

RESEARCH PAPER

# Effect of Sorghum-Based Intercropping System on Nutrient Uptake and Yield of Crops in Southern Dry Zone of Karnataka

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## ABSTRACT

A field experiment was conducted during *kharif* season of 2020 at All India Co-ordinated Research Project on Sorghum, Krishi vigyan kendra, Chamarajanagar district, Karnataka to study the effect of sorghum-based intercropping system on nutrient uptake and yield of crops in southern dry zone of Karnataka. Treatments consisted of sole crops and different row proportions of Sorghum + intercrops (greengram, blackgram, cowpea and field bean at 2:1, 4:1 and 4:2). Intercropping increased total N, P and K uptake enhancing grain and straw/haulm yield of sorghum and intercrops. Among intercropping systems highest total nitrogen and potassium uptake by sorghum was recorded in sorghum intercropped with black gram at 4:2 row proportion (172.95 kg ha<sup>-1</sup> and 178.68 kg ha<sup>-1</sup> respectively) as compared to other treatment combination. But in case of phosphorous sorghum intercropped with green gram at 4:2 row proportion recorded significantly higher total uptake of phosphorous (45.63 kg ha<sup>-1</sup>). Among all the intercrops, sole field bean recorded higher uptake of nitrogen, phosphorous and potassium (41.31, 21.62 and 43.68 kg ha<sup>-1</sup>) compared to other treatments. The combined effect of sorghum intercropped with black gram at 4:2 row proportion recorded the highest sorghum yield (16.23 q ha<sup>-1</sup>) and straw yield (144.30 q ha<sup>-1</sup>). From the results it was confirmed that sorghum + black gram in 4:2 row proportion was better in terms of nutrient uptake and yield compared to the other treatments.

## HIGHLIGHTS

- Impact of sorghum-legume intercropping system on productivity of crops.
- Influence of legume-based intercropping systems for increased nutrient uptake of different cropping systems.

**Keywords:** Intercropping, nutrient uptake, yield, sorghum, black gram, green gram, field bean

The cereal-legume intercropping is mainly practiced for subsistence agriculture to get the full yield of cereal crop for food and legumes for protein besides some additional returns to the growers (Maitra *et al.* 2023a, 2024; Ray *et al.* 2025). Due to ever increasing pressure on cultivated land for food and commercial crops, it may not be possible to increase the arable area under pulse crops (Maitra, 2020; Sarath Kumar and Maitra, 2020). One of the potential and novel

opportunities to meet this demand is by inclusion of pulses in intercropping systems. The scientific intercropping of pulses with cereals and other

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non-legume companion crops has certain inbuilt advantage over pure cropping (Kavya *et al.* 2022; Santosh *et al.* 2022). The yield advantage in cereal-legume intercropping is due to their differential rooting habit, differential growth, demand for resources, complementary interactions as brought by nitrogen fixation of legumes and legumes add enormous organic biomass (leaf, nodules, roots, *etc.*). Further, legume inclusion in cereal based intercropping system helps to increase productivity per unit land area by extracting moisture and nutrient from deeper layer of soil besides solving the problem of weeds, pest and disease due to differential biodiversity (Palai *et al.* 2021; Manasa *et al.* 2021; Maitra *et al.* 2023a). Keeping the above points in view, the research was designed to evaluate effect of sorghum based intercropping system on nutrient uptake and yield.

## MATERIALS AND METHODS

The field experiment was conducted at All India Coordinated Research Project (AICRP) on sorghum, Krishi Vigyana Kendra (KVK), Hardanahalli, Chamarajanagar district, University of Agricultural Sciences, Bangalore. The soil from experimental site falls under black soil with clay loam in texture and bulk density of 1.27 Mg m<sup>-3</sup>. Soil was neutral in reaction with pH of 7.55 and low in electrical conductivity (0.489 dS m<sup>-1</sup>). The fertility status of the soil at experimental site was low in organic carbon (0.48%), low in available nitrogen (232.5 kg ha<sup>-1</sup>), medium in available phosphorus (37.98 kg ha<sup>-1</sup>) and available potassium (192.60 kg ha<sup>-1</sup>). The experiment was laid out with randomized complete block design and replicated thrice. The experiment consists of seventeen treatment combination with different legumes *viz.*, green gram, black gram, cowpea and field bean in different row ratios *viz.*, 2:1, 4:1 and 4:2, respectively. Legumes were sown as per the treatment combination. The sole sorghum sown at a spacing of 40 cm × 15 cm. The plot size was 4.8 m × 3 m. Recommended dose of fertilizer for sorghum was 65:40:40 kg nitrogen, phosphorous and potassium per hectare. Other recommended practices like thinning, weeding, application of pesticide was uniformly followed. Crop was harvested at maturity stage, seed yield per net plot of each treatment was recorded. The various biometric observations, analytical data of

plant sample and the computed data were subjected to statistical scrutiny as per the procedures given by Gomez and Gomez, 1984. The treatment differences were worked out at five per cent probability level.

