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Yield potential, land equivalent ratio and economic viability of summer sorghum (*Sorghum bicolor* L.) under sole crop and intercropping systems in south Gujarat condition

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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 indicated that sole sorghum (T_1) recorded significantly higher grain yield. Among all the treatments sorghum intercropped with greengram at 2:1 row ratio recorded higher sorghum equivalent yield, land equivalent ratio, net returns and B: C ratio.

Keywords: Sorghum, greengram, blackgram, intercropping, SEY, LER and net returns

Introduction
Sorghum (*Sorghum bicolor* L.) belongs to the family Poaceae. 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 hence it is popularly known as “camel crop”. Sorghum will perform better than maize in marginal land under moisture stress or excessive moisture conditions. Sorghum is principal cereal that forms an important staple diet throughout the semiarid Asian and African regions. 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 country.
Intercropping is considered as the practical application of ecological principles such as diversity, crop interaction and other natural regulation mechanisms. It 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.

Material and Methods
A field experiment was conducted during the summer season 2018 at College Farm, N. M. 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 $N\text{-}P_2O_5\text{-}K_2O$ 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. Growth and yield parameters were recorded as per standard procedures. Sorghum equivalent yield (SEY) was calculated by considering the prices of both the crops using following formula.

$$\text{SEY} = \text{Yield of sorghum} + \frac{\text{Yield of intercrop x Price of intercrop}}{\text{Price of sorghum}}$$

Results and Discussion

Among all the treatments sole sorghum (T_1) recorded significant higher grain yield (3370 kg ha^{-1}) 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. 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) [3] in maize with pegionpea, Muhammad and Ranamukhaarachchi (2012) [8] in sweet sorghum, Himmatrao *et al*. (2013) [1] in maize, Layek *et al*. (2014) [2] in soyabean with cereals, Yogesh *et al*. (2014) [9] in maize with soyabean.

Treatment T_6 sorghum + greengram (Paired 2:1) recorded significantly higher SEY (4293 kg ha^{-1}) 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. The higher SEY with sorghum + greengram (2:1) was due to higher grain yield obtained by both sorghum and greengram and higher market price of greengram. 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) [7] in maize and French bean, Marer *et al*. (2007) [5] in maize and pigeonpea, Mishra and Elamathi, (2009) [6] in maize and greengram.

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.

Results pertaining to the economics indicated that treatment T_6 sorghum + greengram (2:1) recorded considerably maximum net realization (₹ 88472 ha^{-1}) and B: C ratio (3.50), which was closely followed by treatment T_7 sorghum + greengram (3:2) and treatment T_8 sorghum + blackgram (2:1) with net realization (₹84657 and 75775 ha^{-1}, respectively) and B: C ratio (3.36 and 3.13, respectively) and increase in net returns to an extent of 23%, 31% and 33% over sole sorghum treatments T_1, T_1 and T3, respectively. The higher net income and B: C ratio among these treatments was due to higher compliment effect between two component crops which produced higher biological yield and additional returns. Similar results were also observed by Mohan *et al*. (2005) [7] in maize based cropping system, Marer *et al*. (2007) [5] in maize and peagionpea, Madhavi Latha and Prasad (2008) [4] in maize and greengram, Mishra and Elamathi, (2009) [6] maize based cropping system.

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

	Treatment	Length of earhead (cm)	Girth of earhead (cm)	Grain weight per earhead (g)	Number of grains per earhead	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
	S.Em±	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

Table 2: Effect of sole and different intercropping systems on yield, land equivalent ratio and economics of sorghum

	Treatment	Grain yield (kg ha^{-1})	Fodder yield (kg ha^{-1})	Sorghum equivalent yield (kg ha^{-1}) (SEY)	Sorghum fodder equivalent Yield (kg ha^{-1})	Land equivalent ratio (LER)	Net realization (₹ ha^{-1})	B:C ratio
T_1	Sole sorghum	3370	12176	3370	12176	1.00	71608	3.22
T_2	Sole sorghum (Paired rows at 30-60 cm)	3175	12023	3175	12023	1.00	67237	3.08
T_3	Sole sorghum (Paired rows at 30-30-75 cm)	3130	11928	3130	11928	1.00	66059	3.04
T_4	Sole greengram	-	-	3630	3123	1.00	48926	2.48
T_5	Sole blackgram	-	-	2471	3028	1.00	25068	1.75
T_6	Sorghum + greengram (Paired 2:1)	3098	11771	4293	12670	1.31	88472	3.50
T_7	Sorghum + greengram (Paired 3:2)	2900	11333	4142	12545	1.28	84657	3.36

T_8	Sorghum + blackgram (Paired 2:1)	2917	11495	3712	12360	1.24	75775	3.13
T_9	Sorghum + blackgram (Paired 3:2)	2758	11190	3602	12356	1.23	73117	3.03
S.Em±		125	745	140.74	637.13			
CD at 5%		370	NS	410.83	1859.72			
CV %		8.17	12.74	8.03	12.44			

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