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Improving Maize Yield and Soil Productivity through N Management Practices in Maize-legume Intercropping

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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 to investigate the effects of maize intercropping and nitrogen management on crop productivity. The study comprised two factors: maize intercropping with five treatments (sole maize, skipped row maize, and maize intercropped with greengram, blackgram, or

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cluster bean) and nitrogen management with three treatments (100%, 75%, and 50% of the recommended nitrogen dose). The results showed that sole maize at 60 x 20 cm spacing and maize intercropped with cluster bean, blackgram, or greengram significantly outyielded sole maize in skipped rows. Applying nitrogen at the full recommended dose (100%) significantly enhanced maize yields, while the cluster bean intercropping system excelled in terms of maize grain equivalent yield and land equivalent ratio. The study highlights the potential of maize intercropping and optimized nitrogen management to enhance crop productivity, reduce soil nutrient depletion, and promote sustainable agriculture practices.

Keywords: Maize intercropping; nitrogen management; crop productivity; sustainable agriculture.

1. INTRODUCTION

"Sustainable crop productivity is crucial in Indian agriculture, necessitating innovative strategies for crop intensification with sustainable nutrition. Maize (*Zea mays* L.) is the world's third most important cereal crop and India's seventh largest producer. Its multidimensional uses, high production potential, and adaptability make it an essential crop for food production. In southern Andhra Pradesh's agro-climatic zone, maize intercropping has gained popularity. However, hybrid maize requires high nutrient levels, particularly nitrogen, with recent hybrids responding to over 240 kg N/ha. The prohibitive cost of fertilizer nitrogen limits its application, and environmental concerns necessitate alternative nitrogen sources. Legumes, when associated with maize, can reduce nitrogen requirements while maintaining soil health. Despite considerable research on maize nutrition, most studies focused on resource exploitative approaches rather than conservation-based methods" (Arya & Saini, 1989; Asmat Ullah et al., 2007). "Traditional nitrogen recommendations for maize-based intercropping systems have been determined by individual crop responses, leading to suboptimal nitrogen management and reduced economic returns. The cropping system, sole crop resulted in the highest yield attributes, grain yield (3,913 kg/ha), stover yield (6,565 kg/ha), harvest index (37.21%), uptake of nitrogen (101.36 kg/ha), phosphorus (19.80 kg/ha) and potassium (110.90 kg/ha) (Chittapur *et al.,* 1994). A rational agronomic approach, considering uniform plant populations of both base and intercrops, is essential for optimizing maize + legume intercropping systems. The production potential and economic viability of these systems depend on the nature and type of associated legume and fertilizer application. In a field trial at Pantnagar in the 1989 rainy season, maize grown alone or intercropped with soybeans or black gram [*Vigna mungo*] was given 0, 30 or 60 kg N/ha, or sole-cropped maize was given 90 kg N/ha (Bhattacharya *et al.,*1996).This study aims to explore the possibilities of intercropping short-duration legumes with maize under variable nitrogen doses and intercropping sequences using different crop geometries. By adopting a sustainable and conservation-based approach, this research seeks to optimize maize production, reduce environmental degradation, and promote economic viability for farmers" (Barik, 1997; Bhagat, 2002). Intercropping of green gram [*Vigna radiata*], black gram [*V. mungo*], groundnuts, cowpeas or soybeans (with application of 0, 50 or 100% of the NP rate recommended for each crop) in maize grown with the recommended NP rate for it had no adverse effect on grain yields of maize compared with its yields in pure stands; the intercrops gave additional seed/pod yields of 300-330, 170-260, 850-890, 180-240 and 250-290 kg/ha, resp (Bhatt and Damor, 1985).

