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Performance of Sorghum based Intercropping System in Northern Dry Zone of Karnataka

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ABSTARCT: A field experiment was conducted during *rabi* season of 2020-21 at Agricultural Research Station, Hagari on medium deep black soil to study the performance of sorghum based intercropping system in Northern Dry Zone of Karnataka. Growing of sole sorghum may not be profitable. Again, continuous sole cropping of sorghum may lead to decline in yield levels mainly because of conspicuous of nitrogen in particular and other nutrients in general. The lower productivity of *rabi* sorghum has been attributed to the fact that large area is under rainfed condition in addition to that cost of cultivation also increased due to shortage of labours, higher input prices and fluctuation of market price. In order to minimize the risk and maximize the net income for farmer, the suitable *rabi* crop selection as intercrop has to be done in sorghum based intercropping system. Keeping the above information in view, an investigation was carried out to study the suitable intercrop under *rabi* grain sorghum based cropping system in northern dry zone of Karnataka. The experiment consists of ten treatment combinations with five *rabi* crops (Sorghum, chickpea, safflower, linseed and coriander). The experiment was laid out in randomized complete block design and replicated four times. Significantly taller plants (264.8 cm), more number of leaves (5.9), higher leaf area (22.3 dm^2 $plant^{-1}$), dry matter production (98.7 g $plant^{-1}$), number of grains $earhead^{-1}$ (749.2), grain weight (27.5 g $plant^{-1}$). Significantly higher grain, stover and biological yield (1670, 4401 and 6071 kg ha^{-1}, respectively) of sorghum was recorded in sole sorghum followed by sorghum + bengalgram (2:1) (1301, 3374 and 4674 kg ha^{-1}, respectively). Significantly lower stover and biological yield (2983 and 4130 kg ha^{-1}) was noticed in sorghum + linseed (2:1). Gross returns, and benefit-cost ratio (Rs. 84636 ha^{-1}, Rs. 49520 ha^{-1} and 2.41, respectively) were significantly higher with sorghum + bengalgram in 2:1. Significantly lower gross returns, net returns and benefit-cost ratio (Rs. 26678 ha^{-1}, Rs. 330 ha^{-1} and 1.01) were noticed in sole coriander.

Keywords: Chickpea, coriander, intercropping system, linseed, net returns, safflower, sorghum, sorghum equivalent yield, yield.

INTRODUCTION

Sorghum (*Sorghum bicolor* L. Monech) is one of the major food grains of the world. It is one of the most widely grown dryland food grain in India. It does well even in low rainfall areas. It makes comparatively quick growth and gives not only good yields of grain but also very large quantities of fodder. Sorghum is important source of protein and carbohydrates. Sorghum is grown in states like Maharashtra, Karnataka, Andra Pradesh, Telangana, Madhya Pradesh, Gujarat and Tamilnadu. In India total area under sorghum is 4.24 million hectares with an annual production of 4.78 million tonnes and productivity of 1100 kg ha^{-1}. India ranks third in area and fifth in production in the world (Anon., 2021).

Willey (1979) found that yield advantage in intercropping occurs because of component crops differ in their use of growth resources in such a way that when they are grown in combination, they are able to complement each other with better use of overall resources than when grown separately. Intensification of cropping through integration of legumes and cereals could provide a more sustainable system than the currently practiced cereal monoculture in the subsistence agriculture (Reda *et al*., 2005).

Sankaranarayanan *et al*. (2005) reviewed that augmentation of protein could be attempted by cultivation of forage sorghum intercropped with leguminous fodder crops. A more balanced nutritive feed can be obtained by mixing fodder sorghum and leguminous crops. Sorghum based intercropping system increases LER, nitrogen balance and monetary returns.

Mousavi and Eskandari (2011) showed that intercropping is a way to increase diversity in an agricultural ecosystem. Ecological balance, more utilization of resources, increases the quantity and quality of products and reduction in incidence of pests, diseases and weeds under intercropping systems. Soil fertility increases by using plants of Leguminosae family in intercropping, due to the increasing amount of biological nitrogen fixation.

Duvvada and Maitra (2020) revealed that sorghum-based intercropping system fulfills multiple benefits like enhancement of yield under challenged ecological conditions with more economic return. Moreover, intercropping of sorghum with legumes and other crops ensures greater use and conservation of resources along with qualitative improvement. Under resource poor soil and erratic weather conditions, successful raising of crops is a great challenge and sorghum-based intercropping is one of the suitable options for uninterrupted productivity, agricultural sustainability and livelihood security of small-scale farmers in arid and semi-arid regions.

