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PERFORMANCE OF FORAGE SORGHUM INTERCROPPED WITH FORAGE LEGUMES UNDER DIFFERENT PLANTING PATTERNS

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Abstract

An experiment was conducted to study the feasibility of forage legume intercropping in forage-sorghum based intercropping system at 30 cm spaced single rows, 30 × 30 cm cross planting with intercrop, 45 cm spaced two-row strips (15/45 cm) and 75 cm spaced four-row strips. The results displayed that the highest forage yield (46.1 t ha^{-1}) was obtained from sorghum grown alone in 45 cm spaced paired rows compared to the minimum of 36.0 t ha^{-1} from sorghum intercropped with clusterbean under the pattern of 75 cm spaced four-row strips. The data exhibited that planting geometry of 45 cm spaced double-row strips produced the highest forage sorghum yield during both the years while in intercropping systems, sorghum alone produced significantly the maximum green forage yield in 30 cm spaced single rows. Legume associations decrease the forage sorghum yield than pure stand of sorghum. However, intercropping of forage sorghum with legumes in the pattern of 45 cm spaced double-row strips appeared to be more productive and profitable than the monocropped sorghum. It would suggest that for the purpose of getting higher yield of palatable, nutritious and high quality sorghum fodder, farmers should adopt the practice of intercropping forage sorghum with forage legumes, preferably cowpea and sesbania, under the planting pattern of 45-cm spaced two-row strips with 15 cm space between the rows in a strip (15/45).

Introduction

The growth patterns when two forage species are intercropped may be different from that in a mono crop. Interspecies competition is mediated through competition for soil, water, available nutrient and solar radiation, although other factors such as temperature fluctuation, pest infestation and agro-management practices are equally important. Crops grown together frequently compete for essential growth factors differently. Interspecies growing conditions, such as in multi-species cropping system, may be more common since two or more plant types with vastly different growing habits often compete for the same space. Direct and indirect effects of mutual shading in an intercropping system on forage quality, morphological development and forage yield have been reported. These differences may have resulted from species variation, length of shading period, change in leaf-to-stem ratio or environmental conditions (Buxton & Fales, 1993). In general, beneficial effects of legumes intercropped in cereals like maize have been observed under low fertility condition (Ibrar *et al.*, 2002). They further stated that legumes that fix atmospheric nitrogen besides meeting their own N requirements, serve as a viable media for soil enrichment. This eventually helps in meeting the N needs of cereals partially.

Although fodder is the cheapest form of feed for animals but the present fodder production in Pakistan does not meet the fodder requirements in terms of both quantity and quality, which consequently results in the under-nourishing of animals. Contrarily, there is a lot of scope and potential for increasing the supply of balanced quality fodder in the country. In Pakistan, the conventional forage crops include Egyptian clover, Persian clover, Indian clover, lucern, oats, sorghum, millet, maize, cowpea, clusterbean, sudan grass and some new fodders like ricebean, mazenta, bajra napier grass hybrid, mott grass, etc. Among the kharif forage crops, sorghum (*Sorghum bicolor* L.) is an important one that possesses a wide range of ecological adaptability because of its xerophytic characteristics. It is widely grown by the subsistence growers for feed and fodder in rainfed as well as in irrigated regions of Pakistan. Its fodder is fed to almost every class of livestock and can be used as hay or silage. However, sorghum fodder is poor in quality due to low protein content and presence of hydrocyanic acid (Hingra *et al.*, 1995). It is, therefore, imperative to improve the quality and quantity of sorghum fodder. Mixed cropping especially with forage legumes can improve both the forage yield and quality, as legumes are a good source of protein (Moreira, 1989).

Thus, there is a need to develop an appropriate sorghum-forage legume intercropping system leading to higher forage production of good quality. The present study was, therefore, designed to explore the production potential of diversified sorghum-forage legume intercropping systems under different planting patterns.

Materials and Methods

The studies were conducted using a randomized complete block design in split-plot arrangement of the treatments with three replications during two consecutive years (2004 and 2005) at the University of Agriculture, Faisalabad, Pakistan. The experiment comprised of the following treatments.

