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Performance of sorghum based intercropping systems under dry sowing and normal sowing conditions

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ABSTRACT : A field experiment was conducted at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad on medium black clayey soil during *Kharif* 2011 to study the performance of sorghum based intercropping systems under dry and normal sowing conditions. Significantly higher plant height (188.3 cm), LAI (3.21), LAD (60.06 days) and total dry matter production (182.18 g) were recorded at harvest of sorghum in dry sowing as compared to normal sowing of sorghum. Similarly, plant height (46.6 cm), LAI (2.38) and total dry matter production (11.73 g) were higher at harvest of legumes in dry sowing as compared to normal sowing of legumes. However, sole sorghum recorded significantly higher LAI (3.41), LAD (60.26 days) and total dry matter production (184.93 g) at harvest which was at par with sorghum intercropped with soybean. Dry sowing enhanced yield of sorghum and legumes by 16.8 and 19.95 per cent, respectively (51.85 q ha^{-1} and 12.74 q ha^{-1} grain yield of sorghum and legumes, respectively) over normal sowing of sorghum (43.14 q ha^{-1}) and legumes (10.30 q ha^{-1}). However, sole crop of sorghum recorded significantly higher grain yield (52.48 q ha^{-1}) and stover yield (14.91 t ha^{-1}) and it was at par with sorghum intercropped with soybean (48.38 q ha^{-1} and 12.51 t ha^{-1}, grain and stover yield, respectively).

KEY WORDS : Dry sowing, Intercropping, Leaf area index, Leaf area duration, Normal sowing

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The economy of India has a close and vital link with rainfall during the southwest monsoon season. The onset and advancement of southwest monsoon over the country play a crucial role during the sowing of *Kharif* and *Rabi* crops. The timely onset of southwest monsoon over Kerala and its northward progress across the country is of vital importance to the agriculture operations all over India as well as for water replenishment and management. A late onset or advancement of monsoon may have devastating effects on agriculture, even if the mean annual rainfall is normal (Tyagi *et al*., 2011). However, these rational distribution of rainfall which affected crop growth and development, in turn reduced the sorghum/legume productivity. This indicates the role of soil moisture even at the time of planting. In this context, there is a need for an alternate crops/cropping systems with sorghum which are ideal even under changing climatic situations, so that, farmers can meet out their basic needs of food and fodder. Sowing of crops immediately after the receipt of soaking rains is the traditional practice of farming known as wet sowing or normal sowing. However, in vertisol where dependable rains (P>60%) followed by reliable monsoon exists sowing of bold seeded crops before onset of pre-monsoon

rain in dry soil is advantageous and confers multiple benefits (Periyathambi and Palaniappan, 1984). Hence, the present experiment was designed to study the effect of dry and normal sowing on the performance of sorghum based intercropping systems.

RESEARCH METHODS

A field experiment was conducted during *Kharif* season of 2011 at the Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad. The soil was neutral having pH of 7.4, 0.42 per cent organic carbon, available nitrogen (228.5 kg ha^{-1}) availale phosphorus (32.43 kg P_2O_5 ha^{-1}) and available potash (406.3 kg K_2O ha^{-1}). The field experiment was laid out in Randomized Complete Block Design in factorial concept with the first factor as sowing time includes, S_1 (dry sowing) and S_2 (normal sowing) and the second factor as cropping system includes, T_1 : sorghum + greengram (2:2), T_2 : sorghum + soybean (2:2), T_3 : sorghum + blackgram (2:2), T_4 : sole sorghum, T_5 : sole greengram, T_6 : sole soybean and T_7: sole blackgram with three replications. The recommended dose of fertilizer @ 60:40:40, 12.5:25:00, 40:80:25, 12.5:25:00 kg N, P_2O_5 and K_2O ha^{-1} for sole sorghum, greengram, soybean and blackgram were applied, respectively. Nitrogen, phosphorus and potassium were applied in the form of urea, DAP and muriate of potash, respectively. Half of the nitrogen and the entire quantity of P_2O_5 and K_2O were band placed at 5 cm deep and 5 cm away from the row as a basal dose for sorghum and the remaining half of nitrogen was top dressed at 30 days after sowing for sole sorghum and sole legumes. In intercropping system sole sorghum dose was applied as above. Whereas, for legumes recommanded dose of fertilizers was applied at the time of sowing. Seeds were sown on 30-05-2011 and 14-06-2011 in dry and normal sowing conditions, respectively. The seeds were sown in each plot at 5 cm deep as the dry sown seeds cannot be affected by frequent light showers. The excess seedlings were thinned out at 15 DAS (days after sowing) so as to maintain the required plant population. There was rainfall in evening immediately after dry sowing and 4-5 days dry spell was noticed in case of normal sowing in June month. However, sufficient moisture was present in the soil for germination of normal sown crop.

