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Evaluation of growth characters in cotton-pulses intercropping system under rainfed condition

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Abstract
A field experiment was conducted during Kharif and Rabi season of 2015 at Agronomy Farm, College of Agriculture, Dhule (Maharashtra) to study the effect of cotton based intercropping system on yield of succeeding Rabi sorghum under relay cropping. Among cotton-pulse intercropping system the Growth of cotton in terms of growth attributes *viz.* number of monopodial and sympodial branches and dry matter plant^{-1} were higher in sole cotton, whereas in intercropping systems, growth attributes were superior in cotton + green gram(1:1) row ratio. Among intercropping treatments, plant height (35.86 cm) was higher in the treatment of cotton + green gram (1:2) row ratio and minimum in cotton + green gram (1:1) row ratio and maximum dry matter per plant (14.63 g)was recorded in treatment of sole cropping, followed by cotton + green gram (1:1) row ratio (12.35 g). Growth of black gram crop in terms of growth attributes *viz.* plant height (35.46 cm) was higher in the treatment of sole cropping followed by cotton + black gram (1:2) row ratio (34.27 cm)and maximum dry matter per plant (12.94 g)was recorded in treatment of sole cropping followed by cotton + black gram (1:1) row ratio (10.48 g). Green gram Rabi sorghum crop sequence found more profitable in respect of income per rupee instead than cotton-pulse based relay cropping of Rabi sorghum.

Keywords: Cotton, pulses, intercropping, relay cropping, monopodial branches, sympodial branches

Introduction
Intercropping is a potential system for maximizing the crop production in dry land over space and time in subsistence farming situations. The major objectives of intercropping system are to produce an additional crop to optimize the use of natural resources and stabilize the yield of crops [1]. The main concept of intercropping is to get increased productivity per unit land area and time and also equitable and judicious utilization of land resources and farming inputs including labour. The system aimed at increasing productivity per unit area and guarantee insurance against total crop failure, particularly under aberrant weather conditions. Intercropping system is one of the important way to increase production of pulses, which is the most important group of field crop in India, providing protein for human consumption. There is dire need to increase the production of pulses in the country because we are deficient in protein in our daily diet and large amount of foreign exchange is being spent annually on the import of pulses. Relay cropping system is an effective production system for increasing the income and production per unit area. By relay cropping, farmers may be able to effectively extend the growing season by several weeks. Cotton being a long duration and widely spaced crop with a row spacing of 90 to 120 cm, offers great scope for intercropping of short to medium duration legume crop without much effect on main crop. Legumes have the ability to fix the atmospheric nitrogen in soil and give benefits to cotton and relay *rabi* sorghum. Cotton is a deep rooted crop, hence, it is not competitive for moisture with green gram and black gram.

Materials and Methods
A field experimental was undertaken during *kharif* season of 2015 at Agronomy Farm, College of Agriculture, Dhule.The soil was black cotton soil having pH 7.5 and organic carbon 0.27 per cent. The available nitrogen, phosphorus and potassium contents were 162.24, 14.75 and 352.30 kg ha^{-1}, respectively. The experiment with seven treatment combinations were laid out in randomized block design in three replications with gross and net plot size of 5.40 x 4.50 m^2 and 3.60 x 2.70 m^2, respectively. The seven treatment consisted of T_1: Sole Cotton, T_2: Sole Green gram, T_3: Sole Black gram, T_4: Cotton + Green gram (1:1), T_5: Cotton + Green gram

(1:2), T_6: Cotton + Black gram (1:1), T_7: Cotton + Black gram (1:2). Cotton variety 'Bt Hybrid-Mallika' was sown at 90 x 90 cm, green gram variety 'Vaibhav' was sown at 30 x 10 cm, black gram variety 'TAU-1' at 30 x 10 cm. Cotton, green gram and black gram were sown on 15th June 2015. Two seeds of cotton was dibbled at each hill. Green gram and black gram were sown by line sowing in between two rows of cotton as per row proportion. Harvesting of green gram on 29th August 2015, black gram on 26th August 2015 and cotton on 28th October 2015.At the time of sowing of cotton 125:65:65 (Split application of N), green gram 20:40:00 and black gram 20:40:00 $N:P_2O_5:K_2O$ kg ha^{-1} were applied through urea, singal super phosphate (SSP) and muriate of potash (MOP). In case of intercropping treatments the general recommended dose of fertilizer of base crop was applied.