Practice of intercropping is as old as agriculture. Intercropping is one of the important ways for better stability, productivity and profitability. Among the different crops grown during *rabi* under dryland conditions, sorghum, bengalgram, safflower, linseed and coriander are the important crops. These crops are usually grown as sole as well as in inter/mixed crops. The intercropping of these crops is also in vogue as it gives higher yields, greater land use efficiency per unit area besides improving soil fertility. In deep black soils cropping under residual moisture (*rabi*) conditions. The low productivity of *rabi* sorghum has been attributed to the fact that large area is under rainfed condition in addition to that cost of cultivation also increased due to shortage of labours, high input prices and fluctuation of market price. In order to minimize the risk and maximize the net income of the farmer, the suitable *rabi* intercrop has to be done in sorghum based intercropping system.

MATERIAL AND METHODS

A field experiment entitled "Performance of sorghum based intercropping system in Northern Dry Zone of Karnataka" was conducted at Agricultural Research Station, Hagari, which is located in Northern Dry Zone of Karnataka (Zone-III) and situated at 15^o 14' N latitude and 77^o 07' E longitude with an altitude of 414 meters above the mean sea level. There were ten treatments of which five are sole cropping and five are intercropping treatments *viz*., T_1: Sorghum + Bengal gram (2:1), T_2: Sorghum + safflower (2:1), T_3: Sorghum + linseed (2:1), T_4: Sorghum + coriander (2:1), T_5: Linseed + safflower (2:1), T_6: Sole sorghum, T_7 : Sole bengalgram, T_8 : Sole safflower, T_9 : Sole linseed and T_{10} : Sole coriander. The experiment was laid out in randomized complete block design (RCBD) with four replications. The gross plot size for each plot was 5.40 m length × 5.1 m width. The soil of the experimental site belongs to *vertisol* (black soil) with alkaline in reaction (pH-8.35), low in EC (0.42 dSm^{-1}) and medium in organic carbon content (0.49 %). The soil was low in available nitrogen (236.00 kg ha^{-1}), medium in available phosphorus (43.61 kg ha^{-1}) and high in available potassium (346.00 kg ha^{-1}). The mean rainfall during crop growth period (September 2020 to February 2021) was 102mm. All the crops were sown simultaneously and recommended dose of fertilizers were applied to sole crops and in intercropping system, the component crops received fertilizer at the time of sowing in proportion to their plant density in the form of urea, DAP and MOP. The crops were sown on 24th October, 2020 as per the row proportions and spacing. The observations on growth, yield and yield parameters of sorghum and all other intercrops were made at harvest. Sorghum and intercrops yields were recorded separately in each intercropping system and later converted into yield per hectare based on the area occupied by the individual crops. Sorghum equivalent yield for each intercropping system was calculated based on the yield of individual crops in each intercropping systems and their market prices prevailing at the time of experimentation for comparison of intercropping systems with sole sorghum. Economics of each intercropping system was carried out based on the prevailing market rates of inputs and produce of each crop during the period of experimentation. All the parameters were subjected for statistical analysis and interpretation as outlined by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

A. Performance of sorghum

Intercropping of different *rabi* crops with sorghum had significant effect on growth and yield parameters (Table 1). Sorghum + bengalgram (2:1) intercropping system was recorded significantly taller plant (264.8 cm), more number of leaves (5.9), higher leaf area (22.3 dm^2 plant^{-1}), and drymatter production (DMP) of 98.7 g plant^{-1}. Significantly lower DMP was recorded in sorghum + safflower (2:1) (71.9 g plant^{-1}) (Table 1). Higher drymatter accumulation in leaves, stem, and earhead of sorghum in sorghum + bengalgram leads to higher total dry matter production. This might be due to higher plant height and better uptake of nutrients in all the growth stages of the crop. The dry matter accumulation is considered to be the reliable index of crop growth and is a result of photosynthesis and cumulative effect of all growth the attributes viz. plant height, number of functional leaves per plant and leaf area plant^{-1}. Patil (2019) also reported that enhancement in number of leaves and leaf area resulted in higher drymatter production of safflower intercropped with chickpea (1:3 or 2:4 row ratios) due to availability of more resources. The results are in agreement with those reported by Berhane *et al.* (2015); Somu *et al.* (2020).

