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RESEARCH PAPER

Nutrient management in summer cowpea (*Vigna unguiculata* (L.) Walp.) through natural farming practices

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Abstract: A field experiment entitled "Nutrient management in *summer* cowpea (*Vigna unguiculata* (L.) Walp.) through natural farming practices" was conducted during the *summer* 2022 at the College of Agriculture, Vijayapura, Karnataka on medium deep black soil of the Northern Dry Zone of Karnataka. The experiment was laid out in a Complete Randomized Block Design (RCBD) with three replications and thirteen treatments, including *ghanajeevamrutha* and *jeevamrutha* concentrations. The results revealed that soil application of *ghanajeevamrutha* @ 2000 kg ha^{-1} combined with a foliar application of *jeevamrutha* @ 20% during the flowering and pod development stages, significantly enhanced seed yield (1625 kg ha^{-1}), haulm yield (3432 kg ha^{-1}), and other yield attributes such as the number of pods per plant (24.93) and length of the pod (18.07 cm) compared to other treatments. This treatment also significantly improved nutrient uptake, with values of 134.12 kg N ha^{-1},18.79 kg P_2O_5ha^{-1} and 73.42 kg K_2O ha^{-1} and increased soil enzyme activities such as dehydrogenase (5.87 µg TPF g^{-1} soil day^{-1}) and urease (16.95 µg NH_4-N g^{-1} soil hr^{-1}) at flower initiation stage. Economically, this treatment combination provided significantly higher gross returns (₹ 81,266 ha^{-1}) and net returns (₹ 56,366 ha^{-1}), which was *ghanajeevamrutha jeevamrutha* followed by application of 5 t FYM along with 25 kg N,50 kg P_2O_5, 25 kg K_2O, 20 kg S and 25 kg $ZnSO_4$ha^{-1},which resulted ingross returns of ₹ 76,400 ha^{-1} and net returns of ₹ 49,290 ha^{-1}. It concludes, the soil application of *ghanajeevamrutha* @ 2000 kg ha^{-1}along with a foliar application of *jeevamrutha* @ 20% concentration offers an effective and sustainable approach to enhance cowpea yields, soil fertility and improve overall economic returns of farmers.

Key words: Dehydrogenase, Folia spray, *Ghanajeevamrutha*, *Jeevamrutha*, Urease

Introduction

Cowpea (*Vigna unguiculata* L.) is an important food legume crop. Cowpea is often referred to as the poor man's meat and "hunger-season crop" as it is a significant source of protein, minerals and vitamins for rural people. Cowpea is a multipurpose arid grain legume referred to as southern pea, black-eyed pea, *etc*. It is adapted to a wide range of soils, rainfall situations, seasons and fits as a niche crop in multiple and intercropping systems and is extensively cultivated in arid and semiarid regions of Africa and Asia. Cowpea belongs to the family Leguminosae and genus *Vigna* (Frey, 1990) and is primarily grown for its chief source of dietary protein lysine. It is used as a pulse or green pod vegetable and haulm as an excellent animal feed. Cowpea is a nutritious crop. It is considered a very good source of protein, carbohydrates and vitamins (Phillips and Mc Watters, 1991) and a rich source of calcium (0.08-0.11%) and iron (0.005%). It accounts for a high per cent of protein (23.14%), which is double that of cereals and carbohydrates (56.8%), fiber (3.9%), ash (3.20%) and fat (1.3%). Cowpea is cultivated in various parts of the world and India is one of the major countries contributing to global cowpea production. It is grown for its green pod, dry seeds and forage, which are used for food and fuel. In India, cowpea is cultivated on approximately 3.9 million hectares with a production of 2.2 million tonnes and an average productivity of 564 kg ha^{-1}. Karnataka covers an area of 0.88 lakh hectares, with a production of 0.42 lakh tonnes and productivity of 477kg ha^{-1} (Indiastat, 2019). In Karnataka, while cowpea is traditionally grown in *kharif* (June–August), farmers are increasingly cultivating it in rabi and summer, driven by changing climate patterns and its benefits for climate adaptation (Shashidhar *et al.,* 2024).

