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# Impact of sorghum-pulse intercropping with nitrogen levels on growth and yield of sorghum

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**Abstract**
In the summer of 2021 and 2022, field trials were conducted at the Navsari Agricultural University College Farm, Navsari, Gujarat to investigate the effects of intercropping systems with nitrogen levels on sorghum growth and yield. Experimental results showed that the values were significantly higher. Growth parameters *i.e.* plant height (60 DAS and at harvest), number of leaves per plant at harvest, dry matter accumulation in plant (60 DAS and at harvest), and yield characteristics *i.e.* earhead girth, earhead length, grain-weight/earhead, increase in number of grains per earhead, grain yield and straw yield of sorghum were recorded with sole sorghum and 100% RDN.

**Keywords:** Growth, intercropping, nitrogen, sorghum, yield

## Introduction
Sorghum is one of the world's most significant crops. After maize, wheat, rice, and barley, it is the world's fifth most cultivated grain. It is a true dual-purpose crop, producing both grain and straw as high-value byproducts. It is the main source of food for more than 400 million people in many countries. Approximately 40 million hectares of sorghum are cultivated in 105 countries across Africa, Asia, and Oceania, as well as in the United States and Canada. Africa and Asia contribute for about 25-30% of world output (www.icrisat.org/sorghum.htm). Sorghum is a nutrient-rich crop, containing 2.0–3.0% fats, 9.7–12.0% proteins, 1.5–2.0% minerals, 25–35 mg carbohydrates, 314–330 mg phosphorous, 5–7 mg iron, and 350–370 calories for every 100 grams of seed.

Sorghum ranks third in India's semi-arid tropics, after rice and wheat. Sorghum occupies 4.24 million hectares of land in 2020-21, with a yearly abdicate of 4.78 million tons and a productivity of 1128 kilogram per hectare. (Anon., 2021a) [2]. The main regions where sorghum is cultivated are Gujarat, Madhya Pradesh (MP), Maharashtra, Andhra Pradesh, Tamil Nadu and Karnataka. The major cultivation areas in Gujarat are Junagadh, Mehsana, Surendranagar, Surat, Bharuch and Baroda with area of 4.1 million hectares and the yield of 5.2 million tonnes per annum with a productivity of 1286 kilogram per hectare in 2020-21 (Anon., 2021b) [3].

Intercropping is the process of growing two or more crops at the same time in the same field. It is also referred to as mixed cropping, or multiple cropping. The main objective of intercropping is to enhance productivity and overall efficiency compared to monoculture (the cultivation of a single crop in a given area). By combining complementary plant species, intercropping can promote beneficial interactions between the crops, leading to improved nutrient utilization, pest and disease control, and better soil health. When it comes to fertilizer recommendations for intercropping systems, it can be a bit more challenging compared to sole cropping systems. The nutrient requirements of different crops may vary and their interaction in the same field can affect nutrient availability and uptake. Therefore, it's important to consider the specific crops of intercropping and their nutrient needs. Keeping the foregoing circumstances in mind, the investigation was carried out at the farm of Navsari Agricultural University, Navsari, during the summer season of 2021 and 2022.

## Materials and Methods
Field trials were conducted in the summer season of 2021 and 2022 at Navsari Agricultural University's College Farm in Navsari (Gujarat). The experimental site was fairly uniform and levelled. The university campus is situated at 20°57' north latitude, 72°54' east longitude, and 10 meters above mean sea level. The soil of South Gujarat is known to be “Deep Black Soil”.

The soil in the experimental field has a flat topography. The soil has moderate to poor drainage and considerable water retention. According to soil analysis data, the experimental site's soil quality was clay in texture, low in organic carbon (0.45% and 0.48%) and available nitrogen (204.10 kg/ha and 206.47 kg/ha), medium in available phosphorus (44.30 kg/ha and 46.88 kg/ha), and high in available potassium (291.10 kg/ha and 310.49 kg/ha). The soil was slightly alkaline with normal electrical conductivity.

The trial included a total of fourteen treatments, seven of which were various intercropping systems *viz*., $I_1$: Sole Sorghum, $I_2$: Sole Cowpea, $I_3$: Sole Greengram, $I_4$: Sorghum + Cowpea (paired 2:1), $I_5$: Sorghum + Greengram (paired 2:1), $I_6$: Sorghum + Cowpea (paired 3:2) and $I_7$: Sorghum + Greengram (paired 3:2) along with the nitrogen levels of $N_1$: 75% RDN (60 kg/ha) and $N_2$: 100% RDN (80 kg/ha) in randomized block design with factorial concept which replicated three times. The seeds of cultivar GNJ-1 for sorghum, GC-6 for cowpea and GM-6 for greengram were used in the present investigation. The crop was seeded at 45 x 10 $cm^2$ spacing, and the recommended fertilizer dose for the main crop (sorghum) was 80-40-0 N-$P_2O_5$-$K_2O$ kg/ha, along with all other approved crop procedures. Area based fertilizer dose for the intercrops (cowpea and greengram) was given to the different treatments. Crop growth and yield characteristics were collected from the five tagged plants in each plot. The net plot area was used to calculate seed and stover yield, which was then converted into to kilograms per hectare.

