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# Spatial arrangement and nitrogen management effects on yield attributes and yield of maize in maize + mungbean intercropping

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**Abstract**
A field trial was conducted to assess the productivity of maize + greengram intercropping systems under different levels of nitrogen doses at Agricultural College Farm, Bapatla, Andhra Pradesh. The experiment was carried out in split plot design with five main treatments ($M_1$:Sole maize, $M_2$: Sole mungbean, $M_3$: Normal planting of maize with one row of mungbean (1:1), $M_4$: Normal planting with two rows of mungbean (1:2), $M_5$: Paired row planting of maize with three rows of mungbean (2:3) and four sub plots ($S_1$: Control, $S_2$: 50% RDN to maize, $S_3$: 75% RDN to maize, $S_4$: 100% RDN to maize) replicated thrice. According to statistical analysis, yield attributes and yield of maize were maximum with paired row planting of maize with three rows of mungbean however on a par with sole maize. The lowest parameters were manifested under normal planting of maize with one row of mungbean. Significantly higher values for yield contributing factors were registered with the supply of 100% RDN to maize followed by 75% RDN to maize. The results concluded that paired row planting accommodating 75% of mungbean population with 100% RDN to maize was found economically profitable.

**Keywords:** Maize, mungbean, intercropping, nitrogen doses and yield

## Introduction
The sustainable productivity of crops is the need in the present Indian farming. Hence, possibility for crop intensification with sustainable nutrition for achieving the sustainability is urgently required. Hybrid maize being an exhaustive crop, requires high quantity of nutrients particularly nitrogen. The recent maize hybrids are responding to more than 240 kg N $ha^{-1}$. But, due to high cost and rate of fertilizer specially nitrogen, the farmers do not apply adequate quantity. In the present day's concern about environmental degradation coupled with high cost of nitrogen, there is a need to find out supplemental alternative sources. Intercropping of maize with legume proved to be remunerative than growing maize alone (Mandal *et al*., 2014) [6]. Legumes, if associated with maize can minimize nitrogen requirement to some extent, besides maintaining soil health. (Naik *et al*., 2017) [7] Hence, the present study was designed to explore the possibilities of intercropping of short duration legumes under varied doses of nitrogen to maize.

## Materials and Methods
A field experiment was conducted at Agricultural College Farm (ANGRAU), Bapatla, Andhra Pradesh during *rabi*, 2021-22. The experiment was carried out in split plot design with five main treatments ($M_1$:Sole maize, $M_2$: Sole mungbean, $M_3$: Normal planting of maize with one row of mungbean (1:1), $M_4$: Normal planting with two rows of mungbean (1:2), $M_5$: Paired row planting of maize with three rows of mungbean (2:3) and four sub plots ($S_1$: Control, $S_2$: 50% RDN to maize, $S_3$: 75% RDN to maize, $S_4$: 100% RDN to maize) replicated thrice. The results of physico chemical analysis of soil revealed that the soil was sandy clay loam in texture, near alkaline in reaction, low in organic carbon and available nitrogen and medium in available phosphorus and potassium. Under this experiment the main crop was maize hybrid variety P 3396 and the intercrop greengram variety was LGG 460. Spacing was 60 × 20 cm in sole maize and for paired row spacing was 90/30 × 20 cm. Intercrop i.e., mungbean sown at spacing of 30 × 10 cm. Uniform dose of 80 kg $P_2O_5$ and 80 kg $K_2O$ $ha^{-1}$ through Single super phosphate and Muriate of potash, respectively were applied as basal to the maize in all the plots. Nitrogen was applied as per the treatments in three equal splits *viz*., basal, knee height and at tasseling stage. Recommended dose of nitrogen applied to maize was 240 kg $ha^{-1}$.

Gap filling was done at one week after sowing, to maintain desired population as per treatments. Thinning was carried out at one week after sowing, to retain one seedling hill-1. The cobs of maize and pods of intercrops from net plot area were sun dried, threshed, cleaned and weighed separately. Growth and yield parameters were recorded as per standard procedures.

## Results and Discussion

### Growth Parameters of Maize

The data revealed that plant height of maize increased progressively with advance in age of the crop up to harvesting stage. The tallest plant of maize (245 cm) was recorded under paired row planting of maize intercropped with three rows of greengram ($M_5$: 2:3 RR) which was significantly superior over all the treatments. The shortest plant stature (231 cm) of maize was depicted under normal planting of maize with one row of greengram ($M_3$:1:1 RR). This might be due to symbiotic associative relationship of maize with greengram might have created a congenial condition for better utilization of natural resources like soil moisture and solar radiation. This confirms the findings of Madhavi Latha *et al*. (2004) [5]. Likewise, significantly maximum values (18457 kg ha$^{-1}$) of drymatter accumulation was recorded under paired row planting of maize intercropped with three rows of greengram ($M_5$: 2:3 RR) which was statistically comparable with sole crop of maize ($M_1$). Normal planting of maize with one row of greengram ($M_3$:1:1 RR) registered minimum values (16208 kg ha$^{-1}$) of drymatter production. This might be due to variations in growth habit, pattern, ontogeny and their morphology of two component crops might have allowed efficient utilization of limited valuable resources. Significantly higher values were recorded with 100% RDN to maize followed by 75% RDN to maize. Similar trend was followed in growth attributes. Increasing levels of N increased the photosynthetic activity, leaf area index and crop growth rate results in increased drymatter production.

