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RESEARCH PAPER

Fodder productivity of cowpea (*Vigna unguiculata* L.) varieties as influenced by phosphorus management

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Abstract: A field experiment was conducted during *kharif* 2024 at ICAR-IGFRI, SRRS, Dharwad to study the effect of phosphorus application in conjunction with biofertilizers *viz.,* phosphate solubilizing bacteria (PSB) and vesicular arbuscular mycorrhiza (VAM) on fodder productivity of cowpea varieties. The experiment was laid out in split-plot design with three varieties of cowpea in main plots, five phosphorus levels in sub plots and replicated thrice. The fodder type cowpea variety 'IGFRI-DC-215' recorded higher green fodder yield (26.62 t ha^{-1}), dry fodder yield (2.99 t ha^{-1}), gross returns (₹ 88840 ha^{-1}), net returns (₹ 55791 ha^{-1}) and B:C ratio (2.68). Among the phosphorus levels, application of 100% recommended rate of phosphorus (RRP) + PSB + VAM recorded higher green fodder yield (20.80 t ha^{-1}), dry fodder yield (2.64 t ha^{-1}), gross returns (₹ 71863 ha^{-1}), net returns (₹ 36584 ha^{-1}) and B:C ratio (2.05). There were no significant interaction effects among cowpea varieties and phosphorus levels on any growth or yield parameters, yield and economics.

Key words: Cowpea varieties, Dry fodder, Economics, Green fodder, Phosphorus, PSB, VAM

Introduction

Cowpea (*Vigna unguiculata* L.) is an important multi-utility legume crop cultivated widely in tropical and sub tropical regions of the world. It plays an important role in ensuring food, fodder, nutritional security with an ability to fix atmospheric nitrogen. Its short duration makes it a preferred crop for rainfed farming systems particularly in marginal and resource constraint areas. It responds well to phosphorus nutrition. However, the phosphorus availability in many Indian soils is limited due to its fixation in unavailable form. This challenge becomes even more enormous under rainfed conditions where soil moisture stress further restricts phosphorus mobility and availability.

Fodder cowpea is a fast growing annual legume crop cultivated for animal feed due to its high crude protein content. It contains 20-24% crude protein, 43-49% neutral detergent fiber, 34-37% acid detergent fiber, 23-25% cellulose and 5-6% hemicelluloses on dry matter basis. The digestibility of cowpea fodder is above 70%. Fully nodulated cowpea can fix 20 to 140 kg N ha^{-1} in the soil.

Material and methods

A field experiment was conducted at the farm of the ICAR-IGFRI, Southern Regional Research Station, Dharwad. The soil of the experimental plot was *alfisols* (red sandy soil) having slightly acidic pH (6.20), electrical conductivity (0.22 dSm^{-1}), medium in organic carbon (0.59), low in available nitrogen (178.32 kg ha^{-1}), phosphorus (16.07 kg ha^{1}) and potassium (214.53 kg ha^{-1}). The experiment was laid out in split-plot design with three varieties of cowpea in main plots, five phosphorus levels in sub plots and replicated thrice. The main plot treatment combinations were M_1: Fodder type cowpea variety 'IGFRI-DC-215', M_2: Dual type cowpea variety 'DCS-47-1' and M_3: Grain type cowpea variety 'DC-15'. The sub plot treatments comprised of S_1: 0% RRP, S_2: PSB + VAM, S_3: 50% RRP + PSB + VAM, S_4: 100% RRP and S_5: 100% RRP + PSB + VAM. A common dose of 25 kg N ha^{-1} and 25 kg K_2O ha^{-1} was provided to all the treatments. The cowpea varieties were harvested for fodder at 50% flowering stage of crop. The total annual rainfall for the experimental year (2024) was 941.00 mm distributed in 62 rainy days. The months of July, August, September and October had the highest rainfall, with 240.0 mm, 85.6 mm, 108.2 mm and 249.2 mm, respectively during the experimental year. Sowing was done on 2nd July 2024. The excessive rainfall during experimental period lead to water logging, root damage, nutrient leaching, soil erosion, increased insect pests and pathogen incidence in the crop. The crop recovered in spite of higher rainfall in the later stages. The data recorded were analyzed as per the procedure outlined for split-plot design (Gomez and Gomez, 1984).

