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Productivity and Soil Nutrients in Skip Row Planting of *Deshi* Cotton with Various Intercrops under Rainfed Conditions

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ABSTRACT

The study entitled "Productivity and soil nutrient dynamics in skip row planting of *deshi* cotton with various intercrops" was conducted at Post Graduate Research Farm, Agronomy Section, College of Agriculture, Dhule (Maharashtra) during *kharif* season of 2018-19. The results revealed that sole skip row planting of cotton registered the highest seed cotton yield (₹1966.48 kg ha^{-1}) than skip row planting of cotton + pearl millet (2:1) (₹925.70 kg ha^{-1}), however, it is on par with rest of the treatments. Similar trend was observed in respect of yield of stalk kg ha^{-1}. There was a drastic reduction in seed cotton yield ha^{-1} due to pearl millet intercropping (52.9 %) as compared to sole skip row planting of cotton. The least yield reduction in cotton was observed with black gram (3.06%) and green gram (3.62%) as intercrops.The cost of cultivation of skip row planting of cotton + pearl millet (2:1) is higher (₹40491ha^{-1}) and minimum cost of cultivation (₹37596 ha^{-1}) was recorded in sole cotton and sole skip row planting of cotton. The highest gross monetary returns (₹112960 ha^{-1}), net monetary returns (₹73546 ha^{-1}) and B:C ratio (2.87) were obtained with the skip row planting of cotton + green gram (2:1). Skip row planting of cotton + pearl millet (2:1) recorded lowest gross returns (₹69079ha^{-1}), net returns (₹28588 ha^{-1}) and B:C ratio (1.71). The available soil nitrogen content was significantly higher in skip row planting of cotton+ green gram (2:1) at 178.75 kg ha^{-1}. The available phosphorus content was higher in skip row planting of cotton + soybean (2:1) at 29.89 kg ha^{-1} and the available potassium content was higher in skip row planting of cotton and black gram (2:1) at 248.80 kg ha^{-1}). Minimum available nitrogen (144.25 kg ha^{-1}), phosphorus (16.08 kg ha^{-1}) and potassium (224.93 kg ha^{-1}) content was observed in the skip row planting of cotton + pearl millet (2:1).

Key words: *Economics, Intercrops, Soil nutrients, Yield*

Introduction

Cotton (*Gossypium* spp.) is among the most significant commercial fiber crops globally. It is a cash crop grown in over 80 countries, with major producers including China, India, the United States, Brazil, and Pakistan. The fiber derived from cotton serves various purposes, with its primary use being in the textile industry to produce clothing. Since the beginning of civilization, cotton has fulfilled the need for clothing and continues to be dominant despite the presence of numerous synthetic fibers in the market. Often referred to as the "King of Fibers" and "White Gold," cotton maintains its crucial role in textile manufacturing.

Cotton seed is used for extraction of oil. Oil content ranges from 15-25 per cent. Cotton seed cake after extraction of oil is good organic manure con-

tains 6.4, 2.9 and 2.2 per cent N, P and K, respectively. Cottonseed and cotton pulp from oil extraction, along with cottonseed meal, are excellent concentrated feeds for cattle. Thus, cotton plays important role in farmers financial position as well as national economy. India is the first largest producer and the second largest consumer of cotton in the world. Cotton has share of Indian agricultural output nearly 2-5 per cent. Cotton provides 68 per cent raw material to the Indian textile industry and gainful employment to millions of people in the country who are engaged in its cultivation, trading, processing, manufacturing, fabricating and marketing.

The Deshi cotton varieties are good yielders and requires minimal chemical inputs like fertilizers and pesticides to achieve yields comparable to or better than American cotton. Thus, the cost of cultivation is less than Bt-cotton hybrids. *Deshi* varieties are highly tolerant to drought, salinity, diseases and a range of insect pests including the bollworms. *Deshi* cotton varieties are deep rooted.

Cotton is the major crop grown in the vertisols of central India occupying about 5×10^6 ha. Low soil fertility significantly contributes to the reduced crop productivity. The significant risk associated with rainfed agriculture is the primary reason for the lack of investment in fertilizer and/or manure. The significance of nitrogen fertilizer on the growth and yield of cotton is widely recognized. Potassium is abundant in the cotton-growing vertisols and is typically excluded from fertilizer recommendations. The response to phosphorus has also been variable. Cotton-growing farmers typically use only nitrogen fertilizers. However, the application of potassium has been noted to enhance fiber quality. Recently, integrated nutrient management, which combines organic manure and chemical fertilizer, has garnered significant attention (Wagh *et al*., 2016).