### Yield Attributes and Yield of Maize

#### Cob length

Significantly higher length of cob (15.7 cm) was recorded under paired row planting of maize intercropped with three rows of greengram ($M_5$: 2:3 RR) as compared to other intercropping treatments which was statistically comparable with sole crop of maize ($M_1$). The shortest cob length (14.4 cm) of maize was recorded under normal planting of maize with one row of greengram ($M_3$:1:1 RR). The higher length of cob might be due to better utilization of natural resources and source sink mobilizations with less tip sterility effects. Application of nitrogen @ 100% RDN to maize registered significantly longest cob length (16.5 cm) when compared to all the intercropping treatments. Nitrogen plays an important role in plant metabolic and bio-chemical activations since it is an essential constituent of a number of metabolically active components, finally resulting in the improvement in growth, development and productivity and quality of maize. Similar findings were also reported by Shivay *et al*. (2002) [9], Singh and Pareek (2003) [10], Gosavi and Bhagat (2009) [2] and Jat *et al*. (2014) [3].

#### Number of Kernel rows Cob$^{-1}$

Maximum number of kernel rows per cob (14.8) were noticed with the paired row planting of maize intercropped with three rows of greengram ($M_5$: 2:3 RR) and was closely associated with sole crop of maize ($M_1$) but significantly superior over normal planting of maize with two rows ($M_4$:1:2 RR). This might be due to complementary effect of annidation on one another results in reduced competition and allowed to make better utilization of resources. A greater number of kernel rows per cob increased with higher N rates and the maximum number of kernel rows per cob (15.5) under 100% RDN to maize. Better performance of maize is due to transfer of additional nitrogen availability by decaying nodules of legume extracts from root parts throughout the growth period without exerting any competition between the component crops for their nitrogen requirement.

#### Number of Kernels per Cob

Maximum number of kernels per cob (512.6) were manifested with the paired row planting of maize intercropped with three rows of greengram ($M_5$: 2:3 RR) comparable with sole crop of maize ($M_1$) but significantly superior over normal planting of maize with two rows ($M_4$:1:2 RR). It might be due to the development of both temporal and spatial complementarity as a result of which there was no competition for nitrogen and there was a possibility of current transfer of biological fixed nitrogen from atmosphere to greengram legume further moved to fibrous rhizosphere and rhizoplane area of the maize with the help of some beneficial and non- symbiotic bacteria like Azatobacteria and Azospirillum. Similar findings was observed by Kheroar and Patra (2014).

A greater number of kernels per cob increased with higher N rates and the maximum number of kernel rows per cob (531.8) under 100% RDN to maize followed by 75% RDN, 50% RDN, 0% RDN to maize respectively. Whereas, all the plots with the sub treatment 0% RDN to maize recorded the minimum number of kernel rows per cob (417). This might be due to treatment with higher N levels noticed higher N concentration and uptake of plant there by increased the number of grain rows cob$^{-1}$ number of grains row in the form of sink development.

#### Test Weight (100 kernel weight)

Among all the nitrogen level plots application of 100% RDN to maize resulted in highest hundred grain weight which was comparable with 75% RDN to maize. It was followed by 50% RDN to maize. Significantly lowest hundred grain weight was recorded with 0% RDN to maize.

#### Yield of maize

**Grain Yield:** The highest grain yield (7776 kg ha$^{-1}$) of maize under paired row planting of maize intercropped with three rows of greengram ($M_5$: 2:3 RR) which was on a par with sole crop of maize ($M_1$). The minimum grain yield (6750 kg ha$^{-1}$) of maize was recorded under normal planting of maize with one row of greengram ($M_3$:1:1 RR). This increase could be assigned to the improvement of yield attributes namely cobs plant$^{-1}$ and number of grains per cob (Ogunlela *et al*. 1988; Kumar and Singh 1992 and Jat *et al*. (2014) [8, 4, 3] and similar results were also reported by Guggari and Kalaghatagi (2005) [1] for pearl millet and pigeon pea intercropping system. The data revealed that the crop nourished with 100% RDN to maize yielded significantly higher grain yield (8131 kg ha$^{-1}$) than that of all the treatments. The next maximum yield was recorded with 75% RDN to maize which was found to be superior over 50% and 0% RDN to maize.

**Stover Yield**

Significantly maximum stover yield (10079 kg ha$^{-1}$) of maize was recorded under paired row planting of maize intercropped with three rows of greengram ($M_5$: 2:3 RR) which was however on a par with sole crop of maize ($M_1$). Increased plant height and drymatter accumulation under paired row planting might have increased stover yield. The data concluded that the crop nourished with 100% RDN to maize yielded significantly higher stover yield than that of all the treatments. The second best yield was recorded with 75% RDN to maize which was found to be superior over 50% and 0% RDN to maize. Increase in N levels increased plant height and drymatter acccumulaton which results in increased stover yield.

