	39.92
NPK @ 50% + Biochar @ 100%	1.181	1.392	2.152	2.414	45.12	42.36	43.30	41.22
NPK @ 100% + Biochar @ 0%	1.180	1.391	2.150	2.413	45.13	42.37	44.84	42.09
NPK @ 100% + Biochar @ 50%	1.178	1.389	2.148	2.411	45.16	42.39	47.51	44.85
NPK @ 100% + Biochar @ 100%	1.177	1.385	2.145	2.409	45.18	42.41	48.26	47.71
F-Test	NS	NS	NS	NS	S	S	S	S
S.Ed. (±)	-	-	-	-	0.62	0.48	0.68	0.55
C.D. at 0.5%	-	-	-	-	1.32	0.99	2.06	1.65

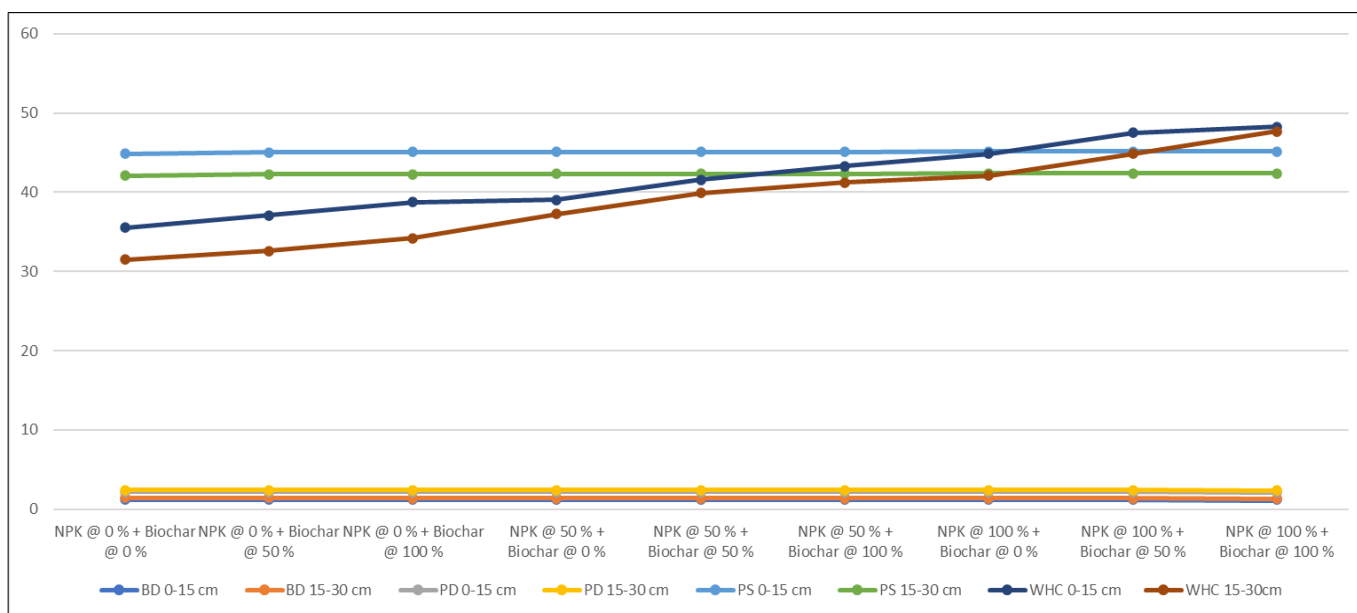


Fig 1: Effect of different levels of NPK and Biochar on Bd (Mg m⁻³), Pd (Mg m⁻³), PS (%), and WHC (%) of soil depth (0-15 cm) and (15-30 cm)

Table 2: Effect of NPK and Biochar on soil chemical properties

Treatment	pH		EC (dS m ⁻¹)		Organic carbon (%)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T ₁ - NPK @ 0% + Biochar @ 0%	7.25	7.34	0.246	0.214	0.52	0.46
NPK @ 0% + Biochar @ 50%	7.23	7.29	0.247	0.216	0.54	0.48
NPK @ 0% + Biochar @ 100%	7.03	7.06	0.249	0.217	0.56	0.51
NPK @ 50% + Biochar @ 0%	7.01	7.04	0.251	0.220	0.53	0.49
NPK @ 50% + Biochar @ 50%	6.97	6.98	0.253	0.223	0.55	0.52
NPK @ 50% + Biochar @ 100%	6.99	6.96	0.257	0.226	0.57	0.56
NPK @ 100% + Biochar @ 0%	6.88	6.99	0.259	0.228	0.54	0.53
NPK @ 100% + Biochar @ 50%	6.84	6.85	0.261	0.230	0.58	0.58
NPK @ 100% + Biochar @ 100%	6.72	6.76	0.264	0.232	0.62	0.60
F-Test	NS	NS	NS	NS	NS	NS
S.Ed. (±)	-	-	-	-	-	-
C.D. at 0.5%	-	-	-	-	-	-

