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# Effect of Planting Geometry and Legumes Intercropping System on the Yield of Sorghum

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**Abstract:** An experiment was conducted to study the feasibility of legumes intercropping in sorghum based cropping system at 60,30/90 and 30/120 cm spaced single, double and triple row strips, respectively. The data showed that planting pattern of double row strips (30/90 cm) significantly ($P < 0.05$) increased the grain yield (5.95 t $ha^{-1}$) of sorghum than single (5.65 t $ha^{-1}$) or triple row strip (5.53 t $ha^{-1}$) planting pattern. Legumes associations decreased the sorghum grain yield by 3.72 and 6.60% then pure stands of sorghum. The interaction between planting geometry and associated legumes culture was non-significant in both the years. However, double row strip planting with two rows of intercrop between the 90 cm space was found superior to other treatment combinations. Thus, this planting technique of sorghum-based legumes intercropping can be recommended for adoption to the farmers.

**Key words:** *Sorghum bicolor,* planting geometry, intercropping, legumes, yield

## Introduction

Sorghum (*Sorghum bicolor* L.) is an important kharif crop and possesses a wide range of ecological adaptability due to its xerophyllic characteristics. It is usually grown by the subsistence farmers for feed and fodder in rainfed as well as in irrigated regions of Pakistan. In some parts of the world, it is also consumed as staple food grain and is used for a variety of other products like alcohol, edible oil, sugar and wax etc. Research studies evinced that sorghum can successfully be grown as component of intercrop combinations in tropical areas of the world (Francis *et al.,* 1976; Okigbo and Greenland, 1976).

Intercropping, a unique system in tropical, sub-tropical regions and particularly popular among small farmers (Finlay, 1974) has become a common practice of farming in developing countries. Wahua and Miller (1978) studied the association of sorghum cultivars of two different height 1.3 and 2.0 m with soybean and found that the yield of dwarf and tall variety of sorghum were reduced by 74 and 14%, respectively when intercropped with soybeans as compared to yield obtained from sorghum pure crop. Willey *et al.* (1983) reported that legume/non-legume intercropping pattern gave higher yield than monoculture due to efficient utilization of soil. Similarly, Zougmore *et al*. (2000) reported that sorghum-cowpea intercropping system reduced run-off by 20-30% compared to sorghum monoculture and by 45-55% compared to a cowpea monoculture. The grain yield of the intercropped plots was double that obtained from monoculture of these crops. Keerio and Singh (1985) indicated that intercropping of sorghum with guar bean, cowpea, moth bean and soybean increased grain yield by 50.9, 41.5, 38.5 and 6.7% over sorghum alone (3.3 $tha^{-1}$), respectively.

Malai and Muthusankaranarayanan (1999) evaluated sorghum based intercropping systems and found that higher growth and yield parameters, grain and stover yield were recorded in sorghum alone than in sorghum intercropped with either black gram (Vigna mungo) or cowpea. Ayisi *et al.* (2001) indicated that superior intercropped sorghum yield was obtained when component crops were arranged in alternate rows at a 0.90 m spacing. The overall land use efficiency, assessed by the land equivalent ratio, was improved by an average of 11% with intercropping at a row spacing of 0.90 m. However, no yield benefit was observed when crops were arranged in an alternate row pattern at a narrow row spacing of 0.45 meter. Sharma *et al.* (2000) studied the comparative performance of sorghum based cropping systems and found that the highest yield was given by sorghum + soybean, which was 38-124% higher than other cropping systems. Monetary returns were greatest from a sorghum + soybean 30/90 cm paired row system with 2 rows of soybeans.

The development of sustainable and economically viable intercropping system largely depends on planting pattern of the crops grown in association. Jafar *et al.* (1988) studied the effect of planting pattern on growth and yield of summer maize and found significant increase in grain yield (50.49 q $ha^{-1}$) of maize planted in double row strips 90 cm apart compared to single rows 60 cm apart or triple row strips 120 cm apart giving grain yield of 46.44 or 40.06 q $ha^{-1}$, respectively. In view of the production potential of intercropping system, this study was undertaken to determine feasible planting geometry for sorghum-based legume intercropping system.

**Materials and Methods**

The two factors experiment was laid out in a randomized complete block design (RCBD) with four replications. The details of the treatments were as follows.

