Growth and yield response of *deshi* cotton to skip row planting in combination with intercrops

ABSTRACT

This study aims to assess the performance of *deshi* cotton in skip row planting with different intercrops of green gram, black gram, sesamum, soybean and pearl millet. The experiment was laid out in randomized block design with seven treatments and three replications. Field experiment was carried out during the *kharif* season of 2018-19 at Post Graduate Research Farm,College of Agriculture,Mahatma Phule Krishi Vidyapeeth,Rahuri, Maharashtra. Measurements were taken for growth parameters (plant height, leaf area plant^{-1}, Number of sympodial branches and dry matter accumulation) and yield components (number of picked bolls plant^{-1}, weight of seed cotton boll^{-1}, yield of seed cotton and stalk ha^{-1}) of *deshi* cotton. Results showed that plant height of cotton was influenced due to different intercrops at 60 DAS, except at 30 DAS. Intercrops *viz.,* green gram, black gram, soybean and sesamum did not show any influence on plant height of cotton. However, pearl millet reduced plant height of cotton drastically and shown its dominance.Similar trend was observed in respect of leaf area plant^{-1} of cotton as regards to pearl millet.Dry matter accumulation in cotton was influenced during flowering stage only. Planting cotton with solid sole and sole skip row techniques resulted in better dry matter accumulation. Cotton grown as either sole or with intercrops recorded similar total number of picked bolls of cotton. Average weight of seed cotton boll^{-1} was higher in skip row planting of cotton + sesamum (2:1). Sole skip row planting of cotton registered the highest seed cotton yield (1966.48 kg ha^{-1}).Skip row planting of cotton + sesamum (2:1) recorded highest stalk yield (2828.54 kg ha^{-1}). It can be concluded that the growth and yield parameters of Deshi cotton drastically reduced when intercropped with pearl millet compared to other intercrops, and it is advisable to avoid intercropping hybrid pearl millet with cotton.

Keywords:*Deshi cotton, Growth, intercrops, pearl millet, yield*

1.INTRODUCTION

Cotton is a crucial fiber and cash crop in India, significantly influencing both the industrial and agricultural economy of the nation. It supplies the essential raw material (cotton fiber) to the cotton textile industry.In India, the cotton sector directly sustains 6 million farmers and engages roughly 40-50 million people in cotton trading and processing.

In India, ten major cotton-producing states are grouped into three zones, viz. north zone, central zone and south zone. North zone consists of Punjab, Haryana and Rajasthan. Central zone comprises Madhya Pradesh, Maharashtra, and Gujarat. The South zone consists of Andhra Pradesh, Telangana, Karnataka, and Tamil Nadu.Beyond these ten states, cotton cultivation is also growing in the eastern state of Orissa. Cotton is also grown in limited areas of non-traditional states like Uttar Pradesh and West Bengal and Tripura.

Among techniques, planting pattern stands out as a critical factor influencing the efficient use of natural resources to enhance cotton production. Skip row planting increased the yield than conventional planting and also made available the space for growing intercrops without sacrificing the plant population of base crop [2]. Skip row system not every row is planted, thus creating skips in an established pattern. Potential economic benefits of skip-row planting encompass lower costs along the rows, including savings on seed, in-furrow insecticides and fungicides, starter fertilizers, and banded herbicides. Savings in field time associated with planting and harvesting with skip row production may subsequently accrue since fewer actual acres are farmed.

A large number of crops belonging to different groups are grown as intercrops in cotton in India. However, legumes and some oilseed crops are better adapted to rainfed farming because of better root development enabling them to extract moisture from deep soil layers. Legumes are preferred for

their role of fixing atmospheric nitrogen and maintaining soil fertility. In an intercropping system involving a legume and non-legume, part of nitrogen fixed in the root nodule of the legume may become available to non-legume component. These crops intercept light energy more efficiently resulting in higher total production. Crop with differing rooting patterns and root growths can tap available plant nutrients from different soil layers more evenly. Period of critical and peak water requirements vary in different crops and therefore even limited moisture supply is better utilized by component crops in this system. It is common observation that thick canopy of the intercrop suppresses the weed growth at least partially and thus infestation by weeds is reduced. There is evidence that shedding of fruiting parts of cotton caused by insect attack is less in plots intercropped with some legume crops [6].

