PERFORMANCE OF FODDER SORGHUM WITH DIFFERENT FORAGE LEGUMES COMBINATION UNDER TEMPERATE CONDITIONS OF KASHMIR

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SUMMARY

Taking into consideration the huge gap between the demand and supply of green nutritious fodder and quality dry matter, the present investigation was undertaken at Agronomy farm, FoA, Wadura of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir during Kharif 2018, to recognize suitable combination of legume with fodder sorghum for higher yield and quality. The experiment comprising of 10 treatment combinations laid out in a randomized complete block design with three replications. Sole sorghum ranked top in forage equivalent yield (531.87 q/ha) followed by sorghum + soybean (2:1) (452.14 q/ha). Sorghum + soybean (2:1) recorded higher crude protein yield (17.22 q/ha) followed by sorghum (70%) + soybean (30%) (16.79 q/ha). However, sorghum + soybean (2:1) was found superior in quality than rest of cropping systems. The highest benefit: cost ratio of Rs. 2.43 and net profit of Rs. 2, 75,423.5 ha-1 was recorded with sole sorghum followed by sorghum + soybean (2:1).

Key words : Cropping system, fodder legumes, fodder sorghum, fodder yield, quality

India has the largest cattle population in the world but the land available for fodder cultivation is limited (4% of the cropped area). Forages are deemed to be the most nutritious and economical feed for dairy animals (Iqbal *et al*., 2015). Forages have always been an extremely important source of nutrients in livestock rations. Additionally, they provide fiber in the ration which enhances proper digestion in forage consuming animals. Among forages, cereal forages occupy central position due to higher biomass production per unit area and ultimately farmers are able to extract more economic returns with increased milk and meat production (Addo *et al.,* 2011). In Jammu and Kashmir, livestock population is 9.2 million (Ishtyaq, 2017) and have only 0.6 lakh hectare under cultivated fodder crops and faces a net deficit of 19% in fodder (Raja, 2013).

Among cereal forages, sorghum (*Sorghum bicolor* L.) holds great potential to yield large quantities of green forage for dairy entrepreneurs as well as small farmers and that too with considerably less irrigation and fertilization requirements than forage maize (Iqbal and Bethune, 2015). Intercropping of forage sorghum with legumes like cowpea, soybean etc can be an option to increase green forage yield per unit land area with better agro-qualitative attributes of forage (Surve *et al*., 2011). Cereal-legume intercropping has been accepted as an advantageous crop production per unit area per unit time. Legumes (soybean, cowpea) has the potential to yield a reasonably high dry matter yield and that too in a short span of time with higher digestibility (Addo *et al*., 2011). Although cereal forages has a high energy content, quick growing, give a high tonnage of fodder and low crude protein, legumes have long been recognized as a good source of crude protein. Instead of growing these crops separately, it is possible to grow them together in intercrops to improve soil fertility by fixing atmospheric nitrogen. Keeping these aspects in view, a field experiment was conducted to study performance of fodder sorghum under different legume combination.