The cost of inputs, including seed, fertilisers, irrigation, and more, was determined using current local costs. The gross realization per hectare in rupees was derived from the seed yield and stover yield from each treatment, taking into account of local market values. The net return for each treatment was calculated by taking the total cost of cultivation and dividing it by the gross returns. The benefit-to-cost (B: C) ratio was calculated by dividing the total income by the cost of cultivation.

## Results and Discussion

### Effect on growth of sorghum

The intercropping system has a considerable impact on the growth characteristics of sorghum, namely plant height. Sole sorghum had the greatest results (151.00 and 220.50 cm at 60 DAS and harvest, respectively). The number of leaves per plant (12.00) and dry matter accumulation per plant (171.08 g) were substantially greater in the sole sorghum than in the 2:1 and 3:2 intercropping systems. Among the nitrogen levels, the application of 100% RDN resulted in considerably increased plant height (251.50 cm), number of leaves per plant (11.63), and dry matter accumulation per plant (165.13 g) of sorghum. Intercropping sorghum with cowpea and greengram did not showed a result in a substantial difference in days to 50% flowering of sorghum. The present findings are in agreement with the results of Amedie *et al*. (2004) [1], Rao *et al*. (2009) [7], Randhawa *et al*. (2005) [6] and Shilpa and Kubsad (2020) [8].

### Effect on yield attributes of sorghum

Over the 2:1 and 3:2 intercropping systems, sole sorghum had considerably higher values for earhead length (22.42 cm), girth of earhead (13.46 cm), number of grains per earhead (2035), and grain weight per earhead (45 g). However, the intercropping system and varied nitrogen levels had no effect on sorghum test weight or harvest index. Among the nitrogen levels, all yield contributing metrics of sorghum, such as length of earhead (21.62 cm), girth of earhead (12.69 cm), number of grains per earhead (1936), and grain weight per earhead (42.75 g), were shown to be considerably greater when 100% RDN was applied over 75% RDN application. These results are in confirmatory with the finding of Bhutada *et al*. (2019) [4] and Dixit *et al*. (2005) [5].

### Effect on yield of sorghum

Under sole sorghum ($I_1$), seed and straw yields of sorghum were much greater (3511 kg/ha and 4788 kg/ha, respectively) which was remained at par with treatment $I_4$ - sorghum + cowpea (paired 2:1) and treatment $I_5$- sorghum + greengram (paired 2:1) in both years but only $I_5$ - sorghum + greengram (paired 2:1) on pooled basis. The sole sorghum ($I_1$) had significantly higher biological yield (8300 kg/ha) of sorghum and remained at par with treatment $I_4$ - sorghum + cowpea (paired 2:1) and treatment $I_5$ - sorghum + greengram (paired 2:1) in both years. The application of 100% RDN produced considerably greater grain yield (3754 kg/ha), straw yield (4914 kg/ha), and biological yield (8668 kg/ha) than 75% RDN. The results are in accordance with the findings of Amedie *et al*. (2004) [1], Dixit *et al*. (2005) [5], Bhutada *et al*. (2019) [4] and Tajane *et al*. (2019) [9].