While designing new cropping systems involving cotton as principal component, overall productivity and profitability must be considered against the sole cotton crop. Inclusion of legumes should be one of the main considerations as these can enrich the soil by fixing atmospheric nitrogen on addition of organic matter and can make efficient land use. Short duration varieties with higher yield potential should be selected to suit the local agro-climatic condition. These varieties should be amenable to high plant density, should be more responsive to input factors and tolerant to certain insect-pests and diseases. Such genotypes can be ideal choice for development of new cropping system. The total productivity of the system depends upon how efficient are the component crops in utilizing environmental and natural resources and other available inputs and to what extent they complement each other over a period of growth duration. Wide variety of crops like cereals, legume grains, oilseeds, etc. may be grown as intercrop in cotton. However, choice of crops are determined primarily by the duration of crops, length of growing season, amount, intensity and distribution of rainfall, soil types etc. Short and compact growing crops completing their growth within 90 days can fit well in intercropping system with cotton. Intercropping is such a potential system through which a number of short durations, wide adaptable, deep rooted, drought resistant pulse and oilseed crops can be grown successfully in association with the main crop of a region. Legumes like green gram, black gram due to their short duration, drought tolerant habit are most suitable in intercropping with cotton. Among many oilseed crops, sesame preferred due to their better adaptation in rainfed condition.

2. MATERIALS AND METHODS

Field experiment was conducted at Post Graduate Research Farm, Agronomy Section, College of Agriculture, Dhule, Maharashtra during *kharif* season of 2018-19 under rainfed conditions.This is situated in Scarcity Agro-climatic Zone of Maharashtra. Climatologically, this area falls under the sub-tropical region at the North. It is situated on latitude 20.4^0 N and longitude 74^0 E with an altitude of 258 m above mean sea level.The average annual rainfall is 607 mm, mostly received in 38 rainy days in year. The mean maximum and minimum temperature were 46.6 and 6.8^0C, respectively with maximum 8.4 bright sunshine hours.

The experiment was laid out in randomized block design with seven treatments and three replications with gross and net plot size of 3.60 X 4.50 m^2 and 2.70 X 3.60 m^2, respectively. The seven treatments consisted of T_1: Sole cotton, T_2: Sole skip row planting of cotton, T_3: Skip row planting of cotton + intercropping of green gram (2:1), T_4: Skip row planting of cotton + intercropping of black gram (2:1), T_5: Skip row planting of cotton + intercropping of soybean (2:1), T_6: Skip row planting of cotton + intercropping of sesamum (2:1) and T_7: Skip row planting of cotton + intercropping of pearl millet (2:1).

In the experiment, *deshi* cotton variety JLA-505, green gram variety BM 2003-02, black gram variety TAU-1, soybean variety JS-335, sesamum variety JLT-408, and pearl millet hybrid Adishakti were used. Recommended dose of fertilizer of *deshi* cotton (50:25:25 N: P_2O_5: K_2O kg ha^{-1}) was applied to all the treatments. In additional treatments, recommended dose of fertilizer viz., 20:40:00 N:P_2O_5:K_2O kg ha^{-1} was applied to sole green gram and black gram, sole soybean (50:75:45 N:P_2O_5:K_2O kg ha^{-1}), sole sesamum (50:00:00 N:P_2O_5:K_2O kg ha^{-1}), sole pearl millet (50:25:25 N:P_2O_5:K_2O kg ha^{-1}). Fertilizers were applied through the source of urea, single super phosphate and muriate of potash.