MATERIALS AND METHODS

The field experiment was conducted at Agronomy Farm of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, FoA, Wadura, Sopore during *Kharif* 2018 ($34^0 17'$ N, $74^0 33'$ E, 1524 m above mean sea level) under rainfed conditions. The experimental site falls in temperate zone of north western Himalaya characterized by hot summers and very cold winters with mean annual rainfall of 339.5 mm. The mean maximum and minimum temperature was 28.6^0 and 14.4^0 C respectively. The soil was sandy loam, having pH 7.06 , organic carbon 1.49%, available N,P and K of 175.21, 11.02 and 220 kg/ha respectively. The experiment was laid out in a randomized block design with 10 treatments of sorghum based cropping system and replicated thrice and having a net plot size of 5.1 m × 4.0 m. The experimental treatments comprised of sole sorghum in 30 cm apart rows, sole cowpea in 30 cm apart rows, sole soybean in 30 cm apart rows, sorghum intercropped with cowpea in 1:1 and 2:1 ratio, sorghum intercropped with soybean in 1:1 and 2:1 ratio, sorghum (70%) mixed cropping with cowpea and soybean (30%) and sorghum (70%) mixed with cowpea (15%) and soybean (15%). Varieties for fodder sorghum, fodder cowpea and fodder soybean were 'MP Chari', 'Shalimar Cowpea-1' and 'Shalimar Soybean-1' respectively. All other agronomic practices except those under studies were kept normal and uniform for all the treatments. Forage sorghum and legumes were harvested at 50% flowering and at pod formation stage respectively. For dry matter accumulation the samples were dried in shade and then oven dried at 60° C for 72 hours. Samples were weighed to a constant weight and dry matter was expressed as q/ha. The leaf area index was calculated by dividing the leaf area /plant by the ground area provided to each plant. The yield parameters like green fodder yield and hay fodder yield were taken from each net plot and was weighed in kilogram and then converted into q/ha. Relative yield total and relative crowding coefficient were estimated to calculate the relative dominance of one species over other in intercropping. For economic analysis (cost of cultivation, gross returns, net returns and benefit cost ratio) cost of inputs and price of outputs were calculated at prevailing market price. The treatment differences were tested by F test of significance on the basis of hypothesis Cochran and Cox (1963).

RESULTS AND DISCUSSION

Plant height of sorghum

The data given in Table 1 showed that sorghum plant height was significantly affected by the planting techniques. The sorghum sown alone with 30 cm spacing produced taller plants and was at par with rest of the treatments. In turn, sorghum + soybean (mixed) was found superior in plant height than sorghum + soybean (2:1) and sorghum + soybean (1:1), sorghum + cowpea (2:1) and sorghum + cowpea (1:1). The minimum plant height of sorghum (278.66 cm) was observed when sorghum was intercropped with cowpea in 1:1 row ratio but was statistically similar with sorghum + soybean (1:1). Moreover, the row ratio of 2:1 recorded higher plant height of sorghum than 1:1 ratio. The maximum plant height in case of sole crop of forage sorghum may be due to closer spacing in sole sorghum, increased competition for resources especially solar radiation. Similarly, reduction in plant height of sorghum in intercropping and mixed cropping may be due to less competition offered by intercrops for solar radiation which results in dwarf plants. The results are quite in line with those of Ahmad *et al*., (2007).

Leaf area index

Leaf area index under sole sorghum was found significantly superior to sole cowpea, sole soybean, and intercropping system. However, leaf area index of sole

TABLE 1
Growth characteristics of sorghum and legumes influenced by different cropping systems

Treatments	Plant height of sorghum (cm)	Leaf area index	Dry matter accumulation (q/ha)	Leaf stem ratio of sorghum
Sole sorghum (30 cm)	291.13	5.61	186.15	0.75
Sole cowpea (30 cm)	-	3.40	59.48	-
Sole soybean (30 cm)	-	3.68	87.62	-
Sorghum + cowpea (1:1)	278.66	4.22	121.40	0.55
Sorghum + cowpea (2:1)	280.23	4.56	141.08	0.63
Sorghum + soybean (1:1)	279.43	4.34	123.89	0.58
Sorghum + soybean (2:1)	281.00	4.90	162.85	0.71
Sorghum (70%) + cowpea (30%) mixed cropping	285.40	4.49	136.45	0.60
Sorghum (70%) + soybean (30%) mixed cropping	288.40	4.72	149.38	0.68
Sorghum (70%) + cowpea (15%) + soybean (15%) mixed cropping	282.03	4.59	146.55	0.65
S. Em±	2.48	0.12	3.65	0.01
C. D. (P=0.05)	7.95	0.39	11.34	0.03