Materials and Methods

The research was conducted during *kharif* season of 2018-19 under rainfed conditions at Post Graduate Research Farm, Agronomy Section, College of Agriculture, Dhule (Maharashtra) is situated in Scarcity Agro-climatic Zone of Maharashtra. Climatologically, this area falls under the sub-tropical region at the North. The onset of monsoon was in 25th meteorological week. The data indicated that the maximum temperature ranged between 29.1 to 36.7^{0}C and minimum temperature ranged between 11.3 to 24.6^{0}C. The relative humidity during morning and evening ranged from 53 to 89.4 and 16.9 to 77.4 per cent, respectively. The total rainfall of 315.20 mm was received in 19 days during the experimentation, which was 52 per cent of the annual normal rainfall. The sunshine hours ranged between 00.3 to 08.6 hours. The distribution of rainfall was uniform from the month of June to August. However, there was a complete dry spell from September onwards which affected the growth of both base and intercrops. Hence, life saving irrigation was applied to the experimental crop in first week of October. High humidity in the month of July and August created major incidence of sucking pest, hence, recommended plant protection measures were under taken. In general, the *kharif* season was abnormal, short of total rainfall and ill distribution of rain.

The topography of the experimental field was uniform leveled and well drained. The soil of experimental field was clayey in nature. Composite soil sample was collected at 0 to 30 cm depth from experimental field before laying out of the experiment. The experimental site soil was clay in texture, low in available nitrogen (168.25 kg/ha), moderately high in available phosphorus (26.88 kg/ha) and high in available potassium (235.20 kg/ha) content and moderately alkaline in reaction (pH 7.5) electrical conductivity of 0.33 ds/m.

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). *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 in the experiment. Application of organic manure was done through farmyard manure @ 7.5 tones ha^{-1} before last harrowing. The recommended dose of fertilizer of cotton *viz*., 50:25:25 N:P_2O_5:K_2O kg ha^{-1} was applied to all the treatments. In additional treatments, recommended fertilizer doses for sole crop of green gram (20:40:00 N:P_2O_5:K_2O kg ha^{-1}), black gram (20:40:00

$N:P_2O_5:K_2O$ kg ha^{-1}), soybean (50:75:45 $N:P_2O_5:K_2O$ kg ha^{-1}), sesamum (50:00:00 $N:P_2O_5$: K_2O kg ha^{-1}), pearl millet (50:25:25 $N:P_2O_5:K_2O$ kg ha^{-1}**)** and skip row planting with intercrops (50:25:25 $N:P_2O_5:K_2O$ kg ha^{-1}) were applied in the form of urea, single super phosphate and muriate of potash. Nitrogen was applied in two splits for cotton and full dose of phosphorus and potassium as basal dose.

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. Treatment wise cost of cultivation was worked out by addition of all the cost incurred towards purchasing of various inputs, cost incurred towards mechanical operations and labor charges. Gross monetary returns ha^{-1} accrued due to different treatments in the present study, were worked out by considering prices during the experimental year. Net monetary returns (₹ha^{-1}) of each treatment were worked out by deducting the mean cost of cultivation (₹ha^{-1}) of each treatment from the gross monetary returns (₹ha^{-1}) gained from the respective treatment.The benefit: cost ratio was worked out by using the following formula.

$$\text{Benefit : Cost ratio} = \frac{\text{Gross monetary returns (₹ha}^{-1}\text{)}}{\text{Cost of cultivation (₹ha}^{-1}\text{)}}$$

Composite soil samples from 0-30 cm soil depth from each net plot were collected before sowing and after harvest of main crop (cotton) for estimation of available nitrogen, phosphorus and potassium content of soil. Available nitrogen was measured using the alkaline permanganate method, available phosphorus was assessed by Olsen's method, and available potassium was determined by a flame photometer (Jackson, 1973).

A statistical method of analysis of variance and interpretation of data as suggested by Panse and Sukhatme (1995) 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 worked out and presented.

