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EFFECT OF DIFFERENT SOWING METHODS AND PLANTING DENSITIES ON GROWTH, YIELD, FIBER QUALITY AND ECONOMIC EFFICACY OF COTTON

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ABSTRACT:- Crop growth and productivity may differ under different sowing methods and planting densities. A field experiment was conducted to evaluate the influence of different sowing methods and planting densities on growth, yield, quality and economic returns of cotton. Sowing methods included pit planting (1 m × 1 m pits), bed planting (75 cm apart beds), ridge planting (75 cm apart ridges) and line sowing with varied inter row spacing (25, 50 and 75 cm). Sowing methods significantly affected growth and yield of cotton. Pit planting imposed maximum increase in plant height (152 cm), number of monopodial branches (4.7) and sympodial branches (22.6) per plant, number of unopened (9.4) and opened bolls (41.1) per plant, and average boll weight (3.0 g) of cotton. However, highest seed cotton yield (2944.5 kg ha^{-1}) was obtained by flat sowing on 25 cm apart rows owing to highest planting density per unit area. Maximum ginning out turn (GOT) (41.6%) was noticed in pit planting of cotton, while, fiber quality was not affected significantly by sowing methods. Economic analysis showed that economic returns and benefit cost ratio (BCR) (1.52) was elevated by flat sowing on 25 cm apart rows. In conclusion, maximum seed cotton yield and economic returns can be acquired by flat sowing with 25 cm apart rows, while, fiber quality is independent of sowing methods.

Key Words: Gossypium hirsutum, Sowing Methods, Yield, Fiber Quality, Economic Efficacy

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is a leading fiber and oil producing crop and an important industrial commodity of the world (Fryxell, 1992). It is the most important cash crop in asian countries including India and Pakistan and many Latin American countries (Fortucci, 2002). Among many agronomic factors responsible for cotton growth and yield, the planting method has prime impor-tance because it not only helps in establishing the appropriate crop stand but also facilitates the conver-sion of light energy by balancing plant to plant competition in order to produce maximum crop yield (Ali et al., 2012). Plant growth and development depends upon favorable soil conditions which have suitable soil moisture content, temperature and minimum root penetration resistance. Therefore, an effective sowing methods is required that may use such tillage system which improves the soil physical properties and enhance the germination, plant growth and development as well as yield (Krause et al., 2009). However, each sowing method has its own associated merits and demerits under

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different conditions, therefore, studies are required to determine the suitability of different sowing methods on site specific basis. Bed planting enhances the seedling emergence and eliminates the formation of crust on the soil surface (Ahmad et al., 2009). Iftikhar et al. (2010) reported that cultivation of cotton on beds gave better yield than flat sowing method. Ridge sowing of cotton has been found to improve the soil physical properties such as increased soil moisture content and decreased root penetration resistance and also enhances the emergence and seed cotton yield (Gürsoy et al., 2011). Recently, pit planting techno-logy has been developed for various crops, but it is still to be compared with other existing methods to establish its superiority. Some preliminary studies have been conducted in the past for raising cotton under pit plantation. Nazir et al. (2001) revealed that fruiting potential and boll size was improved significantly in 100 cm apart 100 × 100 cm pits, however, fiber quality was not affected significantly. Line sowing of cotton via drill method ensures uniform seed distribution and sowing at desired depth, which usually results in higher seed germination and uniform crop stand (Tariq et al., 2001). Various sowing methods exert significant effects on growth and yield of cotton however; the fiber quality has been found to be unaffected by different sowing methods (Siebert et al., 2006).

Row spacing is a key component of management for improving crop productivity. Cotton production in narrow rows can be a viable approach than conventionally grown cotton to enhance lint yield (Jahedi et al., 2013). Although number of bolls per plant, boll weight and lint yield per plant increases when cotton is grown in wider plant spacing (Boquet et al., 2005), however, it has been observed that increased plant population of cotton compensates for the yield losses (Kasap and Killi, 2004). Despite of changes in growth pattern and yield response of cotton crop to different row spacing, fiber quality has been found consistent regardless of any row spacing (Ali et al., 2009; Awan et al., 2011). In the light of above discussion, it is established that growth and productivity of cotton may differ under different sowing methods. It is essential to develop such planting techniques and practices that maintain the optimum plant population, facilitating air circulation, light penetration, regulation of soil temperature and water saving for enhancing crop productivity. Therefore, this comparative study was designed to evaluate the effect of different sowing methods and row spacing on growth, yield, fiber quality and economic efficacy of cotton and assess the feasibility of different sowing methods in terms of economic benefits.