**Treatments**

**Planting geometry**

$P_1$: Sorghum single row 60 cm apart

$P_2$: Sorghum double row strip with 30/90 cm space between the rows/strips

$P_3$: Sorghum triple row strip with 30/120 cm space between the rows/strips

**Intercropping system**

$A_0$: Sole Sorghum

$A_1$: Sorghum + Mungbean

$A_2$: Sorghum + Guar.

Plot size maintained was 4 x 3.60 $m^2$ in both the years of study. Sorghum variety 'PARC-SS-II', mungbean 'MN-92' and guar cultivar 'DK-3' were planted on a well prepared seedbed on 22nd and 26th July in 1999 and 2000 respectively. Standard seed rate of 20 kg $ha^{-1}$ was used for sowing. Sixty kg $ha^{-1}$ phosphorus as single super phosphate and ninety kg $ha^{-1}$ nitrogen as urea were applied. Nitrogen @ 30 kg $ha^{-1}$ as a starter dose was applied with full dose of phosphorus at the time of land preparation for sowing. The remaining dose of nitrogen (60 kg $ha^{-1}$) was applied in two split doses of 30 kg $ha^{-1}$ each to sorghum crop only with 15 days interval after 30 days of planting of the crop.

Adequate plant protection measures were made during the crop growing seasons. Furadon granules @ 25 kg $ha^{-1}$ were applied for the control of shoot fly and stem borer in sorghum. At harvest of the crops, the data collected were analyzed statistically at 5% level of probability using Duncan's multiple rangetest (DMRT).

**Results and Discussion**

The data (Table 1) showed that modified planting geometries of double and triple rows strips significantly ($P<0.05$) reduced the plant height of sorghum than conventional planting of single rows 60 cm apart in both the years. In 1999, plant height of sorghum in double rows (139.8 cm) and triple rows (137.6 cm) strip was significantly less than the plant height (141.5 cm) of single row pattern. Similar trend was noted during 2000. The legumes intercropping also affected the plant height in both the years. Sole sorghum plants were significantly taller (144.8 cm) than mung bean and guar associated sorghum showing plant height of 138.0 and 136.1 cm, respectively during 1999. The same trend was recorded in the year 2000. The interaction between planting geometry and legume association was also found to be significant ($P<0.05$) during 1999. Sole sorghum grown in single row pattern attended maximum plant height of 148.2 cm compared to the lowest plant height (135.1 cm) of guar associated sorghum in triple rows strip planting. However, interaction was non-significant in the year 2000. The planting geometry had no significant affect on LAI during 1999 but in 2000, LAI (5.04) was significantly more in double row strip pattern than single (4.89) and triple row strip (4.92) pattern. This could be attributed to maximum utilization of environmental resources in double row strip pattern of planting. However, legumes associated sorghum crop significantly reduced the LAI than sole sorghum crop in 1999. Similar trend was observed during 2000. The interaction between planting geometry and companion legumes as regards LAI was non-significant in 1999. However, during 2000, sole sorghum grown in double row strip significantly increased the LAI (5.10) over all other treatments of combinations. Minimum LAI (4.82) was recorded in guar-associated sorghum crops grown in single row pattern.

The data (Table 1) indicated that grains weight per panicle was significantly ($P<0.05$) affected by planting geometry. Double row strip (30/90 cm) planting significantly increased grains weight per panicle (69.04 g) than single and triple row strip system giving grains weight of 66.53 and 66.22 g, respectively in 1999. The same trend was noted during 2000 except that triple row strip planting showed significantly less grains weight per paniclethan single row planting. It was further observed that legumes associated sorghum crop significantly reduced the grains weight per panicle than sole sorghum in both the years of study. During 1999, sole sorghum gave higher grains weight per panicle 68.80 g than double and triple rows strip with grains weight per panicle of 67.27 and 65.72 g respectively. Similar trend was exhibited during 2000. The interaction between planting geometry and legumes intercropping as regards grains weight per panicle was non-significant in both years. In 1999 planting geometry showed non-significant affect on the 1000-grains weight of sorghum but in 2000, the 1000-grains weight of single (32.18 g) and triple row (32.14 g) strip pattern was significantly higher than double row (32.00 g) strip planting. It was further noted that the 1000-grains weight of guar-associated sorghum (32.18 g) was significantly higher than sole sorghum (31.94 g) and mungbean associated sorghum (31.96 g) in 1999 but both the legumes association showed non-significant affect on the 1000-grains weight of sorghum during 2000. The interaction between planting geometry and legumes association was non-significant in 1999 but in 2000, guar associated sorghum grown in single row pattern ($P_1xA_2$) gave maximum 1000-grains weight of 32.30 g showing non-significant difference with treatment combination of $P_1xA_1$, $P_3xA_0$, and $P_3xA_2$.