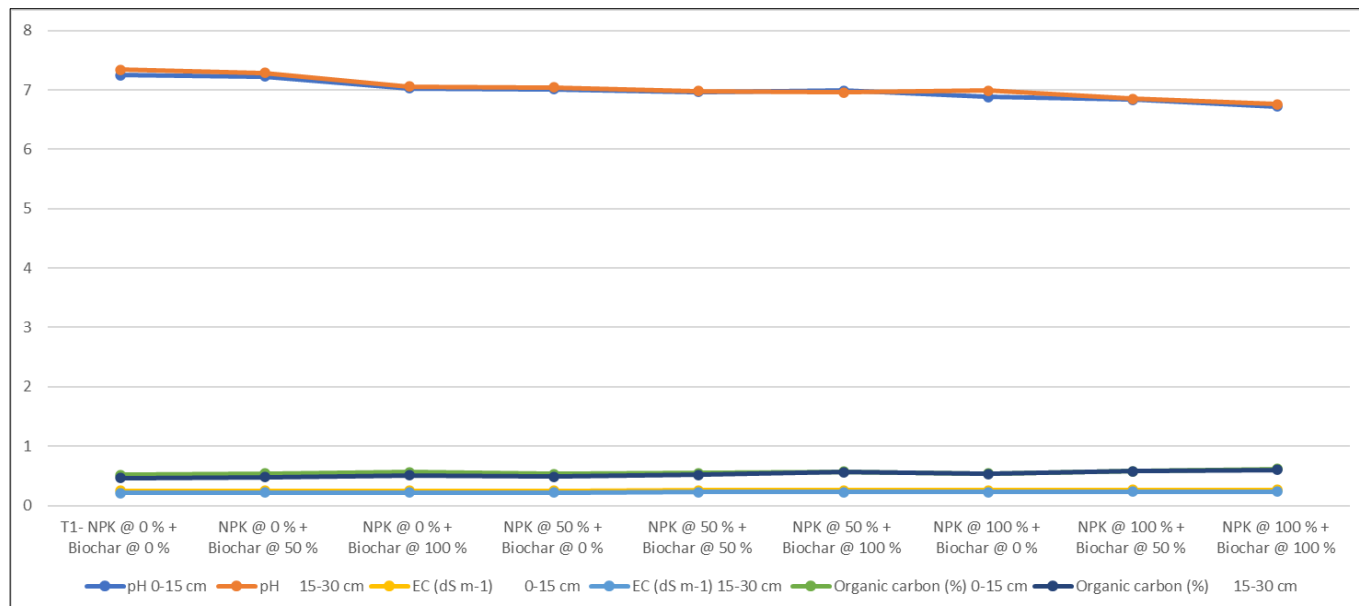


Fig 2: Effect of different levels of NPK and Biochar on pH, EC (dS m⁻¹), OC (%), of soil depth (0-15 cm) and (15-30 cm)

Table 3: Effect of NPK and Biochar on soil chemical properties

Treatment	Available Nitrogen (kg ha ⁻¹)		Available Phosphorus (kg ha ⁻¹)		Available Potassium (kg ha ⁻¹)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
NPK @ 0% + Biochar @ 0%	291.61	287.34	18.20	16.38	183.43	181.05
NPK @ 0% + Biochar @ 50%	292.50	288.21	18.52	17.87	184.38	183.80
NPK @ 0% + Biochar @ 100%	303.84	290.88	19.90	18.09	187.59	185.52
NPK @ 50% + Biochar @ 0%	304.43	292.62	20.02	18.65	188.10	186.65
NPK @ 50% + Biochar @ 50%	305.32	294.01	21.50	19.32	189.54	188.89
NPK @ 50% + Biochar @ 100%	305.54	298.50	22.43	19.83	192.70	190.24
NPK @ 100% + Biochar @ 0%	306.12	301.23	23.96	20.19	194.05	192.16
NPK @ 100% + Biochar @ 50%	307.65	304.35	24.38	22.39	196.97	193.65
NPK @ 100% + Biochar @ 100%	309.76	305.56	25.55	24.82	197.89	194.03
F-Test	S	S	S	S	S	S
S.Ed. (±)	2.18	1.80	1.10	0.68	1.75	1.41
C.D. at 0.5%	4.42	3.62	2.23	1.40	3.28	3.85