Results and discussion

The information regarding plant height (cm) and dry matter production (g plant^{-1}) of cowpea varieties as influenced by phosphorus nutrition are presented in Table 1.

The fodder type cowpea variety 'IGFRI-DC-215' recorded higher plant height of 18.9, 59.8 and 73.6 cm at 30 DAS, 60 DAS and at fodder harvest, respectively. It was followed by dual type variety 'DCS-47-1' (17.5, 58.2 and 62.6 cm) and grain type variety 'DC-15' (17.0, 56.2 and 62.3 cm) at 30 DAS, 60 DAS and at fodder harvest, respectively. Application of 100% RRP + PSB + VAM recorded higher plant height of 19.7, 60.4 and 68.8 cm at 30 DAS, 60 DAS and at fodder harvest, respectively. It was followed by application of 100% RRP (18.3, 59.3 and

Table 1. Plant height and dry matter production of cowpea varieties as influenced by phosphorus nutrition in conjunction with biofertilizers

Treatments	Plant height (cm)			Dry matter production (g plant^{-1})		
	30 DAS	60 DAS	At fodder harvest	30 DAS	60 DAS	At fodder harvest
Cowpea varieties						
M_1: IGFRI-DC-215	18.9	59.8	73.6	1.81	19.85	24.59
M_2: DCS-47-1	17.5	58.2	62.6	1.72	18.54	21.62
M_3: DC-15	17.0	56.6	62.3	1.67	17.98	20.82
S.Em±	0.17	0.50	0.52	0.02	0.31	0.32
C.D. at 5%	0.60	1.75	1.80	0.08	1.06	1.12
Phosphorus levels						
S_1: 0% RRP	16.4	56.4	64.0	1.61	17.41	21.12
S_2: PSB + VAM	17.0	57.0	64.9	1.66	18.08	21.68
S_3: 50% RRP + PSB + VAM	17.7	58.0	65.7	1.71	18.40	22.13
S_4: 100% RRP	18.3	59.3	67.4	1.78	19.75	22.83
S_5: 100% RRP + PSB + VAM	19.7	60.4	68.8	1.89	20.32	23.96
S.Em±	0.39	0.39	0.55	0.02	0.29	0.40
C.D. at 5%	1.27	1.28	1.78	0.08	0.96	1.29
Interaction (M×S)	NS	NS	NS	NS	NS	NS

Note: NS: Non-significant

RRP: Recommended rate of phosphorus (50 kg P_2O_5 ha^{-1}), PSB: Phosphate solubilizing bacteria, VAM: Vesicular arbuscular mycorrhiza

67.4 cm). The lowest plant height of 16.4, 56.4 and 64.0 cm were recorded with 0% RRP at 30 DAS, 60 DAS and at fodder harvest, respectively. The interaction effects among the cowpea varieties and phosphorus rates were non-significant with respect to plant height across all stages of crop growth.

Increased plant height due to higher rates of phosphorus along with biofertilizers increased the availability of phosphorus, which is essential in root and shoot tip where metabolism of plant is high. Due to increased meristematic activity, cell wall, cell size, cell division and cell elongation which led to increased internodal length of plant. These results are in line with findings of Purushotham *et al.* (2001), Singh *et al*. (2019), Sandeep and Monisha (2022), Ankit (2022) and Shashidhar *et al.* (2024).

The fodder type cowpea variety 'IGFRI-DC-215' recorded higher dry matter of 1.81, 19.85 and 24.59 g palnt^{-1} at 30 DAS, 60 DAS and at fodder harvest, respectively. It was succeeded by dual type variety 'DCS-47-1' (1.72, 18.54 and 21.62 g plant^{1}) and grain type variety 'DC-15' (1.67, 17.98 and 20.82 g plant^{1}) at 30 DAS, 60 DAS and at fodder harvest, respectively. Application of 100% RRP + PSB + VAM has recorded higher dry matter of 1.89, 20.32 and 23.96 g plant^{-1} at 30 DAS, 60 DAS and at fodder harvest, respectively. It was followed by 100% RRP (1.78, 19.75 and 22.83 g plant^{-1}). The lowest dry matter was recorded with 0% RRP (1.61, 17.41 and 21.12 g plant^{-1}) at 30 DAS, 60 DAS and at fodder harvest, respectively. The interaction effects among the cowpea varieties and phosphorus rates were non-significant with respect to dry matter production across various stages of crop growth.