The natural farming approach is gaining importance and getting growing acceptance among farmers. *Beejamrutha*, *jeevamrutha*, *ghanajeevamrutha*, mulching (*acchadana*) and moisture (*whapasa*), the top five goals, were implemented comprehensively to increase soil quality, productivity and quality of products. However, standardization of these procedures in various crops and agroecological settings is required. Apart from using conventional farm-based products, there is an increasing demand for organics like *jeevamrutha* and *ghanajeevamrutha*, which help quickly build soil fertility through enhanced soil microflora and fauna activity. *ghanajeevamrutha* is organic manure that has been regenerated utilizing traditional ways for crucial crop requirements. This is prepared to meet two major needs of agricultural land providing major and minor supplements to plants and providing food to earthworms and other beneficial microflora and fauna in the soil (Poojar *et al.,* 2022; Duraivadivel *et al*., 2022). It improves aeration in the root zone and enhances the mineralization process in the soil,which helps in the sustained release of nutrients in the soil, which in turn makes useful elements available to plants (Devakumar *et al*., 2008). Several researchers have demonstrated that cowpea requires a complete nutrient supply, including major, secondary and micronutrients, along with appropriate agronomic practices to maximize growth and yield potential (Patel *et al*., 2023; Ram *et al*., 2023). Veeranna *et al.* (2023) reported that the combined application of *ghanajeevamrutha* and *jeevamrutha* in four equal splits was as effective as inorganic fertilizers combined with FYM in rainfed groundnut. Their findings showed that this organic nutrient management approach resulted in statistically comparable pod and haulm yields, highlighting its potential as a sustainable alternative to conventional fertilization. This study supports the research on the application of *ghanajeevamrutha* and *jeevamrutha*, emphasizing their role in enhancing crop productivity while promoting soil health and reducing dependency on synthetic inputs.

Further more, liquid organic manures meet crop nutrient requirements by providing better nutrient availability during peak growing periods. Their application in organic production systems helps address nutrient deficiencies (Shwetha, 2008). Despite the many advantages of organic liquid formulations, they have not been extensively utilized in arable crop production, particularly in cowpeas. Ingredients like cow dung, urine, milk, curd, ghee, legume flour and jaggary are used to prepare liquid organic solutions such as *beejamrutha*, *jeevamrutha* and *panchagavya*. Vermiwash and cow urine also contain macronutrients, essential micronutrients, various vitamins, vital amino acids, growth factors like IAA and GA, and beneficial bacteria. Greater soil fertility and productivity, as along with increased ability to conserve soil organic carbon and moisture, have the potential to increase pulse yield and quality (Palekar, 2006). With these insights, the current study was conducted to determine the nutrient release and availability from various levels of *ghanajeevamrutha* and assess the impact of *ghanajeevamrutha* and liquid *jeevamrutha* on soil fertility and productivity of cowpea grown during the summer season.

Material and methods

Experimental site and treatment details

A field experiment was conducted during the *summer* season of 2022 at the College of Agriculture, Vijayapura, Karnataka on *vertisols* having pH 8.27 and EC 0.39 dSm^{-1}. The soil was medium in organic carbon content (0.52%), low in available Nitrogen (174 kg N ha^{-1}), medium in available Phosphorus (30.50 kg P_2O_5 ha^{-1}) and high in available Potassium (418 kg K_2O ha^{-1}). The experimental site was located at a latitude of 16° 77' North, a longitude of 75° 74' East and an altitude of 516.29 meters above mean sea level in the Northern Dry Zone of Karnataka (Zone 3). The actual annual rainfall in 2021 was 632.8 mm, which increased to 793.2 mm in 2022, with an average annual rainfall of 594.4 mm. During the cropping season, actual rainfall was 71.6 mm, which was below the average. The highest monthly rainfall received in April (71.2 mm).

The experiment was arranged in a Complete Randomized Block Design (RCBD) with three replications and thirteen treatments. The treatments included soil application of *ghanajeevamrutha* @ 1000, 1500 and 2000 kg ha^{-1} (T_1, T_2 and T_3), foliar application of *jeevamrutha* @10 and 20% concentrations at both the flower initiation and pod development stages (T_4 and T_5) and combined soil application of *ghanajeevamrutha* @ 1000, 1500 and 2000 kg ha^{-1} with foliar application of *jeevamrutha* @ 10% (T_6, T_8 and T_{10}) and *jeevamrutha* 20% (T_7, T_9 and T_{11}). Additionally, there were treatments with recommended package of practice (RPP) (T_{12}) and an absolute control (T_{13}).