Table 1. Treatment details of the experiment

Treatmentnumber	Treatment details
T_1	Sole cotton at 45 x 22.5 cm spacing
T_2	Sole skip row planting of cotton at 45 x 15 – 90 – 45 x 15 cm (One row skip after every two rows)
T_3	Skip row planting of cotton at 45 x 15 – 90 – 45 x 15 cm + Intercropping of green gram (2:1)
T_4	Skip row planting of cotton at 45 x 15 – 90 – 45 x 15 cm + Intercropping of black gram (2:1)
T_5	Skip row planting of cotton at 45 x 15 – 90 – 45 x 15 cm + Intercropping of soybean (2:1)
T_6	Skip row planting of cotton at 45 x 15 – 90 – 45 x 15 cm + Intercropping of sesamum (2:1)
T_7	Skip row planting of cotton at 45 x 15 – 90 – 45 x 15 cm + Intercropping of pearl millet (2:1)

The initial plant population was calculated by taking actual plant count from each net plot immediately after thinning and final plant count was recorded before harvest of the crop. The number of plants per hectare was computed from the number of plants per net plot.The height of five randomly chosen plants was recorded. The measurement was made from base of plant to the base of growing tip at 30 and 60 DAS.The functional leaves of plant uprooted for dry matter studies were removed and classified into three groups viz. big, medium and small. One representative leaf from each group was selected and leaf area was measured with the help of Leaf Area Meter. The actual leaf area then calculated by multiplying the number of leaves in each group and then by addition of all group area, final leaf area per plant was recorded.The number of sympodial branches was counted from the randomly selected five plants and recorded at 30 and 60 DAS.One representative plant from border lines was uprooted randomly and kept in labeled brown paper bags. The samples were dried first in sunlight and then in oven at 60^0C for 24 hours and weighted at 30 and 60 DAS.Number of picked bolls was recorded from each observation plant at I, II, III picking.The weight of seed cotton from ten bolls was taken and average weight was calculated at each picking.The weight of seed cotton from all picking from net plot was recorded and calculated to yield of seed cotton kilogram ha^{-1}. The cotton stalks were cut from the net plot area of each treatment and dried in the sunlight and the weight was recorded. The stalk yield ha^{-1} was worked out.

A statistical method of analysis of variance and interpretation of data as suggested by [3] for randomized block design. Standard error of mean (SEm) was worked out for each factor. Whenever the results were significant, the critical difference (C.D.) at 5% level of significance was work out and presented.

3. RESULTS AND DISCUSSION

3.1 Growth parameters

3.1.1 Initial and final plant count of*deshi*cotton

The initial count and plant stand at harvest of cotton were not influenced significantly. Plant population in skipped row planting was maintained as in solid sole cropping by reducing plant to plant spacing, hence, there was no significant difference in plant population.

3.1.2 Plant height

The rate of increase of plant height was rather slow up to 30 DAS but increased abruptly at 60 DAS. The plant height was significantly affected due to treatments at all stages of crop growth, except at 30 DAS. At 60 DAS, sole skip row planting of cotton recorded significantly higher plant height than skip row planting of cotton + pearl millet (2:1), however, it was on par with the rest of the treatments.

This might be due to availability of optimum space to utilize the soil and environmental resources to the maximum extent due to less competition among crop plants. However, adverse effect of pearl

millet may be due to its dominance and hybrid nature. [5] concluded that more plant height was from skip row spacing as compared to regular row spacing of the same plant population.

Table 2. Initial and at harvest plant count and plant height of *deshi*cotton as influenced by different treatments

	Plantpopulationha^{-1}		Plant height (cm)	
Treatments	**Initial**	**At harvest**	**30 DAS**	**60 DAS**
T_1:Sole cotton	97394	92935	29.72	104.93
T_2:Sole skip row planting of cotton	97394	92249	32.20	114.93
T_3: Skip row planting of cotton + green gram (2:1)	97051	92935	29.69	104.13
T_4: Skip row planting of cotton + black gram (2:1)	96365	92249	27.78	105.93
T_5: Skip row planting of cotton + soybean (2:1)	96708	93621	29.77	108.67
T_6: Skip row planting of cotton + sesamum (2:1)	97736	94650	29.79	113.33
T_7: Skip row planting of cotton + pearl millet (2:1)	96708	91907	27.69	76.40
SEm ±	493.57	908.87	1.40	4.12
CD (P=0.05)	NS	NS	NS	12.68

DAS: Days After Sowing

3.1.3 Leaf area plant^{-1}

Leaf area plant^{-1} was significantly influenced due to different treatments except at 30 DAS. At 60 DAS, sole cotton recorded significantly the highest leaf area plant^{-1}than skip row planting of cotton + pearl millet (2:1) and skip row planting of cotton + green gram (2:1), however, it was on par with rest of the treatments.