Significantly higher grain number (749.2) and grain weight (27.5g plant^{-1}), grain and stover yield were recorded in sole sorghum (1670 kg ha^{-1} and 4401 kg ha^{-1}, respectively), among various intercropping systems, higher grain yield and stover yield were recorded in sorghum + bengalgram (2:1) (1301 kg ha^{-1} and 3374 kg ha^{-1}, respectively) as compared to the rest of the intercropping treatments. Superior values of grain yield in solitary stand of sorghum might be attributed to competition free environment and optimum population level compared to intercropping treatments. The difference in stover yield was with the tune of population level and drymatter accumulation in leaves and stem at harvest. Oseni (2010) reported that grain and stover and haulm yields of both sorghum and cowpea were higher in sole cropping than in the intercropping mixtures. The results are in conformity with the findings of Manjithkumar *et al.* (2009); Suryawanshi (2009); Singh *et al.* (2010); Shubha (2014); Gobade *et al.* (2015); Gangadhar (2016); Somu *et al.* (2020).

Sorghum intercropped with bengalgram (2:1) produced significantly higher sorghum equivalent yield of 2853 kg ha^{-1} as compared with other treatments followed by sorghum + safflower (2:1) (2248 kg ha^{-1}). This was due to higher yield of sorghum and bengalgram coupled with better utilization of resources by the component crops in intercropping system. Crop compatibility, higher ability to utilize nutrients, moisture, space and light efficiently by the crops resulted in higher crop yield in intercropping system. Similar findings were supported by Gangadhar (2016); Krishnamurthy *et al.* (2020).

B. Performance of intercrops

Higher seed and haulm yield was recorded with sole crop of bengalgram (1156 and 1815 kg ha^{-1}, respectively), safflower (963 and 1736 kg ha^{-1}, respectively) linseed (558 and 1009 kg ha^{-1}) and coriander (412 and 576 kg ha^{-1}, respectively) as compared to intercropping system (Table 2). Higher seed and haulm yield in sole crops were mainly due to higher plant population, higher vegetative growth, no interspecific competition for growth resources, maximum source (leaf) development which led to higher photosynthetic rate and total dry matter production which ultimately resulted in higher grain and haulm yield in sole crops. Further, improved growth parameters *viz*., plant height, leaf area per plant and leaf area index, which have contributed towards higher yield and yield attributes in sole crops. Higher number of pods/capsules/umbels plant^{-1}, weight of pods / capsules / umbels plant^{-1}, number of seeds pod^{-1}/capsule^{-1}/ubellates^{-1}, weight of grains pods^{-1}/ capsule^{-1}/umbellates^{-1}, weight of seeds plant^{-1}, and 1000 seeds weight (g) wsere recorded in sole chickpea/ safflower/ linseed/ coriander, respectively. Whereas, lower in their respective intercropping. This might be due to as source size was large in sole cropping. The larger sources might support larger sinks (pods/capsules/umbels) in producing more seeds and seeds weight plant^{-1}. Where as in sole cropping the optimum availability of moisture, nutrients and duration of sunshine and solar energy might have favoured development of better root system, which might have helped in better uptake of nutrients and leads to better growth of intercrops. These results are correlated with the findings of Raghuwanshi *et al.* (2002); Shubha (2014); Gangadhar (2016); Ramarao (2018).

Economics: Significantly higher gross return (Rs. 84636 ha^{-1}) was recorded with sorghum + bengalgram (2:1) as compared to other sorghum based intercropping systems. The lower gross return was obtained with the sole coriander (Rs. 26678 ha^{-1}). Significantly higher net return and benefit cost ratio (Rs. 49520 ha^{-1} and 2.41, respectively) (Table 3) was recorded in sorghum + bengalgram (2:1) as compared to rest of the treatments. The higher net returns was obtained with sorghum + bengalgram (2:1) intercropping treatment was due to higher complementarities between these two component crops which produced higher yield and there by higher net returns. Though, intercrop yields were lower than their respective sole crop yields, but they produced higher equivalent yields and income in combination. Higher benefit cost ratio was also observed with sorghum intercropped with bengalgram in 2:1 which might be attributed to higher net returns in these treatments and lower cost of cultivation. These results are in agreement with findings of Biradar *et al.* (2015); Kalaghatagi *et al.* (2017); Chaudhary *et al.* (2020); Krishnamurthy *et al.* (2020).

Table 1: Growth, yield and yield components and sorghum equivalent yield of *rabi* sorghum at harvest as influenced by different intercropping system.