Table 1: Growth and yield attributes of sorghum as influenced by planting geometry and legumes intercropping system

| | Plant height (cm) | | Leaf area index | | Grains weight/panicle (g) | | 1000 grains weight (g) | |
|---|---|---|---|---|---|---|---|---|
| Treatments | 1999 | 2000 | 1999 | 2000 | 1999 | 2000 | 1999 | 2000 |
| **Planting geometry** | | | | | | | | |
| $P_1$: Sorghum single row 60 cm apart | 141.5a | 144.8a | 4.91 | 4.89c | 66.53b | 65.71b | 32.13 | 32.18a |
| $P_2$: Sorghum double row strip 30/90 cm pattern | 139.8b | 142.8b | 5.00 | 5.04a | 69.04a | 67.44a | 31.92 | 32.00b |
| $P_3$: Sorghum triple rows strip 30/120 cm pattern | 137.6c | 141.1c | 4.97 | 4.92b | 66.22b | 65.00c | 32.03 | 32.14a |
| LSD(0.05) value | 1.347 | 1.528 | NS | 0.0154 | 0.7676 | 0.4971 | NS | 0.1221 |
| **Inter-cropping system** | | | | | | | | |
| $A_0$: Sole sorghum | 144.8a | 149.0a | 5.03a | 5.00a | 68.80a | 67.46a | 31.94b | 32.09 |
| $A_1$: Sorghum + mungbean | 138.0b | 141.0b | 4.96ab | 4.94b | 67.27b | 65.77b | 31.96b | 32.08 |
| $A_2$: Sorghum + Guar | 136.1c | 138.7c | 4.90c | 4.90b | 65.72c | 64.91c | 32.18a | 32.15 |
| LSD (0.05) value | 1.347 | 1.528 | 0.0843 | 0.0154 | 0.7676 | 0.4971 | 0.1807 | NS |
| **Interaction** (PxA) | | | | | | | | |
| $P_1xA_0$ | 148.2a | 150.0 | 5.05 | 4.95c | 67.89 | 67.02 | 32.00 | 32.05bcd |
| $P_1xA_1$ | 139.1cd | 143.9 | 4.90 | 4.90d | 66.46 | 65.60 | 32.15 | 32.18abc |
| $P_1xA_2$ | 137.2def | 140.6 | 4.80 | 4.82e | 65.25 | 64.50 | 32.24 | 32.30a |
| $P_2xA_0$ | 145.2b | 148.1 | 5.05 | 5.10a | 70.39 | 68.39 | 31.85 | 32.05bcd |
| $P_2xA_1$ | 138.1de | 141.1 | 5.00 | 5.02b | 69.35 | 67.32 | 31.80 | 32.06bcd |
| $P_2xA_2$ | 136.2ef | 139.3 | 4.95 | 4.99b | 67.38 | 66.60 | 32.10 | 31.90d |
| $P_3xA_0$ | 140.9c | 149.1 | 4.99 | 4.95c | 68.12 | 66.96 | 31.98 | 32.17abc |
| $P_3xA_1$ | 136.9def | 138.1 | 4.98 | 4.90d | 66.00 | 64.40 | 31.92 | 32.00cd |
| $P_3xA_2$ | 135.1f | 136.2 | 4.95 | 4.90d | 64.54 | 63.64 | 32.20 | 32.25ab |
| LSD(0.05) value | 2.333 | NS | NS | 0.0266 | NS | NS | NS | 0.2115 |

Means followed by different letters differ significantly at P<0.05, NS: Non significant