Pearl millet intercropped in cotton severely competed with it and reduced its leaf area plant^{-1} to a greater extent. This may be due to the exhaustive nature of hybrid pearl millet. [7]indicated that the different treatments examined showed that the leaf area per plant was greater in sole cotton than in the other treatments.

3.1.4 Number of sympodial branches

Number of sympodial branches was significantly influenced due to different treatments. At 60 DAS, sole skip row planting of cotton recorded significantly the highest number of sympodial branches plant^{-1} than the skip row planting of cotton + pearl millet (2:1), however, it was comparable to the other treatments. Increase in height might have increased the number of sympodial branches. [4] observed that sympodial reduced significantly by intercropping of sesamum, groundnut or soybean, but not due to green gram, black gram or cowpea during 2004 and 2005.

3.1.5 Dry matter accumulation

Dry matter accumulation was found to be non significantat 30 DAS. At 60 DAS, higher dry matter plant^{-1} was observed in sole cotton than skip row planting of cotton + green gram (2:1), skip row planting of cotton + black gram (2:1), skip row planting of cotton + soybean (2:1) and skip row planting of cotton + sesamum (2:1), however, it was on par with sole skip row planting of cotton. Higher dry matter accumulation in sole cotton may be due to extended leaf area and early flowering. However, no pronounced effect of intercrops was observed on dry matter accumulation plant^{-1}. It may due to no excessive vegetative growth under rainfed condition.

Table 3. Growth parameters of *deshi*cotton as influenced bydifferent treatments

Treatments	Leaf area plant^{-1} (d cm^2)		No. of sympodial branches plant^{-1}	Dry matter plant^{-1} (g)	
	30 DAS	60 DAS	60 DAS	30 DAS	60 DAS
T_1:Sole cotton	20.27	151.64	12.93	2.33	32.67
T_2:Sole skip row planting of cotton	21.27	129.34	13.93	2.87	25.20
T_3:Skip row planting of cotton + green gram (2:1)	21.13	123.64	12.80	2.27	21.27
T_4:Skip row planting of cotton + black gram (2:1)	22.44	134.21	13.13	2.73	22.93
T_5:Skip row planting of cotton + soybean (2:1)	20.06	131.54	12.27	2.20	22.13
T_6:Skip row planting of cotton + sesamum (2:1)	23.56	139.50	13.47	3.13	20.87
T_7:Skip row planting of cotton + pearl millet (2:1)	22.80	91.34	8.27	2.80	15.07
SEm ±	2.05	7.46	0.70	0.28	2.75
CD (P=0.05)	NS	22.99	2.15	NS	8.47

DAS: Days After Sowing

3.2 Yield parameters

3.2.1 Number of picked bolls plant^{-1}

Number of picked bolls plant^{-1} was significantly influenced by different treatments, except at third picking. At first picking, sole skip row planting of cotton recorded significantly the highest number of picked bolls (8.40) than the skip row planting of cotton + soybean (2:1) and skip row planting of cotton + pearl millet (2:1). The second-best treatment was sole cotton; however, it was on par with the skip row planting of cotton + green gram (2:1), skip row planting of cotton + black gram (2:1) and skip row planting of cotton + sesamum (2:1). At second picking, skip row planting of cotton + black gram (2:1) recorded significantly the highest number of picked boll (3.60) than the sole cotton, sole skip row planting of cotton and skip row planting of cotton + pearl millet (2:1), however, it was on par with the rest of the treatments. The highest total number of picked bolls per plant (12.91) was recorded in the sole skip row planting of cotton compared to the skip row planting of cotton and pearl millet (2:1), however, it was comparable to the other treatments. This may be due tomore number of sympodial branches and no competition as being sole crop. Minimum number of picked boll plant^{-1} was observed in skip row planting of cotton + pearl millet (2:1). This was ascribed to an intensive competition between main crop (cotton) and intercrop (pearl millet) for the factor such as water, nutrient, light etc. required for overall growth.[7] indicated that treatments of sole cotton recorded significantly higher number of picked bolls per plant.