The uptake of nutrients by the crop at harvest was estimated by multiplying the nutrient concentration and total dry matter yield of the plant as given in the following formula and uptake of nitrogen, phosphorous and potassium expressed as kg ha<sup>-1</sup>.

$$\text{Uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient concentration (\%)} \times \text{weight of dry matter (kg ha}^{-1}\text{)}}{100}$$

## RESULTS AND DISCUSSION

Nutrients uptake by sorghum was influenced by the combination and proportion of intercropping (Table 1). Sorghum intercropped with black gram at 4:2 row proportions recorded significantly higher total uptake of nitrogen (172.95 kg ha<sup>-1</sup>) and potassium (178.68 kg ha<sup>-1</sup>) and it was on par with sole sorghum, sorghum + green gram (4:2), sorghum + black gram (2:1) and sorghum + green gram (2:1). But in case of phosphorous sorghum intercropped with green gram at 4:2 row proportion recorded significantly higher total uptake of phosphorous (45.63 kg ha<sup>-1</sup>) and it was on par with sole sorghum and sorghum + black gram (4:2).

Sorghum intercropped with black gram at 4:2 row proportion recorded significantly higher total uptake of nitrogen and potassium it is due to better crop growth, development, higher accumulation of all three primary nutrients in the plant tissues, production of higher dry matter and the continuous availability and supply of nitrogen and potassium by the black gram intercropped with sorghum during the growing period of the crops. These results are in confirmatory with Choudhary *et al.* (2014) and Telkar *et al.* (2017). Intercropping sorghum with green gram increased the wide range of microbes of plant rhizosphere to mobilize the inherent phosphorous which increases their availability and total uptake of phosphorous by plants. These results are in confirmatory with Choudhary *et al.* (2014).

Nutrients uptake by intercrops was influenced by the combination and proportion of intercropping (Table 2). Among all the intercrops, sole field bean recorded higher uptake of nitrogen, phosphorous

**Table 1:** Effect of sorghum based intercropping system with different row proportion and intercrops on nitrogen, phosphorus and potassium uptake by sorghum

Treatments	Nitrogen uptake (kg ha <sup>-1</sup> )			Phosphorous uptake (kg ha <sup>-1</sup> )			Potassium uptake (kg ha <sup>-1</sup> )		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T <sub>1</sub> : Sorghum + Green gram (2:1)	19.02	136.64	155.66	7.92	26.28	34.20	4.47	149.78	154.25
T <sub>2</sub> : Sorghum + Black gram (2:1)	19.59	143.51	163.10	8.25	28.43	36.68	4.71	157.05	161.77
T <sub>3</sub> : Sorghum + Cowpea (2:1)	17.48	99.57	117.05	7.21	22.76	29.96	4.00	109.05	113.06
T <sub>4</sub> : Sorghum + Field bean (2:1)	18.30	99.52	117.82	7.24	24.39	31.63	4.64	115.13	119.78
T <sub>5</sub> : Sorghum + Green gram (4:1)	17.71	92.73	110.44	7.48	22.32	29.80	4.59	97.89	102.48
T <sub>6</sub> : Sorghum + Black gram (4:1)	18.22	111.61	129.83	8.13	23.55	31.68	5.05	117.75	122.80
T <sub>7</sub> : Sorghum + Cowpea (4:1)	15.23	82.69	97.93	5.87	21.68	27.54	3.61	93.13	96.74
T <sub>8</sub> : Sorghum + Field bean (4:1)	15.94	87.14	103.08	6.91	18.73	25.65	3.63	95.29	98.92
T <sub>9</sub> : Sorghum + Green gram (4:2)	22.12	143.37	165.49	8.72	36.91	45.63	5.97	168.92	174.89
T <sub>10</sub> : Sorghum + Black gram (4:2)	21.43	151.52	172.95	9.58	31.75	41.32	5.52	173.17	178.68
T <sub>11</sub> : Sorghum + Cowpea (4:2)	18.90	109.96	128.86	8.04	25.37	33.41	5.08	127.93	133.01
T <sub>12</sub> : Sorghum + Field bean (4:2)	18.59	119.46	138.05	7.38	27.05	34.43	4.40	134.11	138.51
T <sub>13</sub> : Sole Sorghum	20.11	147.43	167.54	8.34	36.86	45.20	5.21	171.53	176.74
<b>F-test</b>	*	*	*	*	*	*	*	*	*
<b>S.Em ±</b>	<b>0.85</b>	<b>6.26</b>	<b>7.05</b>	<b>0.36</b>	<b>1.37</b>	<b>1.71</b>	<b>0.22</b>	<b>7.01</b>	<b>7.21</b>
<b>CD at 5%</b>	<b>2.49</b>	18.27	20.57	1.05	4.00	4.98	0.63	20.47	21.05

