International Journal of Plant & Soil Science

20(6): 1-6, 2017; Article no.IJPSS.38591
ISSN: 2320-7035

Yield and Yield Components of Winter Cotton (*Gossypium hirsutum* L.) Genotypes Influenced by Plant Spacings

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Authors' contributions

This work was carried out in collaboration between both authors. Author EITM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author SL managed the analyses of the study. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2017/38591
Editor(s):
(1) Ni Xiang, Department of Entomology and Plant Pathology, Auburn University, Alabama, USA.
Reviewers:
(1) Abdulmajeed Bashir Mlitan, Misurata University, Libya.
(2) Mrityunjoy Biswas, Sylhet Agricultural University, Bangladesh.
Complete Peer review History: http://www.sciencedomain.org/review-history/22555

Original Research Article

Received 1st December 2017
Accepted 20th December 2017
Published 2nd January 2018

ABSTRACT

Field experiment was conducted to study the influence of plant spacings on the seed cotton yield and yield components in cotton during winter 2016–2017 at Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India. The experiment was laid out in a split-plot design and replicated thrice with two cotton genotypes Co 14 and TCH 1819 and seven spacings 90 cm x 45 cm, 60 cm x 30 cm, 90 cm x 45-10 cm, 60 cm x 30-10 cm, 80 cm x 10 cm, 90 cm x 10 cm and 100 cm x 10 cm. Observations on yield attributes and seed cotton yield were recorded. Yield components including number of sympodial branches/plant (14), number of flowers/plant (20), number of bolls/plant (13), single boll weight (3.13 g) and seed cotton yield (2734 kg/ha) were higher in the Co 14 variety when compared to TCH 1819. In the present study, Co 14 with 80 cm x 10 cm spacing gave high seed cotton yield.

Keywords: Genotype; plant spacing; seed cotton yield; yield component.

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1. INTRODUCTION

Cotton plays a key role in socio-economic and political affairs of the world [1]. Its production, processing and trade generate revenue and sustain livelihoods in many countries. It is the world's leading source of natural textile fibre and fifth largest oilseeds crop which covers 40% of the global textile need [2] and 3.3% of the edible oil [3], respectively. At global level India ranks first in cotton cultivation as well as production, it has been cultivated in 105 lakh hectares and the production is 351 lakh bales with average productivity of 568 kg/ha [4]. Among the nine major cotton growing states of India, Maharashtra stands first in the cultivated area (38.06 lakh ha) followed by Gujarat (24 lakh ha) and Telangana (12.5 lakh ha). Tamil Nadu had a cotton cultivated area of 1.5 lakh hectares with a production of 3.8 lakh bales and productivity of 680 kg/ha. Gujarat produce 91.8 lakh bales, the highest, followed by Maharashtra (83.25 lakh bales) and Telangana (47.40 lakh bales). Karnataka had high productivity of cotton (769 kg/ha) followed by Andhra Pradesh (719 kg/ha) [4]. Not only locally but also globally cotton is facing challenges that not only affect sustainable production but also competition with other artificial fibres in the textile industry. At present cotton production face problems of rising input costs with static or declining returns. The cotton producers are persistently searching for ways to compensate, the increase in production cost through more production of bolls per unit area. The adjustment of plant density has been an important agronomic practice for enhancing yield and profitability of cotton (*Gossypium hirsutum* L.) world-wide [5]. Maximum yield can be achieved by maintaining an optimal plant population, with good crop growth and better plant morphological characteristics. Establishment of an acceptable population of cotton seedlings is paramount for high yields [6]. Plant population factor in cotton production is directly related to seed cotton yield, thus spacing plays a significant role for cotton production and productivity. The maximum yield potential of any new developed genotype in hirsutum cotton can be attained by manipulating and suitable spacing choice. Therefore the present research was designed to study the performance of newly developed cotton genotypes with different plant spacings.