sorghum was marginally higher than sorghum + soybean (2:1), sorghum (70%) + soybean (30%) and sorghum (70%) + cowpea (15%) + soybean (15%). Sorghum + soybean (2:1) recorded significantly higher leaf area index than sorghum + cowpea (2:1), sorghum + soybean (1:1), sorghum + cowpea (1:1), sole soybean, sole cowpea. However, the difference in leaf area index recorded under sorghum + soybean (2:1) was at par to sorghum (70%) + soybean (30%). Sole cowpea and sole soybean recorded lowest leaf area index than other cropping systems. The higher leaf area index of sole sorghum may be attributed to different morphological characteristics and leaf architecture of sorghum compared to cowpea and soybean. It may be due to less number of sorghum plants per unit area under intercropping system compared to sole sorghum and shading effect imposed by sorghum crop, which do not allow entire solar radiation to reach cowpea and soybean for normal photosynthetic activity in intercropping system. These results are similar to Zandvakili *et al.,* (2012). Sorghum + soybean (2:1) recorded higher leaf area index compared to sole cowpea, sole soybean and intercropping system are due to higher number of plants of sorghum per unit area compared to 1:1 row ratio, efficient utilization of resources compared to mixed cropping and quick growth of soybean (taller plants) than cowpea. Similar finding were also reported by Barik *et al*. (1998).

Dry matter accumulation

It was observed that total dry matter accumulation was significantly higher under the treatment sole sorghum. The next treatment in the order of significance was sorghum + soybean sown in (2:1) row proportion, followed by sorghum (70%) + soybean (30%), sorghum (70%) + cowpea (15%) + soybean (15%). In turn, sorghum + soybean (2:1) recorded significantly higher dry matter accumulation than sorghum + cowpea (2:1), sorghum + soybean (1:1), sorghum + cowpea (1:1), sole soybean, sole cowpea. However, the difference in dry matter accumulation recorded under sorghum + soybean (2:1) was at par to sorghum (70%) + soybean (30%).

The perusal of results also revealed that among all the treatments, the sole legumes produced significantly lower dry matter than the treatments involving their intercropping or mixed cropping with sorghum. The higher dry matter accumulation of sole sorghum was attributed to high LAI resulted in better interception and utilization of radiant energy leading towards higher photosynthesis and finally more accumulation of dry matter of sorghum plants. The results are in close conformity with the findings of several researchers (Patidar and Mali, 2004, Dixit *et al.,* 2005).

Sorghum + soybean (2:1) recorded higher dry matter accumulation compared to sole cowpea, sole soybean and intercropping system might be also due to high LAI with sorghum + soybean (2:1) might have improved photosynthetic activity and production of more photosynthesis resulting in high dry matter production compared to sole cowpea, sole soybean and intercropping system. These results are similar to findings of Singh, 2007.

Leaf stem ratio of sorghum

It was observed that the higher leaf stem ratio was recorded under sole sorghum and was followed by sorghum + soybean (2:1) row proportion and the lowest was recorded in sorghum + cowpea (1:1). Leaf stem ratio of sorghum decreased with the advancement

TABLE 2
Green fodder yield, hay fodder yield and forage equivalent yield of sorghum and legumes in different combinations

Treatments	Green fodder yield (q/ha)	Hay fodder yield (q/ha)	Forage equivalent yield (q/ha)
Sole sorghum (30 cm)	531.87	271.25	531.87
Sole cowpea (30 cm)	174.96	73.48	218.70
Sole soybean (30 cm)	243.39	111.95	304.23
Sorghum + cowpea (1:1)	371.60	178.36	384.72
Sorghum + cowpea (2:1)	392.75	192.44	395.37
Sorghum + soybean (1:1)	375.51	187.06	387.88
Sorghum + soybean (2:1)	439.37	215.28	452.14
Sorghum (70%) + cowpea (30%) mixed cropping	386.43	192.21	389.05
Sorghum (70%) + soybean (30%) mixed cropping	406.82	207.46	412.90
Sorghum (70%) + cowpea (15%) + soybean (15%) mixed cropping	399.76	203.85	405.71
S. Em±	9.93	7.62	11.74
C. D. (P=0.05)	31.76	22.51	36.42

of growth in all treatments because at early stage of growth there was more leafy growth than stem. These results are in close proximity with those of Desai (1980) and Jena *et al.* (1995). Leaf stem ratio of sole sorghum was higher compared to intercropping system. This may be attributed to high LAI compared to intercropping system. Sorghum + soybean (2:1) recorded higher leaf stem ratio of sorghum as compared to other intercropping system. This might be due to high LAI with sorghum + soybean (2:1) compared to other intercropping system.