**Table 2:** Effect of sorghum based intercropping system with different row proportion and intercrops on nitrogen, phosphorus and potassium uptake by intercrops

Treatments	Nitrogen uptake (kg ha <sup>-1</sup> )			Phosphorus uptake (kg ha <sup>-1</sup> )			Potassium uptake (kg ha <sup>-1</sup> )		
	Seed	Haulm	Total	Seed	Haulm	Total	Seed	Haulm	Total
T <sub>1</sub> : Sorghum + Green gram (2:1)	7.27	2.16	9.43	2.05	2.16	4.21	6.76	2.42	9.18
T <sub>2</sub> : Sorghum + Black gram (2:1)	5.96	2.42	8.38	1.75	2.33	4.09	5.68	2.84	8.53
T <sub>3</sub> : Sorghum + Cowpea (2:1)	10.12	3.04	13.16	2.88	3.16	6.04	9.43	3.52	12.95
T <sub>4</sub> : Sorghum + Field bean (2:1)	9.31	3.98	13.29	2.72	3.98	6.69	8.79	4.60	13.39
T <sub>5</sub> : Sorghum + Green gram (4:1)	3.49	1.40	4.88	1.04	1.40	2.44	3.24	1.50	4.75
T <sub>6</sub> : Sorghum + Black gram (4:1)	4.46	1.69	6.15	1.35	1.69	3.04	4.11	1.84	5.95
T <sub>7</sub> : Sorghum + Cowpea (4:1)	6.48	2.50	8.98	1.89	2.40	4.29	6.06	2.73	8.79
T <sub>8</sub> : Sorghum + Field bean (4:1)	7.05	3.58	10.63	1.98	3.45	5.43	6.40	3.90	10.30
T <sub>9</sub> : Sorghum + Green gram (4:2)	11.05	6.47	17.52	3.18	5.89	9.07	9.88	7.28	17.16
T <sub>10</sub> : Sorghum + Black gram (4:2)	13.38	4.73	18.10	3.75	4.48	8.23	11.97	5.24	17.20
T <sub>11</sub> : Sorghum + Cowpea (4:2)	11.54	3.46	14.99	3.21	3.33	6.53	10.50	3.84	14.34
T <sub>12</sub> : Sorghum + Field bean (4:2)	12.86	5.41	18.27	3.50	5.20	8.70	11.59	6.34	17.94
T <sub>13</sub> : Sole Sorghum	—	—	—	—	—	—	—	—	—
T <sub>14</sub> : Sole Green gram	22.69	7.34	30.03	6.44	7.20	13.64	21.43	8.61	30.04
T <sub>15</sub> : Sole Black gram	29.76	8.77	38.53	8.82	8.77	17.59	28.11	10.26	38.37
T <sub>16</sub> : Sole Cowpea	20.24	9.26	29.50	6.03	8.35	14.38	20.55	10.71	31.25
T <sub>17</sub> : Sole Field bean	28.31	13.00	41.31	8.62	13.00	21.62	28.60	15.08	43.68
<b>F-test</b>	*	*	*	*	*	*	*	*	*
<b>S.Em ±</b>	<b>0.65</b>	<b>0.25</b>	<b>0.90</b>	<b>0.19</b>	<b>0.24</b>	<b>0.43</b>	<b>0.62</b>	<b>0.29</b>	<b>0.91</b>
<b>CD at 5%</b>	1.13	0.44	1.55	0.33	0.42	0.75	1.08	0.50	1.58

**Table 3:** Yield of sorghum and component crops as influenced by different row proportion and intercrops in sorghum based intercropping system