2. MATERIALS AND METHODS

Field experiment was conducted to study the influence of plant spacing in cotton on the growth and yield during winter season of 2016-2017 (September to February). The experiment field is located in the North Western agro climatic zone of Tamil Nadu at 11°N latitude and 76°57´E longitude with an altitude of 426.7 metres above MSL. The soil of the experimental field was sandy clay loam in texture, low in available nitrogen (168 kg/ha), high in available phosphorus (28.4 kg/ha) and high in available potassium (523.5 kg/ha). The experiment was laid out in a split-plot design and replicated thrice with two cotton genotypes viz. Co 14 and TCH 1819 and seven spacings viz. 90 cm x 45 cm, 60 cm x 30 cm, 90 cm x 45-10 cm, 60 cm x 30-10 cm, 80 cm x 10 cm, 90 cm x 10 cm and 100 cm x 10 cm. Parentage of Co 14 variety was MCU 5/ TCH 92-7 with a duration of 150 days, suitable to cultivate during winter season, having good quality characters *viz.* extra long staple cotton (35.0 mm), fibre strength 23.4 g/tex and good ginning out turn (34.8%). TCH1819 is a compact and erect type with duration of 135 days and synchronized boll maturity comes to harvest early. The crop was sown and raised using the recommended package of practices as per TNAU crop production guide (Ridges and furrow method, sowing date - August 15 to September 15). Observations were recorded for yield parameters like sympodial branches/plant, number of flowers/plant, number of bolls/plant, number of bolls/m^2, single boll weight (g), number of seeds/boll, seed cotton yield (kg/ha) and lint yield (kg/ha). The experimental data on different characters of observation was statistically analyzed as described by [7]. Agres software was used for the analysis. Wherever the results were significant, critical differences were worked out at 5% level of probability. The treatment differences that were non significant are denoted as NS.

3. RESULTS

3.1 Yield Components

The number of sympodia/plant recorded in Co 14 variety was 14 which was significantly higher compared to TCH 1819 genotype recording 12 sympodia (Table 1). Among the plant spacings, the spacing of 90 cm x 45 cm recorded 17 sympodial branches/plant which was higher and at par with spacing of 90 cm x 45-10 cm and recorded 15 sympodia/plant. Significantly lower sympodial branches was observed in closer spacing of 80 cm x 10 cm (10/plant) which was at par with spacing of 90 cm x 10 cm (11/plant) and 100 cm x 10 cm (12/plant).

Table 1. Effect of cotton genotypes and plant spacing on yield components

Treatments	Number of sympodia/ plant	Number of flowers/ plant	Number of bolls/ plant	Number of bolls/ m^2	Number of seeds/ boll	Single boll weight (g)
Genotype						
M_1- Co 14	14	20	13	79	22	3.13
M_2- TCH 1819	12	17	12	71	21	3.01
SEd	0.3	0.4	0.3	2	1	0.10
CD (p=0.05)	**1.3**	**1.9**	**1.0**	**7**	**NS**	**NS**
Spacing (cm)						
S_1- 90 x 45	17	23	15	34	22	3.45
S_2- 60 x 30	14	20	13	63	22	3.22
S_3- 90 x 45-10	15	21	14	52	21	3.34
S_4- 60 x 30-10	13	19	12	83	22	3.11
S_5- 80 x 10	10	15	10	101	21	2.76
S_6- 90 x 10	11	16	11	97	21	2.76
S_7- 100 x 10	12	17	12	92	21	2.86
SEd	1	1	0.6	4	1	0.20
CD (p=0.05)	**2**	**2**	**1.3**	**8**	**NS**	**0.30**
Interaction	**NS**	NS	NS	NS	NS	NS

Yield parameters recorded at 60, 90, 120 DAS and at harvest
If Observed Difference (OD) > Critical Difference (CD), treatments are significantly differed. If OD < CD, difference between two treatments are varied.
NS – Non Significant

The variety Co 14 recorded significantly higher flowers/plant (20) compared to genotype TCH 1819 (17). The wider spacing of 90 cm x 45 cm registered 23 flowers/plant, which was higher and at par with spacing of 90 cm x 45-10 cm registered 21 flowers/plant. Significantly lower number of flowers/plant (15) was observed in 80 cm x 10 cm spacing, which was at par with spacing of 90 cm x 10 cm (Table 1).

The higher number of bolls/plant was recorded by the variety Co 14 (13) compared with genotype TCH 1819 (12). Significantly higher number of bolls recorded in spacing of 90 cm x 45 cm was 15 bolls/plant, which was at par with 90 cm x 45-10 cm spacing recorded 14 bolls/plant and lower number of bolls/plant (10) was observed in 80 cm x 10 cm spacing, which was at par with 90 cm x 10 cm and 100 cm x 10 cm spacings (Table 1). In cotton genotype, Co 14 variety was recorded 79 bolls/m^2 which was higher, compared to genotype TCH 1819 which recorded 71 bolls/m^2. Significantly higher number of bolls/m^2 recorded in 80 cm x 10 cm spacing (101 bolls/m^2), which was at par with spacing of 90 cm x 10 cm. Lower number of 34 bolls was recorded with the wider spacing of 90 cm x 45 cm (Table 1).