Ghanajeevamrutha preparation and application

Initially, 100 kg of dried desi cow dung was spread on the polythene sheet. 10 liters of desi cow urine, 2 kg of powdered jaggery, and 2 kg pulse flour were added to the desi cow dung. All the materials were thoroughly mixed with the desi cow dung, and the mixture was kept under shade, covering with a wet gunny bag to maintain 60 per cent moisture. The mixture was turned twice a day for up to seven days to improve aeration and microbial population. After seven days of turning, *ghanajeevamrutha* was ready for field appication. *ghanajeevamrutha* was applied to the soil as a one-time application at the time of sowing as per the treatments.

Jeevamrutha preparation and application

Jeevamrutha was prepared by mixing 10 kg of desi cow dung, 10 liters of cow urine, 2 kg of jaggery, 2 kg of pulse flour, and a handful of soil collected from the field near the bund. All these ingredients were placed in a 200-liter plastic drum and mixed thoroughly by adding water until the volume reached 200 liters. The mixture was stirred well in a clockwise direction three times a day using a wooden stick until the mixture became homogeneous. The plastic drum was kept under shade and covered with a wet gunny bag. Well-fermented *jeevamrutha* was applied in the respective treatments in two equal splits,during the flowering and pod development stages.

Crop husbandry and observations recorded

The test variety, Dharwad Cowpea-15 (DC-15) was sown at a spacing of 45 x 10 cm on January 1, 2022. The first picking was harvested on April 7, 2022 and second picking on April 16, 2022.

Irrigation was provided at 15-20 days intervals through sprinkler irrigation, depending on the crop stage and soil conditions, to ensure better crop establishment. Aphid infestation was first observed at 35-40 days after sowing and was managed by spraying bioinsecticide *Verticillium lecani* @ 2.5 g lit^{-1} of water. The plant samples were partitioned into leaves, stems and reproductive parts (pod) and samples were dried first in the air for 2-3 days, then further dried in a hot air oven at 65 ± 5°C until a constant dry weight was obtained. The total dry matter refers to the combined dry weight of all plant parts (leaves, stems and pods) without them individually. All completely dried plant samples, including leaves, stems and pods were collected. Each completely dried plant sample individually weighed using a precision balance and the sum of the individual dry weight represented the total dry matter of the whole plant. The total dry matter was expressed in grams per plant. Harvesting was done by manually by picking of pods once they were completely dried. Two rounds of pickings were carried out, with a week interval between successive pickings. After harvesting, the pods were kept for sun drying in the field for 2-3 days. The dried pods were then threshed by beating them with wooden sticks, followed by winnowing. Finally, the clean collected seed and haulm yields were weighed and recorded separately.

The yield attributes and yield observations were recorded from the net plots and seed yield was converted to a hectare basis in kilograms. The economics of each treatment was computed using the prevailing market prices for the corresponding year. The yield was further computed for gross and net returns as well as the benefit-cost ratio to assess profitability. The benefit-cost ratio was worked out by dividing the gross returns by the total cost of cultivation for each respective treatment.

Statistical analysis

The data collected from the experiment at different growth stages and harvest was subjected to statistical analysis as described by Gomez and Gomez (1984). The level of significance used for the 'F' and 't' tests was P=0.05. Critical Difference (CD) values were calculated at a 5 per cent probability level if the F test was found to be significant. The coefficient of correlation was worked out among the growth and yield parameters using OPSTAT software according to the method given by Sheoran *et al.* (1998).