Treatments	Grain yield (q ha <sup>-1</sup> )	Straw yield (q ha <sup>-1</sup> )	Seed yield (kg ha <sup>-1</sup> )	Haulm yield (kg ha <sup>-1</sup> )
T <sub>1</sub> : Sorghum + Green gram (2:1)	14.42	131.37	336	423
T <sub>2</sub> : Sorghum + Black gram (2:1)	14.76	135.30	278	462
T <sub>3</sub> : Sorghum + Cowpea (2:1)	13.34	94.93	464	607
T <sub>4</sub> : Sorghum + Field bean (2:1)	13.65	97.70	431	780
T <sub>5</sub> : Sorghum + Green gram (4:1)	13.12	85.80	162	263
T <sub>6</sub> : Sorghum + Black gram (4:1)	14.02	102.40	207	312
T <sub>7</sub> : Sorghum + Cowpea (4:1)	11.32	80.30	304	471
T <sub>8</sub> : Sorghum + Field bean (4:1)	11.72	81.37	325	650
T <sub>9</sub> : Sorghum + Green gram (4:2)	16.14	142.00	488	1155
T <sub>10</sub> : Sorghum + Black gram (4:2)	16.23	144.30	586	844
T <sub>11</sub> : Sorghum + Cowpea (4:2)	14.11	105.67	517	639
T <sub>12</sub> : Sorghum + Field bean (4:2)	14.19	112.60	574	1040
T <sub>13</sub> : Sole Sorghum	14.87	141.73	—	—
T <sub>14</sub> : Sole Green gram	—	—	1055	1411
T <sub>15</sub> : Sole Black gram	—	—	1377	1655
T <sub>16</sub> : Sole Cowpea	—	—	1022	1814
T <sub>17</sub> : Sole Field bean	—	—	1437	2600
<b>F-test</b>	*	*	—	—
<b>S.Em ±</b>	<b>18.03</b>	<b>0.19</b>	<b>NA</b>	<b>NA</b>
<b>CD at 5%</b>	<b>52.62</b>	<b>0.54</b>	—	—

and potassium (41.31, 21.62 and 43.68 kg ha<sup>-1</sup>) compared to other treatments. This is due to sole field bean mobilizes the inherent nitrogen, phosphorous and potassium by the influence of wide range of microbes in the rhizosphere and also by addition of organic matter through leaf litter which in turn increases the uptake efficiency of legume (Yamuna *et al.* 2017).

Sorghum + blackgram at 4:2 row proportion recorded the highest yield of 16.23 (q ha<sup>-1</sup>) and straw yield of 144.30 (q ha<sup>-1</sup>) (Table 3) compare to the other treatment combination. Higher yield of sorghum when grown with the blackgram is due to the complementary effect between base crop and intercrop. Blackgram is a short statured crop, early maturing crop and offered lesser competition for the available resource like solar radiation, water and nutrient compare to the crop like cowpea and field bean. Similar findings were reported by Amedie *et al.* (2010) and Ananthi *et al.* (2017). Increased straw yield of sorghum in sorghum + black gram intercropping at 4:2 row proportion is due to high nitrogen fixation by blackgram, triggered growth

of ground part of the sorghum, which enable the sorghum to effectively utilize the solar radiation which resulted in the corresponding increment of photosynthetic rate. Increase in the photosynthetic rate increases the accumulation of dry matter. Similar results are observed with the finding of (Jat *et al.* 2014; Singh and Verma, 2018; Maitra *et al.* 2025).

Among intercropped legumes respective sole stand treatments viz T<sub>14</sub> (sole green gram), T<sub>15</sub> sole black gram, T<sub>16</sub> (sole cowpea) and T<sub>17</sub> (sole field bean) recorded higher grain yield (1055,1377,1022 and 1437 kg/ha respectively) and haulm yield (1411,1655, 1814 and 2600 kg/ha respectively). This is mainly due to higher number of branches per plant, number of pods per plant and number of seeds per plant. Similar findings were also observed by Rasul *et al.* (2012) and Pushpa *et al.* (2022).

## CONCLUSION

The study revealed that nutrient uptake and productivity of sorghum were significantly influenced by the choice of intercrop and row proportion. Sorghum intercropped with black gram



at a 4:2 row proportion recorded the highest uptake of nitrogen and potassium, along with superior grain and straw yields, due to better nutrient availability, enhanced dry matter production, and complementary growth behavior. In contrast, higher phosphorus uptake was observed when sorghum was intercropped with green gram at the same row proportion, likely due to increased microbial activity in the rhizosphere. Among the intercrops, sole field bean showed the highest uptake of nitrogen, phosphorus, and potassium, attributed to efficient nutrient mobilization and organic matter addition. Sole cropping of legumes also recorded higher grain and haulm yields compared to their intercropped counterparts, owing to improved pod and seed development. Overall, sorghum + black gram at a 4:2 row proportion emerged as the most effective intercropping system for maximizing nutrient uptake and yield, making it a promising approach for sustainable crop production.

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