The plant spacing had significant influence on the single boll weight. Comparing the plant spacing, wider spacing of 90 cm x 45 cm recorded higher value of 3.45 g single boll weight, which was at par with 60 cm x 30 cm and 90 cm x 45-10 cm spacings in the boll weight recorded. Lower value of 2.76 g single boll weight was recorded with the closer spacing of 80 cm x 10 cm which was at par with 90 cm x 10 cm and 100 cm x 10 cm spacings. The interaction effect was non significant with cotton genotype and plant spacing on single boll weight. There was non significant difference between the cotton genotype in boll weight (Table 1). The interaction effect on sympodial branches/plant, number of flowers/plant, number of bolls/plant, number of bolls/m^2 were non significant with cotton genotype and plant spacings. There was non significant difference observed with cotton genotype and plant spacings on the number of seeds/boll recorded.

3.2 Seed Cotton Yield

Cotton variety Co 14 recorded significantly higher seed cotton yield of 2288 kg/ha compared to TCH 1819 genotype which recorded 1935 kg/ha (Table 2). Among the plant spacings, the closer spacing of 80 cm x 10 cm recorded higher seed cotton yield of 2734 kg/ha, which was at par with spacing of 90 cm x 10 cm (2615 kg/ha) and 100 cm x 10 cm (2573 kg/ha). Lower seed cotton yield of 1068 kg/ha was observed with the plant spacing of 90 cm x 45 cm.

Table 2. Effect of cotton genotypes and plant density on seed cotton yield, lint yield and seed yield

Treatments	Seed cotton yield (kg/ha)	Seed cotton yield (g/plant)	Lint yield (kg/ha)	Seed yield (kg/ha)
Genotype				
M_1- Co 14	2288	34	758	1530
M_2- TCH 1819	1935	29	715	1220
SEd	55	1	18	31
CD (p=0.05)	**239**	**2**	**NS**	**134**
Spacing (cm)				
S_1- 90 x 45	1068	44	369	700
S_2- 60 x 30	1936	35	594	1269
S_3- 90 x 45-10	1465	40	546	909
S_4- 60 x 30-10	2389	30	837	1522
S_5- 80 x 10	2734	22	915	1813
S_6- 90 x 10	2615	24	943	1707
S_7- 100 x 10	2573	26	861	1706
SEd	105	1	32	63
CD (p=0.05)	**217**	**3**	**66**	**130**
Interaction	**NS**	**NS**	**NS**	**NS**

Yield was recorded at harvest

If Observed Difference (OD) > Critical Difference (CD), treatments are significantly differed. If OD < CD, difference between two treatments are varied.

NS – Non Significant

Co 14 recorded significantly higher seed cotton yield of 34 g/plant compared to TCH 1819 recorded 29 g/plant. In plant spacings, the wider spacing of 90 cm x 45 cm recorded higher seed cotton yield of 44 g/plant, followed by spacing of 90 cm x 45-10 cm. Lower seed cotton yield of 22 g/plant was observed with the plant spacing of 80 cm x 10 cm, which was at par with spacing of 90 cm x 10 cm (Table 2). The cotton variety Co 14 recorded higher lint yield of 753 kg/ha compared to TCH 1819 genotype. Significantly higher lint yield was recorded in the closer spacing of 80 cm x 10 cm (943 kg/ha) which was at par with spacing of 90 cm x 10 cm, 100 cm x 10 cm and 60 cm x 30-10 cm. Lower lint yield of 369 kg/ha was observed with the plant spacing of 90 cm x 45 cm (Table 2). Non significant difference was observed with genotype and spacing interaction effect.

4. DISCUSSION

The sympodial branches were significantly higher in Co 14. The reason may be attributed to the genetic make up of the material and efficiency of the variety to adopt the climatic conditions. Considering plant spacing, more number of monopodia and sympodia recorded with 90 cm x 45 cm spacing and this might be due to reduced competition for resources like nutrients, light, spacing *etc.* This is in confirmation with the earlier findings of [8] stating that higher plant density decreased monopodia and sympodia number.