Results and discussion

Total dry matter production

The total dry matter accumulation different significantly due to different treatments (Fig. 1) and it was observed that dry matter production was significantly higher in the treatment that received a soil application of *ghanajeevamrutha* @ 2000 kg ha^{-1} + foliar application of *jeevamrutha* @ 20% (24.03 and 38.64 g plant^{-1} at 60 DAS and harvest, respectively). In contrast, the lowest values were recorded under absolute control (15.61 at 60 DAS and 23.94 g plant^{-1}at harvest). This increment is mainly due to the enrichment of soil with *ghanajeevamrutha* and plant with foliar sprays of *jeevamrutha* both helped in providing the essential plant nutrients to the crop throughout the crop life cycle. Additionally, the combined application of these organics helped in better photosynthetic efficiency of crop plants, which in turn increased the translocation of plant food to sink. This is the main tool for getting higher total dry matter accumulation, higher test weight, grain and haulm yield of cowpea (Upendranaik *et al.,* 2018).

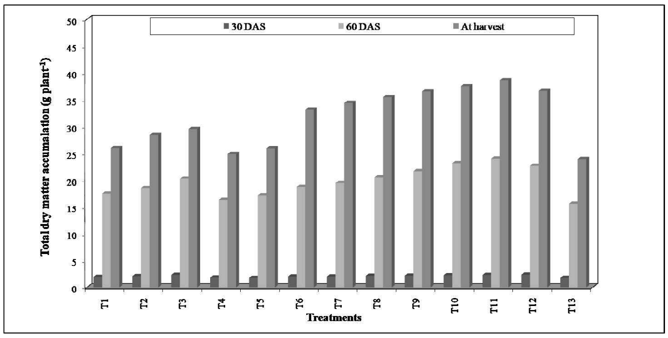

Fig 1. Total dry matter production per plant of cowpea at different growth stages as influenced by *ghanajeevamrutha* and *jeevamrutha* application

Yield and yield attributing characters

A significantly higher number of pods per plant (24.93) and pod length (18.07 cm) were recorded with the soil application of *ghanajeevamrutha* @ 2000 kg ha^{-1} + foliar application of *jeevamrutha* @ 20%, which was on par with *treatments ghanajeevamrutha* @ 2000 kg ha^{-1} + *jeevamrutha* @ 10% (23.96 and 17.31 cm, respectively) and RPP (22.38 and 16.79 cm, respectively). However, the hundred seed weight was not influenced significantly due to different treatments. A numerically higher hundred seed weight of 11.92 g was recorded with *ghanajeevamrutha* @ 2000 kg ha^{-1} + *jeevamrutha* @ 20% treatment compared to absolute control (10.04 g), which is depicted in Table 1. *ghanajeevamrutha* and *jeevamrutha* are organic nutrient sources and their application likely improved the nutrient availability to the cowpea plants. This availability of essential nutrients such as nitrogen (N), phosphorus (P),

Table 1. Yield and yield attributes of cowpea as influenced by *ghanajeevamrutha* and *jeevamrutha* application

Treatment details	Number of pods plant^{-1}	Length of pod (cm)	Test weight (g)	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest index (%)
T_1: *Ghanajeevamrutha* @ 1000 kg ha^{-1}	15.40	13.34	10.43	1182	2374	33.38
T_2: *Ghanajeevamrutha* @ 1500 kg ha^{-1}	17.07	13.82	10.74	1211	2497	32.72
T_3: *Ghanajeevamrutha* @ 2000 kg ha^{-1}	18.32	14.35	10.61	1321	2682	33.11
T_4: Foliar application of *jeevamrutha* @ 10%	13.60	11.79	10.10	1025	2116	32.54
T_5: Foliar application of *jeevamrutha* @ 20%	13.93	11.97	10.33	1048	2128	32.94
T_6: T_1 + foliar application of *jeevamrutha* @ 10%	18.70	14.76	11.56	1383	2786	33.21
T_7: T_1+ foliar application of *jeevamrutha* @ 20%	20.20	14.63	11.61	1404	2854	33.02
T_8: T_2+ foliar application of *jeevamrutha* @ 10%	20.94	15.04	11.59	1452	2920	33.32
T_9: T_2 + foliar application of *jeevamrutha* @ 20%	21.87	16.26	11.80	1510	3019	33.44
T_{10}: T_3+ foliar application of *jeevamrutha* @ 10%	23.96	17.31	11.86	1567	3352	31.88
T_{11}: T_3+ foliar application of *jeevamrutha* @ 20%	24.93	18.07	11.92	1625	3432	32.19
T_{12}: Recommended package of practice (RPP)	22.38	16.79	11.56	1528	3214	32.25
T_{13}: Absolute control	12.33	10.76	10.04	902	2097	30.31
S.Em±	1.13	0.81	0.49	62	154	1.49
C.D. (p=0.05)	3.30	2.38	NS	182	450	NS