Green fodder yield

A cursory look of the data (Table 2) revealed that green fodder yield value varied from 174.9 q/ha (sole cowpea) to 531.87 q/ha (sole sorghum). All sorghum based cropping systems produced significantly higher green fodder yield over sole legumes. Sorghum sown alone with 30 cm spacing produced significantly higher green fodder yield than all the treatments and was followed by sorghum + soybean (2:1). The minimum green fodder yield was obtained in sole cowpea with 30 cm spacing. The higher yield obtained in case of sole sorghum can be attributed to taller plants, higher plant population and efficient utilization of resources in sole sorghum compared to sorghum in intercropped system. Sole sorghum produced higher total green fodder yield than sole cowpea, sole soybean and intercropping system. Taller plants, higher leaf area index and high dry matter accumulation (Table 1) in sole sorghum were the reasons for higher total green fodder yield compared to sole cowpea, sole soybean and intercropping system. Same were the reasons for higher green fodder yield in sorghum + soybean (2:1) compared to sole cowpea, sole soybean and intercropping system. These results confirm the findings of Ntare and Williams, 1992, Ajeigbe *et al*., 2006, and Biabani *et al.,* 2008.

Hay fodder yield

Data presented in Table 2 revealed that hay fodder yield varied from 73.4 q/ha to 271.25 q/ha under different cropping systems. The sole sorghum registered higher hay fodder yield (271.25 q/ha) and was followed by sorghum + soybean (2:1) (215.28 q/ha) row proportion and was found significantly superior over remaining treatments. The lower hay fodder yield was obtained in sole cowpea (73.48 q/ha) and sole soybean (111.95 q/ha). Higher hay fodder yield in sole sorghum compared to sorghum in intercropped system might be due to taller plants, higher plant population and efficient utilization of resources in sole sorghum compared to sorghum in intercropped system. Sole sorghum produced higher total hay fodder yield than sole cowpea, sole soybean and intercropping system. Taller plants, higher leaf area index and high dry matter accumulation (Table 1) in sole sorghum were the reasons for higher hay fodder yield compared to sole cowpea, sole soybean and intercropping system. Same were the reasons for higher hay fodder yield in sorghum + soybean (2:1) compared to sole cowpea, sole soybean and intercropping system. These results confirm the findings of Ajeigbe *et al.,* 2006, Ntare and Williams, 1992 and Biabani *et al*., 2008.

Forage equivalent yield

The data in Table 4 revealed that the forage equivalent yield was significantly higher in sole

TABLE 3
Crude protein content, crude protein yield and crude fiber content of sorghum and legumes influenced under different cropping systems

Treatments	Crude protein content (%)	Crude protein yield (q/ha)	Crude fiber content (%)
Sole sorghum	8.70	16.19	36.96
Sole cowpea	13.14	7.81	23.36
Sole soybean	13.15	11.52	25.25
Sorghum + cowpea (1:1)	11.17	13.56	30.16
Sorghum + cowpea (2:1)	10.21	14.40	32.42
Sorghum + soybean (1:1)	11.47	14.21	31.10
Sorghum + soybean (2:1)	10.58	17.22	33.05
Sorghum + cowpea (mixed)	10.42	14.21	31.16
Sorghum + soybean (mixed)	11.24	16.79	32.10
Sorghum + cowpea + soybean (mixed)	11.01	16.13	28.52
S. Em±	0.38	0.57	1.11
C. D. (P=0.05)	1.27	1.83	3.26

sorghum with 531.87 q/ha and was followed by sorghum + soybean (2:1) with 452.14 q/ha than remaining treatments while the lowest forage equivalent yield was recorded in sole cowpea with 218.70 q/ha. The highest forage equivalent yield in sole sorghum may be attributed to higher green fodder yield (Table 2) compared to sole legumes and intercropping system. The next promising treatment in forage equivalent yield was sorghum + soybean (2:1) might be due to high green fodder yield produced with sorghum + soybean (2:1) compared to sole legumes and intercropping system.