Geometric arrangements (main plots)

P_1 = 30 cm spaced single rows
P_2 = 30 × 30 cm cross planting with intercrop
P_3 = 45 cm spaced two-row strips (15/45 cm)
P_4 = 75 cm spaced four-row strips (15/75 cm)

Intercropping systems (subplots)

I_0 = Sorghum alone (*S. bicolor* L.) var JS-263
I_1 = Sorghum + mungbean (*Vigna radiata* L.) var M-1
I_2 = Sorghum + clusterbean (*Cyamopsis tetragonoloba* L.) var BR-90
I_3 = Sorghum + cowpea (*Vigna unguiculata* L.) var No.1
I_4 = Sorghum + sesbania (*Sesbania sesban* L.) var sesbania Local

The net plot size maintained was 3.6 m × 7.0 m in both years of study. The experiment was planted at the same time on well-prepared seedbed on 18th and 14th of March during 2004 and 2005, respectively. Recommended seed rate, both for forage sorghum and legumes intercrops, was used for sowing. A basal fertilizer dose recommended for forage sorghum @ 50 – 50 kg NP ha^{-1} in the form of urea and single superphosphate (SSP) was applied at the time of sowing while additional 50 kg N ha^{-1} was applied with first irrigation only to the sorghum crop to meet its full nitrogen requirement. Three irrigations each of 7.5 cm were given during the entire growth period. The first irrigation was given 21 days after germination, second 35 days after germination and third at full vegetative stage. All other agronomic practices were kept normal and uniform. Forage sorghum and legume intercrops were harvested at the same time manually at ground level just before the initiation of flowering (65DAS). The data on different agronomic traits, green fodder yield and protein content were collected and were subjected to analysis of variance according to Steel & Torrie (1984) to sort out significant differences among treatments. Differences among treatment means were compared using LSD at 5% probability level.

Results

1. Plant population at harvest: Table 1 displayed that planting pattern of 30 × 30 cm cross planting with intercrop, 45 cm spaced two-row strips and 75 cm spaced four-row strips were statistically at par with each other but significantly higher than 30 cm spaced single rows during 2004, while in 2005, the effect of all planting patterns on plant population was non-significant. However, in respect of intercropping systems, forage sorghum alone produced the highest number of plants of 58.0 and 70.2 m^{-2} during 2004 and 2005, respectively. The interaction between planting geometry and legume intercropping system was significant during both the years. During 2004, the maximum plant population was recorded in P_1I_0, P_1I_2, P_2I_0, P_2I_1, P_2I_2, P_2I_4, P_3I_0, P_3I_2, P_3I_3 and P_4I_0 compared to minimum of 47.6 and 48.0 plants m^{-2} in P_1I_4 and P_1I_3, respectively. While during 2005, the highest plants m^{-2} were recorded in P_4I_0, P_2I_0, P_2I_3, P_3I_0 and P_1I_0 against the minimum of 60.2 plants m^{-2} in P_2I_1.

2. Plant height: It was observed that during 2004, plant height of sorghum was significantly increased in planting patterns of 45 cm spaced double-row strips and 75 cm spaced four-row strips (Table 1). While during 2005, significantly the maximum plant height was indicated only in 45 cm spaced double-row strips. The interaction of planting geometry and intercropping system was found non-significant during 2004 while during 2005 it was significant. Sole forage sorghum grown in all the planting patterns produced significantly the tallest plants (142.8, 142.0, 141.3 and 141.0 cm in the four planting patterns, respectively) than the lowest (118.9 cm) in P_2I_1 combination.

3. Number of leaves plant^{-1}: The number of leaves plant^{-1} presented in the Table 1, exhibited non-significant differences during both the years in case of planting patterns while in intercropping systems, significantly more number of leaves (7.49) were noted in sorghum + clusterbean and 7.15 in sorghum alone during 2004. However, in 2005, significantly higher number of leaves (8.30 per plant) was produced by sorghum alone compared to the rest of the intercropping systems. Among the interactive treatments, non-significant differences were observed during 2004, while significantly more number of leaves plant^{-1} (8.77) in P_3I_0 (sorghum alone in 45 cm spaced paired rows strips) was produced in the second year.