Table 2: Grain and stalk yield of sorghum as influenced by planting geometry and legumes intercropping system

| | Grain yield ($t\ ha^{-1}$) | | Stalk yield ($t\ ha^{-1}$) | |
|---|---|---|---|---|
| Treatments | 1999 | 2000 | 1999 | 2000 |
| **Planting geometry** | | | | |
| $P_1$: Sorghum single row 60 cm apart | 5.65b | 5.51b | 17.53ab | 16.44ab |
| $P_2$: Sorghum double row strip 30/90 cm | 5.94a | 5.78a | 18.76a | 17.50a |
| $P_3$: Sorghum triple row strip 30/120 cm | 5.53c | 5.38c | 16.87b | 15.57b |
| LSD (0.05) value | 0.1130 | 0.0923 | 1.219 | 1.171 |
| **Inter cropping system** | | | | |
| $A_0$: Sole Sorghum | 5.91a | 5.76a | 18.66a | 17.45a |
| $A_1$: Sorghum+Mungbean | 5.69b | 5.55b | 17.59ab | 16.53ab |
| $A_2$: Sorghum + Guar | 5.52c | 5.38c | 16.91b | 15.54b |
| LSD (0.05) value | 0.1130 | 0.0923 | 1.219 | 1.171 |
| **Interaction (PxA)** | | | | |
| $P_1xA_0$ | 5.85 | 5.69 | 18.78 | 17.65 |
| $P_1xA_1$ | 5.59 | 5.45 | 17.00 | 15.92 |
| $P_1xA_2$ | 5.51 | 5.41 | 16.81 | 15.76 |
| $P_2xA_0$ | 6.12 | 5.93 | 19.68 | 18.29 |
| $P_2xA_1$ | 5.98 | 5.82 | 18.99 | 17.98 |
| $P_2xA_2$ | 5.71 | 5.60 | 17.60 | 16.22 |
| $P_3xA_0$ | 5.76 | 5.65 | 17.52 | 16.40 |
| $P_2xA_1$ | 5.49 | 5.37 | 16.77 | 15.68 |
| P3x$A_2$ | 5.33 | 5.12 | 16.32 | 14.63 |
| LSD (0.05) value | NS | NS | NS | NS |

Means followed by different letters differ significantly at P<0.05, NS: Non significant

It was evident that planting geometry of double row strip pattern (30/90 cm) had significantly increased the grain yield (5.94 t $ha^{-1}$) of sorghum over single row or triple row stripe planting pattern giving grain yield of 5.65 and 5.53 t $ha^{-1}$, respectively in 1999 (Table 2). The same trend was observed in 2000. This could be attributed to the maximum grains weight per panicle of sorghum obtained from double row strip pattern. The findings were supported by Jafar *et al.* (1988). The data further indicated that grain yield of sorghum was significantly decreased by legumes association. In terms of percent decrease it was noted that the grain yield of sorghum was decreased by 3.72 and 6.60% in the association of mungbean and gaur, respectively than sole sorghum grain yield (5.91 $tha^{-1}$) during 1999. Exactly similar trend was observed in 2000. The maximum reduction in grain yield of guar associated sorghum may be the result of long term association and serve competition of guar with sorghum than mungbean. These results are in line with Wahua and Miller (1978) and Malai and Muthasankaranarayanan (1999). By contrast, Waghmare (1980) reported that sorghum grain yield increased when grown in association with different legumes compared to pure stands of sorghum. The interactions between planting geometry and companion legumes was non-significant during both the years of study.

Data on stalk yield (Table 2) of sorghum evinced that planting geometry and associated legume culture significantly affected the stalk yield of sorghum. During 1999, highest stalk yield (18.76 t $ha^{-1}$) was obtained when sorghum was grown in double rows strips compared to the stalk yield in single row (17.53 t $ha^{-1}$) and triple rows (16.87 t $ha^{-1}$) planting pattern but the difference between the treatment means of stalk yield in single row (60 cm apart) pattern and double row strip (30/90 cm) was non-significant. Similar trend was observed in the year 2000. The data further indicated that during 1999, guar associated sorghum significantly reduced the sorghum stalk yield (16.91 t $ha^{-1}$) than pure stands of sorghum (18.66 t $ha^{-1}$). However, stalk yield (17.59 t $ha^{-1}$) of sorghum in mungbean association was statistically non-significant with pure sorghum. This might be attributed to short term association of mungbean as compared to longer association of guar with sorghum. Similar trend was noted in the year 2000. The interaction between planting, geometry and legumes intercropping as regards stalk yield of sorghum was non-significant in both years. It can be concluded that double row strip planting of sorghum with two rows of intercrop was superior planting method than single or triple row strip system in the agro climatic conditions of D.I. Khan.

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