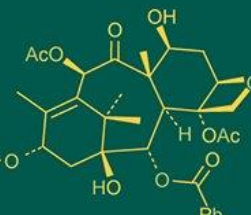
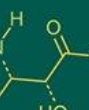
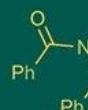


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Influence of farming system on phenological stages in blackgram + foxtail millet intercropping system

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Abstract

A field experiment was conducted during the *kharif* season of 2025 at Certified organic farm, CONFRT research farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, on black clayey soil. The experiment was laid out in a Randomized Block Design (RBD) comprising seven nutrient management treatments, each replicated three times.

The results revealed that the application of T₃—Integrated Organic Farming, comprising seed treatment with Beejamrutha + Ghanajeevamrutha (250 kg ha⁻¹) + vermicompost (1 t ha⁻¹) + phosphocompost (PROM) (150 kg ha⁻¹) + Jeevamrutha applied at 15-days interval (500 L ha⁻¹) + mulching, significantly enhanced plant height, dry matter accumulation and leaf area in both blackgram and foxtail millet compared with the other nutrient management treatments.

Keywords: Blackgram, foxtail millet, beejamrutha, ghanajeevamrutha, vermicompost, phosphocompost, jeevamrutha, plant height, dry matter accumulation, leaf area

Introduction

In response to the increasing concerns regarding soil health, nutrient cycling and the long-term sustainability of food production systems, the application of organic manures is considered a more sustainable approach than relying exclusively on synthetic fertilizers for improving crop performance (Kumar *et al.*, 2021) [8]. Although organic manures have been used in crop production since ancient times, their importance declined following the widespread adoption of inorganic fertilizers during the 1960s. Consequently, bulky organic inputs were increasingly neglected and regarded as secondary sources of plant nutrients. Therefore, there is an urgent need to promote biological and sustainable agricultural practices by reducing excessive dependence on chemical fertilizers and integrating suitable crop varieties with environmentally sound nutrient-management strategies to protect soil, plant, human and ecosystem health from further degradation.

Pulses are an important source of dietary protein, particularly in tropical and subtropical regions where protein deficiency is common. Compared with cereals, they generally contain nearly three times more protein and also contribute appreciable amounts of essential minerals and vitamins. Blackgram (*Vigna mungo* L.), a prominent pulse crop of the family Fabaceae, contains approximately 26% protein, 1.2% fat and 56.6% carbohydrates on a dry weight basis, besides being a valuable source of calcium and iron (Divyavani *et al.*, 2020) [3]. Furthermore, blackgram can serve as a green manure crop and reduces soil erosion. Its adaptability to warm and relatively dry conditions makes it well suited to drought-prone tropical regions. As a legume, it also contributes to soil fertility through biological nitrogen fixation, with the potential to fix considerable quantities of atmospheric nitrogen in association with *Rhizobium* spp. (Raju and Menon, 2020) [12].

Foxtail millet is among the oldest domesticated millet crops and is widely recognized for its drought tolerance and diverse culinary uses. Its increasing popularity is attributed to its high nutritional value and potential to support sustainable agricultural production. Taxonomically, foxtail millet belongs to the tribe Paniceae of the family Poaceae. Its widespread cultivation is largely associated with its numerous health-promoting properties, which are attributed to its rich composition of starch, protein, dietary fibre, fats and vitamins. Consumption of foxtail millet has also been associated with low glycemic and hypolipidemic effects.

In addition, its ability to produce satisfactory yields with limited agricultural inputs, coupled with its tolerance to drought, salinity and other environmental stresses, makes it an important crop for sustainable agriculture. (Gobikashri *et al.*, 2025) ^[4].

Intercropping is widely recognized as a promising approach for enhancing crop productivity, particularly among small and marginal farmers in rainfed regions. The system promotes more efficient utilization of available natural resources, reduces production costs, and provides greater economic stability. In addition, intercropping can help suppress weed growth, reduce the incidence of pests and diseases, improve soil fertility, and enhance both the yield and quality of produce compared with sole cropping. These advantages make intercropping a sustainable and productive alternative to monocropping systems (Choudhari *et al.*, 2017; Kamara *et al.*, 2017; Rex Immanuel *et al.*, 2020; Chunjie *et al.*, 2023) ^[1, 6, 13, 2]. Legume-based intercropping systems offer greater stability than sole cropping systems by contributing to the improvement of soil fertility, enhancing crop productivity, and increasing economic returns (Legodi and Ogola, 2020) ^[10].