3.2.2 Weight of seed cotton boll^{-1}

Weight of seed cotton boll^{-1} was not influenced significantly due to different treatments at all pickings, except at average weight of seed cotton boll^{-1}. In average weight of seed cotton, skip row planting of cotton + sesamum (2:1) recorded significantly higher weight of seed cotton boll^{-1} than the sole cotton, sole skip row planting of cotton, skip row planting of cotton + black gram (2:1), skip row planting of cotton +soybean (2:1) and skip row planting of cotton + pearl millet (2:1), however, it was at par with the skip row planting of cotton + green gram (2:1). The lowest weight of seed cotton boll^{-1} was recorded in the skip row planting of cotton + soybean (2:1), possibly due to increased competition with the main crop (cotton) and intercrop (soybean) for longer duration.

Table 4. Number of picked bolls plant^{-1} of *deshi*cotton as influenced by different treatments

Treatments	Number of picked of bolls plant^{-1}			
	I Picking	II Picking	III Picking	Total no. of picked bolls
T_1: Sole cotton	8.07	2.08	0.53	10.68
T_2:Sole skip row planting of cotton	8.40	2.51	2.00	12.91
T_3:Skip row planting of cotton + green gram (2:1)	7.07	2.80	2.87	12.73
T_4:Skip row planting of cotton + black gram (2:1)	7.27	3.60	1.43	12.30
T_5:Skip row planting of cotton + soybean (2:1)	5.73	2.87	2.33	10.93
T_6:Skip row planting of cotton + sesamum (2:1)	7.47	3.30	2.00	12.77
T_7:Skip row planting of cotton + pearl millet (2:1)	2.72	1.80	2.53	7.05
SEm ±	0.74	0.35	0.70	1.16
CD (P=0.05)	2.29	1.09	NS	3.56

DAS: Days After Sowing

Table 5. Weight of seed cotton boll^{-1} at each picking as influenced by different treatments

Treatments	Weight of seed cotton boll^{-1} (g)			
	I Picking	II Picking	III Picking	Average
T_1: Sole cotton	2.11	2.03	1.56	1.90
T_2:Sole skip row planting of cotton	2.10	1.90	1.54	1.84
T_3:Skip row planting of cotton + green gram (2:1)	2.25	2.01	1.58	1.95
T_4:Skip row planting of cotton + black gram (2:1)	2.12	1.89	1.49	1.83
T_5:Skip row planting of cotton + soybean (2:1)	2.08	1.93	1.33	1.78
T_6:Skip row planting of cotton + sesamum (2:1)	2.19	1.98	1.97	2.05
T_7:Skip row planting of cotton + pearl millet (2:1)	1.93	1.93	1.64	1.83
SEm ±	0.70	0.10	0.11	0.05
CD (P=0.05)	NS	NS	NS	0.14

DAS: Days After Sowing

3.2.3 Yield of *deshi*seed cotton hectare^{-1}

Different treatments significantly influenced the yield of seed cotton ha^{-1}. The highest seed cotton yield (1966.48 kg ha^{-1}) was recorded in the sole skip row planting of cotton, which was significantly greater than the yield from skip row planting of cotton and pearl millet (2:1) (925.70 kg ha^{-1}), however, it was on par with the sole cotton, skip row planting of cotton + green gram (2:1), skip row planting of cotton + black gram (2:1), skip row planting of cotton + soybean (2:1) and skip row planting of cotton + sesamum (2:1). The greatest reduction in seed cotton yield per hectare (52.9%) was noted in the skip row planting of cotton + pearl millet (2:1). This was attributed to the significant shading effect of the fast-growing pearl millet on the cotton at an early stage, leading to taller plants and potentially due to the inter-specific competition from pearl millet on cotton.[1] reported that the seed cotton yields from skip row pattern were significantly higher than solid and paired treatments.