**Table 1:** Effect of intercropping and nitrogen levels on growth of sorghum

| Treatment | Plant height (cm) | | Number of leaves per plant at harvest | Dry matter accumulation per plant (g) | |
|---|---|---|---|---|---|
| | At 60 DAS | At Harvest | | At 60 DAS | At Harvest |
| **A. Intercropping system** | | | | | |
| $I_1$: Sole Sorghum | 151.00 | 220.50 | 12.00 | 62.42 | 171.08 |
| $I_2$: Sole Cowpea | - | - | - | - | - |
| $I_3$: Sole Greengram | - | - | - | - | - |
| $I_4$: Sorghum + Cowpea (paired 2:1) | 139.58 | 211.75 | 10.92 | 58.83 | 159.33 |
| $I_5$: Sorghum + Greengram (paired 2:1) | 141.33 | 213.83 | 11.42 | 60.58 | 163.75 |
| $I_6$: Sorghum + Cowpea (paired 3:2) | 127.00 | 196.50 | 9.83 | 53.33 | 153.08 |
| $I_7$: Sorghum + Greengram (paired 3:2) | 135.75 | 197.50 | 9.67 | 54.42 | 154.83 |
| S.Em± | 3.26 | 4.25 | 0.30 | 1.49 | 2.99 |
| CD at 5% | 9.35 | 12.20 | 0.86 | 4.26 | 8.58 |
| **B. Nitrogen levels** | | | | | |
| $N_1$: 75% RDN (60 kg/ha) | 128.03 | 200.53 | 9.90 | 55.87 | 155.70 |
| $N_2$: 100% RDN (80 kg/ha) | 149.83 | 215.50 | 11.63 | 59.97 | 165.13 |
| S.Em± | 2.06 | 2.69 | 0.19 | 0.94 | 1.89 |
| CD at 5% | 5.92 | 7.72 | 0.54 | 2.69 | 5.43 |
| **Interaction (I X N)** | | | | | |
| S.Em± | 4.61 | 6.02 | 0.42 | 2.10 | 4.23 |
| CD at 5% | NS | NS | NS | NS | NS |
| Sig. interactions with Y | - | - | - | - | - |
| CV (%) | 8.13 | 7.08 | 9.65 | 8.89 | 6.46 |

**Table 2:** Effect of intercropping and nitrogen levels on yield attributes of sorghum

| Treatment | Length of earhead (cm) | Girth of earhead (cm) | Number of grains/earhead | Grain weight per earhead (g) |
|---|---|---|---|---|
| **A. Intercropping system** | | | | |
| $I_1$: Sole Sorghum | 22.34 | 13.46 | 2135 | 45.00 |
| $I_2$: Sole Cowpea | - | - | - | - |
| $I_3$: Sole Greengram | - | - | - | - |
| $I_4$: Sorghum + Cowpea (paired 2:1) | 20.94 | 12.27 | 1908 | 41.73 |
| $I_5$: Sorghum + Greengram (paired 2:1) | 21.26 | 12.50 | 1925 | 42.60 |
| $I_6$: Sorghum + Cowpea (paired 3:2) | 18.06 | 10.39 | 1580 | 37.88 |
| $I_7$: Sorghum + Greengram (paired 3:2) | 19.24 | 10.83 | 1615 | 39.72 |
| S.Em± | 0.53 | 0.30 | 39.46 | 0.93 |
| CD at 5% | 1.53 | 0.87 | 113 | 2.66 |
| **B. Nitrogen levels** | | | | |
| $N_1$: 75% RDN (60 kg/ha) | 18.42 | 11.08 | 1672 | 40.02 |
| $N_2$: 100% RDN (80 kg/ha) | 22.31 | 12.69 | 1993 | 42.75 |
| S.Em± | 0.34 | 0.19 | 24.95 | 0.59 |
| CD at 5% | 0.97 | 0.55 | 72 | 1.69 |
| **Interaction (I X N)** | | | | |
| S.Em± | 0.76 | 0.43 | 55.80 | 1.31 |
| CD at 5% | 2.17 | NS | 160 | NS |
| Sig. interactions with Y | - | - | - | - |
| CV (%) | 9.08 | 8.83 | 7.46 | 7.78 |

**Table 3:** Effect of intercropping and nitrogen levels on yield of sorghum

| Treatment | Grain yield (kg/ha) | Straw yield (kg/ha) | Biological yield (kg/ha) |
|---|---|---|---|
| **A. Intercropping system** | | | |
| $I_1$: Sole Sorghum | 3511 | 4788 | 8300 |
| $I_2$: Sole Cowpea | - | - | - |
| $I_3$: Sole Greengram | - | - | - |
| $I_4$: Sorghum + Cowpea (paired 2:1) | 3316 | 4492 | 7809 |
| $I_5$: Sorghum + Greengram (paired 2:1) | 3462 | 4682 | 8145 |
| $I_6$: Sorghum + Cowpea (paired 3:2) | 2758 | 3621 | 6379 |
| $I_7$: Sorghum + Greengram (paired 3:2) | 2854 | 3720 | 6574 |
| S.Em± | 56.85 | 135.70 | 143.09 |
| CD at 5% | 163 | 389 | 410 |
| **B. Nitrogen levels** | | | |
| $N_1$: 75% RDN (60 kg/ha) | 2606 | 3608 | 6214 |
| $N_2$: 100% RDN (80 kg/ha) | 3754 | 4914 | 8668 |
| S.Em± | 35.96 | 85.82 | 90.50 |
| CD at 5% | 103 | 246 | 260 |
| **Interaction (I X N)** | | | |
| S.Em± | 80.40 | 191.91 | 202.36 |
| CD at 5% | 231 | 550 | 580 |
| Sig. interactions with Y | - | - | - |
| CV (%) | 6.19 | 11.03 | 6.66 |

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