Nevertheless, no single nutrient source is capable of fulfilling the complete nutritional requirements of crops throughout their growth cycle. Hence, the integrated application of organic manures and synthetic fertilizers offers considerable potential for meeting crop nutrient requirements according to the needs of specific genotypes (Kumar *et al.*, 2020, Meena *et al.*, 2020) ^[7, 11]. Such an integrated approach can help sustain higher crop productivity while simultaneously improving the quality of natural resources, enhancing soil health and contributing to better economic returns for farmers.

Materials and Methods

The present experiment was conducted in 2025 at plot number 66 Certified organic farm, CONFRT research farm, Dept. of Agronomy, Dr. PDKV, Akola which is situated at 20.6° N latitude and 77.02° E longitude. 307.42 meters above mean sea level in central (Vidharbha) agro-ecological zone of Maharashtra or the eastern Maharashtra plateau.

Weather

During the *Kharif* season of 2025-26 (July-October), a total rainfall of 810 mm was recorded over 44 rainy days.

Soil characteristics

Soil type black cotton soils with a clayey texture, a neutral to moderately alkaline pH (pH 7.87), low to medium organic carbon (0.46%), low to medium nitrogen (212.91 kg/ha), low phosphorus (13.37 kg/ha) and high potassium (332.94 kg/ha).

Experiment details

The experiment was laid out with seven treatments and 3 replications. The treatments were T₁-Natural Farming-Beejamrutha + Ghanajeevamrutha (500 kg/ha) + Jeevamrutha @ 500 l/ha + Mulching, T₂-Organic Farming-Recommended practices (Vermicompost 2 t/ha + Jeevamrutha (500l/ha) + Phosphocompost (PROM) @ (300 kg/ha), T₃-Integrated Organic Farming-Beejamrutha + Ghanajeevamrutha (250 kg/ha) + Vermicompost (1 t/ha) +

Phosphocompost.

(PROM) (150 kg/ha) + Jeevamrutha at 15 days interval (500 l/ha) + Mulching, T₄-Panchagavya Farming-FYM (2 t/ha) + Vermicompost (1 t/ha) + Cow urine @ 10%, T₅-Integrated Conventional Farming-Vermicompost (1 t/ha) + Jeevamrutha (500l/ha) + Phosphocompost (PROM) (150 kg/ha) + 10 kg/ha urea + 50 kg ha DAP + 25 kg/ha MOP (50% RDF), T₆-Conventional Farming-FYM @ 5 t/ha, 20:40:20 NPK kg/ha (GRDF), T₇-Absolute Control-No nutrients are applied.

Specimen details

The crops were blackgram and foxtail millet intercropping (2:1) with varieties AKU-10-1 and PDKV Yashshree, respectively. Plot measuring 6 m × 6 m area. Sowing was carried out at a spacing of 45 cm × 10 cm, using seed rates of 12 kg ha⁻¹ for blackgram and 3 kg ha⁻¹ for foxtail millet. Fertilizers were applied at a recommended dose of 20:40:20 NPK kg ha⁻¹. Throughout the crop growth period, all recommended agronomic practices were followed uniformly.

Observation and statistical analysis

The data pertaining to crop equivalent yield and economic returns were statistically analyzed using the analysis of variance (ANOVA) technique. The significance of treatment effects was assessed using the “F” test at a 5% level of probability, following the procedure described by Gomez and Gomez (1984) ^[5].