MATERIALS AND METHOD

A field study was conducted to check the effect of different sowing methods on growth, yield, fiber quality and economic efficacy of cotton at Agronomic Research Area, University of Agriculture, Faisalabad, during 2013. The experiment was laid out in randomized complete block design with three replications and net plot size of 8.0 m × 3.0 m. The treatments were comprised of different sowing methods including pit planting (1 m × 1 m pits), bed planting (75 cm apart beds), ridge planting (75 cm apart

ridges) and line sowing with varied inter row spacing (R × R) viz. 25, 50 and 75 cm. Pits of 1 m × 1 m size were made by digging up the soil to a depth of 45 cm and refilling up to 35 cm with the same soil by putting the upper 30 cm soil at bottom and subsoil at the upper part of the pit. The pit to pit distance was kept 50 cm and in pits the line to line and plant to plant (P × P) distance was 30 and 22.5 cm, respectively. In bed and ridge planting the distance between beds and ridges was kept 75 cm and plant to plant distance was maintained at 30 cm. In line sowing method, space between rows was varied as per treatment viz. 25, 50 and 75 cm and plant to plant spacing was kept 30 cm for each treatment.

Cotton variety FH-142 was sown at the end of May, 2013. Seed rate of 25 kg ha^{-1} was used for pit, bed, ridge as well as line sowing with row to row distance of 75 cm. While, the seed rate for line sowing having row to row distance of 25 cm and 50 cm was 75 and 38 kg ha^{-1}, respectively. Fertilizers were applied at the rate of 200 kg N, 115 kg P_2O_5 and 115 kg K_2O ha^{-1}. One-third of nitrogen, and whole phosphorus and potassium were applied at the time of sowing. The remaining nitrogen was applied with 1st irrigation and at flowering stage. Thinning was done at four leaf stage to maintain plant to plant distance as per treatment. In total eight irrigations were applied during the entire growth period of crop. Weeds and insect pests were maintained below economic threshold level by three hoeing and using insecticides, respectively. Crop was harvested in two pickings manually during September-October.

Standard procedures were used for recording data regarding growth, yield and fiber traits. Data regarding plant height (cm), number of monopodial and sympodial branches per plant and number of unopened and opened bolls per plant was collected from randomly selected ten plants at maturity. Average weight of boll (g) was measured by collecting ten opened bolls from the selected plants and measured with an electric balance. The seed cotton obtained from all the pickings was mixed and subjected to roller type laboratory ginning machine. The 100-cotton seed weight was measured by counting and weighing 100 cotton seeds collected after ginning from each replication. Seed cotton yield was determined by weighing the seed cotton from each replication and converted to kg ha^{-1}. The ginning out turn (GOT) was calculated using the formula of Singh (2004).

Fiber characters like fiber length (mm), fineness (µg $inch^{-1}$), strength (g tex^{-1}), uniformity (%) and elongation (%) of each sample were measured using spin lab high volume instrument (HVI-900). The data collected was analyzed using Fischer's analysis of variance technique and treatments' means were compared using least significant difference test at 5% probability level (Steel et al., 1997). Economic analysis was carried out to find out the total cost, net returns and benefit cost ratio using the procedure given by CIMMYT (1988).

RESULTS AND DISCUSSION

There was a significant effect of different sowing methods on growth, yield and yield components of cotton.

Maximum number of plants of cotton per m^2 (10.3) at harvest was observed in flat sowing with 25 cm row to row distance. Highest plant height (152.0 cm), number of monopodial branches (4.7) and sympodial branches (22.6) per plant, number of unopened bolls (9.4) and opened bolls (41.1) per plant, and average boll weight (3.0 g) of cotton was observed when the crop was sown in pits. The effect of flat sowing with 25 cm apart rows on plant height and ridge planting on number of sympodial branches per plant as well as average boll weight of cotton was statistically similar with pit planting. The influence of bed planting and flat sowing with 75 cm apart rows on average boll weight of cotton was also statistically similar with pit planting. However, 100-cotton seed weight was not affected significantly by different sowing methods while maximum seed cotton yield (2944.5 kg ha^{-1}) was produced by flat sowing with 25 cm apart rows (Tables 1 and 2). The results showed that growth and yield of cotton was affected significantly by the influence of different sowing methods. The occurrence of highest number of plants m^{-2} at harvest by flat sowing at 25 cm inter row spacing is attributed to reduced inter row spacing which increased the number of plants m^{-2} (Table 1). Increase in plant height, number of monopodial and sympodial branches per plant, number of unopened and opened bolls per plant and boll weight of cotton by sowing the crop in pits may be due to improved soil moisture content and better light penetration in the crop plants which enhanced the plant growth and development (Maqsood et al., 2006). Similar results were reported by Ali et al. (2009) who observed greater monopodial and sympodial branches per plant, number of bolls per plant and boll weight of cotton at lower plant population as compared to higher plant population. Similarly, Stephenson et al. (2011) reported increased plant height, number of monopodial and sympodial branches, and bolls per plant at lower plant density.