The number of squares and flowers/plant were higher with Co 14 variety, also due to genetic make-up. In plant spacing, more number of squares and flowers were recorded with wider spacing of 90 cm x 45 cm. According to [9] the drop or abortion of flower buds is a natural phenomenon of the culture, however, the effect can be enhanced due to imbalance between ethylene and sugar content in the tissues and factors that determine photosynthetic decline or excessive metabolic expenditure which will result in senescence of reproductive structures. The same author has described that one of the factors that culminates under such situation is the self-shading caused by the plants themselves.

Number of bolls/plant is considered as the first important contributor to seed cotton yield, followed by boll weight [10]. The higher number of bolls in Co 14 cotton variety might be due to better assimilation and translocation of photosynthates to the reproductive sink. Higher number of bolls/plant was recorded in the spacing of 90 cm x 45 cm adopted. These results are corroborated with the earlier findings of [11] who reported increase in number of bolls/plant with increase in plant spacing can be attributed to reduced competition within plants and more available space which would have enabled the plants to uptake more water and nutrients to produce more sympodial branches that ultimately would have resulted in more number of bolls/plant.

The single boll weight in the study was not influenced by the cotton genotype. The heavier boll weight was recorded in the spacing of 90 cm x 45 cm than 80 cm x 10 cm to be closer spacing compared to former spacing. By increasing plant spacing there was increase in boll weight because all the natural resources *i.e*. radiation, nutrient and moisture were fully utilized by the plant. The present findings are in agreement with [12] who reported that maximum average boll weight (3.92 g) was obtained in 45 cm plant spacing against the minimum value (3.34 g) in 30 cm plant spacing.

Maximum yield potential of crop can be realized by adopting suitable agronomic practices like promising genotypes and plant population. Seed cotton yield is the reflection of yield attributing parameters like boll number and boll weight. Parabolic correlation was found between crop yields and plant density, if other factors are in an optimal level, thus either too high or too low plant density would sacrifice crop yield [13]. Stable cotton genotype with high yielding potential is of paramount importance among the large number of varieties recommended for cultivation. Co 14 variety had recorded comparably higher yield over TCH 1819 cotton genotype, which could be attributed due to the better vegetative growth and profuse boll bearing.

All the yield attributing characters in closer spacing of 80 cm x 10 cm were lesser compared to other spacing levels, thus the increase in seed cotton yield might be due to more plant population over wider spacing in the experiment. Further the angle and orientation of leaves were found adjusted at higher population, thereby minimizing overlapping and mutual shading, responsible for greater leaf development at high population resulting in increased growth and yield attributes [14]. This is in line with the findings of [15] who found that significantly maximum seed cotton yield was obtained with narrow spacing of 15 cm followed by 30 cm and 45 cm row spacing in silt loam soil. Close spaced plants had fewer bolls and per plant basis yield was less when compared to wider spacing [16]. But this adverse effect was neutralized by its higher plant population on per unit area basis and proved more seed cotton yield than the wider spacing. [17] reported a positive correlation of seed cotton yield with plant geometries.

The ultimate seed cotton yield is the manifestation of yield contributing characters. These yield attributing characters were significantly affected by different plant populations. Eventhough the per plant yield higher at wider spacing, the total seed cotton yield was less compared to that of closer plant populations as it could not compensate the loss in number of plants/hectare.

Higher yields at closer spacing might be due to more number of bolls/unit area. Similar observations of higher seed cotton yield at higher plant density compared to lower plant density were reported by [18,19,20,21,22].

5. CONCLUSION

Worldwide cotton research manipulation on plant geometry, plant population and spatial arrangement of cotton plants continues to be the major topic and India is no exception. It is widely accepted that increasing density as an option to increase yield or profits in cotton cultivation. Maximum seed cotton yield of 2734 kg/ha was recorded when the spacing was 80 cm × 10 cm. The lowest cotton yield (1068 kg/ha) was obtained in 90 cm × 45 cm spacing. Among the cotton variety and genotype, Co 14 variety recorded higher mean seed cotton yield. The plant spacing of 80 cm x 10 cm favourably increased yield attributes and seed cotton yield in both the genotypes (Co 14 and TCH 1819).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/22555