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Effect on yield and soil fertility status of summer sorghum (*Sorghum bicolor* L.) under sole crop and different inter cropping systems

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Abstract

A field experiment was carried out on clay soil during summer season of 2018 at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari to evaluate the Performance of summer sorghum (*Sorghum bicolor* L.) under sole crop and different intercropping systems in south Gujarat condition. Total nine treatments v*iz*., T_1 sole sorghum, T_2 sole sorghum (Paired rows at 30-60 cm), T_3 sole sorghum (Paired rows at 30-30-75 cm), T_4 sole greengram, T_5 sole blackgram, T_6 sorghum + greengram (Paired 2:1), T_7 sorghum + greengram (Paired 3:2), T_8 sorghum + blackgram (Paired 2:1) and T_9 sorghum + blackgram (Paired 3:2) were allocated in randomized block design with four replications. The soil of the experimental area was low in available nitrogen (185.26 kg ha^{-1}), high in available phosphorus (31.88 kg ha^{-1}) and potassium (390.41 kg ha^{-1}), slightly alkaline in reaction with normal electrical conductivity. Results revealed that, sole sorghum (T_1) recorded significant higher grain yield although it was remained at par with T_2, T_3 and T_6. Among all the treatments, treatment T_6 sorghum + greengram (Paired 2:1) recorded significantly higher SEY, which was at par with treatment T_7 sorghum + greengram (Paired 3:2). Sorghum + greengram paired at 2:1 (T_6) recorded maximum LER (1.31) followed by sorghum and greengram paired at 3:2 (T_7), sorghum + blackgram paired at 2:1 (T_8) and sorghum + blackgram paired at 3:2 (T_9) with LER 1.28, 1.24 and 1.23, respectively.

Keywords: Sorghum, Greengram, Blackgram, intercropping, SEY, LER and net returns

Introduction

Sorghum (*Sorghum bicolor* L.) is principal cereal that forms an important staple diet throughout the semiarid Asian and African regions. It belongs to the family Phocaea. It is the fifth most important cereal after wheat, maize, rice and barley in the world and third most important crop in India after rice and wheat in total area and production. Sorghum is widely cultivated crop covering wider areas in Africa, America, Asia and many other parts of the world. It has greatest capacity to withstand drought. Sorghum will perform better than maize in marginal land under moisture stress or excessive moisture conditions. Pulses play an important role in Indian agriculture as it improves physical, chemical and biological properties of soil and due to short duration and photo insensitive varieties fitted well in many intensive cropping systems across the nation. Pulses are rich source of vegetable protein for vegetarians and also serve as excellent forage for large cattle population in the country.

Intercropping has been recognized as a potentially beneficial system of crop production which can provide sustained yield advantages compared to sole cropping. To take the advantage of different rooting depths, duration, nutrient and water requirement of the crops and better utilization of all the resources, the concept of intercropping has been introduced in primitive agriculture. The main objective of intercropping is to increase productivity per unit area by crop intensification. The cereal-legume intercropping is mainly practiced for subsistence agriculture i.e. to get full yield of cereal crops for food and legumes are included in intercropping system to get protein and some additional returns. Studies at ICRISAT indicated that cereal-legume intercropping is superior over cereal-cereal intercropping system (Rao and Willey, 1980) [13].

Material and methods

A field experiment was conducted during the summer season 2018 at College Farm, NM College of Agriculture, Navsari Agricultural University, Navsari (Gujarat) to study Performance of summer sorghum (*Sorghum bicolor* L.) under sole crop and different intercropping systems in south Gujarat condition in Randomized Block Design with 9 treatments (Table 1), replicated four times. The soil of the experimental field was clayey in texture, low in available nitrogen (185.26 kg ha^{-1}), high in available phosphorus (31.88 kg ha^{-1}) and available potassium (390.41 kg ha^{-1}), slightly alkaline in reaction with normal electrical conductivity. There was no rainfall during crop growth period as well as no severe attack of insect and pest on the base of visual observation. Recommended cultivars like 'GNJ-1' of sorghum, 'GM-6' of greengram and 'GU-1' of blackgram were used in the experiment. The final plant to-plant distance in main crop and intercrop was maintained at 10 cm. The recommended fertilizer schedule (80-40-00 and 20-40-00 kg of N-P_2O_5-K_2O ha^{-1} for main crop and intercrop respectively) was followed both for sole and intercropping systems. The other agronomic practices were done as per recommended package of practices for both main and intercrops. Observations on desired parameters of the component crops were noted using standard procedures and the obtained data were analyzed statistically.