There was an increase in seed cotton yield in flat sowing which is attributed to high plant population in flat sowing with 25 cm inter row spacing (Table 1). The results of our study are similar to Nazir et al. (2001) who reported that greater number of monopodial and sympodial branches per plant, number of bolls per plant and weight of seed cotton per boll was obtained by sowing the crop in pits as compared to flat sowing. However, the seed cotton yield was less in pit planting than flat sowing owing to

Table 1. Effect of different sowing methods on growth and yield components of cotton

Treatments	PD	PH	MB	SB	UOB
	m^{-2}	cm	-	-	-
Pit planting (1m × 1m)	2.8^{d}	152.0^{a}	4.7^{a}	22.6^{a}	9.4^{a}
Bed planting (75 cm apart)	3.5^{c}	122.3^{bc}	3.4^{b}	20.3^{bc}	4.6^{bc}
Ridge planting (75 cm apart)	3.8^{c}	119.6^{c}	2.4^{bc}	21.5^{ab}	3.7^{cd}
Flat planting ® × R = 25 cm)	10.3^{a}	137.0^{ab}	1.1^{d}	16.5^{d}	2.5^{d}
Flat planting ® × R = 50 cm)	5.7^{b}	127.0^{bc}	1.3^{cd}	18.7^{c}	3.6^{d}
Flat planting ® × R = 75 cm)	3.8^{c}	119.6^{c}	2.0^{cd}	19.5^{c}	5.8^{cd}
LSD at p ≤ 0.05	0.531	16.667	1.118	1.577	1.814

Any two means not sharing a letter in common differ significantly at p ≤ 0.05, PD = Plant density, PH = Plant height, MB = Monopodial branches, SB = Sympodial branches, UOB = Unopened bolls

less plant population. This indicates that higher number of bolls as well as boll weight do not compensate for lower plant population per unit area in terms of yield. The results of our study are also correlated to the findings of Chhabra and Bishnoi (1993) who reported that seed cotton yield increased with an increase in plant density. Ali and Ehsanullah (2007) reported significant effect of different sowing methods on seed cotton yield and found that highest seed cotton yield was observed by flat sowing along with alternate row earthing up as compared to ridge and bed planting. Similarly, Cheema et al. (2008) observed more number of bolls per plant and seed cotton yield by flat sowing with each row earthen up as compared to bed planting. The 100-cotton seed weight was not influenced significantly by different sowing methods (Table 2). However, our results are contrary to Nadeem et al. (2010) who reported a significant difference in 100-seed cotton weight by different sowing methods.

There was a significant effect of different sowing methods on the ginning out turn of cotton. Maximum ginning out turn (41.6%) was recorded by sowing the crop by pit planting. However, fiber quality traits of cotton viz. fiber length, fineness, strength, uniformity and elongation were not affected significantly by the influence of different sowing methods (Table 3). Similar results were reported by Nazir et al. (2001) who studied the effect of pit planting versus flat planting at varying plant densities on cotton and reported a non-significant effect on fiber length. Siebert et al. (2006) observed a non significant effect of different planting configurations and inter row spacing on fiber quality characteristics viz. fiber length, strength, fineness and uniformity. Similarly, Awan et al.

Table 2. Effect of different sowing methods on yield and yield components of cotton.

Treatments	OB	BW	HSCW	SCY	GOT
	-	g	g	kg ha^{-1}	%
Pit planting (1m × 1m)	41.1^{a}	3.0^{a}	5.9	2586.1^{b}	41.6^{a}
Bed planting (75 cm apart)	28.7^{b}	2.9^{a}	5.8	1966.7^{d}	40.1^{bc}
Ridge planting (75 cm apart)	29.8^{b}	2.8^{ab}	5.6	2441.7^{b}	40.0^{bc}
Flat planting ® × R = 25 cm)	18.5^{d}	2.2^{c}	5.4	2944.5^{a}	38.5^{d}
Flat planting ® × R = 50 cm)	24.5^{c}	2.5^{bc}	5.8	2147.2^{cd}	39.4^{cd}
Flat planting ® × R = 75 cm)	27.3^{bc}	2.8^{ab}	5.7	2369.5^{bc}	40.4^{b}
LSD at p ≤ 0.05	3.728	0.322	NS	245.220	0.997

Any two means not sharing a letter in common differ significantly at p ≤ 0.05, NS = Non-significant, OB = Opened bolls, BW = Boll weight, HCSW = 100-cotton seed weight, SCY = Seed cotton yield, GOT = Ginning out turn

Table 3. Effect of different sowing methods on fiber quality of cotton.

