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INFLUENCE OF MICROBIAL CONSORTIUM AND NUTRIENT MANAGEMENT ON SEED YIELD AND QUALITY IN COWPEA (*VIGNA UNGUICULATA* L.)

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ABSTRACT

Improving productivity and quality of leguminous crops like cowpea (*Vigna unguiculata* L.) is important for achieving sustainable nutritional security. Integrated nutrient management, involving the combined use of chemical fertilizers along with beneficial microorganisms, has emerged as a promising strategy to enhance both yield and seed quality. In this context, a field experiment was conducted to study the influence of microbial consortia and nutrient management on seed yield and quality in cowpea during *Kharif* 2024 at AICRP on Arid Legumes, GKV, UAS, Bengaluru. The experiment consists of ten treatments which were replicated thrice in Randomized Complete Block Design (RCBD). Among all treatments, application of 100% RDF+ seed treatment and soil application of microbial consortia show significantly higher plant growth, seed yield and seed quality attributes. This treatment recorded the highest plant height (38.16 cm), number of root nodules (37.90), dry weight of root nodules (0.73 g plant⁻¹), number of pods plant⁻¹ (13.83), pod length (18.16 cm, hundred seed weight (12.33 g) and seed yield (18.14 q ha⁻¹). Further, soil chemical properties after harvest of crop show that available nitrogen (N₂) (275.93 kg ha⁻¹), P₂O₅ (44.60 Kg ha⁻¹) and K₂O (268.81 Kg ha⁻¹) seed moisture (10.92 %) seed germination (93.00%), seed health (88.33%) and higher net returns (67,808 Rs. ha⁻¹) and benefit cost ratio (2.5) were recorded with same treatment. Hence, it can be concluded that integration of microbial consortia with 100% RDF not only enhanced seed yield and quality in cowpea but also contributed to higher economic returns.

Keywords: Microbial consortia, Rhizosphere microorganisms, Seed yield, Seed quality

Introduction

Cowpea (*Vigna unguiculata* L.), is a multipurpose leguminous crop belonging to the family *Fabaceae*, originating from Central Africa. It is widely known as "black-eyed pea" due to its distinctive seed hilum. Nutritionally, cowpea is often referred to as "vegetable meat" due to its high protein content (23.1%), which is approximately double that of cereals. In India, it is grown in an area of 3.9 million ha with a production of 0.22 million metric tonnes (Government of India, 2024), where as in Karnataka, it is grown in an area of 0.94 lakh ha with a production of 0.39 lakh tonnes and (Government of Karnataka, 2024).

Indian agriculture relies extensively on inorganic fertilizers to fulfill the escalating food demands driven

by a rapidly growing population. However, the indiscriminate and imbalanced application of chemical fertilizers has led to a progressive decline in nutrient use efficiency, rendering fertilizer inputs economically unsustainable. Moreover, such practices have precipitated a range of environmental concerns, including soil degradation, groundwater contamination, biodiversity loss, and disruption of essential ecosystem functions. In light of these challenges, the exploration and adoption of sustainable nutrient sources that are both cost-effective and environmentally sustainable has become imperative.

Microbial consortium treatment and nutrient management emerges as a viable and holistic strategy aimed at enhancing crop productivity while preserving

soil health. It advocates the judicious and synergistic application of chemical fertilizers alongside organic amendments such as farmyard manure, compost, and green manures, in addition to bio-fertilizers. Among these, microbial inoculants including nitrogen-fixing bacteria (*Rhizobium*, *Azospirillum*), phosphate-solubilizing bacteria (PSB) and plant growth-promoting rhizobacteria (PGPR)-play a critical role.

Microbial consortia are synergistic mixtures of beneficial microorganisms that, when applied to seeds, soil, or root surfaces, enhance nutrient availability by stimulating biological activity and colonizing the rhizosphere. This colonization supports the development of beneficial micro-flora, ultimately improving soil health. These consortia show great promise in addressing the challenges associated with sustainable and eco-friendly agriculture.

Seed quality is a fundamental determinant of successful crop production, directly influencing germination, seedling vigor, establishment and ultimately yield potential. Seed quality is influenced by several physiological, biochemical, and environmental factors, many of which are governed by nutrient availability during seed development. This research highlights that integrated nutrient management, particularly involving microbial consortia, can significantly improve seed quality attributes.