Result and Discussion

Plant height of 30.12, 85.25, 102.20, 113.0 and 120.25 cm were recorded in sole cotton at an interval of 30, 60, 90, 120 DAS and at harvest, respectively, which were comparatively lower than the height recorded in intercropping systems. Among intercropping treatments, cotton + green gram (1:2) row ratio recorded maximum plant height of cotton (33.10, 94.26, 106.50, 119.53 and 126.56 cm at 30, 60, 90, 120 DAS and at harvest) than rest of the treatments, (Table 1) followed by cotton + black gram (1:2) treatment [2]. Plant height of green gram (37.93 cm) and black gram (35.46 cm) were maximum in sole cropping, followed by cotton + green gram 1:2 and cotton + black gram 1:2 row ratio at harvest in intercropping systems [3]. reported that plant height of mungbean intercropped in any of the planting patterns was statistically at par with the height of mungbean plants grown as a sole crop.

The mean number of monopodial branches $plant^{-1}$ of cotton were 1.86, 2.14, 2.68 and 2.80 at 60, 90, 120 DAS and at harvest, respectively. Maximum number of monopodial branches $plant^{-1}$ (1.95, 2.26, 2.88 and 2.95) were recorded in sole cotton at 60, 90, 120 DAS and at harvest, respectively. Among intercropping treatments, cotton + green gram (1:1) row ratio recorded more number of monopodial branches $plant^{-1}$ 1.90, 2.20, 2.70 and 2.80 at 60, 90, 120 DAS (Table 2) and at harvest than other intercropping treatments [4]. also found that sole cotton recorded higher number of monopodial branches $plant^{-1}$ (1.90).

The mean number of sympodial branches $plant^{-1}$ of cotton were 9.34, 14.24, 17.53 and 19.18 at 60, 90, 120 DAS and at harvest, respectively. Maximum number of sympodial branches $plant^{-1}$ (9.88, 14.93, 18.40 and 20.80) were recorded in sole cotton at 60, 90, 120 DAS and at harvest, respectively. Among intercropping treatments, cotton + green gram (1:1) row ratio recorded more number of sympodial branches $plant^{-1}$ 9.42, 14.46, 17.83 and 19.13 at 60, 90, 120 DAS (Table-3) and at harvest than other intercropping treatments. Similar results were also obtained by [5, 6].

The mean dry matter $plant^{-1}$ of cotton were 7.54, 101.73, 317.31, 520.94 and 574.02 g at 30, 60, 90, 120 DAS and at harvest, respectively. Higher dry matter production $plant^{-1}$ (7.83, 108.24, 348.40, 580.12 and 640.39 g) were recorded in sole cotton at 30, 60, 90, 120 DAS and at harvest, respectively.

In intercropping systems, higher dry matter production $plant^{-1}$ (7.70, 102.84, 327.38, 540.37 and 578.15 g) were recorded in cotton + green gram (1:1) system at all intervals of observations, respectively, than the other intercropping treatments (Table 4). The lowest dry matter production $plant^{-1}$ (7.18, 97.32, 297.73, 470.82 and 537.38 g) were recorded in cotton + black gram (1:2) row ratio at all intervals of observations, respectively [7]. also observed significantly higher dry matter (40.26 g $plant^{-1}$) in sole cotton than cotton intercropped with black gram and cluster bean.

Mean dry matter $plant^{-1}$ of green gram (4.63, 9.48 and 12.81 g) and black gram (4.39, 8.66 and 10.95 g) were recorded at 30, 60 DAS and at harvest, respectively.

Sole cropping of green gram and black gram produced the highest dry matter $plant^{-1}$ at all the growth stages. In different intercropping systems, cotton + green gram (1:1) (4.43, 9.18 and 12.35 g) and cotton + black gram (1:1) row ratio (4.36, 8.64 and 10.48 g) recorded the maximum dry matter $plant^{-1}$ at 30, 60 DAS and at harvest, respectively, than the intercropping row ratio of 1:2 of each intercrop.