Treatments	FL	FF	FS	FU	FE
	mm	µginch^{-1}	g tex^{-1}	%	%
Pit planting (1m × 1m)	25.1	4.4	23.5	47.5	6.7
Bed planting (75 cm apart)	22.4	4.5	23.8	50.0	6.9
Ridge planting (75 cm apart)	25.7	3.9	23.6	46.8	7.3
Flat planting ® × R = 25 cm)	24.4	4.0	23.6	51.7	6.7
Flat planting ® × R = 50 cm)	24.5	4.1	23.2	47.9	7.5
Flat planting ® × R = 75 cm)	23.8	3.6	23.1	48.0	7.1
LSD at p ≤ 0.05	NS	NS	NS	NS	NS

Any two means not sharing a letter in common differ significantly at p ≤ 0.05, NS = Non-significant, FL = fiber length, FF = Fiber fineness, FS = Fiber strength, FU = Fiber uniformity, FE = Fiber elongation

(2011) noticed a significant effect of different plant spacing on ginning out turn of cotton and non-significant effect on fiber length, strength, fineness and uniformity.

The economic analysis revealed that maximum net field profit (Rs. 76400.05 ha^{-1}) was achieved when cotton was sown under flat planting at 25 cm apart rows, followed by pit planting (Rs. 50021.05 ha^{-1}). While the minimum net field benefits (Rs. 16316.05 ha^{-1}) were recorded in bed-furrow planting method (Table 4). The analysis showed that cotton planted under flat planting at 25 cm apart row configuration gave highest BCR (1.52) followed by ridge planting (1.37) and minimum (1.12) was recorded when crop was sown under bed-furrow planting method (Table 4). It was observed that maximum economic returns as well as BCR was found when the crop was sown by flat sowing with 25 cm row spacing, although highest total variable cost was also noticed for the same sowing method. The increase in total variable cost due to this sowing method is attributed to the establishment of high plant density per unit area. However, there was production of greater seed cotton by this method, owing to higher plant population that produced greater number of bolls per unit area than other methods, due to which more economic returns were gained. Pit planting followed the flat sowing with 25 cm apart rows in total variable cost as well as net returns. Increased cost of production was due to the digging of pits; however, less plant population per unit area resulted in less seed cotton yield and thus less economic returns (Table 1 and 2). Muhammad et al. (2012) also reported similar results for maize showing that different methods of sowing differed in economic efficacy.

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Table 4. Partial budget analysis of cotton production under different sowing methods

Treatments	SCY kg ha^{-1}	NI Rs. ha^{-1}	GI Rs. ha^{-1}	TVC Rs. ha^{-1}	TC Rs. ha^{-1}	NR Rs. ha^{-1}	BCR -
Pit planting	2586.1	193957.5	193957.5	42275.0	143936.4	50021.05	1.35
Bed planting	1966.7	147502.5	147502.5	29525.0	131186.4	16316.05	1.12
Ridge planting	2441.7	183127.5	183127.5	31700.0	133361.4	49766.05	1.37
Flat planting (25 cm apart rows)	2944.5	220837.5	220837.5	42776.0	144437.4	76400.05	1.52
Flat planting (50 cm apart rows)	2147.2	161040.0	161040.0	32026.0	133687.4	27352.55	1.20
Flat planting (75 cm apart rows)	2369.5	177712.5	177712.5	29476.0	131137.4	46575.l05	1.35

SCY = Seed cotton yield, NI = Net income, GI = Gross income, TVC = Total cost, NR = Net return, BCR = Benefit cost ratio

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AUTHORSHIP AND CONTRIBUTION DECLARATION

S.No	Author Name	Contribution to the paper
1.	Dr. Ehsanullah	Conceived the idea, Supervised the study
2.	Mr. Muhammad Amjad Shahzad	Conduct the experiment, Took Observation and data collection
3.	Dr. Shakeel Ahmad Anjum	Planned and reviewed the write up
4.	Mr. Ali Zohaib	Analyzed the literature and research, prepared write up of paper and did overall management of the article.
5.	Mr. Muhammad Ishfaq	Helped in data collection
5.	Mr. Ejaz Ahmad Warraich	Contributed in conclusion

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