Material and Methods

The experiment was conducted during *kharif* season 2024 at AICRP on Arid Legumes, GKVK, UAS, Bangalore. The center is situated in the Agro-climatic zone V: Eastern Dry Zone of Karnataka at 12°58' North latitude and 77°35' East longitude with an altitude of 924 m above mean sea level. During the year 2024, a total of 1436 mm rainfall was received as against the average normal rainfall of 941 mm. The mean of normal maximum air temperature ranged from 26.3 °C (December) to 33.6 °C (April). Whereas, the mean normal minimum air temperature ranged between 14.1 °C (January) to 20.5 °C (April to May). The normal mean monthly maximum relative humidity ranged from 77 per cent (March) to 89 per cent (August to September) and the normal mean sunshine hours varied from 4.5 (July) to 9.6 hours day⁻¹ (February). The soil was red sandy loam in texture, classified under the soil order *Alfisols*, consisting of 53.3 per cent coarse sand, 14.9 per cent fine sand, 16.7 per cent silt and 15.2 per cent clay. The soil pH was acidic (5.89) in reaction with an electrical conductivity of 0.38 ds m⁻¹. The organic carbon content was 0.32 per cent. The soil was low in available nitrogen (248.0 kg ha⁻¹) and medium in available phosphorous (26.4 kg

ha⁻¹) and available potassium (239.1 kg ha⁻¹), using KBC-9 variety at a spacing of 45 cm x10 cm. The experiment laid out in Randomized Complete Block Design with ten treatments and three replications. The ten treatments were, T₁: Control (100% RDF), T₂: 100% RDF + seed treatment with microbial consortia, T₃: 100% RDF + soil application of microbial consortia, T₄: 100% RDF + seed treatment with microbial consortia and soil application of microbial consortia, T₅: 75% RDF + seed treatment with microbial consortia, T₆: 75% RDF + soil application of microbial consortia, T₇: 75% RDF + seed treatment with microbial consortia and soil application of microbial consortia, T₈: 50% RDF + seed treatment with microbial consortia, T₉: 50% RDF + soil application of microbial consortia and T₁₀: 50% RDF + seed treatment with microbial consortia and soil application of microbial consortia. The Recommended dose of fertilizer is 25 kg N+50 kg P₂O₅ +25 kg K₂O ha⁻¹. Seed treatment was done by mixing seeds with microbial consortia at the rate of 4 ml per kg seed and shade dried for 10 minutes before sowing. For soil application, microbial consortia at the rate of 5 liter per hectare was mixed with required quantity of well decomposed, powdered farm yard manure. This mixture is applied by broadcasting at the time of sowing (Microbial consortium: *Rhizobium* + PSB + Zn mobilizing bacteria).

Five plants from each plot were randomly selected from the net plot and tagged. These plants were used for recording growth and yield attributes observations. The plant height was measured from the ground level to the tip of leaf leaves in main shoot of the selected five plants from each net plot. Five plants were uprooted randomly in each treatment and number of nodules per plant were counted and root nodules obtained from the five plants of each plot were oven dried at 69°C 18hour to remove moisture from nodules and then dry weight was recorded help of an electronic balance. The plants from the net plot were harvested and threshed separately and the seed yield parameters were recorded and expressed on hectare basis. The average of all the replications is expressed as mean values of the respective treatments. The data recorded on various parameters were subjected to Fisher's method of analysis of variance and interpretation of the data was made as given by Gomez and Gomez (1984). The level of significance used in 'F' and 't' test was P = 0.05. Whenever F-test was significant for comparison amongst the treatments means the critical differences (CD) was worked out. Otherwise against CD values abbreviation 'NS' (Non-significant) is indicated.

Economic analysis

1. Cost of cultivation

The prices of inputs used and labour cost has considered for computing the cost of cultivation and which was expressed in rupees per hectare.

2. Gross returns

The gross returns were calculated by considering product price that was prevailing in the market at the time of harvest and was expressed in rupees per hectare.

Gross returns (Rs. ha⁻¹) = Market price × seed yield

3. Net returns

The net returns were calculated treatment-wise by subtracting the total cost of cultivation from gross returns and was expressed in rupees per hectare.