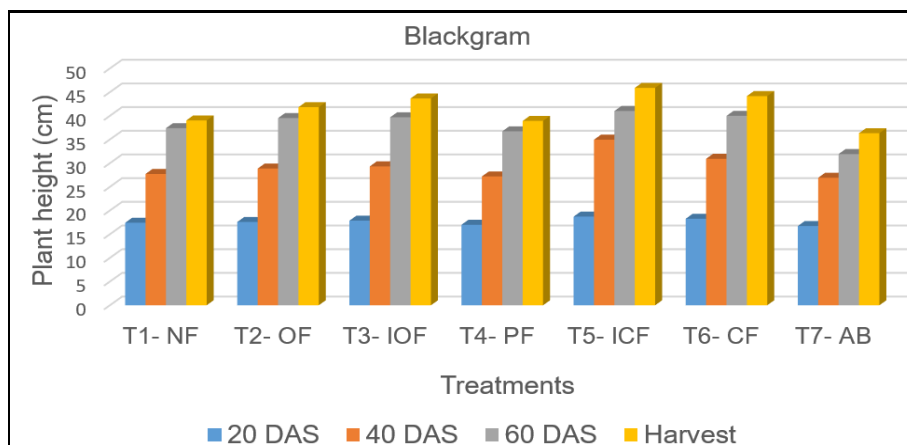
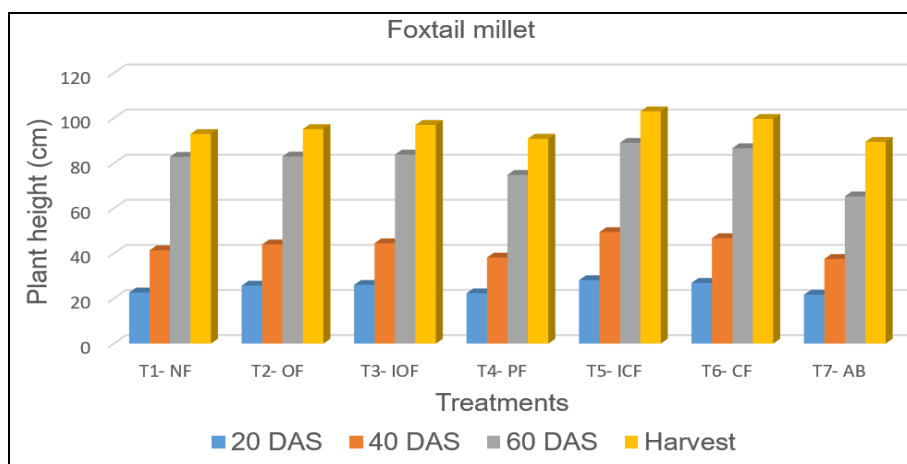
Results and Discussion

Plant height (cm)

The data presented in table 1 and fig. 1. Plant height of blackgram was significantly highest in Integrated Conventional Farming treatment (45.90 cm at harvest). Among organic nutrient management treatments, Integrated organic farming treatment was significantly higher in plant height of 43.67 cm at harvest. Lowest plant height was seen in Absolute control treatment recorded 36.33 cm at harvest. The data pertaining to foxtail millet was presented in table 1 and graphically in fig. 2. Plant height of foxtail millet was significantly highest in Integrated Conventional Farming treatment 103.00 cm at harvest. Among Organic nutrient management treatments, Integrated organic farming treatment was significantly higher in plant height showed 97.00 cm at harvest. Similar results were given by Saha *et al.* (2007) ^[15] and Sah (2017) ^[14].

Leaf area per plant (dm²)

Data related to leaf area per plant of blackgram and foxtail millet were represented in table 2 and fig 3 and 4 respectively. Significantly higher leaf area per plant in blackgram and foxtail millet were reported in Integrated Conventional Farming treatment. In blackgram (7.77dm² at 40) and foxtail millet (5.87 dm² at 60 DAS). Among Organic nutrient management treatments, leaf area per plant was significantly higher in Integrated organic farming treatment of blackgram (7.17 dm² at 40 DAS) and foxtail millet (5.30 dm² at 60 DAS). It is at par with Organic Farming Treatment of blackgram (6.90 dm² at 40 DAS) and foxtail millet (5.13 dm² at 60 DAS).

Dry matter accumulation per plant (g/plant)**Fig 1:** Plant height of blackgram (cm) as influenced by different farming system modules.**Fig 2:** Plant height of foxtail millet (cm) as influenced by different farming system modules.**Table 1:** Plant height (cm) of blackgram and foxtail millet as influenced by different farming system modules.

Treatments	Plant height (cm)							
	Blackgram				Foxtail millet			
	20 DAS	40 DAS	60 DAS	Harvest	20 DAS	40 DAS	60 DAS	Harvest
T ₁ -NF	17.43	27.73	37.40	39.03	22.67	41.40	82.87	93.00
T ₂ -OF	17.60	28.87	39.53	41.83	25.73	43.97	83.00	95.17
T ₃ -IOF	17.87	29.33	39.70	43.67	26.07	44.53	83.87	97.00
T ₄ -PF	17.00	27.20	36.73	38.93	22.33	38.17	74.87	90.90
T ₅ -ICF	18.73	34.97	41.03	45.90	28.13	49.50	89.07	103.00
T ₆ -CF	18.27	30.93	40.00	44.17	26.93	46.77	86.67	99.67
T ₇ -AB	16.73	26.93	31.93	36.33	21.67	37.57	65.33	89.47
SE(m)±	0.64	1.50	1.76	1.20	1.61	2.31	4.66	1.21
CD at 5%	1.96	4.60	5.41	3.69	4.93	7.08	14.29	3.73
GM	17.66	29.42	38.05	41.41	24.79	43.13	80.81	95.46

Table 2: Leaf area per plant (dm²) of blackgram and foxtail millet as influenced by different farming system modules.