To keep the crop free of weeds, one inter-cultivation with hoe and one hand weeding were carried out. Malathion dust @ 20 kg ha^{-1} was incorporated into the soil to minimize the losses due to damage by ants and termites in dry sown condition. Greengram, blackgram, soybean and sorghum were harvested on 2nd August, 18th August, 1st September and 28th September, respectively in dry sown condition. In normal sown condition crops were harvested on 20th August, 11th September, 22nd September and 11th October, respectively.

RESEARCH FINDINGS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads :

Effect of sowing time and cropping systems on sorghum:

Dry sowing of sorghum in the last week of May (30.05.2011) recorded significantly higher grain yield (51.85 q ha^{-1}) as compared to normal sowing (43.14 q ha^{-1}) in the second week (14.06.2011) of June. Similar trend was noticed with respect to stover yield of sorghum. In the present investigation the factors which indirectly influenced the grain and stover yield of sorghum in dry sowing were growth attributes like (Table 1) plant height, LAI, LAD and total dry matter production (TDMP). Plant height at harvesting of sorghum differed significantly in dry sowing (188.3 cm) than the normal sowing (179.5 cm). Dry sowing of sorghum recorded significanly higher LAI (3.21) as compared to normal sowing (2.86). Although the plant height is basically a genetic character, it is influenced by environmental conditions as well as management practices. Increased plant height and leaf area in dry sowing at all the growth stages indicated that there was a significant use of environmental resources like light, moisture and nutrients which might have resulted in higher LAI (Anonymous, 2000). Higher LAI ultimately increased the LAD. Significantly higher LAD was obtained in dry sowing (60.06 days at 90-harvest) as compared to normal sowing (52.85 days). Similar results were obtained by Negalur (2000). LAD is a useful concept not only in depicting the efficiency of photosynthetic system, but also in showing a linear relationship with dry matter accumulation. In the present study, similar significant effect of LAD with grain and stover yield was obseved. The total dry matter production in dry sowing at harvest (Table 1) was higher (182.18 g) which decreased with normal sowing (170.55 g) to an extent of 6.31 per cent. More number of long days and

short nights prevailed for dry sown crops resulted in more TDMP accumulation than normal sown crop after the onset of monsoon which were experienced less number of long days before entering reproductive stage. Similar results were reported by Reddy *et al*. (2010). However, the improvement in grain and stover yields in dry sowing were attributed to improved yield attributes like (Table 1) grain weight per ear (95.10 g) and test weight (33.51 g). The increase in grain and stover yield of sorghum in dry sowing might be due to sufficient rainfall received during the early stages of crop growth along with higher light intensity at the time of boot leaf stage. Halemani *et al*. (1993) reported that higher grain and stover yield of sorghum was to an extent of 30 per cent when sown in dry soil as compared to normal practice of sowing.

The yield reduction in normal/wet sowing was attributed to unfavourable conditions like cloudy situation with higher relative humidity which might have increased disease and insect, pest infestation on the legume crops which resulted in less translocation of assimilates from vegetative parts to reproductive structures. This was evidenced by reduction in dry matter production with normal sowing than the dry sowing of legumes.

Growing of sorghum as a sole crop recorded significantly higher grain yield (52.48 q/ha) as compared to sorghum intercropped with legumes. The higher grain yield of sole sorghum was attributed (Table 1) to higher grain weight per ear (99.02 g), higher test weight (34.55 g) and dry matter production (184.93 g) as compared to intercropped sorghum**.** However, dry matter production per plant and it's distribution into different plant parts invariably depends on magnitude and persistence of photosynthetic capacity of plant. In turn the photosynthetic capacity of plant was reflected by higher LAI (3.41) and LAD (60.26 days) at harvest (Table 1). These results are in agreement with the findings of Biru *et al.* (2004) and Kumar *et al.* (2011). Similarly, the plant height of sorghum differed significantly due to intercropping systems. Sorghum with soybean intercropping recorded significantly higher plant height (189.4 cm) as compared to the rest of the treatments. Similar observations of increased height of sorghum when grown with mixed crops were reported by Iqbal (1976).

