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Response of Intercropping Finger Millet on Growth and Yield of Pulses

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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 during *kharif* season in Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P.) India. The current research aims to evaluate the growth and yield of various pulses namely cowpea (*Vigna unguiculata* L.), black gram (*Vigna mungo* L.) and green gram (*Vigna radiata* L.) and when cultivated as intercrops with finger millet. The soil of the experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.6), low in organic carbon (0.51 %), available N (78.9 kg/ha), available P (32.88 kg/ha) and available K (385.10 kg/ha). The treatments consisted of 3 pulse crops (Cowpea, Black gram and green gram) and 3 row ratios (2:1, 4:1 and 6:1). The experiment was laid out in a Randomized Block Design with 13 treatments and replicated thrice. Maximum plant height and yield attributes was recorded in sole plots of cowpea (treatment 11), Black gram (treatment 12) and Green gram (treatment 13) respectively. Finger millet equivalent yield was recorded high in (treatment 7) where finger millet was intercropped with green gram in 2:1 ratio.

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Keywords: Black gram; cowpea; finger millet equivalent yield; green gram; yield attributes.

1. INTRODUCTION

Pulses are widely recognized as key sources of plant-based protein, particularly for those following a vegetarian diet. They contribute significantly to soil health due to their nitrogen-fixing capabilities, enhancing soil fertility. According to Tiwari and Shivhare [1] pulses can fix between 72 to 350 kg of nitrogen per hectare annually. This ability positions pulses as crucial components of sustainable farming practices. Additionally, the structural and functional characteristics of pulses allow them to thrive in rainfed environments with limited water supply, making them versatile for various agricultural systems including intercropping, mixed cropping, and crop rotations.

The use of fallow lands is a strategic approach to augmenting pulse production, particularly during the summer when water scarcity limits irrigation options. Millets, known for their drought resilience, are an excellent choice for such conditions. Finger millet, scientifically known as *Eleusine coracana* (L.) Gaertn., stands out for its remarkable water efficiency, requiring only 28% of the water needed for paddy cultivation, as reported by Rurinda et al. [2]. This characteristic makes finger millet an ideal crop for areas with limited water availability, contributing to sustainable agricultural practices [3-5].

Intercropping is a strategic agricultural practice that maximizes resource use efficiency in both space and time. Kumar and Ray's [6] study found that finger millet cultivated alone yielded the highest productivity. However, when it comes to intercropping systems, the combination of finger millet and black gram led to the highest yield of finger millet. Nonetheless, the success of intercropping hinges on the compatibility and synergistic relationship between the different plant species involved. To further boost crop yields and maintain soil health, integrating biofertilization with intercropping has been suggested as a sustainable approach, as per Wezel et al. [7] Li et al. [8] also highlighted that specific root-microbe interactions can influence nutrient mobilization, leading to more effective nutrient uptake.

Crops which vary in their growth habits are grown together so that they complement one another resulting in higher resource use efficiency. Legumes assume paramount importance in intercropping systems involving cereals / millets because of their ability to fix and transfer nitrogen. Millets + legumes intercropping systems also help in conserving moisture, improving the physical properties of the soil and in building up soil fertility [9]. Further, sole cropping of millets like finger millet is usually not appreciably remunerative and it fails to satisfy the diverse consumer demand. The initial slow growth phase of finger millet can be utilized for raising short duration pulses. Moreover, intercropping with fast growing pulses will also help in reducing the weed problems. Intercropping as an example of sustainable agricultural systems following objectives such as ecological balance, more utilization of resources, increasing the quantity and quality and reduce yield damage to pests, diseases and weeds [10]. Intercropping is a system that focuses on the better exploitation of sunlight, effective utilization of nutrients and water, risk reduction and higher exploration of the growth factors from the environment [11,12].

2. MATERIALS AND METHODS

The experiment was conducted to know the Response of Intercropping with Finger millet on Growth and Yield of Pulses at Crop Research Farm of Sam Higginbottom University, Prayagraj, Uttar Pradesh, India where finger millet variety *VL Mandua 376*, was intercropped with pulses, *viz*., cowpea (*Kashinidhi*),black gram (*Cac 3315)* green gram (*SML 668*), and in the ratio of 2:1, 4:1 and 6:1. The soil of the experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.6), low in organic carbon (0.51 %), available nitrogen (178.9 kg/ha), available phosphorus (32.88 kg/ha) and available potassium (385.10 kg/ha). The experiment was laid out in Randomized Block Design with thirteen treatments including control each replicated thrice. The treatments consisted of 3 pulse crops (Cowpea, Black gram and Green gram) and 3 row ratios (2:1, 4:1 and 6:1).

In order to facilitate sowing, the experimental field was thoroughly ploughed and followed by harrowing and brought to fine tilth. Stubbles and weeds were picked up from the field and the land was levelled with the help of rake and the plots were demarcated according to layout. The nutrient sources were SSP and MOP to fulfill the requirement of phosphorous and potassium. The recommended dose of 40 kg/ha phosphorous and 20 kg/ha potassium. Entire dose of phosphorus and potassium were applied at the time of sowing. Seeds were dibbled 4-5 cm deep in line manually. Gap filling & Thinning was done at 8 DAS to maintain the plant population. Weeding was done manually with Khurpi to remove all weeds from the field. Three irrigations were given 2 irrigations before flowering stage and 1 irrigation was given during the pod formation stage.

