



# Effect of Integrated Sources of Nutrients on Growth, Yield and Economics of Cowpea (*Vigna unguiculata* L.) var Ankur Gomati

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## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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## ABSTRACT

A field experiment was conducted in randomized block design with 7 treatments and 3 replications to study the effect of fertilizers, organic manures, biochar and crop residues on growth, yield and economics of cowpea (*Vigna unguiculata* L.) in Inceptisols of Prayagraj, Uttar Pradesh, India in 2022. A research variety Ankur Gomati was taken for this research trial. Recommended doses of fertilizers (N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O @ 25, 75 and 60 kg ha<sup>-1</sup>) was applied with inorganic fertilizers (Zn and

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B), organic manures (FYM, vermicompost, neem cake and poultry manure), biochar and crop residues (rice straw and wheat straw). Growth parameters such as the maximum plant height 46.96 cm, 70.21 cm and 92.22 cm, maximum number of branch plant<sup>-1</sup> 5.82, 7.56 and 9.79, highest number of leaf plant<sup>-1</sup> 28.32, 30.56 and 32.22, highest length of leaf as 5.37 cm, 7.31 cm and 9.18 cm were recorded in T<sub>7</sub>[RDF + Poultry Manure @2 t ha<sup>-1</sup> + Biochar @2.5 t ha<sup>-1</sup> + Vermicompost @2 t ha<sup>-1</sup> + Neem Cake @500 kg ha<sup>-1</sup>] at 30 DAS, 55 DAS and 70 DAS respectively. And yield parameters such as high pod length as 21.72 cm and 20.01 cm, highest number of pods plant<sup>-1</sup> 35.52 and 35.75, highest number of seed pod<sup>-1</sup> 10.01 and 10.21 and highest test weight 27.12 g and 26.23 g were recorded in T<sub>7</sub> [RDF + Poultry Manure @2 t ha<sup>-1</sup> + Biochar @2.5 t ha<sup>-1</sup> + Vermicompost @2 t ha<sup>-1</sup> + Neem Cake @500 kg ha<sup>-1</sup>] at 55 DAS and 70 DAS respectively. Highest yield 160.12 q ha<sup>-1</sup> were obtained in treatment T<sub>7</sub> [RDF + Poultry Manure @2 t ha<sup>-1</sup> + Biochar @2.5 t ha<sup>-1</sup> + Vermicompost @2 t ha<sup>-1</sup> + Neem Cake @500 kg ha<sup>-1</sup>]. Maximum gross return ₹ 2,41,680 was recorded in treatment T<sub>7</sub>[RDF + Poultry Manure @2 t ha<sup>-1</sup> + Biochar @2.5 t ha<sup>-1</sup> + Vermicompost @2 t ha<sup>-1</sup> + Neem Cake @500 kg ha<sup>-1</sup>]. Maximum B:C ratio (2.80) was recorded in T<sub>4</sub> [RDF + Vermicompost @ 2 t ha<sup>-1</sup> + Rice Straw @ 6 t ha<sup>-1</sup>]. But maximum net return (₹ 1,47,624.1) was recorded in treatment T<sub>4</sub>[RDF + Vermicompost @ 2 t ha<sup>-1</sup> + Rice Straw @ 6 t ha<sup>-1</sup>]. The yield and growth parameters also significantly increased with the application of the combination of organic and inorganic fertilizers.

**Keywords:** Fertilizes; organic manures; biochar; crop residues; cowpea; growth; yield; economics.

## 1. INTRODUCTION

Cowpea [*Vigna unguiculata* (L.) Walp] is one of the important kharif pulse crops grown for vegetable, grain, forage and green manuring belonging to family Leguminaceae (Ahmed et al., 2012). In India cowpea grown states are Uttar Pradesh, Punjab, Haryana, Rajasthan and Madhya Pradesh and cowpea cultivated in arid and semi-arid. Uttar Pradesh is the leading state among them (Meena et al., 2014). Green tender pods of cowpea are used as vegetable, the vegetable cowpea pods contain 24.8% protein, 63.6% carbohydrate, 1.9% fat, 6.3% fiber, 7.4 ppm thiamine, 4.2 ppm riboflavin and 28.1 ppm niacin (Ahlawat and Shivkumar, 2005).