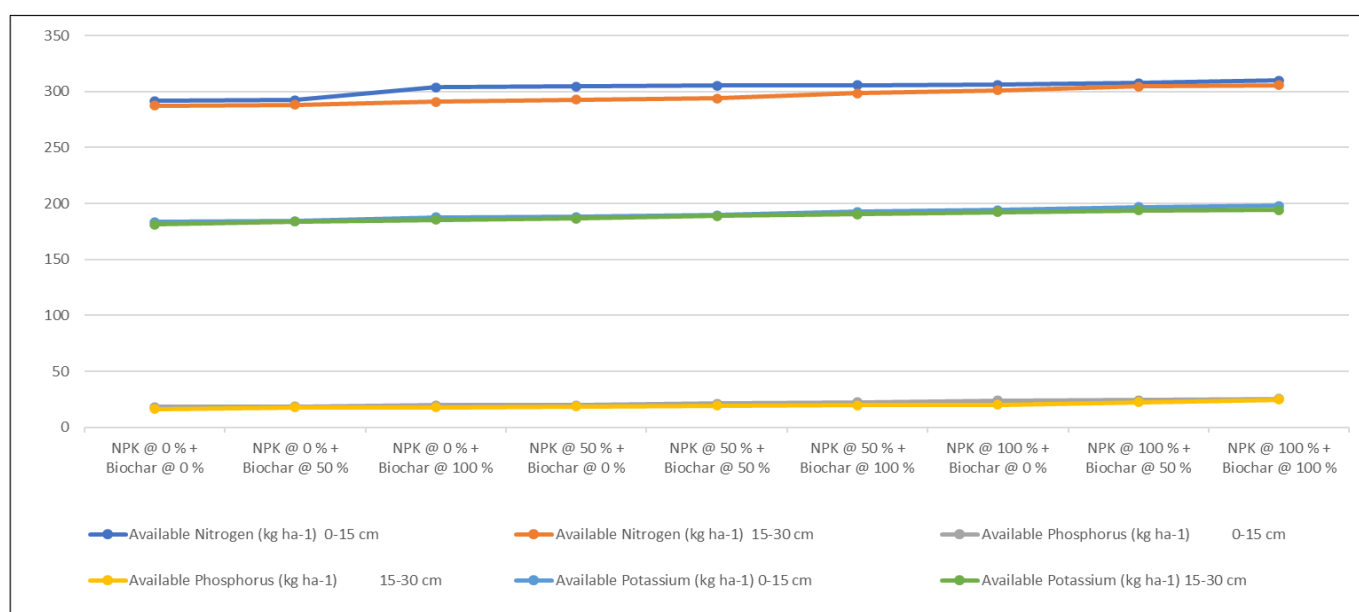


Fig 3: Effect of different levels of NPK and Biochar on Available N (kg h⁻¹), P (kg h⁻¹) and K (kg h⁻¹) of soil depth (0-15 cm) & (15-30 cm)

Conclusion

The results showed that the soil's bulk density, panicle density, pH, and electrical conductivity were non-significant after the crop was harvested, while the soil's organic carbon,

nitrogen, phosphorus, nitrogen, porosity, and water holding capacity were significant and the crop was harvested with various applications of the inorganic fertilizers and Biochar. The best result was recorded in T₉ and the second-best result

was recorded in T₈. The application of [NPK @ 100% + Biochar @ 100%] considerably enhanced the accessible nitrogen, phosphorus, and potassium content of soil following crop harvest. The use of T₉ [NPK @ 100% + Biochar @ 100%] resulted in significantly higher vegetative growth and yield characteristics, as well as impact on net return up to 94826.56 ha with a C:B ratio of 1:2.31. Therefore, the application of [NPK @ 100% + Biochar @ 100%] found most suitable dose for cluster bean to obtain higher yield.

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