Treatments	Plant height (cm)	No. of leaves	Leaf area (dm^2 plant^{-1})	Dry matter accumulation (g plant^{-1})	Number of grains earhead^{-1}	Grain weight (g plant^{-1})	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Sorghum equivalent yield (kg ha^{-1})
T_1 : Sorghum + bengalgram (2:1)	264.8	5.9	22.3	98.7	749.2	27.5	1301	3374	2853
T_2 : Sorghum + safflower (2:1)	221.9	4.6	16.4	71.9	644.8	20.5	1131	3070	2248
T_3 : Sorghum + linseed (2:1)	233.5	4.7	17.2	75.8	653.0	21.0	1147	2983	1584
T_4 : Sorghum + coriander (2:1)	238.1	5.1	17.6	79.5	685.1	21.1	1168	3039	1829
T_5 : Linseed + safflower (2:1)	-	-	-	-	-	-	-	-	1963
T_6 : Sole sorghum	243.0	5.5	19.3	85.8	716.3	25.1	1670	4401	1670
T_7 : Sole bengalgram	-	-	-	-	-	-	-	-	2233
T_8 : Sole safflower	-	-	-	-	-	-	-	-	1944
T_9 : Sole linseed	-	-	-	-	-	-	-	-	1141
T_{10} : Sole coriander	-	-	-	-	-	-	-	-	967
S. Em±	**6.7**	**0.1**	**0.8**	**3.6**	**17.5**	**0.7**	**42**	**91**	**73**
C.D. (P=0.05)	**20.6**	**0.4**	**2.5**	**11.1**	**54.1**	**2.1**	**129**	**280**	**211**

Table 2: Growth, yield and yield components of intercrops at harvest as influenced by different intercropping system.

Treatments	Plant height (cm)	Dry matter production (g plant^{-1})	Number of pods/ capsules/ capitula /umbels (plant^{-1})	Number of seeds per pods/ capsule/ capitula /umbels	Seed weight (g plant^{-1})	Test weight (g 1000 seeds^{-1})	Grain yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
T_1 : Sorghum + bengalgram (2:1)	37.2	16.4	37.2	1.2	7.1	213.6	804	1282
T_7 : Sole bengalgram	43.1	18.6	39.8	1.3	7.3	214.2	1156	1815
T_2 : Sorghum + safflower (2:1)	101.8	83.8	38.4	16.1	25.4	53.1	554	987
T_5 : Linseed + safflower (2:1)	107.4	86.5	40.8	16.4	26.0	53.8	522	946
T_8 : Sole safflower	112.2	88.6	45.4	18.2	28.5	55.3	963	1736
T_3 : Sorghum + linseed (2:1)	74.6	5.6	34.3	5.4	1.5	5.3	213	410
T_5 : Linseed + safflower (2:1)	76.3	5.9	36.2	5.6	1.8	5.7	444	887
T_9 : Sole linseed	79.2	6.6	38.1	6.7	2.1	5.9	558	1009
T_4 : Sorghum + coriander (2:1)	52.4	7.0	6.0	7.7	2.5	10.1	281	373
T_{10} : Sole coriander	60.5	7.4	6.2	7.9	2.7	10.3	412	576

Table 3: Economics of different intercropping systems.

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	Benefit cost ratio
T_1 : Sorghum + bengalgram (2:1)	35116	84636	49520	2.41
T_2 : Sorghum + safflower (2:1)	35875	66467	30592	1.85
T_3 : Sorghum + linseed (2:1)	35518	48172	12654	1.36
T_4 : Sorghum + coriander (2:1)	35264	54360	19096	1.54
T_5 : Linseed + safflower (2:1)	27736	53654	25916	1.93
T_6 : Sole sorghum	32203	52884	20681	1.64
T_7 : Sole bengalgram	29437	62587	33150	2.13
T_8 : Sole safflower	26278	53059	26781	2.02
T_9 : Sole linseed	21145	31134	9985	1.47
T_{10} : Sole coriander	26348	26678	330	1.01
S. Em±	-	**2027**	**2027**	**0.06**
C.D. (P=0.05)	-	**5882**	**5882**	**0.18**

CONCLUSIONS

The experimental findings indicated that there were marked variations in the productivity of sorghum was observed with different intercropping system. Based on the present investigation, it can be concluded that sorghum crop grown with bengalgram in 2:1 row proportion is most productive, economically viable, sustainable, remunerative and superior as they recorded higher net returns (Rs. 49520 ha^{-1}) and benefit cost ratio (2.41) compared to sole and other intercropping system.

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Conflict of Interest. None.

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