3.2.4 Yield of stalk hectare^{-1}

Yield of stalk kg ha^{-1} was significantly influenced by different treatments. Skip row planting of cotton + sesamum (2:1) (2828.54 kg ha^{-1}) recorded significantly higher yield of stalk than the skip row

planting of cotton + pearl millet (2:1) (1168.73 kg ha^{-1}), however, it was on par with the sole cotton, sole skip row planting of cotton, skip row planting of cotton + green gram (2:1), skip row planting of cotton + black gram (2:1), skip row planting of cotton + soybean (2:1). The next most effective treatment was the sole skip row planting of cotton. Wankhade *et al.* (2000) found that straw yield was significantly higher in cotton + soybean intercropping than cotton + black gram and cotton + green gram intercropping systems.

Table 6.Yield of seed cotton and stalk of cotton as influenced by different treatments

Treatments	Yield ofseed cotton (kg ha^{-1})	Yield ofstalk (kg ha^{-1})
T_1: Sole cotton	1869.45	2720.17
T_2:Sole skip row planting of cotton	1966.48	2811.39
T_3:Skip row planting of cotton + green gram (2:1)	1895.21	2704.06
T_4:Skip row planting of cotton + black gram (2:1)	1906.37	2637.53
T_5:Skip row planting of cotton + soybean (2:1)	1827.37	2606.66
T_6:Skip row planting of cotton + sesamum (2:1)	1862.27	2828.54
T_7:Skip row planting of cotton + pearl millet (2:1)	925.70	1168.73
SEm ±	79.20	136.20
CD (P=0.05)	244.01	419.66

DAS: Days After Sowing

4. CONCLUSION

Sole skip row planting of *deshi* cotton did not show any significant influence on growth and yield of cotton as compared to sole cotton, however, ease in picking of seed cotton and created space for growing intercrop in skipped row. Performance of *deshi* cotton in respect of growth and yields was better with green gram, black gram and sesamum as compared to soybean and pearl millet. Intercropping of hybrid pearl millet may be avoided with cotton.

REFERENCES

1. Brashears AD, BilbroJD.Production of dryland cotton under skip row, double row planting patterns. 112 cotton Res. USA cotton and Tropical Fibres Abst.1981;6 (10):149.
2. Khan MB, Akhtar M, KhaliqA. Effect of Planting Patterns and Different Intercropping Systems on the Productivity of Cotton (*Gossypium hirsutum L*.) Under Irrigated Conditions of Faisalabad. International Journal of Agriculture & Biology.2001;3 (4): 432-435.
3. Panse VG,SukhatmePV. Statistical method for Agriculture workers, Revised Edn. ICAR New Delhi. 1995.
4. Reddy PR. Planting techniques and intercropping studies in cotton. Indian Journal of Agriculture Sciences.2006;60 (2): 112-114.
5. Sharma JK, KhampariaSK,ParsalGS,MishtraUS,MandloiKC.Performance of cotton genotype in relation of spacing and fertility levels in East Nimar. Journal of Cotton Research and Development.2000;14 (2):235-237.
6. Sheshadri V, NatarajanK. Effect of different intercrops on the growth and yield of cotton (*Gossypium hirsutum L*.) and their economics. Indian Journal of Agriculture Science.1989;59 (4): 227-230.
7. Singh G, ChoudharyP, SainiD, Lal JatB. Effects of legume intercrops on growth, yield and economics of hybrid American cotton under controlled condition, Department of Agriculture, Bhagwant University Ajmer, Rajasthan. Global Journal of Bio-Science and Biotechnology. 2017;6(1): 61-82.
8. Wankhade ST,TurkhedeAB, SolankeVM,MalviSD,KatkarRN. Effect of intercropping on yield of cotton. Crop Research.2000;19 (3): 409-413.