**Harvest Index**

The data revealed that the intercropping and nitrogen levels are not significantly influenced harvest index.

**Table 1:** Plant height and Drymatter accumulation of maize crop at different growth stages as influenced by Crop stand and nitrogen levels

| Crop stand | Plant Height (At harvest) | Dry matter (At harvest) |
|---|---|---|
| $M_1$ (Sole Maize) | 245.0 | 17290 |
| $M_3$ (Maize+ Greengram 1:1) | 231.0 | 16208 |
| $M_4$ (Maize + Greengram 1:2) | 233.0 | 16521 |
| $M_5$ (paired Maize + Greengram 2:3) | 251.7 | 18547 |
| SE (m)± | 4.1 | 431.32 |
| CD (p=0.05) | 14.2 | 1492.6 |
| CV | 5.9 | 8.7 |
| **Nitrogen levels (kg ha$^{-1}$)** | | |
| $S_1$ (control) | 175.1 | 13645 |
| $S_2$ (50% RDN) | 255.6 | 17377 |
| $S_3$ (75% RDN) | 263.6 | 18086 |
| $S_4$ (100% RDN) | 266.4 | 19457 |
| SE (m)± | 4.3 | 344.98 |
| CD (p=0.05) | 12.5 | 1007.0 |
| CV | 6.2 | 7.0 |

**Table 2:** Yield attributes of Maize crop as influenced by Crop stand and nitrogen levels

| Yield attributes of maize | | | | |
|---|---|---|---|---|
| **Crop stand** | **Cob length (cm)** | **No. of kernel rows cob$^{-1}$** | **No. of kernels cob$^{-1}$** | **100 kernel weight (g)** |
| $M_1$ (Sole Maize) | 15.3 | 14.2 | 501.9 | 24.7 |
| $M_3$(Maize+ Greengram 1:1) | 14.4 | 13.4 | 444.0 | 23.9 |
| $M_4$ (Maize + Greengram 1:2) | 14.7 | 13.8 | 477.6 | 24.0 |
| $M_5$ (paired Maize + Greengram 2:3) | 15.7 | 14.8 | 512.6 | 25.1 |
| SE(m)± | 0.23 | 0.27 | 7.70 | 0.36 |
| CD(p=0.05) | 0.8 | 0.9 | 26.5 | 1.2 |
| CV | 5.4 | 6.6 | 5.5 | 5.0 |
| **Nitrogen levels (kg/ha)** | | | | |
| $S_1$ (control) | 12.7 | 12.7 | 417.1 | 23.3 |
| $S_2$ (50% RDN) | 15.0 | 13.6 | 473.6 | 24.0 |
| $S_3$ (75% RDN) | 15.9 | 14.2 | 513.5 | 25.0 |
| $S_4$ (100% RDN) | 16.5 | 15.5 | 531.8 | 25.4 |
| SE(m)± | 0.35 | 0.21 | 8.90 | 0.48 |
| CD(p=0.05) | 1.0 | 0.6 | 25.9 | 1.4 |
| CV | 8.1 | 5.2 | 6.4 | 6.8 |

**Table 3:** Yield (kg ha$^{-1}$) of maize crop as influenced by Crop stand and nitrogen levels

| Crop stand | Kernel yield (kg ha$^{-1}$) | Stover yield (kg ha$^{-1}$) | Harvest index (%) | Test weight (g) |
|---|---|---|---|---|
| $M_1$ (Sole Maize) | 7644 | 9971 | 43.4 | 24.7 |
| $M_3$ (Maize+ Greengram1:1) | 6750 | 8895 | 43.1 | 23.9 |
| $M_4$ (Maize + Greengram 1:2) | 7411 | 9696 | 43.4 | 24.0 |
| $M_5$ (paired Maize + Greengram 2:3) | 7776 | 10079 | 43.5 | 25.1 |
| SE (m)± | 178.36 | 219.81 | 0.58 | 0.35 |
| CD (p=0.05) | 617.22 | 760.66 | 2.00 | 1.2 |
| CV | 8.4 | 7.9 | 4.6 | 5.0 |
| **Nitrogen levels(kg/ha)** | | | | |
| $S_1$ (control) | 6586 | 8726 | 43.1 | 23.3 |
| $S_2$ (50% RDN) | 7189 | 9431 | 43.2 | 24.0 |
| $S_3$ (75% RDN) | 7676 | 10076 | 43.3 | 25.0 |
| $S_4$ (100% RDN) | 8131 | 10407 | 43.8 | 25.4 |
| SE (m)± | 144.1 | 176.2 | 0.58 | 0.38 |
| CD (p=0.05) | 420.5 | 514.3 | 1.68 | 1.3 |
| CV | 6.7 | 6.3 | 4.6 | 6.7 |

Overall, the results from the experiment concluded that the best performance of maize under paired row planting of maize with three rows of greengram with application of 100% RDN to maize on sandy loam soils was found to be profitable besides sustaining soil health.

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