Results and Discussion

Yield of seed cotton hectare^{-1}

Different treatments significantly influenced the yield of seed cotton $ha^{-1}$is presented in Table 1. Sole skip row planting of cotton (1966.48 kg ha^{-1}) resulted in a significantly higher seed cotton yield compared to skip row planting of cotton + pearl millet (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 maximum reduction (52.9 %) in seed cotton yield ha^{-1} was observed in skip row planting of cotton + pearl millet (2:1) which was ascribed to much shading effect of pearl millet on adjacent cotton is due to its rapid early-stage growth, leading to taller plants, and possibly due to the interspecific competition between pearl millet and cotton. Kote *et al.* (2007) studied that cotton intercropped with black gram produced higher seed cotton yield than cotton intercropped with soybean. However, Buriro *et al.* (2018) reported that intercropping systems reduced the seed cotton yield to a significant extent as compared to cotton alone.

Yield of stalk hectare^{-1}

Yield of stalk kg ha^{-1} was significantly influenced by different treatments presented in Table 1. 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 second 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.

Cost of cultivation

The cost of cultivation of skip row planting of cotton + pearl millet (2:1) is higher (₹40491ha^{-1}) followed by skip row planting of cotton + soybean (2:1) (40315 ha^{-1}). The minimum cost of cultivation (₹37596 ha^{-1}) was recorded in sole cotton and sole skip row planting of cotton (Table 1).

Gross monetary returns

Data presented in Table 1 revealed that the highest gross monetary returns of ₹112960 ha^{-1} was obtained

with skip row planting of cotton + green gram (2:1) than sole cotton and skip row planting of cotton + pearl millet (2:1), however, it was on par with the skip row planting of cotton + black gram (2:1) (107873 ha^{-1}), skip row planting of cotton + soybean (2:1) (102082 ha^{-1}), skip row planting of cotton + sesamum (2:1) (105859 ha^{-1}) and sole skip row planting of cotton (101274 ha^{-1}). The lowest gross monetary returns (69079 ha^{-1}) was noted in skip row planting of cotton + pearl millet (2:1). Vekariya *et al.* (2015) also reported that higher gross monetary returns when cotton was intercropped with green gram (21720 ha^{-1}) followed by cotton + black gram (20485 ha^{-1}). However, returns were the lowest in sole cotton (16697 ha^{-1}).

Net monetary returns

Net monetary returns ha^{-1} was significantly influenced by different treatments presented in Table 1. Skip row planting of cotton + green gram (2:1) recorded significantly the highest (73546 ha^{-1}) net monetary returns than sole cotton (58681 ha^{-1}) and skip row planting of cotton + pearl millet (2:1) (28588 ha^{-1}), however, it was on par with the skip row planting of cotton + black gram (2:1) (68623 ha^{-1}), skip row planting of cotton + sesamum (2:1) (67208 ha^{-1}), skip row planting of cotton + soybean (2:1) (61767 ha^{-1}) and sole skip row planting of cotton (63678 ha^{-1}). The minimum net monetary returns (28588 ha^{-1}) was recorded in skip row planting of cotton + pearl millet (2:1).

Higher net monetary returns were obtained in skip row planting of cotton + green gram (2:1) was mainly due to higher economic yield and better price structure for cotton and green gram. Solunke *et al.* (2011) observed that intercropping of Bt cotton + green gram (1:1) gave maximum net monetary returns (₹23151 ha^{-1}) than sole Bt cotton (₹10075 ha^{-1}). Asewar *et al.* (2008) also found similar results in respect of Bt cotton + green gram intercropping systems.

Benefit: Cost ratio

The benefit: cost ratio was significantly influenced by different treatments is presented in Table 1. The highest B:C ratio (2.87) was recorded in the skip row planting of cotton + green gram (2:1) followed by skip row planting of cotton + black gram (2:1) (2.75). Minimum B:C ratio was observed in the skip row planting of cotton + pearl millet (2:1) (1.71). Higher B:C ratio was obtained in skip row planting of cotton + green gram (2:1) and skip row planting of cotton + black gram (2:1) may be attributed to the good market prices with lower cost of cultivation.