4. Leaf area plant^{-1}: The interactive as well as individual effect of planting pattern and intercropping systems for this character were significant during both the years. During 2004, the maximum leaf area plant^{-1} (795.6 cm^2) was recorded for the crop grown in association with cowpea in the pattern of 45 cm spaced paired rows (P_3I_3) which was statistically at par with that grown in the pattern of 30 × 30 cm cross planted with cowpea (P_2I_3) and was closely followed by P_4I_3. Contrarily, the minimum leaf area plant^{-1} (740.5 cm^2) was exhibited by the crop grown in association with mungbean in 30 cm apart single rows. During 2005, the maximum (821.2 cm^2) leaf area plant^{-1} was shown by the crop grown in 45 cm spaced paired rows and intercropped with cowpea (P_3I_3).

5. Green forage yield of sorghum: The effect of planting geometry on the green forage yield of sorghum was significant during 2004 while it was non-significant during 2005. However, the interaction of intercrops and planting patterns was significant during both the years. During 2004, the crop planted in the pattern of 45 cm spaced paired rows with no intercropping (P_3I_0) produced significantly the highest green fodder yield (42.5 t ha^{-1}) which was statistically at par with P_4I_0 giving an average forage yield of 40.7 t ha^{-1}. During 2005, although sorghum grown alone produced statistically similar forage yield under all the planting patterns but it was significantly higher than the intercropped sorghum except that intercropped with clusterbean (P_3I_2) or cowpea (P_3I_3).

6. Mixed green forage yield: The main effects of planting patterns and intercropping systems as well as their interaction on mixed green forage yield ha^{-1} were found significant in both years (Table 2). During 2004, highest mixed green forage yield (98.8 t ha^{-1}) was recorded for the crop grown in the pattern of 45 cm apart paired rows and intercropped with cowpea (P_3I_3) followed by P_4I_3 and P_2I_3 which were statistically at par with each other and produced mixed forage yield of 90.6 and 87.7 t ha^{-1}, respectively. The same trend was exhibited during 2005 with the maximum mixed forage yield of 107.7 t ha^{-1} grown in 45 cm spaced paired rows and intercropped with cowpea (P_3I_3), against the minimum of 44.0 t ha^{-1} for the crop planted in 30 cm spaced single-rows with no intercropping (P_1I_0) which was at par with the P_2I_0 (45.3 t ha^{-1}) and P_3I_0 (46.1 t ha^{-1}).

7. Crude Protein (CP) of sorghum (%): Crude protein of sorghum in respect of planting patterns, intercropping systems and their interactive effects were observed to be non-significant during each year (Table 2). The CP of sorghum on an average ranged from 9.29 to 9.92% during 2004 and from 9.35 to 9.94% in 2005.

8. Crude Protein of mixed forage (%): The data showed that individual effects of intercropping systems on CP percentage of mixed forage were significant while the main and interactive effects of planting patterns were non-significant in both years. During 2004, the maximum CP (14.89%) was recorded for sorghum + sesbania mixed forage which was at par with that recorded for sorghum + cowpea forage (14.73 %) while the minimum (9.69%) was found in sorghum alone. Almost similar trend was exhibited in 2005 with the highest CP percentage (16.74 %) in mixed sorghum + sesbania forage against the minimum (9.74%) in sorghum forage grown alone.

Discussion

The results revealed that the plant population m^{-2} of sorghum was generally higher in the treatments where it was grown alone compared to all other interactive treatments. The variation in the plant population of sorghum in treatments where legumes were intercropped was probably due to more competition for light, water, nutrients, shading effect of intercrop and alleleopathic effect.

It was observed that overall plant height showed a comparative increase during 2005. This was due to more favourable environmental conditions prevailing in this year. The maximum plant height in case of sole crop of forage sorghum was attributed to penetration of light, circulation of air and comparatively more nutritional area available to sole crop under competition free environment. While the decrease in plant height was ascribed to the fast growth of intercrops at an early growth stage and competition offered by intercrop for different environmental resources which suppressed the growth of companion sorghum crop. These results were consistent with Rashid & Himayatullah (2003) who noted the reduction in plant height of sorghum due to intercropping. In contrast, Rana *et al*., (2001) and Ranbir *et al*., (2001) reported that plant height in a maize + legumes intercropping system was significantly greater than pure maize.