RPP: 5 t FYM + 25 kg N + 50 kg P_2O_5 + 25 kg K_2O + 20 kg S + 25 kg $ZnSO_4$ ha^{-1}; DAS-days after sowing; NS- non-significant and potassium (K) promotes healthy plant growth and development, as reflected in the higher number of pods and longer pod lengths.The treatment with *ghanajeevamrutha* at 2000 kg ha^{-1}combined with a foliar application of *jeevamrutha* at 20% concentration enhanced nutrient uptake by the plants. The data indicate that this treatment increased the uptake of N, P and K, which are vital for reproductive growth and pod development (Table2). Organic amendments like *ghanajeevamrutha* and *jeevamrutha* enhance soil microbial activity. This increase in microbial activity improves nutrient cycling and mineralization in the soil, making nutrients more readily available to the plants throughout their growth stages (Chen, 2024). The treatment likely promoted better photosynthesis and carbon assimilation in the cowpea plants, leading to increased dry matter accumulation, a key factor in determining pod development and seed production. More available energy and resources can be directed towards producing pods and seeds, resulting in a higher pod number and longer pod lengths as described by Anusha *et al.* (2018), and also by Devakumar *et al.* (2014).

A significant variation in seed yield was observed (Table 1). Significantly higher seed yield of 1625 kg ha^{-1} was recorded in the treatment receiving the soil application of *ghanajeevamrutha* @ 2000 kg ha^{-1} + foliar application of *jeevamrutha* @ 20% followed by soil application of *ghanajeevamrutha* @ 2000 kg ha^{-1} + foliar application of *jeevamrutha* @ 10% (1567 kg ha^{-1}) compared to the absolute control with a seed yield of 902 kg ha^{-1}.The results indicated a positive correlation between seed yield per hectare with the total dry matter production (Fig. 2a) and yield component (Fig. 2b) *viz*., total dry matter production (R^2=0.951) and pods per plant (R^2=0.976).This astounding increase in seed yield is primarily attributable to the application of *ghanajeevamrutha* at higher doses as well as *jeevamrutha* spray, which improved the soil's physical condition, nutrients that were available, and biological activity. This improved soil condition allowed plants to benefit from a balanced level of nutrition, which increased seed yield.Yogananda *et al.* (2015) and Kumbar and Devakumar (2016) obtained the same findings.

Table 2. Total nitrogen (N), phosphorus (P) and potassium (K) uptake of cowpea as influenced by *ghanajeevamrutha* and *jeevamrutha* application

Treatment details	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
T_1: *Ghanajeevamrutha* @ 1000 kg ha^{-1}	74.64	7.99	43.51
T_2: *Ghanajeevamrutha* @ 1500 kg ha^{-1}	83.30	9.26	47.55
T_3: *Ghanajeevamrutha* @ 2000 kg ha^{-1}	96.77	10.90	56.09
T_4: Foliar application of *jeevamrutha* @ 10%	63.62	6.19	33.01
T_5: Foliar application of *jeevamrutha* @ 20%	66.32	6.65	35.14
T_6: T_1 + foliar application of *jeevamrutha* @ 10%	95.28	10.70	52.18
T_7: T_1+ foliar application of *jeevamrutha* @ 20%	99.19	11.56	54.21
T_8: T_2+ foliar application of *jeevamrutha* @ 10%	107.84	13.05	58.55
T_9: T_2 + foliar application of *jeevamrutha* @ 20%	112.77	13.05	62.60
T_{10}: T_3+ foliar application of *jeevamrutha* @ 10%	127.57	16.26	70.37
T_{11}: T_3+ foliar application of *jeevamrutha* @ 20%	134.12	18.79	73.42
T_{12}: Recommended package of practice (RPP)	121.58	15.17	66.53
T_{13}: Absolute control	56.36	5.36	28.68
S.Em±	6.15	0.79	2.36
C.D. (p=0.05)	17.96	2.32	6.89