Biostatics observation on plant height (cm) were recorded from five sample plants from each treatment at 15, 30, 45 and 60 DAS. The data also included records of yield and its associated characteristics. The overall production potential of intercropping pulses in finger millet was assessed in terms of finger millet equivalent yield (FMEY). Finger millet equivalent yield (kg/ha) was computed based on the seed yield (kg/ha) of the intercropped pulses and prevailing market price (INR kg/ha) of finger millet and pulses, based on the crop equivalent yield concept suggested by Lal and Ray [13] and Verma and Modgal [14].

Treatment Details:

1. Finger millet + Cowpea (2:1 ratio)
2. Finger millet + Cowpea (4:1 ratio)
3. Finger millet + Cowpea (6:1 ratio)
4. Finger millet + Black gram (2:1 ratio)
5. Finger millet + Black gram (4:1 ratio)
6. Finger millet + Black gram (6:1 ratio)
7. Finger millet + Green gram (2:1 ratio)
8. Finger millet + Green gram (4:1 ratio)
9. Finger millet + Green gram (6:1 ratio)
10. Finger millet (sole)
11. Cowpea (sole)
12. Black gram (sole)
13. Green gram (sole)

3. RESULTS AND DISCUSSION

3.1 Growth Parameter

At 60 days after sowing (DAS), cowpea plants in the sole cowpea plot (treatment 11) exhibited a significant increase in height, reaching an average of 55.2 cm (Table 1). In contrast, the height of cowpea plants grown in a 2:1 intercropping ratio with finger millet (treatment 1) was found to be statistically similar. For black gram grown alone (treatment 12), a notable height of 28.8 cm was recorded at 60 DAS. Among the intercropping treatments, black gram achieved greater heights when grown in a 2:1 ratio with finger millet (treatment 4). Similarly, green gram plants cultivated without intercropping (treatment 13) were significantly taller, measuring 37.1 cm at 60 DAS, and this height was observed to be on par with green gram plants intercropped with finger millet in a 2:1 ratio (treatment 7). Dr. P.K. Ghosh et al. [15] observed that intercropping legumes with cereals generally led to reduced plant height in leguminous crops like pulses. They noted that competition for light and nutrients from the taller cereal plants could suppress the upward growth of pulses, thereby reducing their overall height.

3.2 Yield Parameters

In the study of crop yields, the sole crop plots of cowpea, black gram, and green gram, corresponding to treatments 11, 12, and 13 respectively, were observed to have maximum number of pods per plant and seeds per pod (Table 2). De Oliveira et al. [16] Grain yield of cowpea was observed to be significantly higher under sole cropping than under intercropping with millets and it was attributed to the greater plant stand since variation could not be observed in the number of pods per plant, number of grains per pod and thousand grain weight. When exploring the effects of intercropping with finger millet, it was found that cowpea, when paired in a 2:1 ratio (treatment 1), maintained maximum number of pods and seeds per pod. A similar trend was observed in black gram and green gram when intercropped with finger millet in the same ratio (treatments 4 and 7, respectively), with both crops achieving maximum number of pods and seeds per pod. The test weight remained consistent across all treatments, indicating no significant impact from the different cropping methods.

In terms of yield, the sole cropping of cowpea, black gram, and green gram resulted in a significantly higher seed and stover yield. The results of higher yields of sole crops compared to intercropping were in agreement with those of Ndakidemi and Dakora [17]. Among the intercropping treatments, the combination of finger millet with cowpea, black gram, and green gram in a 2:1 ratio (treatment 1, treatment 4 and treatment 7 respectively) led to the highest yields for each crop. Specifically, cowpea recorded a seed yield of 1006.0 kg/ha and a stover yield of 1792 kg/ha, black gram had a seed yield of 1203.0 kg/ha and a stover yield of 1675 kg/ha, and green gram achieved a seed yield of 1468.5 kg/ha and a stover yield of 1715 kg/ha when intercropped with finger millet. Dr. Ch. Srinivas [18] and Dr. B. Venkateswarlu observed that certain configurations of intercropping, such as wider row spacing or alternating rows of finger millet and pulses, can optimize yield attributes like seed yield, root biomass, and water use efficiency. This approach minimizes competition for resources while maximizing complementary benefits between crops. The yield advantage of sole crops could be due to higher plant density and also due to absence of competition with the main crop of finger millet ratios in optimizing crop production.