Increase in dry matter production may be attributed to higher availability of phosphorus through chemical fertilizer and biofertilizer. This increased availability of nutrients, increased photosynthesis and photosynthetic efficiency. Increased photosynthates leading to higher accumulation of leaf weight per plant and higher plant height, number of branches and leaf:stem ratio at all the stages of crop growth. These results are in line with findings of Purushotham *et al.* (2001), Vithal *et al.* (2010), Singh *et al*. (2019), Sandeep and Monisha (2022), Ankit (2022) and Shashidhar *et al.* (2024).

The information regarding green fodder yield (t ha^{-1}), dry fodder yield (t ha^{-1}), crude protein content (%), crude protein yield (kg ha^{-1}) and economics of cowpea varieties as influenced by phosphorus nutrition are presented in Table 2.

The fodder type cowpea variety 'IGFRI-DC-215' recorded higher green fodder yield of 26.62 t ha^{-1} and dry fodder yield of 2.99 t ha^{1}. It was followed by dual type variety 'DCS-47-1' (13.52 and 1.50 t ha^{-1}) and grain type variety 'DC-15' (11.66 and 1.12 t ha^{-1}). Application of 100% RRP + PSB + VAM recorded higher green fodder yield and dry fodder yield (20.80 and 2.64 t ha^{-1}). It was followed by 100% RRP (18.87 and 2.16 t ha^{1}). The lowest green fodder yield and dry fodder yield was recorded with 0% RRP (13.73 and 1.23 t ha^{-1}). The interaction effects among the cowpea varieties and phosphorus rates were non-significant with respect to green fodder yield and dry fodder yield.

This significant difference in varieties with respect to green fodder yield and dry fodder yield may be attributed to differences in genetic makeup of cowpea varieties. Since fodder type cowpea exhibits longer vegetative phase and late switch over to reproductive phase, results in higher plant growth, plant height, branches adding to higher green fodder and consequently dry fodder yield. The overall better root and shoot might have resulted in higher absorption of nutrients and greater photosynthesis which led to increased plant height, number of leaves per plant, number of branches, dry matter production and leaf to stem ratio at all stages with higher levels of phosphorus along with PSB and VAM. Similar results were reported by Purushotham *et al.* (2001), Sudharshan and Palled (2016), Lohithaswa *et al*. (2015), Bhavana *et al*. (2022), Wahane *et al*. (2022), Vidyashree *et al.* (2023) and Surender (2023).

Table 2. Green fodder yield, dry fodder yield, crude protein content, crude protein yield and economics of cowpea varieties as influenced by phosphorus nutrition in conjunction with biofertilizers

Treatments	Green fodder yield (t ha^{-1})	Dry fodder yield (t ha^{-1})	Crude protein (%)	Crude protein yield (kg ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
Cowpea varieties							
M_1- IGFRI-DC-215	26.62	2.99	16.55	503.02	88840	55791	2.68
M_2- DCS-47-1	13.52	1.50	14.45	217.22	45226	11299	1.33
M_3- DC-15	11.66	1.12	12.21	138.80	39882	5955	1.17
S.Em. ±	0.56	0.10	0.20	13.83	1990	1990	0.06
C.D. at 5%	1.95	0.33	0.68	47.87	6885	6885	0.22
Phosphorus levels							
S_1- 0% RRP	13.73	1.23	13.58	174.35	45617	13818	1.44
S_2- PSB + VAM	15.67	1.50	13.91	217.77	52177	19498	1.60
S_3- 50% RRP + PSB + VAM	17.27	1.81	14.37	273.40	57483	23469	1.70
S_4- 100% RRP	18.87	2.16	14.71	335.62	62773	28374	1.83
S_5- 100% RRP + PSB + VAM	20.80	2.64	15.45	430.60	71863	36584	2.05
S.Em. ±	1.05	0.09	0.10	13.47	4261	4261	0.13
C.D. at 5%	3.43	0.28	0.32	43.94	13896	13896	0.41
Interaction (M×S)	NS	NS	*	*	NS	NS	NS