Cowpea is highly responsive to fertilizers. The dose of fertilizer depends on the initial soil fertility status and moisture availability conditions. Although it gives good response to application of recommended dose of fertilizer (Ahlawat and Shivakumar, 2005). Nutrient management with recommended dose of NPK and micronutrients B and Zn can augment the economic yield of cowpea both in green pod and seed production (Debnath et al., 2018). Use of organic manure alone or in combination with chemical fertilizers, helps in improving physio-chemical properties of the soil, improves the efficient utilization of applied fertilizers resulted in higher seed yield and quality (Salem, 2012). Organic manures viz., farm yard manure (FYM), vermicompost (VC), poultry manure (PM) and

oilcakes help in the improvement of soil structure, aeration and water holding capacity of soil (Joshi et al., 2016). According to Behera et al., (2007), it improves plant growth by improving the physical and chemical characteristics of the soil, i.e., cation exchange capacity (CEC), bulk density, water holding capacity and permeability as well as biological properties, all contributing to an increased crop productivity. Crop residues are a potential source of organic matter in soils and Soil organic matter indirectly effects on the plant (Kumari et al., 2019).

Previous researches on cowpea reveal growth and yield attributes enhancements through the use of inorganic nutrients sources (Debnath et al., 2018), organic nutrient sources (Joshi et al., 2016; Patel et al., 2018), crop residues (Ndiso et al., 2018), and even with biochar application (Phares et al., 2020). However, there is no systematic study that involves the integrated use of these nutrient and carbon sources on the performance of cowpea. In this light, the present study aimed to evaluate the effect of integrated sources (inorganic and organic) of nutrients and carbon (biochar) on i) growth and yield, and ii) economics of cowpea crop grown in an Inceptisol of Indo-Gangetic plain.

## 2. MATERIALS AND METHODS

The field experiment was conducted at research farm located at Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj,

Uttar Pradesh (25°24' N latitude, 81° 51' E longitude) during *Kharif* season of 2022. This area experiences sub-tropical to semi-arid climate with extremely hot summer and cold winter. The maximum temperature reaches up to 46– 48°C and seldom falls as low as 4–5°C. The average rainfall in this area is ~1100 mm most of which is received during July-September.

The soil samples from each plot were separately collected through soil auger for laboratory analysis. And sieving with 2 mm brass sieve. Soil samples were analysed for soil physical properties like bulk density ( $\text{Mg m}^{-3}$ ), particle density ( $\text{Mg m}^{-3}$ ), pore space percentage (%) and water holding capacity (%) all given by Muthuvel *et al.*, 1992, soil colour given by Munsell, 1971 in Munsell colour chart and soil texture (sand, silt and clay %) given by Bouyoucos, 1952 and chemical properties like soil pH given by Wilcox, 1950, electrical conductivity ( $\text{dS m}^{-1}$ ) given by Jackson, 1958, organic carbon ( $\text{kg ha}^{-1}$ ) given by Walkley and Black, 1947, available nitrogen ( $\text{kg ha}^{-1}$ ) given by Subbiah and Asija, 1956, available phosphorus ( $\text{kg ha}^{-1}$ ) given by Olsen *et al.*, 1954, available potassium ( $\text{kg ha}^{-1}$ ) given by Toth and Prince, 1949, available Zn ( $\text{mg ha}^{-1}$ ) given by Lindsay and Norvell, 1978 and available B ( $\text{mg ha}^{-1}$ ) given by Berger and Truog, 1939. The readings of Zn were taken in Atomic Absorption Spectrophotometer. The results pre soil sample analysis are texture sandy loam, and soil colour in dry condition is pale brown and in wet condition olive brown, bulk density  $1.33 \text{ Mg m}^{-3}$ , partial density  $2.50 \text{ Mg m}^{-3}$ , porosity 46.80 %, water holding capacity 44.01 %, pH 7.8, EC  $0.20 \text{ dS m}^{-1}$ , organic carbon  $0.40 \text{ kg ha}^{-1}$ , available nitrogen, phosphorus, potassium, boron and zinc are  $240.45 \text{ kg ha}^{-1}$ ,  $20.21 \text{ kg ha}^{-1}$ ,  $159.02 \text{ kg ha}^{-1}$ ,  $0.73 \text{ mg ha}^{-1}$  and  $0.60 \text{ mg ha}^{-1}$  respectively.