Net returns (Rs. ha⁻¹) = Gross returns (Rs. ha⁻¹)
– Cost of cultivation (Rs. ha⁻¹)

4. Benefit cost ratio:

Benefit cost ratio (B:C) was worked out treatment wise as follows

$$B:C \text{ ratio} = \frac{\text{Gross returns (Rs. ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs. ha}^{-1}\text{)}}$$

Chemical study of soil

Available nitrogen, phosphorus and potassium

Available nitrogen in the soil was determined through alkaline potassium permanganate method (Subbiah and Asija, 1956). Ten grams of soil sample was distilled with 25 ml of 0.32 per cent KmnO_4 and 25 ml of 2.4 per cent sodium hydroxide (NaOH). Boric acid (4%) along with mixed indicator was used as trapping agent to trap the released ammonia and it was back titrated against 0.02 per cent sulphuric acid solution. The available nitrogen in soil is expressed as kg ha^{-1}

The available phosphorus was extracted with Bray's No.1 extractant (0.03 N NH_4F + 0.025 N HCl). The phosphorus in the extract was determined by stannous chloride reduced molybdo-phosphoric blue colour method. The intensity of blue colour was read using a spectrophotometer at 660 nm. The intensity of blue colour developed is directly proportional to the phosphorous concentration in the soil. The available phosphorus in soil is expressed as kg ha^{-1} (Jackson, 1973).

Available potassium was extracted from soil using neutral normal ammonium acetate (NH_4OAC) (1:5

soil: NH_4OAC ratio) and the concentration of potassium present in the extractant was determined by using flame photometer (Jackson, 1973).

Seed quality parameters study:

Seed moisture content (%)

The seed moisture content will be determined by using the high constant temperature oven method as per the ISTA (Anon., 2021). Randomly, five grams of cowpea seeds of three replication will be taken from each treatment, and then the seeds are ground by a mixer and dried in aluminium boxes in the oven at $130 \pm 1^\circ\text{C}$ for 1 hours. The aluminium boxes with seed material are cooled in desiccators over silica gel for 30 minutes and seed moisture content will be calculated from the weighed samples and expressed in percentage on a dry weight basis by using the formula

$$\text{Seed moisture (\%)} = \frac{M_2 - M_3}{M_2 - M_1} \times 100$$

M_1 =The weight of the container with its lid, M_2 =The weight of the container with its lid and seeds before drying and M_3 =The weight of the container with lid and seeds after drying.

Germination (%):

The germination test will be conducted as per ISTA guidelines in the laboratory by using between paper method (Anon., 2021). One hundred seeds are randomly selected from each treatment in three replications and placed equidistantly on the paper towel, they are further rolled and kept in a germination chamber with a temperature of $25 \pm 1^\circ\text{C}$ and RH of 90 per cent. The first count and the final count of the germinated seedlings will be taken on the 5th and 8th day respectively and the percentage of germination will be expressed based on the number of normal seedlings present.

$$\text{Seed germination (\%)} = \frac{\text{Number of normal seedlings}}{\text{Number of seeds kept for germination}} \times 100$$

Seed health (%):

Seed Infection, Detection and identification was done by blotter paper method as per ISTA rules 2021. Twenty-five seeds of 3 replications were placed equidistantly in sterile petri dishes of 9 cm diameter containing 3 moist blotter papers. The petri dishes were incubated at 20°C for 7 days with alternate 12 hours light and 12 hours dark. After incubation, seeds were examined under stereo binocular microscope for presence of seed infection of cowpea seeds and the number of cowpea seeds infected was recorded and expressed as percentage.

$$\text{Seed health (\%)} = \left[\frac{\text{Number of seeds infected}}{\text{Total number of seeds}} \right] \times 100$$

Characteristics

The KBC-9 cowpea variety parentage is Arka Garima × VS389 released from University of Agricultural Sciences, Bangalore. It is medium in duration, matures in 80 to 85 days, resistant to dry root rot and collar rot, moderately resistant to yellow mosaic virus, this variety can be grown in all the three seasons of a year.