Soil nutrient status

The available soil nitrogen content was significantly higher in skip row planting of cotton + green gram (2:1) (178.75 kg ha^{-1}) than rest of the treatments presented in Table 2. Skip row planting of cotton + black gram (2:1) (170.18 kg ha^{-1}) and skip row planting of cotton + soybean (2:1) (169.03 kg ha^{-1}) were at par with each other. Minimum available nitrogen content was observed in the skip row planting of cotton + pearl millet (2:1) (144.25 kg ha^{-1}). Solunke *et al.* (2011) observed that nitrogen status in soil increased with all legume intercropping treatments compared to sole Bt cotton. Singh and Singh (2015) observed that the available nitrogen content in the soil after harvesting of Bt cotton remained statisti-

Table 1. Yield and economics of cotton as influenced by different treatments

Treatments	Yield of seed cotton (kg ha^{-1})	Yield of stalk (kg ha^{-1})	Cost of cultivation (₹ha^{-1})	Gross monetary return (₹ha^{-1})	Net monetary return (₹ha^{-1})	B:C Ratio (Cotton + Intercrop)
T_1: Sole cotton	1869.45	2720.17	37596	96277	58681	2.56
T_2: Sole skip row planting of cotton	1966.48	2811.39	37596	101274	63678	2.69
T_3: Skip row planting of cotton + green gram (2:1)	1895.21	2704.06	39414	112960	73546	2.87
T_4: Skip row planting of cotton + black gram (2:1)	1906.37	2637.53	39250	107873	68623	2.75
T_5: Skip row planting of cotton + soybean (2:1)	1827.37	2606.66	40315	102082	61767	2.53
T_6: Skip row planting of cotton + sesamum (2:1)	1862.27	2828.54	38651	105859	67208	2.74
T_7: Skip row planting of cotton + pearl millet (2:1)	925.70	1168.73	40491	69079	28588	1.71
SEm±	79.20	136.20	-	4334	4334	-
CD (P= 0.05)	244.01	419.66	-	13352	13352	-

SEm- Standard error of the mean; CD - Critical Difference

Table 2. Available N, P and K content in soil at harvest as influenced by different treatments

Treatments	Available nitrogen (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})
T_1: Sole cotton	159.93	19.92	233.77
T_2: Sole skip row planting of cotton	151.88	17.45	228.73
T_3: Skip row planting of cotton + green gram (2:1)	178.75	27.76	240.77
T_4: Skip row planting of cotton + black gram (2:1)	170.18	23.29	248.80
T_5: Skip row planting of cotton + soybean (2:1)	169.03	29.89	238.53
T_6: Skip row planting of cotton + sesamum (2:1)	162.75	22.25	242.23
T_7: Skip row planting of cotton + pearl millet (2:1)	144.25	16.08	224.93
SEm±	2.36	1.18	2.29
CD (P= 0.05)	7.27	3.63	7.07
Initial soil nutrient status	168.25	26.88	235.20

SEm- Standard error of the mean; CD - Critical Difference

cally similar among all the intercropping systems except when Bt cotton intercropped with fodder pearl millet, which recorded significantly low available nitrogen content in soil.

Available soil phosphorus content was significantly more in skip row planting of cotton + soybean (2:1) (29.89 kg ha^{-1}) than rest of the treatments, however, it was at par with skip row planting of cotton + green gram (2:1) (27.76 kg ha^{-1}). Minimum available soil phosphorus content was observed in skip row planting of cotton + pearl millet (2:1) (16.08 kg ha^{-1}). Singh *et al*. (2016) observed that the cropping system Bt cotton + sesamum – rabi castor proved its superiority by recording significantly higher available phosphorus at the end of the cropping system.

Available potassium content was significantly higher in skip row planting of cotton + black gram (2:1) (248.80 kg ha^{-1}) than rest of the treatments, however, it was at par with skip row planting of cotton + sesamum (2:1) (242.23 kg ha^{-1}). Minimum available potassium content was observed in skip row planting of cotton + pearl millet (2:1) (224.93 kg ha^{-1}).

Conclusion

Performance of *deshi* cotton in respect of yields was better with green gram, black gram and sesamum as compared to soybean and pearl millet. The economical indices were superior with skip row planting of cotton + green gram (2:1) as compared to other treatments followed by skip row planting of cotton + black gram (2:1). Soil fertility status at harvest of cotton was improved due to growing of legumes as an intercrop in cotton. Green gram, black gram improved available N content, soybean and green gram improved available P_2O_5 content and black gram and sesamum improved available K_2O content in soil.

Conflict of interest

The author declares no conflict of interest.

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