2. MATERIALS AND METHODS

The experiment was conducted at the Agricultural Research Farm, Sri CB Singh Memorial Shikshan Sansthan, Jhinjhak, Kanpur Dehat, U.P., India, during the 2022-23 Kharif season. The research site is located in the Indo-Gangetic Plains, with a geographical position of 26.35° N latitude and 80.09° E longitude, and an elevation of 130.00 m above mean sea level.A randomized block design with a factorial concept was employed, with three replications. The experiment consisted of two factors: maize intercropping systems and nitrogen management. The maize intercropping systems included five treatments: sole maize, skipped row maize, and maize intercropped with greengram, blackgram, or cluster bean. The nitrogen management factor comprised three treatments: 100%, 75%, and 50% of the recommended nitrogen dose (240 kg ha-1). Sole crops of greengram, blackgram, and cluster bean were raised separately outside the experimental layout. Each plot measured 6.0 x 5.4 m (gross) and 4.0 x 3.6 m (net). Intercrops were sown at a spacing of 60 x 5 cm. A uniform dose of 60 kg P2O5 ha-1 and 50 kg K2O ha-1 was applied as basal to maize in all plots. Nitrogen was split into three equal applications: basal, knee stage, and tasseling stage. For the intercrops, 20, 50, and 40 kg N, P2O5, and K2O ha-1, respectively, were applied as basal at sowing.

3. RESULTS AND DISCUSSION

The study's results showed that maize intercropping and nitrogen management significantly impacted maize's growth parameters, yield attributes, and yield. Sole maize planted at 60 x 20 cm spacing exhibited superior growth parameters, including plant height, leaf area index, and dry matter production, which were comparable to those of maize intercropped with cluster bean, blackgram, and greengram. In terms of yield attributes, sole maize at 60 x 20 cm spacing displayed higher cob length and girth, number of grains per cob, and 100-grain weight, closely followed by maize intercropped with cluster bean, blackgram, and greengram. The grain and stover yield of maize was highest in sole maize at 60 x 20 cm spacing, which was statistically at par with the yields obtained from maize intercropped with cluster bean, blackgram, and greengram. Nitrogen application at 100% of the recommended dose significantly enhanced yield attributes and grain and stover yield, whereas applying 50% of the recommended nitrogen dose resulted in significantly lower yield attributes and grain and stover yield.

The study demonstrated that maize + legume intercropping and nitrogen management had a profound impact on yield attributes, yield, and soil fertility. Notably, the treatment with 100% recommended dose of nitrogen (N1) in maize + cluster bean intercropping system exhibited improved yield attributes and yield, resulting in 5.0 clusters per plant, 16.8 pods per cluster, 5.9 seeds per pod, 42.9g 1000 seed weight, and 1063 kg/ha seed yield. Additionally, the haulm yield was recorded at 2900 kg/ha. The highest maize grain equivalent yield (5790 kg/ha) and land equivalent ratio (1.938) were recorded in the treatment where maize was intercropped with cluster bean. Nitrogen management also played a crucial role in influencing maize grain equivalent yield and land equivalent ratio. The highest nitrogen uptake (105.0 kg/ha) was recorded in the treatment where maize was grown alone, while intercropping maize with greengram and blackgram resulted in similar nitrogen uptake (97.1 kg/ha). Furthermore, nitrogen management significantly influenced the nutrient uptake of greengram, blackgram, and cluster bean, with the highest nitrogen uptake recorded in cluster bean (34.0 kg/ha) when 100% recommended nitrogen (N1) was applied.The study also revealed that the highest soil available nitrogen (177 kg/ha) was recorded in the treatment where 100% recommended nitrogen (N1) was applied to maize, while intercropping maize with greengram also resulted in higher soil available nitrogen (176 kg/ha). The highest computed nitrogen balance (125 kg/ha) was recorded in the treatment where maize was intercropped with greengram and cluster bean with 100% recommended nitrogen (N1). "The growth parameters, yield attributes, and yield of the intercrops, including greengram, blackgram, and cluster bean, were higher in their respective sole crops, followed by application of 100%, 75%, and 50% recommended dose of nitrogen to maize. The maize grain equivalent yield and land equivalent ratio were higher in maize + cluster bean intercropping, followed by maize + greengram and maize + blackgram. the rainy seasons of 2001 and 2002 at Udaipur, to evaluate effect of weed control on production potential and economics of maize (Zea mays L.) - legume intercropping system. Cowpea [Vigna unguiculata (L.) Walp.] and soybean [Glycine max (L.) Merr.] as intercrops reduced the weed dry matter. Introduction cf different rainy season legumes did not affect yield attributes and yield of maize but significanlty increased maize-equivalent yield. All weed-control treatments resulted in significant reduction in weed dry matter and helped in significant enhancement in maize yield attributes and yield (Chalka *et al.,* 2005). The application of 100% recommended dose of nitrogen to maize resulted in significant superiority of maize grain equivalent yield and land equivalent ratio. Moreover, the nutrient uptake by maize was influenced by maize intercropping and nitrogen management. The highest value of nitrogen and phosphorus uptake by maize was associated with 60 x 20 cm planting, which was comparable with that of maize + greengram and maize + blackgram intercrops. The post-harvest soil status of available nitrogen, phosphorus, and potassium was influenced by maize intercropping and nitrogen management. The post-harvest soil status of available nitrogen was highest in maize + greengram, closely followed by maize + blackgram and maize + cluster bean intercropping" (Khandkar & Nigam, 1996; Shivay et al., 1999).