Table 1: Effect of different intercropping systems on yield attributes of sorghum

	Treatment	Length of ear head (cm)	Girth of ear head (cm)	Grain weight per ear head (g)	Number of grains per ear head	Test weight (g)
T_1	Sole sorghum	21.63	14.33	45.28	2140	23.34
T_2	Sole sorghum (Paired rows at 30-60 cm)	22.23	13.24	42.13	1955	22.69
T_3	Sole sorghum (Paired rows at 30-30-75 cm)	22.35	12.93	41.21	1903	22.40
T_4	Sole greengram	-	-	-	-	-
T_5	Sole blackgram	-	-	-	-	-
T_6	Sorghum + greengram (Paired 2:1)	22.50	12.56	40.82	1868	22.27
T_7	Sorghum + greengram (Paired 3:2)	23.28	12.55	38.03	1811	21.33
T_8	Sorghum + blackgram (Paired 2:1)	22.45	12.38	38.61	1844	21.46
T_9	Sorghum + blackgram (Paired 3:2)	22.93	11.90	34.06	1805	20.93
SEm±		0.81	0.48	2.10	67.34	0.52
CD at 5 %		NS	1.41	6.25	200.09	1.54
CV %		7.23	7.41	10.52	7.08	4.70

Results and discussion

Effect of intercropping on yield attributes and yield of sorghum

Various sole and intercropping treatments showed significant effect on almost all yield attributes of sorghum except length of ear head. Sole sorghum (T_1) recorded significantly higher yield attributes *viz*., ear head girth, number of grains per ear head, grain weight per ear head and test weight but it was at par with treatment T_2 and T_3 with respect to ear head girth, treatment T_2, T_3 and T_6 with respect to grain weight per ear head and test weight, treatment T_2 with respect to number of grains per panicle. Length of the ear head did not reach to the level of significant and remained in the order of treatments $T_7 > T_9 > T_6 > T_8 > T_3 > T_2 > T_1$. Intercropping considerably reduced the ear head girth, number of grains per ear head, grain weight per ear head and test weight compared sole treatments. Results of intercropping revealed that yield attributing characters reduced significantly due to intense competition effect of intercropping treatments. These results are more or less similar to Lingaraju *et al.* (2008) [6] in maize with pegionpea in maize with pulses.

Sorghum grain yield was significantly affected by different sole and intercropping systems. However, fodder yield of sorghum was not influenced significantly but it remained in same trend. Among all the treatments sole sorghum (T_1) recorded significant higher grain yield although it was remained at par with T_2 sole sorghum (Paired rows at 30-60 cm), treatment T_3 sole sorghum (Paired rows at 30-30-75 cm) and treatment T_6 sorghum + greengram (Paired 2:1), increase in yield by 9%, 16%, 15% and 18% over intercropped treatments T_6, T_7, T_8 and T_9, respectively. Intercropping reduced the grain as well as fodder yield of sorghum. The higher grain yield of sorghum in sole treatments might be due to increase in overall plant growth as reflected from higher values of different growth and yield attributes due to competition free environment and effective utilization all the resources. Intercropping reduced the grain as well as fodder yield of sorghum. However, fodder yield of sorghum was not influenced significantly but it remained in same trend. Similar results were also reported by Lingaraju *et al.* (2008) [6] in maize with pegionpea, Muhammad and Ranamukhaarachchi (2012) [11] in sweet sorghum. Himmatrao *et al*. (2013) [3] in maize. Layek *et al.* (2014) [5] in soya bean with cereals, Yogesh *et al*. (2014) [16] in maize with soybean.

The data on fodder yield sorghum revealed non-significant variations due different sole and intercropping systems. However, it remained in order of $T_1 > T_2 > T_3 > T_6 > T_8 > T_9 > T_7$. This may be attributed to competition free environment in sole cropping and higher availability of water and nutrients, its uptake and further translocation to developing leaves, stem and grain. The lower fodder yield of sorghum in intercropping treatments might be due to reduction in overall plant growth as reflected from lower values of different growth and yield attributes due to intense competition among the intercropping treatments. These findings corroborated the report of Himmatrao *et al*. (2013) [3] in maize and Shah *et al*. (2011) [14] in maize with soya bean.

Effect of intercropping on SEY and LER

Treatment T_6 sorghum + greengram (Paired 2:1) recorded significantly higher SEY among all the treatments which was at par with treatment T_7 sorghum + greengram (Paired 2:1) increase in yield by 27 %, 35% and 36% over sole sorghum treatments T_1,T_2 and T_3, respectively. These treatments were followed by treatment T_8, T_4 and T_9. Treatment T_6 sorghum + greengram (Paired 2:1) recorded the highest (12670 kg ha^{-1}) sorghum fodder equivalent yield among all the treatments, which was statistically at par with all the treatments except treatment T_4 and T_5. Similar findings were also reported by Mohan *et al*. (2005) [10] in maize and French bean, Marer *et al*. (2007) [8] in maize and pigeon pea, Mishra and Elamathi, (2009) [9] in maize and greengram.