Results and Discussion

Study the effect of microbial consortium and nutrient management on growth parameters and seed yield

In the present study, plant height measured at 30 and 60 days after sowing and at harvest of cowpea (Table 1). At 30 DAS, plant height remained statistically similar among different treatments. At 60 DAS, practice of 100% RDF + seed treatment with microbial consortia and soil application of microbial consortia (T_4) exhibited a significantly greater plant height (29.07 cm), lowest plant height (20.03 cm) was documented under the treatment involving 50% RDF + seed treatment with microbial consortia (T_8). Similar trend was observed at harvest stage also. Significantly highest plant height (38.16 cm) was noticed upon the application of 100% RDF + seed treatment with microbial consortia and soil application of microbial consortia (T_4) While, lowest plant height (25.70 cm) was noted upon application of 50% RDF + seed treatment with microbial consortia (T_8). The increase in plant height might result from elevated water and nutrient uptake, phytohormone production, i.e., gibberellic acid, indole acetic acid, and siderophore production by *Pseudomonas* (Waghunde *et al.*, 2021).

At 30 DAS, significantly highest (18.00) number of root nodules per plant were obtained through the application of 100% RDF + seed treatment with microbial consortia and soil application of microbial consortia (T_4). Whereas, least count of nodules per plant (12.57) were recorded with the application of 50% RDF + seed treatment with microbial consortia (T_8). The same pattern was observed at 60 DAS where, application of T_4 : 100% RDF + seed treatment with microbial consortia and soil application of microbial consortia attained a statistically highest value (37.90) number of root nodules per plant While, smallest count of nodules per plant (25.60) were noticed with the application of 50% RDF + seed treatment with microbial consortia (T_8) is presented in table 2.

Statistically higher dry weight of nodules (0.26 and 0.73 g plant⁻¹, respectively) at 30 and 60 DAS were found in response to the application of 100% RDF +

seed treatment with microbial consortia and soil application of microbial consortia (T_4), succeeded by 100% RDF+ soil application of microbial consortia (T_3) (0.23 and 0.70 g plant⁻¹, respectively). Whereas, T_8 : 50% RDF + seed treatment with microbial consortia registered a significantly decreased dry weight of nodules (0.10 and 0.40 g plant⁻¹, respectively) at 30 and 60 DAS, is presented in table 2. Current findings are contemporaneous with Anandaraj and Delapierre (2010).

At harvest, significantly highest number of pods per plant (13.83) were observed under incorporation of 100% RDF + seed treatment with microbial consortia and soil application of microbial consortia (T_4). Whereas, lowest recorded number of pods per plant (5.87) were observed with the application of 50% RDF+ seed treatment with microbial consortia (T_8). Comparable outcomes were also observed in studies conducted by other researchers like Shrikant (2010), Choudhary *et al.* (2011), is presented in (table 3). Incorporation of 100% RDF + seed treatment with microbial consortia and soil application of microbial consortia showed a significant high pod length (T_4) (18.16 cm), followed by, T_3 : 100% RDF + soil application of microbial consortia (17.90 cm). While, lower pod length (15.38 cm) was observed with the application of 50% RDF + seed treatment with microbial consortia (T_8) is presented in (table 3).

Hundred seed weight of cowpea was not markedly affected by different treatments, because test weight is a character mostly governed by genetic influence of the crop and hence, environmental and managerial factors usually have lesser influence. However, slightly bolder grains (12.33 g) were found in T_4 : 100% RDF + seed treatment with microbial consortia and soil application of microbial consortia. While, lowest test weight (11.48 g) was found in application of 100% RDF + seed treatment with microbial consortia (T_8), is presented in table 3.

The maximum seed yield (18.14 q ha⁻¹) was obtained with the application of 100% RDF+ seed treatment with microbial consortia and soil application of microbial consortia (T_4) which outperformed significantly over all other treatments, followed by 100% RDF + soil application of microbial consortia (T_3) (16.41 q ha⁻¹). In contrast, significantly minimum seed yield (12.56 q ha⁻¹) was detected in T_8 : 50% RDF + seed treatment with microbial consortia, is presented in (table 3) (Fig 2). Supporting evidence was provided by previous researchers Kumpawati (2007), Shrikant (2010), Sharma *et al.* (2014) and Pargi *et al.* (2018).

Table 1 : Plant height at different growth stages of cowpea as influenced by microbial consortium and nutrient management.