Crude protein content

Crude protein content of sole soybean and sole cowpea was higher as compared to sole sorghum and intercropping system (Table 4.7). This was attributed to higher nitrogen content in legumes as compared to cereals and also due to young and succulent plants. These results are in accordance with those of Webster 1963 and Malik *et al*., 1992. Sorghum + soybean (2:1) recorded higher crude protein content as compared to sole sorghum and intercropping system might be due to higher fixation of atmospheric nitrogen by soybean as compared to cowpea resulting in higher uptake of nitrogen which led to higher nitrogen content in forage.

Crude protein yield

Sorghum + soybean (2:1) recorded higher crude protein yield as compared to sole sorghum, sole cowpea, sole soybean and intercropping system might be due to additive effect of increased dry fodder yield, protein content of sorghum and production of protein rich fodder under sorghum + soybean (2:1). This is close conformity with the findings of Tripathi *et al*., 1999, Bhilare *et al*., 2002.

Crude fiber content

Sole sorghum recorded higher crude fiber content as compared to sole cowpea, sole soybean and intercropping system. Intercropping of sorghum with legumes significantly decreased the crude fiber content of sorghum whereas, sole sorghum gave the highest value of crude fiber content. This might be due to increase in nitrogen supply to the sorghum by legumes resulting in higher leaf stem ratio and succulent forage production and ultimately reduced crude fiber content. These findings are in accordance to those obtained by Raju *et al*., 1997.

Relative economics

Highest net returns, gross returns and B:C ratio with sole sorghum may be attributed to high green fodder production (531.87q/ha) under sole sorghum. The next promising treatment related to net returns, gross returns, and B : C ratio was sorghum + soybean (2:1) are due to high green fodder production and high price of soybean. Similar findings were also reported by Umrani *et al.* (1984).

CONCLUSION

Based on the results of the present

TABLE 4
Relative Economics of sorghum and legumes under different combination

Treatments	Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B : C ratio
Sole sorghum	30950.5	106374.0	75423.5	2.43
Sole cowpea	32070.5	43740.0	11669.5	0.36
Sole soybean	33170.5	60847.5	27677.0	0.83
Sorghum + cowpea (1:1)	31510.5	76944.0	45433.5	1.44
Sorghum + cowpea (2:1)	31354.1	79074.5	47720.4	1.52
Sorghum + soybean (1:1)	32060.5	77576.5	45516.0	1.41
Sorghum + soybean (2:1)	31728.1	90429.5	58701.4	1.85
Sorghum + cowpea (mixed)	31286.5	77810.5	46524.0	1.48
Sorghum + soybean (mixed)	31616.5	82580.5	50964.0	1.61
Sorghum + cowpea + soybean (mixed)	31451.5	81143.0	49691.5	1.57
Input cost		Out put cost		
Sorghum seed Rs 57/kg		Green fodder yield of Sorghum Rs 2.0/kg		
Cowpea seed Rs 68/kg		Green fodder yield of cowpea Rs 2.5/kg		
Soybean seed Rs 75/kg		Green fodder yield of soybean Rs 2.5/kg		

investigation the sole sorghum recorded significantly higher green fodder yield and hay fodder yield as compared to other cropping system. Sole sorghum was also found economically viable. However, sorghum + soybean (2:1) was superior in crude protein yield compared to other cropping systems. Thus it may be concluded that for higher fodder production and benefit sole sorghum cropping system should be adopted. However, for higher quality fodder production, sorghum + soybean (2:1) should be adopted.

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