Treatments	Leaf area plant ⁻¹ (dm ²)					
	Blackgram			Foxtail millet		
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
T ₁ -NF	1.64	6.67	5.83	0.46	4.63	4.97
T ₂ -OF	1.69	6.90	6.10	0.49	4.83	5.13
T ₃ -IOF	1.80	7.17	6.27	0.52	5.03	5.30
T ₄ -PF	1.58	6.53	5.57	0.48	4.40	4.50
T ₅ -ICF	1.91	7.77	6.73	0.58	5.47	5.87
T ₆ -CF	1.82	7.47	6.43	0.55	5.20	5.57
T ₇ -AB	1.50	5.60	5.71	0.45	4.27	4.32
SE(m)±	0.06	0.34	0.24	0.02	0.20	0.28
CD at 5%	0.19	1.05	0.72	0.06	0.60	0.86
GM	1.71	6.87	6.09	0.50	4.83	5.09

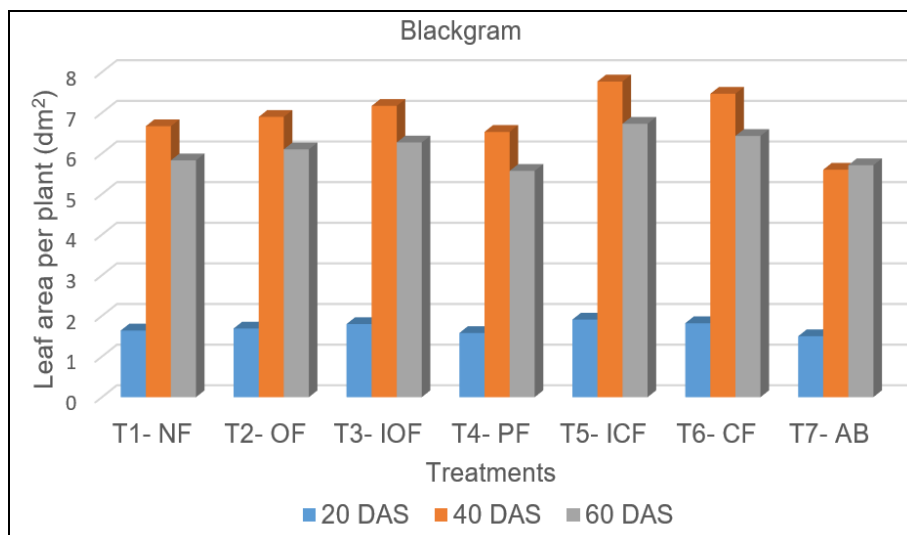


Fig 3: Leaf area per plant of blackgram (dm²) as influenced by different farming system modules.

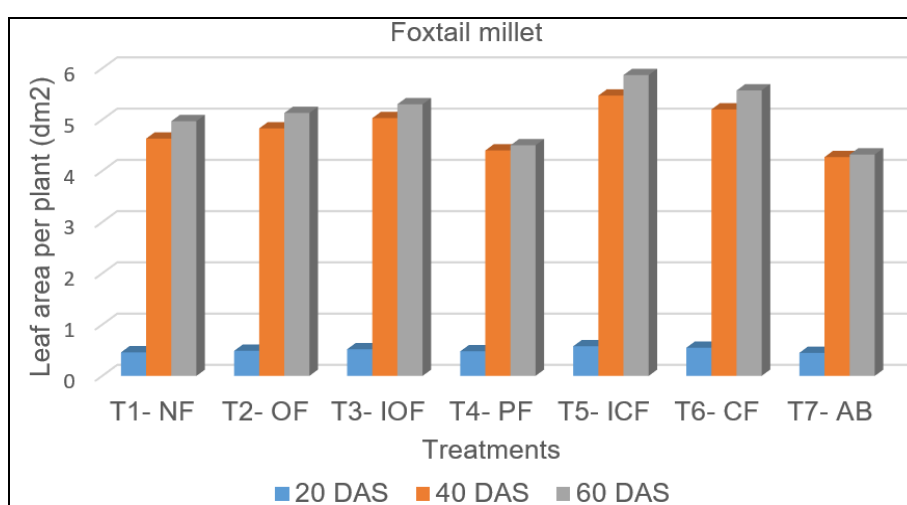


Fig 4: Leaf area per plant of Foxtail millet (dm²) as influenced by different farming system modules.