Grain yield of intercropped sorghum with soybean (48.38 q/ha) in 2:2 row proportion was not much affected (Table 1) as compared to other intercropping systems which was at par with the yield of sole sorghum (52.48 q/ha). This may be attributed to ear weight per plant, test weight, plant height, LAI, LAD and dry matter production which were next in order to sole sorghum. Dubey *et al*. (1995) showed that yield attributes of sorghum were significantly higher in sorghum with soybean intercropping.

Effect of sowing time and cropping systems on legumes:

The grain yield of legumes showed significant variation due to time of sowing when grown as sole and intercropped with sorghum (Table 1). Dry sowing in the last week of May recorded significantly higher grain yield (12.74 q/ha) of legumes as compared to normal/wet sowing of legumes in the second week of June (10.30 q/ha). Haulm yield of legumes did not differ significantly with time of sowing. The variation and increase in grain and haulm yields of legume might be attributed to more duration of crop leading to higher production of photosynthates before the critical period of flowering and thier transformation for seed production under dry sown condition (Arya *et al.*, 1997). The improvement in grain and haulm yield of legumes in dry sown condition was attributed to improved yield attributes (Table 1) like number of pods per plant (37.89 pods/plant) and test weight (67.79 g). The trend of yield increase was also because, the earlier sown crop had an advantage of favourable soil moisture, temperature and day length which made the crop to express its full potentiality and thus resulted in higher grain yield in dry sowing than that of delayed sowing. These results are in agreement with the findings of Ashoka (1991). Grain yield is the product of yield contributing characters and yield attributes are dependent on growth parameters of crop. Dry sowing recorded significantly higher growth attributes like plant height (46.6 cm), LAI (2.38 at 60 DAS) and total dry matter production (11.73 g) than the normal sowing (43.3 cm, 2.15 and 10.34 g of plant height, LAI and total dry matter production at harvest, respectively). Such variation in LAI could be attributed to variation in leaf area, plant height and number of branches per plant. Solar energy interception and its utilization efficiency by the plants are the main aspects of biomass production. Higher LAI at 60 DAS in dry sowing in turn shows higher ground cover which indicates more interception of light that was used for higher total dry matter production at harvest as compared to normal sowing. These results are in agreement with the findings of Goswami (2000).

Similarly, cropping system influenced the grain and

Table 1 : Effect of sorghum based intercropping systems under dry and normal sowing conditions on growth, yield attributes, yield and SEY of sorghum and legumes