The experimental area was laid out in randomized block design with seven treatments and three replications. The treatments comprised of T<sub>1</sub>- RDF @ 25:75:60 N:P:K, T<sub>2</sub>- RDF + B @  $2 \text{ kg ha}^{-1}$  + Zn @  $7 \text{ kg ha}^{-1}$ , T<sub>3</sub>- RDF + Farm Yard Manure @  $5 \text{ t ha}^{-1}$ , T<sub>4</sub>- RDF + Vermicompost @  $2 \text{ t ha}^{-1}$  + Rice Straw @  $6 \text{ t ha}^{-1}$ , T<sub>5</sub>- RDF + Neem Cake @  $500 \text{ kg ha}^{-1}$  + Wheat Straw @  $6 \text{ t ha}^{-1}$ , T<sub>6</sub>- RDF + Biochar @  $2.5 \text{ t ha}^{-1}$  and T<sub>7</sub>- RDF + Poultry Manure @  $2 \text{ t ha}^{-1}$  + Vermicompost @  $2 \text{ t ha}^{-1}$  + Biochar @  $2.5 \text{ t ha}^{-1}$  + Neem Cake @  $2 \text{ t ha}^{-1}$ . The poultry manures were incorporated into soil before three weeks of sowing and other organic and inorganic fertilizers were applied at the time of sowing. The sources of N, P, K, Zn and B were urea, SSP, MOP, zinc sulphate and

zinc sulphate respectively. Half dose of urea was applied at the time of sowing and the other half was applied after 21 days of sowing as split dose. First picking was held on 55 DAS and the final harvesting was held on 70 DAS. All cultural practices were adopted uniformly in each plot as and when required. In general, no incidence of disease and pest was recorded during both the season. The data recorded during the course of the investigation will be subjected to statistical analysis by 3X 3 RBD, as per the method "Analysis of Variance (ANOVA) technique" as given by Fisher (1960). Experiment will be laid out in RBD and the treatment will be replicated three times. The significant and non-significant effect was judged with the help of "F" (variance ratio) table. The significant difference between the means was tested against the critical difference of 5% level.

Growth parameters like plant height (cm), number of branches plant<sup>-1</sup>, no of leaf plant<sup>-1</sup>, leaf length (cm) and pod length taken at 30 DAS, 55 DAS and 70 DAS and yield parameters like no of pod plant<sup>-1</sup>, no of seed pod<sup>-1</sup>, seed weight and pod yield ( $\text{kg ha}^{-1}$ ) taken at 55 DAS and 70 DAS. Economics like net profit, gross return, cost of cultivation and cost benefit ratio (C:B) / return per rupee invested also calculated.

### 3. RESULTS AND DISCUSSION

#### 3.1 Effect on Growth Parameters of Cowpea

The data presented in Table 1 shows that growth parameters significantly increased by using the combination of inorganic fertilizers, organic manures, biochar and crop residues. Maximum plant height 46.96 cm, 70.21 cm and 92.22 cm, maximum number of branch plant<sup>-1</sup> 5.82, 7.56 and 9.79, highest number of leaf plant<sup>-1</sup> 28.32, 30.56 and 32.22, highest length of leaf as 5.37 cm, 7.31 cm and 9.18 cm were recorded in T<sub>7</sub> [RDF + Poultry Manure @  $2 \text{ t ha}^{-1}$  + Biochar @  $2.5 \text{ t ha}^{-1}$  + Vermicompost @  $2 \text{ t ha}^{-1}$  + Neem Cake @  $500 \text{ kg ha}^{-1}$ ] at 30 DAS, 55 DAS and 70 DAS respectively followed by T<sub>4</sub> [RDF + Vermicompost @  $2 \text{ t ha}^{-1}$  + Rice Straw @  $6 \text{ t ha}^{-1}$ ] respectively and minimum result were found in T<sub>1</sub> [RDF]. Increase in plant height due to application of RDF combined with poultry manure, vermicompost, neem cake and biochar may be because of adequate supply of nutrients which helps in vigorous vegetative growth of plants and subsequently increase the plant height through cell elongation, cell division, photosynthesis and