Table 1. Effect of Maize + Legume Intercropping and Nitrogen Management on Plant Height (cm) of Maize

Treatments	25 DAS	50 DAS	75 DAS
Maize intercropping			
T_1: Maize 60 x 20 cm	52.6	126.9	164.9
T_2: Maize skipped row	48.3	109.8	142.6
T_3: T_2 + Greengram	48.2	121.6	158.0
T_4: T_2 + Blackgram	48.6	124.8	158.4
T_5: T_2 + Cluster bean	52.1	125.1	161.6
SEm ±	2.36	3.61	4.02
CD (P=0.05)	NS	10.3	11.5
Nitrogen management			
N_1: 100 % Rec. N to maize	52.4	124.2	164.6
N_2: 75 % Rec. N to maize	50.3	119.2	153.9
N_3: 50 % Rec. N to maize	48.0	105.3	141.6
SEm ±	1.83	4.01	4.23
CD (P=0.05)	NS	11.5	12.1

Table 2. Effect of Maize + Legume Intercropping and Nitrogen Management on Leaf Area Index (LAI) of Maize

Treatments	25 DAS	50 DAS	75 DAS	Harvest
Maize intercropping				
T_1: Maize 60 x 20 cm	0.212	2.50	1.49	1.28
T_2: Maize skipped row	0.181	1.94	1.20	1.20
T_3: T_2 + Greengram	0.199	2.36	1.36	1.25
T_4: T_2 + Blackgram	0.206	2.39	1.39	1.26
T_5: T_2 + Cluster bean	0.212	2.41	1.42	1.28
SEm ±	0.07	0.14	0.048	0.014
CD (P=0.05)	NS	0.40	0.14	0.04
Nitrogen management				
N_1: 100 % Rec. N to maize	0.217	2.38	1.36	1.11
N_2: 75 % Rec. N to maize	0.201	2.36	1.29	1.09
N_3: 50 % Rec. N to maize	0.179	2.01	1.14	0.99
SEm ±	0.006	0.108	0.037	0.010
CD (P=0.05)	0.017	0.31	0.11	0.03

Table 3. Effect of Maize + Legume Intercropping and Nitrogen Management on Dry Matter Production (kg ha-1) of Maize

Treatment	25 DAS	50 DAS	75 DAS	Harvest
Maize intercropping				
T_1: Maize 60 x 20 cm	421.7	4311	7257	9174
T_2: Maize skipped row	408.0	4004	6655	8763
T_3: T_2 + Greengram	412.8	4296	6987	8917
T_4: T_2 + Blackgram	417.6	4298	7056	9003
T_5: T_2 + Cluster bean	419.6	4303	7240	9103
SEm ±	4.8	90.9	112.0	104.2
CD (P=0.05)	NS	262	323	301

Treatment	25 DAS	50 DAS	75 DAS	Harvest
Nitrogen management				
N_1: 100 % Rec. N to maize	420.1	4199	6987	9314
N_2: 75 % Rec. N to maize	418.8	4109	6763	9074
N_3: 50 % Rec. N to maize	404.2	3802	6213	8517
SEm ±	3.61	102.5	86.7	90.2
CD (P=0.05)	10.6	297	251	260

Table 4. Yield attributes of maize as influenced by maize + legume intercropping and nitrogen management