Table 1. Effect of intercropping on plant height of Pulses

Treatment No.	Treatment combination	Plant height (cm) 60 DAS		
		Cowpea	Black gram	Green gram
1	Finger millet + Cowpea (2:1 ratio)	54.0	-	-
2	Finger millet + Cowpea (4:1 ratio)	52.7	-	-
3	Finger millet + Cowpea (6:1 ratio)	51.7	-	-
4	Finger millet + Black gram (2:1 ratio)	-	28.0	-
5	Finger millet + Black gram (4:1 ratio)	-	27.6	-
6	Finger millet + Black gram (6:1 ratio)	-	27.0	-
7	Finger millet + Green gram (2:1 ratio)	-	-	36.4
8	Finger millet + Green gram (4:1 ratio)	-	-	35.5
9	Finger millet + Green gram (6:1 ratio)	-	-	34.8
10	Finger millet (sole)	-	-	-
11	Cowpea (sole)	55.2	-	-
12	Black gram (sole)	-	28.8	-
13	Green gram (sole)	-	-	37.1
	SEm(±)	0.3	0.24	0.20
	CD (p=0.05)	1.0	0.83	0.68

Table 2. Effect of intercropping on yield and yield attributes of Pulses

Treatment No.	Treatment combination	Number of Pods/ plant	Number of Seeds/ pod	Test weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)
1	Finger millet + Cowpea (2:1 ratio)	14.1	9.0	14.7	1006.0	1792
2	Finger millet + Cowpea (4:1 ratio)	13.4	8.9	14.2	957.0	1778
3	Finger millet + Cowpea (6:1 ratio)	13.1	8.5	14.6	928	1663
4	Finger millet + Black gram (2:1 ratio)	23.0	7.9	28.9	1203.0	1675
5	Finger millet + Black gram (4:1 ratio)	22.6	7.7	29.2	1162	1620
6	Finger millet + Black gram (6:1 ratio)	21.3	7.3	29.2	953.0	1563
7	Finger millet + Green gram (2:1 ratio)	27.5	8.3	33.9	1468.5	1715
8	Finger millet + Green gram (4:1 ratio)	26.9	7.7	34.3	1391	1694
9	Finger millet + Green gram (6:1 ratio)	26.1	7.5	34.2	1258.3	1496
11	Cowpea (sole)	14.2	9.1	14.8	1343.6	1956
12	Black gram (sole)	24.1	9	30.8	1419.1	1722

Treatment No.	Treatment combination	Number of Pods/ plant	Number of Seeds/ pod	Test weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)
13	Green gram (sole)	29	8.7	34.4	1691.8	1955
	*SEm(±)	0.14	0.09	0.24	12.2	23.1
	*CD (p=0.05)	0.50	0.33	-	42.2	79.9
	**SEm(±)	0.22	0.07	0.42	36.8	25.8
	**CD (p=0.05)	0.78	0.23	-	127.2	89.3
	***SEm(±)	0.23	0.15	0.63	33.7	37.4
	***CD (p=0.05)	0.79	0.52	-	116.6	129.3

*Cowpea, **Black gram, ***Green gram*

Table 3. Effect of intercropping Finger millet with pulses on Finger millet Equivalent Yield (FMEY)

S. No.	Treatment combination	Finger millet Equivalent yield (FMEY) (kg/ha)
1.	Finger millet + Cowpea (2:1 ratio)	3730
2.	Finger millet + Cowpea (4:1 ratio)	3691.8
3.	Finger millet + Cowpea (6:1 ratio)	3892.2
4.	Finger millet + Black gram (2:1 ratio)	3425.0
5.	Finger millet + Black gram (4:1 ratio)	3465.8
6.	Finger millet + Black gram (6:1 ratio)	3260.3
7.	Finger millet + Green gram (2:1 ratio)	4523.5
8.	Finger millet + Green gram (4:1 ratio)	4484.1
9.	Finger millet + Green gram (6:1 ratio)	4347.6
10.	Finger millet (sole)	-
11.	Cowpea (sole)	-
12	Black gram (sole)	-
13.	Green gram (sole)	-
	SEm(±)	76.3
	CD (p=0.05)	229

3.3 Finger Millet Equivalent Yield (FMEY) (kg/ha)

In the comparative study of pulse crops, the intercropping of finger millet with green gram in a 2:1 ratio (treatment 7) emerged as the most productive, yielding the highest Finger Millet Equivalent Yield (FMEY) at 4523.5 kg/ha (Table 3). This yield was closely matched by the yield from a 4:1 intercropping ratio of finger millet with green gram (treatment 8), which was statistically comparable. Despite the higher market prices of cowpea and black gram, the superior FMEY achieved with green gram can be attributed to the more efficient yield realized in the finger millet and green gram intercropping system, suggesting a better utilization of available resources. Dr. R.K. Malik et al. [19] stating that equivalent yield provides a holistic measure of productivity in intercropping systems, reflecting not only the individual yields of crops but also the synergistic benefits derived from resource complementarity and efficient resource utilization. The findings indicate that intercropping, particularly with green gram, enhances overall productivity when compared to the sole cropping of finger millet. This underscores the potential economic and agricultural benefits of intercropping strategies over traditional sole cropping methods [20-22].

4. CONCLUSION

It can be concluded that intercropping green gram with finger millet at a 2:1 ratio (treatment 7) is a highly effective strategy for enhancing the overall productivity of the agricultural system. This intercropping technique not only maximizes land use efficiency and crop yield but also promotes better resource utilization and soil health. Therefore, implementing this method can significantly improve the sustainability and profitability of farming operations.

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 manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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