**Table 1. Effect of integrated sources of nutrients on growth parameters of Cowpea**

Treatments	Plant height (cm)			No of branch plant <sup>-1</sup>			No of leaf plant <sup>-1</sup>			Length of leaf (cm)		
	30 DAS	55 DAS	70 DAS	30 DAS	55 DAS	70 DAS	30 DAS	55 DAS	70 DAS	30 DAS	55 DAS	70 DAS
T <sub>1</sub>	39.93	58.31	78.12	3.26	5.07	7.21	20.13	24.21	26.33	4.05	6.02	7.66
T <sub>2</sub>	40.36	60.15	80.24	3.55	5.27	7.54	21.54	25.82	27.01	4.61	6.25	7.89
T <sub>3</sub>	43.29	64.23	85.16	4.85	6.02	8.36	25.55	27.16	28.67	5.01	7.01	8.51
T <sub>4</sub>	45.11	68.52	89.56	5.45	7.12	9.23	26.36	28.99	30.31	5.21	7.28	9.01
T <sub>5</sub>	44.82	65.86	86.77	4.98	6.40	8.76	26.01	27.91	29.12	5.04	7.15	8.71
T <sub>6</sub>	41.45	62.11	82.71	3.87	5.51	7.82	25.05	26.12	27.92	4.73	6.11	8.15
T <sub>7</sub>	46.96	70.21	92.22	5.82	7.56	9.79	28.32	30.56	32.22	5.37	7.31	9.18
F-test	S	S	S	S	S	S	S	S	S	S	S	S
S. Em. (±)	0.72	1.18	1.32	0.04	0.01	0.11	0.31	0.31	0.38	0.07	0.08	0.13
C.D.	2.12	3.47	3.89	0.14	0.31	0.34	0.93	0.91	1.12	0.23	0.26	0.40

turbidity of plant cell. The increase in nodulation and nitrogen fixation leads to more plant height. Favorable soil physical environment stimulated root growth and thus increased the capacity of plants for efficient utilization of nutrients and water resulted in better shoot growth and consequently higher plant height. Similar findings were reported by Khandagle *et al.* (2019). RDF combined with poultry manure, vermicompost, neem cake and biochar increase number of branches may be due to adequate y of macro and micro nutrients which enhanced the vegetative growth of plant. Similar results were reported by Lateef *et al.* (2018).

### 3.2 Effect on Yield Parameters of Cowpea

The data presented in Table 2 shows that yield parameters significantly increased by using the combination of inorganic fertilizers, organic manures, biochar and crop residues. Highest average pod yield 161.12 q ha<sup>-1</sup> and yield parameters like high pod length 21.72 cm and 20.01 cm, highest number of pods plant<sup>-1</sup> 35.52 and 35.75, highest number of seed pod<sup>-1</sup> 10.01 and 10.21 and highest test weight 27.12 g and 26.23 g and were recorded in T<sub>7</sub> [RDF + Poultry

Manure @ 2 t ha<sup>-1</sup> + Biochar @ 2.5 t ha<sup>-1</sup> + Vermicompost @ 2 t ha<sup>-1</sup> + Neem Cake @ 500 kg ha<sup>-1</sup>] at 55 DAS and 70 DAS respectively followed by T<sub>4</sub> [RDF + Vermicompost @ 2 t ha<sup>-1</sup> + Rice Straw @ 6 t ha<sup>-1</sup>] respectively and were found to be significant. Minimum yield parameters observed in T<sub>1</sub> [RDF]. Increased in yield parameters like Pod length (cm), No of pods plant<sup>-1</sup>, No of seed pod<sup>-1</sup>, Seed weight (g) and Pod Yield (q ha<sup>-1</sup>) may be due to adequate availability of nutrients during reproductive stage of crop growth (El-Sharawy *et al.*, 2018).

### 3.3 Effect on Economics

The data presented in Table 3 shows that maximum gross return (₹ 2,41,680) was recorded in treatment T<sub>7</sub> [RDF + Poultry Manure @ 2 t ha<sup>-1</sup> + Biochar @ 2.5 t ha<sup>-1</sup> + Vermicompost @ 2 t ha<sup>-1</sup> + Neem Cake @ 500 kg ha<sup>-1</sup>] followed by T<sub>4</sub> [RDF + Vermicompost @ 2 t ha<sup>-1</sup> + Rice Straw @ 6 t ha<sup>-1</sup>] respectively and minimum gross return (₹ 1,51,020) recorded in treatment T<sub>1</sub> [RDF]. Maximum B:C ratio (2.80) was recorded in T<sub>4</sub> [RDF + Vermicompost @ 2 t ha<sup>-1</sup> + Rice Straw @ 6 t ha<sup>-1</sup>] treatment followed by T<sub>3</sub> [RDF + Farm Yard Manure @ 5 t ha<sup>-1</sup>]