Treatment	Cob length (cm)	Cob girth (cm)	No. of grains per cob	100 grain weight (g)
Maize intercropping				
T_1: Maize 60 x 20 cm	14.4	14.7	333	28.8
T_2: Maize skipped row	12.1	12.9	252	23.8
T_3: T_2 + Greengram	13.7	13.4	297	26.4
T_4: T_2 + Blackgram	13.9	14.4	299	27.5
T_5: T_2 + Cluster bean	14.4	14.6	324	27.7
SEm ±	0.74	0.54	26.83	1.15
CD (P=0.05)	2.1	1.6	77	3.3
Nitrogen management				
N_1: 100 % Rec. N to maize	14.8	14.6	333	28.1
N_2: 75 % Rec. N to maize	14.5	14.3	324	27.7
N_3: 50 % Rec. N to maize	12.3	13.0	245	24.7
SEm ±	0.57	0.42	20.78	0.88
CD (P=0.05)	1.6	1.2	60	2.5

Table 5. Effect of Maize + Legume Intercropping and Nitrogen Management on Grain Yield, Stover Yield, and Harvest Index of Maize

Treatment	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index
Maize intercropping			
T_1: Maize 60 x 20 cm	4009	5921	40.4
T_2: Maize skipped row	3071	4277	41.8
T_3: T_2 + Greengram	3791	5685	40.0
T_4: T_2 + Blackgram	3864	5771	40.1
T_5: T_2 + Cluster bean	3905	5825	40.1
SEm ±	86.5	93.7	1.23
CD (P=0.05)	250	271	NS
Nitrogen management			
N_1: 100 % Rec. N to maize	3838	5809	39.7
N_2: 75 % Rec. N to maize	3791	5694	40.0
N_3: 50 % Rec. N to maize	3055	4984	38.0
SEm ±	79.2	83.4	1.01
CD (P=0.05)	229	241	NS

Table 6. Biometric observations of greengram as influenced by maize + legume intercropping and nitrogen management

Treatment	Plant height (cm)			Leaf area index			Dry matter production (kg ha^{-1})		
	25 DAS	50 DAS	Harvest	25 DAS	50 DAS	Harvest	25 DAS	50 DAS	Harvest
(Maize + greengram) + N_1	10.3	59.4	59.6	0.32	2.89	2.02	110	2401	2492
(Maize + greengram) + N_2	10.4	59.1	59.1	0.30	2.80	1.98	96	2398	2413
(Maize + greengram) + N_3	10.3	59.0	59.0	0.30	2.80	1.96	96	2346	2409
Sole greengram	10.5	60.2	59.6	0.33	3.02	2.63	114	2462	2562

N_1, N_2 and N_3 are 100, 75 and 50 % recommended doses of nitrogen to maize respectively

Table 7. Effect of Maize + Legume Intercropping and Nitrogen Management on Yield Attributes and Yield of Greengram

Treatment	Yield attributes				Yield	
	No. of clusters per plant	No. of pods per cluster	No. of seeds per pod	1000 seed weight (g)	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
(Maize + greengram) + N_1	11.0	5.3	5.5	37.5	418	860
(Maize + greengram) + N_2	10.8	4.9	5.2	37.1	394	854
(Maize + greengram) + N_3	9.6	5.4	4.9	36.1	384	851
Sole greengram	11.6	5.5	5.4	38.0	425	860

N_1, N_2 and N_3 are 100, 75 and 50 % recommended doses of nitrogen to maize, respectively

Table 8. Effect of Maize + Legume Intercropping and Nitrogen Management on Biometric Observations of Blackgram

Treatment	Plant height (cm)			Leaf area index			Dry matter production (kg ha^{-1})		
	25 DAS	50 DAS	Harvest	25 DAS	50 DAS	Harvest	25 DAS	50 DAS	Harvest
(Maize + blackgram) + N_1	11.2	45.2	49.8	0.32	3.01	2.19	360	2280	2436
(Maize + blackgram) + N_2	11.0	45.3	48.1	0.29	2.98	2.78	354	2200	2380
(Maize + blackgram) + N_3	11.0	45.3	47.1	0.30	2.98	2.11	350	2196	2300
Sole blackgram	12.2	47.4	50.1	0.32	3.21	3.01	375	2460	2502

N_1, N_2 and N_3 are 100, 75 and 50 % recommended doses of nitrogen to maize, respectively

Table 9. Effect of Maize + Legume Intercropping and Nitrogen Management on Yield Attributes and Yield of Blackgram