Note: * Significant & NS Non-significant

RRP: Recommended rate of phosphorus (50 kg P_2O_5 ha^{-1}), PSB: Phosphate solubilizing bacteria,VAM: Vesicular arbuscular mycorrhiza

The fodder type cowpea variety recorded higher crude protein content (16.55%) and crude protein yield (503.02 kg ha^{-1}) in cowpea fodder. It was followed by dual type cowpea variety 'DCS-47-1' (14.55% and 217.22 kg ha^{-1}) and grain type cowpea variety 'DC-15' (12.21% and 138.80 kg ha^{-1}). Application of 100% RRP + PSB + VAM recorded significantly higher crude protein content (15.45%) and crude protein yield (430.60 kg ha^{-1}) in cowpea fodder. It was followed by 100% RRP (14.71% and 355.62 kg ha^{-1}) alone. The lowest crude protein content of 13.58% and crude protein yield of 174.35 kg ha^{-1} were recorded with 0% RRP in cowpea fodder. The interaction effects among the cowpea varieties and phosphorus rates were significant with respect to crude protein content and crude protein yield of cowpea fodder.

Increase in crude protein could have been due to prominent rise in nitrogen content because of increased level of phosphorus along with biofertilizers like PSB and VAM leading to higher nitrogen fixation in legumes. It facilitated more protein synthesis since nitrogen is an important component of many vital metabolites such as protein and amino acids. Increased root length and dry weight due to higher levels of phosphorus improved nutrient uptake from soil and lesser loss of macro and micro nutrients from soil and plant system. These results are in agreement with the findings of Nyamagouda and Angadi (2002), Balai *et al*. (2017) and Mobeena (2019).

Among the cowpea varieties, fodder type cowpea variety 'IGFRI-DC-215' recorded significantly higher gross returns, net returns and B:C ratio (₹ 88840 ha^{-1}, ₹ 55791 ha^{-1} and 2.68, respectively). It was followed by dual type cowpea variety 'DCS-47-1' (₹ 45226 ha^{-1}, ₹ 11299 ha^{-1} and 1.33, respectively) and grain type variety 'DC-15' (₹ 39882 ha^{-1}, ₹ 5955 ha^{-1} and 1.17, respectively). Significantly higher gross returns, net returns and B:C ratio were recorded with 100% RRP + PSB + VAM (₹ 71863 ha^{-1}, ₹ 36584 ha^{-1} and 2.05, respectively) it was followed by 100% RRP (₹ 62773 ha^{-1}, ₹ 28374 ha^{-1} and 1.83, respectively) alone. The lowest gross returns, net returns and B:C ratio were recorded with 0% RRP (₹ 45617 ha^{-1}, ₹ 13818 ha^{-1} and 1.44, respectively). The interaction effects among the cowpea varieties and phosphorus rates were non-significant with respect to gross returns, net returns and B:C ratio.

The higher monetary returns in fodder type cowpea variety among the cowpea varieties were due to higher fodder yield. The increased availability of phosphorus with optimum doses of phosphorus and synergistic effect of PSB and VAM in augmenting the availability of phosphorus to crop leading to higher productivity and subsequently higher monetary returns. The increased and better monetary returns due to phosphorus nutrition have also been reported by several earlier researchers Sudharshan and Palled (2016), Balai *et al*. (2017), Amit *et al*. (2017), Joharika *et al*. (2023) and Vidyashree *et al.* (2023) Shashidhar *et al.* (2024).

Conclusion

Among the cowpea varieties, 'IGFRI-DC-215' variety with application of 100% RRP + PSB + VAM recorded significantly higher green fodder yield (26.62 t ha^{-1}) and dry fodder yield (2.99 t ha^{-1}) which was 96.4 and 96.7% higher over green and dry fodder yield of 'DCS-47-1' variety (13.55 and 1.52 t ha^{-1}, respectively) and 123.5 and 116.6 % higher over 'DC-15' variety (11.91 and 1.38 t ha^{-1}, respectively). Application of 100% RRP + PSB + VAM is necessary for higher net returns and B:C ratio (₹ 36584 ha^{-1} and 2.05, respectively) for cowpea crop in low to medium fertility soils in the transitional track of Karnataka under rainfed cultivation.

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