Treatment	Plant height (cm)		
	30 DAS	60 DAS	At Harvest
T ₁	9.20	25.27	28.58
T ₂	9.53	26.53	30.58
T ₃	9.98	28.17	31.22
T ₄	11.40	29.07	38.16
T ₅	8.72	25.72	26.14
T ₆	9.40	25.73	30.07
T ₇	9.47	25.77	30.40
T ₈	8.07	20.03	25.70
T ₉	8.47	20.80	25.94
T ₁₀	8.50	23.59	26.17
Mean	9.27	25.06	29.29
SEm±	0.42	0.77	1.12
CD (P=0.05)	NS	2.27	3.33
CV (%)	13.74	9.16	11.46

DAS: Days After Sowing NS: Non-Significant

Table 2 : Number of nodules plant⁻¹ and dry weight of nodules (g plant⁻¹) at 30 and 60 DAS in cowpea as influenced by microbial consortium and nutrient management

Treatments	Number of nodules plant ⁻¹		Dry weight of nodules (g plant ⁻¹)	
	30 DAS	60 DAS	30 DAS	60 DAS
T ₁	13.96	29.90	0.17	0.57
T ₂	15.81	34.60	0.21	0.67
T ₃	16.20	35.50	0.23	0.70
T ₄	18.00	37.90	0.26	0.73
T ₅	13.75	28.50	0.14	0.50
T ₆	14.55	31.50	0.19	0.57
T ₇	15.16	32.80	0.20	0.60
T ₈	12.57	25.60	0.10	0.40
T ₉	13.20	26.80	0.11	0.47
T ₁₀	13.30	28.00	0.13	0.50
Mean	14.64	31.11	0.17	0.56
SEm±	0.29	0.59	0.01	0.01
CD (P=0.05)	0.86	1.75	0.02	0.04
CV (%)	5.91	5.67	10.24	7.82

DAS: Days After Sowing NS: Non-Significant

Table 3 : Influence of microbial consortium and nutrient management on number of pods per plant, hundred seed weight and seed yield.

Treatment	No. of pods plant ⁻¹	Pod length (cm)	Hundred seed weight (g)	Seed yield (q ha ⁻¹)
T ₁	8.53	16.68	12.02	14.28
T ₂	9.73	17.61	12.29	15.49
T ₃	11.40	17.90	12.31	16.41
T ₄	13.83	18.16	12.33	18.14
T ₅	7.67	16.36	11.97	13.66
T ₆	9.67	16.76	12.01	14.26
T ₇	9.97	17.14	12.22	14.86
T ₈	5.87	15.38	11.48	12.56
T ₉	7.07	16.10	11.76	12.97
T ₁₀	7.20	16.31	11.84	13.63
Mean	9.09	16.84	12.02	14.62
SEm±	0.39	0.31	0.30	0.31
CD (P=0.05)	1.15	0.91	1.21	0.94
CV (%)	12.75	5.45	4.34	6.49

DAS: Days After Sowing NS: Non-Significant

To study the effect of microbial consortium and nutrient management on chemical and properties of soil at harvest of crop

Experimental results on nutrient availability in the soil at harvest as influenced by microbial consortium and nutrient management show Significantly, higher available nitrogen ($275.93 \text{ kg ha}^{-1}$), phosphorous (44.60 kg ha^{-1}) and potassium ($268.81 \text{ kg ha}^{-1}$) were observed with 100% RDF + seed treatment with

microbial consortia and soil application of microbial consortia (T_4), followed by T_3 : 100% RDF + soil application of microbial consortia (268.67 , 41.27 and $260.36 \text{ kg ha}^{-1}$, respectively). While, significantly lower available nitrogen ($233.23 \text{ kg ha}^{-1}$), phosphorous (29.23 kg ha^{-1}) and potassium ($223.53 \text{ kg ha}^{-1}$) were obtained through the application of 50% RDF + seed treatment with microbial consortia (T_8).