Treatment	Yield attributes				Yield	
	No. of clusters per plant	No. of pods per cluster	No. of seeds per pod	1000 seed weight (g)	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
(Maize + blackgram) + N_1	6.2	12.6	3.6	46.6	378	609
(Maize + blackgram) + N_2	5.3	12.3	4.3	46.0	362	538
(Maize + blackgram) + N_3	5.2	12.0	4.1	45.7	358	514
Sole blackgram	6.4	13.3	4.2	48.1	421	713

N_1, N_2 and N_3 are 100, 75 and 50 % recommended doses of nitrogen to maize, respectively

Table 10. Effect of Maize + Legume Intercropping and Nitrogen Management on Biometric Observations of Cluster Bean

Treatment	Plant height (cm)			Leaf area index			Dry matter production (kg ha^{-1})		
	25 DAS	50 DAS	Harvest	25 DAS	50 DAS	Harvest	25 DAS	50 DAS	Harvest
(Maize + cluster bean) +N_1	9.9	54.6	70.3	0.7	2.9	1.7	124.8	1286	4402
(Maize + cluster bean) +N_2	8.8	51.4	70.2	0.6	2.6	1.6	117.0	1050	4208
(Maize + cluster bean) +N_3	8.3	43.3	69.1	0.5	2.5	1.4	109.8	1072	3891
Sole cluster bean	10.9	55.6	72.0	0.7	3.1	1.9	128.4	1352	4580

4. CONCLUSION

This study examined the effects of maize intercropping and nitrogen management on maize growth, yield, and economic returns. The results revealed that maize intercropping and nitrogen management significantly impacted maize growth, yield attributes, and yield. Sole maize at 60 x 20 cm spacing and maize + cluster bean intercropping exhibited superior growth parameters, yield attributes, and yield. The application of 100% recommended dose of nitrogen to maize resulted in substantially higher yield attributes and grain and stover yield. The growth parameters, yield attributes, and yield of the intercrops were highest in their respective sole crops, followed by the application of 100%, 75%, and 50% recommended dose of nitrogen to maize. In conclusion, this study suggests that intercropping maize with cluster bean and applying 100% recommended dose of nitrogen to maize can lead to improved growth parameters, yield attributes, and yield, as well as enhanced economic returns. Optimizing nitrogen management in maize-based intercropping systems is crucial for achieving higher yields.

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 the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Arya, M. P. S., & Saini, R. I. (1989). Effect of planting geometry on maize and soybean intercropping system under rainfed condition. *Indian Journal of Agronomy, 34*(3), 322-324.

Asmat Ullah, Bhatti, A. M., Gurmani, Z. A., & Imran, M. (2007). Studies on planting patterns of maize (*Zea mays* L.) facilitating legumes intercropping. *Journal of Agricultural Research, 45*(2), 113-118.

Barik, K. C. (1997). Maize + legume intercropping for north central plateau of Orissa. *Legume Research, 20*(3/4), 218-220.

Bhagat, R. K. (2002). Intercropping of pigeonpea and maize under rainfed condition. *Journal of Research (BAU), 14*(2), 233-235.

Bhatt, B. S., & Damor, U. M. (1985). Relative performance of intercrops at graded levels of fertilizers in maize. *Indian Journal of Agronomy, 30*, 514-515.

Bhattacharya, A., & Goutam, R. C. (1996). Performance of maize legume intercropping at different rates of nitrogen. *Annals of Agricultural Research, 17*(25), 215-216.

Chalka, M. K., & Nepalia, V. (2005). Production potential and economics of maize (*Zea mays*) intercropped with legumes as influenced by weed control. *Indian Journal of Agronomy, 50*(2), 119-122.

Chittapur, B. M., Babalad, H. B., Hiremath, S. M., Kulkarni, G. A., & Sardesh Pande, D. R. (1994). Intercropping of fodder legumes in grain maize. *Journal of Maharashtra Agricultural University, 19*(3), 454-455.

Khandkar, U. R., & Nigam, K. B. (1996). Effect of maize legume intercropping systems on soil fertility. *Indian Journal of Agricultural Sciences, 66*(1), 601-603.

Shivay, Y. S., Singh, R. P., & Pandey, C. S. (1999). Response of nitrogen in maize (*Zea mays*) based intercropping system. *Indian Journal of Agronomy, 44*(2), 261-266.

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