RPP: 5 t FYM + 25 kg N + 50 kg P_2O_5 + 25 kg K_2O + 20 kg S + 25 kg $ZnSO_4$ ha^{-1}

The haulm yield of cowpea was also found to be significantly higher in the application of *ghanajeevamrutha* @ 2000 kg ha^{-1} + foliar application of *jeevamrutha* @ 20% (3432 kg ha^{-1}), followed by application of *ghanajeevamrutha* @ 2000 kg ha^{-1} + foliar application of *jeevamrutha* @ 10% (3352 kg ha^{-1}) compared to the absolute control (2097 kg ha^{-1}) (Table 1). The higher haulm yield in cowpea is attributed to the application of *ghanajeevamrutha* and *jeevamrutha* in various proportions at regular intervals, which might have stimulated the plant's system and increased the production of growth regulators in the cell system. The action of growth regulators then stimulated the

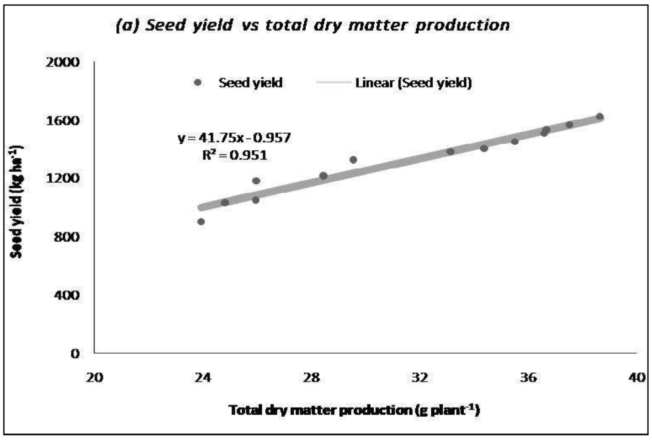

Fig.2a: Association between seed yield per hectare with total dry matter production per plant

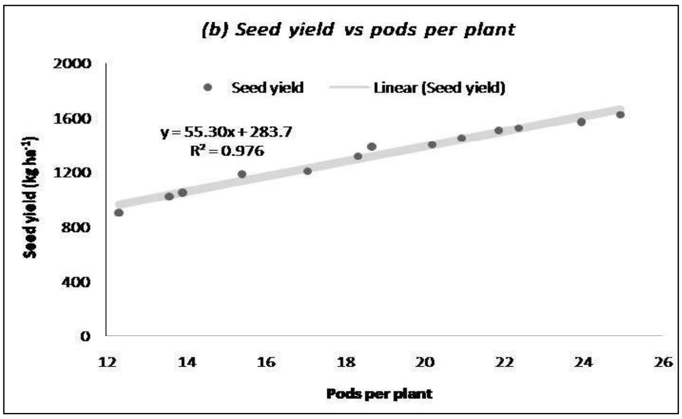

Fig. 2b: Association between seed yield per hectare with number of pods per plant

Table 3. Enzymes activity at different growth stages of cowpea as influenced by *ghanajeevamrutha* and *jeevamrutha* application

Treatmentsdetails	Dehydrogenase activity (ìg TPF g^{-1} soil day^{-1})		Phosphatase activity (ìg PNP g^{-1} soil hr^{-1})		Urease activity (ìg NH4-N g^{-1} soil hr^{-1})	
	at flowering stage	at pod development stage	at flowering stage	at pod development stage	at flowering stage	at pod development stage
T_1: *Ghanajeevamrutha* @ 1000 kg ha^{-1}	4.48	4.36	12.26	12.45	14.10	11.17
T_2: *Ghanajeevamrutha* @ 1500 kg ha^{-1}	4.76	4.42	12.76	12.24	14.58	10.95
T_3: *Ghanajeevamrutha* @ 2000 kg ha^{-1}	5.24	4.48	12.38	13.04	14.86	11.86
T_4: Foliar application of *jeevamrutha* @ 10%	3.50	3.94	11.15	12.08	13.11	10.42
T_5: Foliar application of *jeevamrutha* @ 20%	3.37	4.00	11.57	12.16	13.84	10.67
T_6: T_1 + foliar application of *jeevamrutha* @ 10%	5.37	4.38	12.70	12.65	15.25	11.94
T_7: T_1+ foliar application of *jeevamrutha* @ 20%	5.46	4.40	12.57	12.78	15.47	12.28
T_8: T_2+ foliar application of *jeevamrutha* @ 10% 5.68	4.43	12.78	12.82	15.88	12.16	
T_9: T_2 + foliar application of *jeevamrutha* @ 20%	5.45	4.47	13.15	13.01	16.42	12.59
T_{10}: T_3+ foliar application of *jeevamrutha* @ 10%	5.73	4.52	13.25	13.12	16.83	12.91
T_{11}: T_3+ foliar application of *jeevamrutha* @ 20%	5.87	4.54	13.40	13.21	16.95	12.81
T_{12}: Recommended package of practice (RPP)	5.18	4.67	11.81	12.36	16.50	12.87
T_{13}: Absolute control	3.56	3.68	10.95	11.50	11.67	11.01
S.Em±	0.35	0.19	0.52	0.34	0.81	0.59
C.D. (p=0.05)	1.04	NS	NS	NS	2.37	NS