Table 4 : Nutrient status of soil after harvest of cowpea as influenced by microbial consortium and nutrient management

Treatment	Available (kg ha^{-1})		
	N	P_2O_5	K_2O
T1: Control (100% RDF)	247.37	34.90	241.51
T2: 100% RDF + seed treatment with microbial consortia	263.96	39.90	256.56
T3: 100% RDF + soil application of microbial consortia	268.67	41.27	260.36
T4: 100% RDF + seed treatment with microbial consortia and soil application of microbial consortia	275.93	44.60	268.81
T5: 75% RDF + seed treatment with microbial consortia	245.70	36.00	244.80
T6: 75% RDF + soil application of microbial consortia	255.44	37.23	244.63
T7: 75% RDF + seed treatment with microbial consortia and soil application of microbial consortia	259.30	39.27	254.83
T8: 50% RDF + seed treatment with microbial consortia	233.23	29.23	223.53
T9: 50% RDF + soil application of microbial consortia	238.29	32.03	228.02
T10: 50% RDF + seed treatment with microbial consortia and soil application of microbial consortia	243.71	33.90	237.44
Mean	253.22	36.83	246.04
S.Em. $\pm$	4.44	0.76	3.97
CD ($p=0.05$)	13.18	2.26	11.79

To study the influence of microbial consortium treatment and nutrient management on seed quality

In the present study, the maximum seed moisture content (10.92%) was observed in 100% RDF + seed treatment with microbial consortia and soil application of microbial consortia (T_4). While, lowest seed moisture content (10.45%) was noticed with the application of 50% RDF + seed treatment with microbial consortia (T_8) is presented in (table 4). The present results are supported by Patel *et al.* (2020).

Application of 100% RDF + seed treatment with microbial consortia and soil application of microbial consortia (T_4) exhibited the significantly highest germination percentage (93.00%), While, lowest germination (78.00%) was noticed with the application

of 50% RDF + seed treatment with microbial consortia (T_8) is presented in (table 4). Gracia de Salamone *et al.* (2001) reported that *Pseudomonas* strains produced cytokinin, isopentyl adenosine (IPA), trans-zeatin ribose (ZR) and dihydrozeatin riboside (DHZR).

The treatment T_4 (100% RDF+ seed treatment with microbial consortium and soil application of microbial consortium) registered the highest seed health percentage (88.33 %), Least seed health (%) is recorded in T_8 (74.67 %) is presented in (table.5) (Plate.1). This clearly demonstrates the beneficial impact of microbial consortium and nutrient management in maintaining seed integrity and health during development and post-harvest processing.

Table 4 : Effect of microbial consortium and nutrient management on seed moisture (%) seed germination (%) shoot length and root length (cm) in cowpea.

Treatment	Seed moisture (%)	Seed germination (%)
T ₁	10.76	84.33
T ₂	10.85	89.33
T ₃	10.83	92.00
T ₄	10.92	93.00
T ₅	10.73	84.00
T ₆	10.79	86.00
T ₇	10.81	87.00
T ₈	10.45	78.00
T ₉	10.61	80.67
T ₁₀	10.62	82.00
Mean	10.74	85.63
SEm±	0.08	1.26
CD (P=0.05)	0.31	5.09

DAS: Days After Sowing NS: Non-Significant

Table 5: Effect of microbial consortium and nutrient management on seed health (%) in cowpea

Treatment	Seed health (%)
T ₁ : Control (100% RDF)	80.33
T ₂ : 100% RDF + seed treatment with microbial consortia	84.67
T ₃ : 100% RDF + soil application of microbial consortia	86.67
T ₄ : 100% RDF + seed treatment with microbial consortia and soil application of microbial consortia	88.33
T ₅ : 75% RDF + seed treatment with microbial consortia	79.33
T ₆ : 75% RDF + soil application of microbial consortia	81.67
T ₇ : 75% RDF + seed treatment with microbial consortia and soil application of microbial consortia	82.33
T ₈ : 50% RDF + seed treatment with microbial consortia	74.67
T ₉ : 50% RDF + soil application of microbial consortia	77.33
T ₁₀ : 50% RDF + seed treatment with microbial consortia and soil application of microbial consortia	78.67
Mean	81.40
S.Em. ±	1.63
CD (p=0.05)	6.54
CV (%)	3.46

T₄T₈**Plate 1 :** Comparison of T₄ and T₈ on seed health (%) in cowpea cv. KBC-9

Economics of cowpea as influenced by microbial consortium and nutrient management

The higher gross returns (1,14,104 Rs. ha⁻¹), net returns (67,808 Rs. ha⁻¹) and B:C ratio (2.5) were recorded by the application of 100% RDF + seed treatment with microbial consortia and soil application of microbial consortia (T₄). Whereas, the lower gross returns (79,002 Rs. ha⁻¹), net returns (34,803 Rs. ha⁻¹) and B:C ratio (1.8) were recorded under the application of 50% RDF + seed treatment with microbial consortia (T₈). Presented in (Fig.1).