**Table 2. Effect of integrated sources of nutrients on yield parameters of Cowpea**

Treatments	Pod length (cm)		No of pods plant <sup>-1</sup>		No of seed pod <sup>-1</sup>		Seed weight (g)		Pod Yield (q ha <sup>-1</sup> )
	55 DAS	70 DAS	55 DAS	70 DAS	55 DAS	70 DAS	55 DAS	70 DAS	
T <sub>1</sub>	14.12	15.01	19.21	20.12	6.99	7.45	20.55	19.79	100.68
T <sub>2</sub>	15.63	14.92	21.98	22.11	7.45	8.14	21.21	20.13	107.21
T <sub>3</sub>	17.16	15.55	25.24	26.01	8.21	8.95	23.85	23.21	128.51
T <sub>4</sub>	19.36	19.12	28.74	28.89	9.74	9.86	26.01	25.13	152.01
T <sub>5</sub>	17.75	16.21	26.07	26.52	8.82	9.05	24.31	23.43	140.56
T <sub>6</sub>	16.55	15.16	23.54	23.03	8.12	8.56	22.45	21.54	122.65
T <sub>7</sub>	21.72	20.01	35.52	35.75	10.01	10.21	27.12	26.23	161.12
F-test	S	S	S	S	S	S	S	S	S
S. Em. (±)	0.25	0.26	0.50	0.48	0.14	0.12	0.44	0.39	1.03
C.D.	0.75	0.77	1.47	1.43	0.42	0.35	1.29	1.16	3.02

**Table 3. Economic of Cowpea of different treatment combination**

Treatment	Yield (q ha <sup>-1</sup> )	Yield (₹ha <sup>-1</sup> )	Grossreturn (₹ha <sup>-1</sup> )	Total cost of cultivation (₹ha <sup>-1</sup> )	Net profit (₹ha <sup>-1</sup> )	(C:B)
T <sub>1</sub>	100.68	1500	151020	56890.9	124129.1	1:2.65
T <sub>2</sub>	107.21	1500	160815	59991.4	100823.6	1:2.68
T <sub>3</sub>	128.51	1500	192765	69390.9	103874.1	1:2.77
T <sub>4</sub>	153.01	1500	229515	81890.9	147624.1	1:2.80
T <sub>5</sub>	141.56	1500	212340	78390.9	133949.1	1:2.70
T <sub>6</sub>	122.65	1500	183975	134390.9	49584.1	1:1.36
T <sub>7</sub>	161.12	1500	241680	175390.9	66289.1	1:1.37

respectively and minimum B:C ratio (1.36) recorded in T<sub>6</sub> [RDF + Biochar @ 2.5 t ha<sup>-1</sup>] treatment. But maximum net return (₹ 1,47,624.1) was recorded in treatment T<sub>4</sub> [RDF + Vermicompost @ 2 t ha<sup>-1</sup> + Rice Straw @ 6 t ha<sup>-1</sup>] followed by T<sub>5</sub> [RDF + Neem Cake @ 500 kg ha<sup>-1</sup> + Wheat Straw @ 6 t ha<sup>-1</sup>] respectively and the minimum net return (₹ 49,584.1) was recorded in T<sub>6</sub> [RDF + Biochar @ 2.5 t ha<sup>-1</sup>] (Pharesa et al., 2020 ; Yeboah et al., 2020).

#### 4. CONCLUSION

Application of inorganic fertilizers, organic manures, biochar and crop residues gave the best economics like gross return, net return and cost benefit ratio (C:B) observed in T<sub>4</sub> [RDF + Vermicompost @ 2 t ha<sup>-1</sup> + Rice Straw @ 6 t ha<sup>-1</sup>] followed by T<sub>3</sub> [RDF + Farm Yard Manure @ 5 t ha<sup>-1</sup>] respectively and gave best significant results of growth and yield parameters recorded in T<sub>7</sub> - [RDF + Poultry Manure @ 2 t ha<sup>-1</sup> + Biochar @ 2.5 t ha<sup>-1</sup> + Vermicompost @ 2 t ha<sup>-1</sup> + Neem Cake @ 500 kg ha<sup>-1</sup>] followed by T<sub>4</sub> [RDF + Vermicompost @ 2 t ha<sup>-1</sup> + Rice Straw @ 6 t ha<sup>-1</sup>] respectively and found at par than any other treatments. According to cost of cultivation best three treatments are T<sub>1</sub> [RDF @ 25:75:60 N:P:K] followed by T<sub>2</sub> [RDF + B @ 2 kg ha<sup>-1</sup> + Zn @ 7 kg ha<sup>-1</sup>] and T<sub>3</sub> [RDF + Farm Yard Manure @ 5 t ha<sup>-1</sup>]. So, this is concluded that combination of inorganic, organic and carbon source increase growth and yield parameters of cowpea significantly.

#### DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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