It was observed that in most of the cases intercropped sorghum because of intercrop-competition for essential growth factors produced less number of leaves plant^{-1} than mono cropped sorghum. However, non-significant differences in the number of green leaves plant^{-1} of sorghum grown in association with clusterbean, soybean and mothbean intercropping system was reported by Keerio & Singh (1985), while Chundawat (1997) reported the higher number of leaves plant^{-1} of sorghum when grown in mixture with clusterbean.

Maximum leaf area per plant was observed where sorghum was grown in the pattern of 45 cm spaced strips and intercropped with sesbania. Reduction in leaf area per plant of forage sorghum might be because of less expansion due to competition between the crops for essential growth factors. Increase in leaf area plant^{-1} of sorghum was probably due to efficient utilization of soil and environmental resources during second year. However, these results are in contrast to those of Lee (1988) who reported that leaf area of maize was not affected to a significant level due to intercropping with cowpea.

Differences in green forage yield of sorghum between the years may be attributed to differential day-to-day variation in daily temperature across the year, greater intensity with different patterns of rainfall and variation in relative humidity during 2005, which all resulted a better growth and development of sorghum in 2005. The overall results indicated that green forage yield of sorghum grown in association with legumes was lower than the sole crop of sorghum which was probably the result of plant competition for the nutrients and mutual shading effect due to close spaces among the plants. Another reason for higher forage sorghum yield in the treatments where it was grown alone might be the higher planting density, plant height, number of leaves per plant, leaf area per plant and suppressive/alleleopathic effect of legume intercrops. Singh & Jadhav (2003) have also reported suppressive effect of legume intercrops on the forage yield of sorghum. Contrarily, Krishna *et al*., (1998) and Ayisi *et al*., (2001) have reported greater green fodder yield of sorghum when grown with cowpea.

The increase in the mixed forage green yield due to the presence of associated legume crops which have more vegetative growth/fresh biomass compared to the sorghum. Moreover, increase in mixed green forage yield during 2005 was probably due to more conducive soil and environmental conditions prevailing in that season. These results corroborate the findings of Chittapur *et al*., (1994), Abdullah & Chawdhry (1996) and Tripathy (1997) who reported higher mixed forage yield of maize + legumes than monocropped maize. Similarly, Thippeswamy & Alagundagi (2001) stated that sweet sorghum + field beans in 3:2 rows ratio produced significantly higher mixed green fodder (59.5 t ha^{-1}) than sorghum alone.

The non-significant difference of CP percentage of sorghum in different planting patterns and in intercropping systems was probably due to the genetic constitution of sorghum plant which was not altered by the planting patterns and legume intercropping systems. In contrast to the above findings, Khot *et al*., (1992) reported that CP in maize was the highest when grown in combination with *Crotalaria juncea*. Similarly, Tripathy *et al*., (1997) and Krishna *et al*., (1998) have also reported promotive effect of legume intercrops on protein concentration.

Crude protein percentage of mixed forage exhibited that sorghum grown with sesbania and cowpea has maximum CP while with other legume intercrops mixed forage has higher protein than the sole sorghum. It was further revealed that planting patterns and interaction could not increase or decrease the CP percentage of component crops. However, the increase in CP percentage of mixed forage was due to associated legumes, which have almost 3 to 4 times more CP percentage than sorghum forage. These results are in conformity with Thippeswamy & Alagundagi (2001) who reported higher mixed CP yield when sweet sorghum was grown with field beans. Similarly, Mpairwe *et al*., (2002) also stated that higher fodder CP yield was obtained when cereal was intercropped with forage legumes.

Conclusion

The studies conducted revealed that forage yield of sorghum was reduced to a significant level by legumes association but the mixed forage yield (sorghum + forage legumes) was much higher than the monocropped sorghum. However, among the intercropping systems, sorghum+cowpea and sorghum+sesbania proved to be superior to all other intercropping systems under study in all respects. Furthermore, for intercropping purpose, planting of sorghum in the pattern of 45 cm spaced paired rows appeared to be more appropriate than rest of the planting patterns under study. Thus, it was suggested that for the purpose of getting higher yield of palatable, nutritious and high quality sorghum fodder, farmers should adopt the practice of intercropping forage sorghum with forage legumes preferably cowpea and sesbania under the planting pattern of 45-cm spaced two-row strips with 15 cm space between the rows in a strip (15/45).

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