RPP: 5 t FYM + 25 kg N + 50 kg P_2O_5 + 25 kg K_2O + 20 kg S + 25 kg $ZnSO_4$ ha^{-1}; NS- non-significant

necessary growth and development, resulting in a higher haulm yield. The outcomes are closely similar to the results of Yogananda *et al.* (2015), Kaur *et al.* (2020) and Saraswathi and Vidhyavathi (2020).

Nutrient uptake

Nutrient uptake by the crops is estimated based on dry matter produced. Significantly higher uptake of nitrogen (N), phosphorus (P), and potassium (K) was recorded in the treatment with the *ghanajeevamrutha* @ 2000 kg ha^{-1} + *jeevamrutha* @ 20% with 134.12, 18.79, 73.42 N, P, K kg ha^{-1} and was followed by soil application of *ghanajeevamrutha* @ 2000 kg ha^{-1} + foliar application of *jeevamrutha* @ 10% with 127.57, 16.26, 70.37 N, P, K kg ha^{-1}over the absolute control with 56.36, 5.36, 28.68 N, P, K kg ha^{-1} (Table 2).The increase in nutrient uptake was largely attributed to the combined application of *ghanajeevamrutha* and *jeevamrutha*, which improved the soil's nutrients availability by enriching the rhizosphere.This allowed plants to receive greater sustenance and improved nutrient uptake. The elevated phosphorus absorption was mostly due to by the decreased activity of P-complexing agents'and the solubilization of fixed phosphorus with increased biological activity.These outcomes are in agreement with the findings of Vasanthkumar (2006).

Soil enzymes activity

Significantly higher dehydrogenase (5.87 µg TPF g^{-1} soil day^{-1}) and urease activity (16.95µg NH4-N g^{-1} soil hr^{-1}) were observed in the treatment receiving *ghanajeevamrutha* @ 2000 kg ha^{-1} combined with foliar application of *jeevamrutha* @ 20% at the flower initiation stage compared to the absolute control. However, no significant difference was found at the pod development stage (Table 3). Phosphatase activity in soil was not significantly affected by application *ghanajeevamrutha* and *jeevamrutha* during the flower initiation and pod development stages. The use of *ghanajeevamrutha* significantly contributed to the higher availability of organic matter, which serves as an energy source for microbes, enhancing enzymatic activity and resulting in elevated level of soil enzymes.This in turn, contributed to the higher activity of both dehydrogenase and phosphatase enzymes at the flowering stage. The decreased C: N and higher microbial biomass in *ghanajeevamrutha* simulate enzyme activity. Dehydrogenase enzymes play a key role in the oxidation and reduction of organic materials in the soil. Similar to phosphatase enzymes, inositol phosphorus is released from soil when certain bacteria catalyze hydrolysis and release the free phosphate.This process increases the activities of these enzymes and the availability of nutrients as well as uptake by the cowpea. Soil urease plays a major role in the catalyzing the hydrolysis of urea to its ammonical form, which is subsequently oxidized by nitrifiers into nitrate, increasing nitrogen fertilizer utilization.These findings confirm the studies of Naveena (2017).