With respect to LER, all the intercropping treatments found advantageous as they recorded LER > 1. Sorghum +

greengram paired at 2:1(T_6) recorded maximum LER (1.31) followed by sorghum and greengram paired at 3:2 (T_7), sorghum + blackgram paired at 2:1 (T_8) and sorghum + blackgram paired at 3:2 (T_9) with LER 1.28,1.24 and 1.23, respectively. Sorghum being long duration crop compared to greengram/blackgram and shallow rooted crop, in other hand deep root system of intercrops did not pose any severe competition for natural recourses among the intercropping treatments. These findings corroborated the report of Lingaraju *et al.* (2008) [6] in maize and peagionpea, Ijoyah *et al*. (2013) [4] maize and soya bean, Hamd Alla *et al.* (2014) in maize and cowpea.

Post-harvest fertility status of soil

Different sole and intercropping systems showed significant effect on availability of N and P_2O_5 content of soil after crop harvest. Sole greengram (T_4) recorded sizably higher available N as well as P_2O_5 compared to other treatments. While, it was remained at par with sole blackgram (T_5) and other intercropped treatments (T_6, T_7, T_8 and T_9) with respect to available nitrogen. The improved nitrogen status in sole greengram, blackgram and intercropped treatments may be due to higher number of nodules per plant could attributed the addition of nitrogen to soil through symbiotic nitrogen fixation and by defoliations which in turn enhanced the activity of micro-organisms. Similar reason has also been reported by in peagionpea in cotton based cropping system, Bindhu *et al* (2014) [1] sesame with greengram and blackgram. While in case of available phosphorus content it was at par with treatment T_5 only. Among the intercropping treatments, T_6 sorghum + greengram (Paired 2:1) recorded maximum P_2O_5 content in soil after crop harvest followed by T_7 sorghum + greengram (Paired 3: 2). Whereas, all the sole sorghum treatments (T_1, T_2 and T_3) recorded significantly lower available N and P_2O_5 content. The improved available P_2O_5 content in soil may be due to mineralization of native P in soil by the decomposition of organic matter due to release of root exudates and organic acids in legume sole and intercropping treatments. Similar results were also observed by Tuti *et al*. (2012) in wheat and lentil, Bindhu *et al*. (2014) [1] sesame with greengram and blackgram. However, available K_2O content in soil was not significantly influenced by various treatments, while it was remained in same order like available N and P_2O_5.

Table 2: Grain yield and fodder yield of sorghum as influenced by sole and intercropping systems

Treatment		Grain yield (kg ha^{-1})	Fodder yield (kg ha^{-1})
T_1	Sole sorghum	3370	12176
T_2	Sole sorghum (Paired rows at 30-60 cm)	3175	12023
T_3	Sole sorghum (Paired rows at 30-30-75 cm)	3130	11928
T_4	Sole greengram	-	-
T_5	Sole blackgram	-	-
T_6	Sorghum + greengram (Paired 2:1)	3098	11771
T_7	Sorghum + greengram (Paired 3:2)	2900	11333
T_8	Sorghum + blackgram (Paired 2:1)	2917	11495
T_9	Sorghum + blackgram (Paired 3:2)	2758	11190
SEm±		125	745
CD at 5 %		370	NS
CV %		8.17	12.74

Table 3: Sorghum equivalent yield (kg ha^{-1}) and land equivalent ratio as influenced by sole and intercropping systems

Treatment		Sorghum grain equivalent yield (kg ha^{-1}) (SEY)	Sorghum fodder equivalent Yield (kg ha^{-1})	Land equivalent ratio (LER)
T_1	Sole sorghum	3370	12176	1.00
T_2	Sole sorghum (Paired rows at 30-60 cm)	3175	12023	1.00
T_3	Sole sorghum (Paired rows at 30-30-75 cm)	3130	11928	1.00
T_4	Sole greengram	3630	3123	1.00
T_5	Sole blackgram	2471	3028	1.00
T_6	Sorghum + greengram (Paired 2:1)	4293	12670	1.31
T_7	Sorghum + greengram (Paired 3:2)	4142	12545	1.28
T_8	Sorghum + blackgram (Paired 2:1)	3712	12360	1.24
T_9	Sorghum + blackgram (Paired 3:2)	3602	12356	1.23
SEm±		140.74	637.13	
CD at 5 %		410.83	1859.72	
CV %		8.03	12.44	

Table 4: Available N, P_2O_5 and K_2O (kg ha^{-1}) status of soil after harvest as influenced by sole and intercropping systems

Treatment		Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})
T_1	Sole sorghum	179.23	30.55	372.73
T_2	Sole sorghum (Paired rows at 30-60cm)	173.42	28.92	369.95
T_3	Sole sorghum (Paired rows at 30-30-75cm)	169.60	27.10	364.88
T_4	Sole greengram	226.88	38.99	406.83
T_5	Sole blackgram	220.73	36.20	404.33
T_6	Sorghum + greengram (Paired 2:1)	212.88	34.18	386.03
T_7	Sorghum + greengram (Paired 3:2)	219.00	35.00	392.10
T_8	Sorghum + blackgram (Paired 2:1)	208.75	32.49	383.35
T_9	Sorghum + blackgram (Paired 3:2)	212.03	33.43	389.68
SEm±		7.23	1.40	13.80
CD at 5 %		21.11	4.10	NS
CV %		7.14	8.51	7.16

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