The data related to dry matter accumulation of blackgram and foxtail millet were presented in table 3 and graphically represented in fig. 4 and 5 respectively. Dry matter accumulation of blackgram and foxtail millet intercropping was significantly higher in Integrated Conventional Farming treatment for blackgram (17.40 g/plant at harvest) and for foxtail millet (19.33 g/plant at harvest). Among organic

nutrient management treatments, Integrated organic farming treatment showed significantly higher dry matter accumulation in both blackgram (16.27 g/plant at harvest) and foxtail millet (18.50 g/plant at harvest). It is at par with Organic Farming treatment in blackgram (15.47 g/plant at harvest) and foxtail millet (18.27 g/plant at harvest).

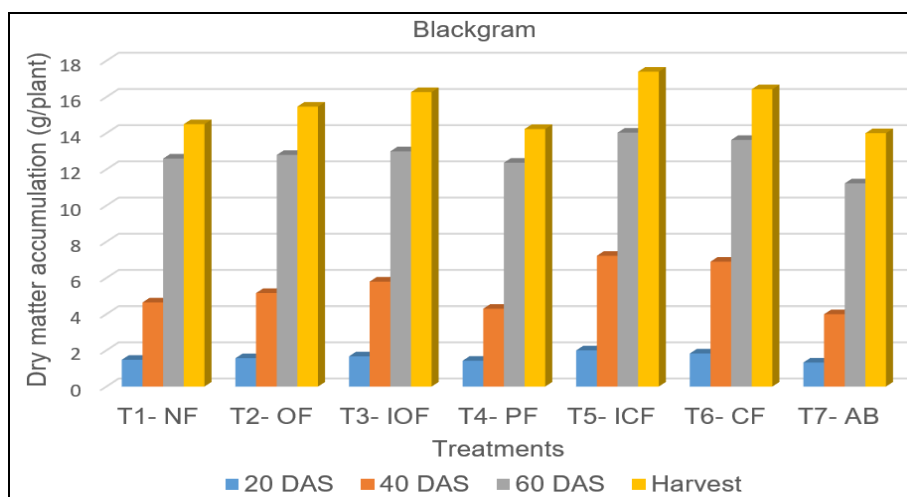


Fig 4: Dry matter accumulation of blackgram (g/plant) as influenced by different farming system modules.

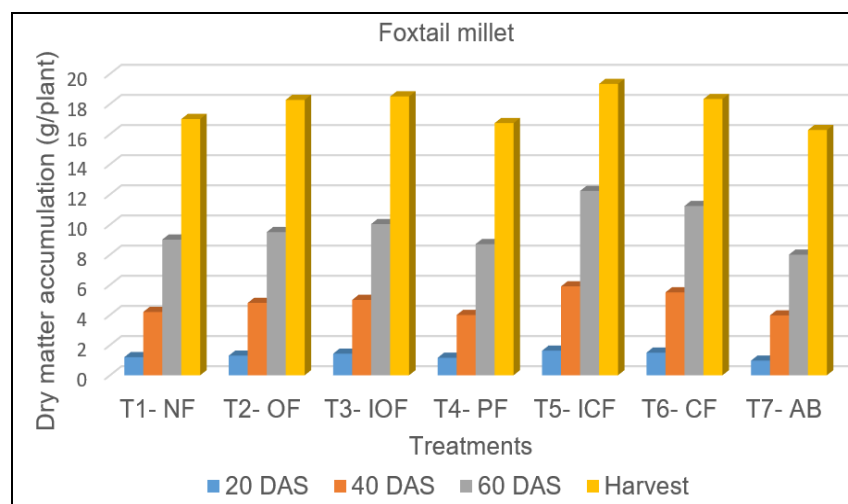


Fig 5: Dry matter accumulation of foxtail millet (g/plant) as influenced by different farming system modules.

Conclusion

Application of 50% RDF along with Vermicompost (1 t/ha) + Jeevamrut (500l/ha) + Phosphocompost (PROM) (150 kg) significantly enhanced Plant height (cm), leaf area per plant (dm²) and dry matter accumulation (g/plant) of blackgram and foxtail millet. Among organic nutrient management treatments application of Beejamrutha + Ghanajeevamrutha (250 kg/ha) + Vermicompost (1 t/ha) + Phosphocompost (PROM) (150 kg/ha) + Jeevamrutha at 15 days interval (500 l/ha) + Mulching significantly increased plant height, leaf area per plant (dm²) and dry matter accumulation (g/plant) of blackgram and foxtail millet. It is at par with organic farming treatment by the application of recommended practices (Vermicompost 2 t/ha + Jeevamrutha (500l/ha) + Phosphocompost (PROM) @ (300 kg/ha).

Disclaimer (Artificial Intelligence)

The author(s) declare that NO generative artificial intelligence (AI) technologies, including ChatGPT and Copilot, or text-to-image generation tools, were used in the preparation, writing, or editing of this manuscript.

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