The higher gross returns, net returns and B:C ratio were the result of higher seed yield, that is obtained due to the combined application of different sources of nutrients in integrated manner, which might have facilitated the greater availability of essential nutrients to plant and better translocation of photosynthates, ultimately resulted in higher seed and haulm yield. The results are in close vicinity with the findings of Sangeeta Meena (2019), Harkesh Meena (2020) and Patel and Thanki (2020).

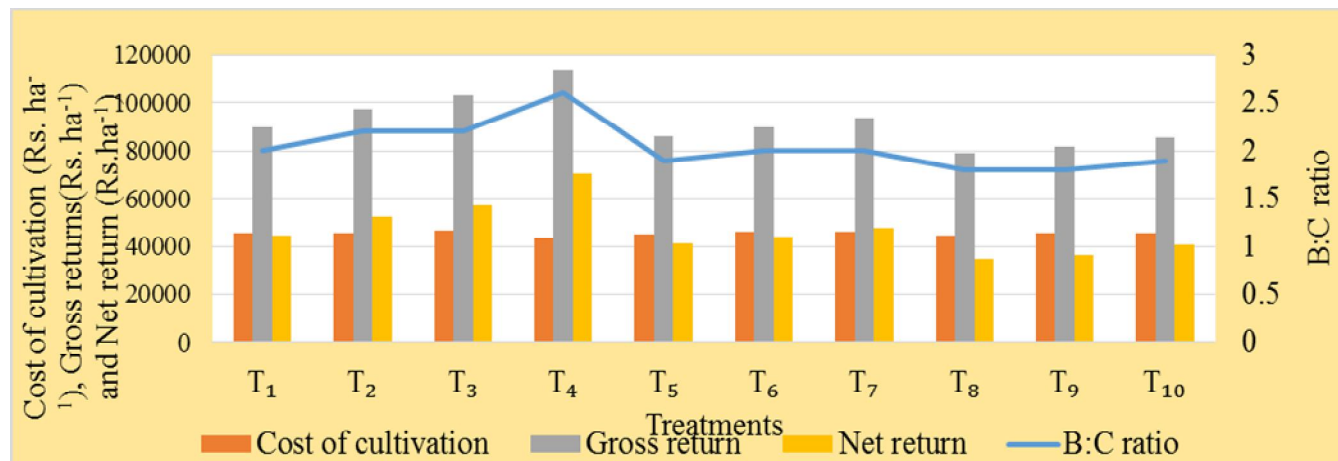


Fig. 1 : Economics of cowpea as influenced by microbial consortium and nutrient managements

Conclusion

On the basis of the obtained results, it is apparent that good response of cowpea was established among different microbial consortium and nutrient management treatments. The results revealed that 100% RDF+ seed treatment with microbial consortium and soil application of microbial consortium was effective in maintaining plant height (26.14 cm at harvest), number of root nodules (37.9 at 60 DAS), dry weight of root nodules (0.73 at 60 DAS) and seed yield attributes. Similarly, the same treatment combination was effective in seed moisture (10.92 %), seed germination (93%), and seed health (88.33 %). Whereas, T₈:50% RDF+ seed treatment with microbial consortium shows poor seed yield and seed quality parameters.

On the basis of the obtained results, it is apparent that good response of cowpea was established among different microbial consortium and nutrient management treatments. Significantly higher seed yield (18.14 q ha⁻¹), higher net returns (67,808 Rs. ha⁻¹) and B:C ratio (2.5) was recorded with the application of 100% RDF + seed treatment with microbial consortia and soil application of microbial consortia.

Therefore, Microbial consortia contribute to improved nutrient solubilization and mineralization. For instance, *Rhizobium* facilitates nitrogen fixation, while *Pseudomonas* aids in phosphate solubilization and siderophore production, making essential nutrients more available to plants. By supplementing or partially replacing synthetic fertilizers and pesticides, microbial consortia contribute to reducing input costs and minimizing environmental pollution, supporting eco-friendly farming systems.

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