Treatments	Sorghum								Legumes							SEY (q ha^{-1})
	Plant height (cm)	LAI	LAD at 91-harvest (days)	TDMP (g)	Grain weight (g ear^{-1})	Test weight (g)	Grain yield (q ha^{-1})	Stover yield (t ha^{-1})	Plant height (cm)	LAI (At 60 DAS)	TDMP (g)	Pods plant^{-1}	Test weight (g)	Grain yield (q ha^{-1})	Haulm yield (q ha^{-1})	
Sowing time (S)																
S_1 - Dry sowing	188.3	3.21	60.06	182.18	37.89	67.79	51.85	13.75	46.6	2.38	11.73	37.89	67.79	12.74	1.81	50.87
S_2 - Normal sowing	179.5	2.86	52.85	170.55	35.19	64.16	43.14	9.52	43.3	2.15	10.34	35.19	64.16	10.30	1.52	40.98
S.E.±	2.89	0.11	0.55	1.92	0.68	0.92	1.51	0.95	0.82	0.07	0.43	0.68	0.92	0.62	0.1	1.55
C.D. (P=0.05)	8.76	0.33	1.67	5.84	1.99	2.71	4.59	2.88	2.41	0.20	1.25	1.99	2.71	1.81	NS	4.52
Cropping system (T)																
T_1 - Sorghum+greengram (2:2)	184.6	2.76	53.87	172.58	89.97	31.73	45.96	9.76	34.6	1.99	8.95	30.41	46.46	7.10	1.15	53.42
T_2 - Sorghum+soybean (2:2)	189.4	3.22	57.68	177.02	92.70	32.38	48.38	12.51	59.4	2.69	12.48	46.97	99.06	11.98	1.67	74.85
T_3 - Sorghum+blackgram (2:2)	183.3	2.74	54.02	170.92	89.02	31.41	43.16	9.37	33.2	2.13	9.15	29.98	47.80	3.99	0.57	62.44
T_4 - Sole sorghum	178.4	3.41	60.26	184.93	99.02	34.55	52.48	14.91	-	-	-	-	-	-	-	52.48
T_5 - Sole greengram	-	-	-	-	-	-	-	-	41.5	2.10	10.95	31.67	50.30	14.51	2.04	17.40
T_6 - Sole soybean	-	-	-	-	-	-	-	-	63.1	2.89	14.50	50.33	102.44	23.63	3.48	49.29
T_7 - Sole blackgram	-	-	-	-	-	-	-	-	37.9	2.22	10.18	31.17	48.80	7.92	1.08	11.6
S.E.±	4.09	0.15	0.78	2.72	2.12	0.78	1.51	0.95	1.42	0.11	0.74	1.18	1.60	1.07	0.18	2.91
C.D. (P=0.05)	NS	0.46	2.36	8.26	6.42	NS	4.59	2.88	4.18	0.34	2.17	3.46	4.70	3.14	0.52	8.45
Interaction (A x B)																
S.E.±	5.78	0.22	1.10	3.85	2.99	1.1	3.03	1.91	2.01	0.16	1.04	1.67	2.26	1.52	0.25	4.11
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	4.44	0.73	NS

NS – Non significant DAS – Days after sowing Market price: Sorghum- Rs. 1500 q^{-1}, Greengram- Rs. 1800 q^{-1}, Soybean- Rs. 2000 q^{-1} and Blackgram- Rs. 2200q^{-1}.

haulm yield of legumes significantly (Table 1). In the present investigation growing of soybean as a sole crop recorded significantly higher grain (23.63 q/ha) and haulm yield (3.48 t/ha) as compared to other legumes. The higher grain and haulm yield of sole soybean might be attributed to (Table 1) significantly higher number of pods per plant (50.33) and test weight (102.44 g). The variation in grain and haulm yield of legumes could be attributed to variation in species characteristics of legumes. Besides, the increase in grain and haulm yield of sole soybean depends upon total dry matter production. Sole soybean recorded significantly higher total dry matter production 14.50 g/plant at harvest (Table 1) as compared to other legumes and legumes intercropped with sorghum. The increase in LAI (2.89 at 60 DAS) in sole soybean was attributed to maximum leaf area per unit area and number of branches as compared to other legumes. Sole crop of soybean recorded significantly higher plant height (63.1 cm at harvest) as compared to sole greengram, sole blackgram and intercropped legumes. In intercropping system there was stiff competition between main and component crops and as a result all the growth parameters were affected as compared to sole legumes (Willey *et al.*, 1986). Trenbath (1974) further suggested that difference in rooting of component crops could occur because of mutual avoidance of different root system. These factors hold good in the present investigation in which sorghum has deep and fibrous root systems and legume has tap root system

Sorghum equivalent yield:

The sorghum equivalent yield (SEY) was higher in intercropping of legumes with sorghum as compared to sole crops. Dry sowing of crops recorded significantly higher SEY (50.8 q ha^{-1}) as compared to normal sowing (40.9 q ha^{-1}), which might be due to increased yield of crops under dry sown condition (Table 1). Significantly higher sorghum equivalent yield (SEY) was recorded in sorghum with soybean in 2:2 row proportion (74.8 q ha^{-1}) followed by sorghum with (62.4 q ha^{-1}) blackgram. The higher SEY in sorghum with soybean was due to higher grain yield obtained with sorghum and soybean while in sorghum and blackgram system the higher SEY was due to higher market price of blackgram as compared to greengram. The extent of increase in SEY was 27.97 and 15.95 per cent when soybean and blackgram were intercropped with sorghum, respectively as compared to sole sorghum (Table 1). These results are in conformity with the findings of Biru *et al.* (2004) and Kumar *et al.* (2011).

The present study indicated that, dry sowing of sorghum with soybean recorded significantly higher growth and yield attributes and found suitable under changing rainfall patterns.

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