Table 1: Plant height of base and intercrops as influenced periodically by different treatments.

Treatments	Plant height (cm)				
	30 DAS	60 DAS	90 DAS	120 DAS	At harvest
T_1: Sole Cotton	30.12	85.25	102.20	113.00	120.25
T_2: Sole Green gram	15.00	31.25	-	-	37.93
T_3: Sole Black gram	15.60	32.46	-	-	35.46
T_4: Cotton + Green gram(1:1)	31.92 (15.20)	91.33 (32.73)	103.50	116.53	121.23 (33.73)
T_5: Cotton + Green gram(1:2)	33.10 (15.46)	94.26 (34.86)	106.50	119.53	126.56 (35.86)
T_6: Cotton + Black gram(1:1)	32.00 (14.33)	92.00 (30.06)	101.50	114.31	118.18 (32.74)
T_7: Cotton + Black gram(1:2)	32.46 (14.73)	93.73 (32.50)	104.63	117.40	124.33 (34.27)
General Mean (Cotton)	31.92	91.31	103.66	116.15	122.11
General Mean (Green gram)	15.22	32.94	-	-	35.84
General Mean (Black gram)	14.88	31.67	-	-	34.15

*Figures in para thesis denotes plant hight of intercrops.

Table 2: Number of monopodial branches $plant^{-1}$ of cotton as influenced periodically by different treatments

Treatments	No. of monopodial branches $plant^{-1}$			
	60 DAS	90 DAS	120 DAS	At harvest
T_1: Sole Cotton	1.95	2.26	2.88	2.95
T_2: Sole Green gram	-	-	-	-
T_3: Sole Black gram	-	-	-	-
T_4: Cotton + Green gram (1:1)	1.90	2.20	2.70	2.80
T_5: Cotton + Green gram (1:2)	1.82	2.08	2.61	2.75
T_6: Cotton + Black gram (1:1)	1.85	2.15	2.65	2.78
T_7: Cotton + Black gram (1:2)	1.80	2.04	2.58	2.73
General Mean	1.86	2.14	2.68	2.80

Table 3: Number of sympodial branches plant^{-1} of cotton as influenced periodically by different treatments

Treatments	No. of sympodial branches plant^{-1}			
	60 DAS	90 DAS	120 DAS	At harvest
T_1: Sole Cotton	9.88	14.93	18.40	20.80
T_2: Sole Green gram	-	-	-	-
T_3: Sole Black gram	-	-	-	-
T_4: Cotton + Green gram(1:1)	9.42	14.46	17.83	19.13
T_5: Cotton + Green gram(1:2)	9.14	13.91	17.06	18.56
T_6: Cotton + Black gram(1:1)	9.30	14.26	17.50	19.04
T_7: Cotton + Black gram(1:2)	8.98	13.66	16.87	18.38
General Mean	9.34	14.24	17.53	19.18

Table 4: Dry matter plant^{-1} of base and intercrops as influenced periodically by different treatments

Treatments	Dry matter plant^{-1} (g)				
	30 DAS	60 DAS	90 DAS	120 DAS	At harvest
T_1: Sole Cotton	7.83	108.24	348.40	580.12	640.39
T_2: Sole Green gram	5.40	10.24	-	-	14.63
T_3: Sole Black gram	4.93	9.46	-	-	12.94
T_4: Cotton + Green gram(1:1)	7.70 (4.43)	102.84 (9.18)	327.38	540.37	578.15 (12.35)
T_5: Cotton + Green gram(1:2)	7.43 (4.06)	98.40 (9.03)	302.48	493.14	550.79 (11.47)
T_6: Cotton + Black gram(1:1)	7.60 (4.36)	101.87 (8.64)	310.56	520.28	563.43 (10.48)
T_7: Cotton + Black gram(1:2)	7.18 (3.90)	97.32 (7.89)	297.73	470.82	537.38 (9.43)
General Mean (Cotton)	7.54	101.73	317.31	520.94	574.02
General Mean (Green gram)	4.63	9.48	-	-	12.81
General Mean (Black gram)	4.39	8.66	-	-	10.95

* Figures in para thesis denotes dry matter of intercrops.

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