Economics

Significantly higher gross returns (₹ 81,267 ha^{-1}) and net returns (₹ 56,367 ha^{-1}) were observed in the treatment involving the soil application of *ghanajeevamrutha* 2000 kg ha^{-1}combined with a foliar application of *jeevamrutha* @ 20%, compared to recommended package of practice. This suggests that the integration of *ghanajeevamrutha* and *jeevamrutha* offers a more economically viable alternative for enhancing crop productivity and profitability. Additionally, the highest benefit-cost ratio (3.28) was recorded with the treatment involving g*hanajeevamrutha* 2000 kg ha^{-1} and *jeevamrutha* @ 10% (Table 4). The cost-effectiveness of these treatments can be attributed to the fact that *ghanajeevamrutha* and *jeevamrutha* preparation require minimal external outputs, and these formulations are primarily made from locally available raw materials like cow dung, cow urine, pulse flour, jaggery, *etc.* The use of these inexpensive, locally sourced materials reduces the overall cost of production significantly, lowering

Table 4. Economics of cowpea as influenced by *ghanajeevamrutha* and *jeevamrutha* application

Treatments details	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	Benefit-cost ratio
T_1: *Ghanajeevamrutha* @ 1000 kg ha^{-1}	18400	59100	40700	3.21
T_2: *Ghanajeevamrutha* @ 1500 kg ha^{-1}	19900	60550	40650	3.04
T_3: *Ghanajeevamrutha* @ 2000 kg ha^{-1}	21700	66067	44367	3.04
T_4: Foliar application of *jeevamrutha* @ 10%	16100	51283	35183	3.19
T_5: Foliar application of *jeevamrutha* @ 20%	17100	52433	35333	3.07
T_6: T_1+ foliar application of *jeevamrutha* @ 10%	20600	69150	48550	3.36
T_7: T_1+ foliar application of *jeevamrutha* @ 20%	21600	70217	48617	3.25
T_8: T_2+ foliar application of *jeevamrutha* @ 10%	22100	72600	50500	3.29
T_9: T_2+ foliar application of *jeevamrutha* @ 20%	23100	75517	52417	3.27
T_{10}: T_3+ foliar application of *jeevamrutha* @ 10%	23900	78350	54450	3.28
T_{11}: T_3+ foliar application of *jeevamrutha* @ 20%	24900	81267	56367	3.26
T_{12}: Recommended package of practice (RPP)	27110	76400	49290	2.82
T_{13}: Absolute control	16350	45133	28783	2.76
S.Em±	-	3128	3128	0.16
C.D. (p=0.05)	-	9131	9131	NS

RPP: 5 t FYM + 25 kg N + 50 kg P_2O_5 + 25 kg K_2O + 20 kg S + 25 kg $ZnSO_4$ ha^{-1}; NS- non-significant

the financial burden on farmers by decreasing the need for synthetic fertilizers and chemicals. As a result, the cost of cultivation is reduced, leading to higher net returns. These results are in agreement with the findings of Deepa (2020), and Dhananjaya (2017), who also reported similar economic and agronomic benefits from the use of organic inputs like *ghanajeevamrutha* and *jeevamrutha*. Their studies highlighted the potential of these inputs in reducing cultivation costs, improving soil. In contrast, Lal *et al.* (2022) reported that the combined application of 75% of the recommended fertilizer dose with 5 t FYM, 2.5 t vermicompost and *rhizobium* culture resulted in higher net returns and a superior benefit-cost (B:C) ratio in green gram.

Conclusion

The soil application of *ghanajeevamrutha* @ 2000 kg ha^{-1}, combined with a foliar spray of *jeevamrutha* @ 10 and 20% *jeevamrutha* concentration at 45 and 60 days after sowing, significantly enhanced cowpea grain yield compared to the recommended package of practices. This study suggests that an integrated use of *ghanajeevamrutha* @ 2000 kg ha^{-1} along with foliar sprays of *jeevamrutha* @ 10 or 20% at 45 and 60 days after sowing maximizes cowpea yield, enhances nutrient uptake, and improves net returns to the recommended package of practice. Consequently, this approach represents a sustainable alternative to conventional agricultural practices, fostering environmental health while meeting the nutritional needs of crops.

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