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RESEARCH PAPER

Economically viable agronomic practices for high density planting system (HDPS) in cotton under irrigated conditions

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Abstract: A field experiment was conducted in black soil at Agricultural College, Raichur during *kharif* 2016-17 and 2017-18. The experiment was laid out in split plot design with three compact cotton genotypes *viz*., G_1: SCS-1206, G_2: DSC-99 and G_3: Suraj as main plot treatments and three planting geometries *viz*., S_1: 60 x 10 cm, S_2: 75 x 10 cm and S_3: 90 x 10 cm as sub plot treatments and it was compared with conventional system of cotton cultivation with Bt cotton hybrid ATM with recommended spacing of 90 x 60 cm. Among the different compact cotton genotypes, SCS-1206 recorded highest seed cotton yield (2886 kg ha^{-1}) followed by genotype Suraj (2754 kg ha^{-1}) which were significantly superior over genotype DSC-99 (2486 kg ha^{-1}). Among the different planting geometry, a closer row spacing of 60 x 10 cm recorded significantly higher seed cotton yield (2896 kg ha^{-1}) over a medium row spacing of 75 x 10 cm (2758 kg ha^{-1}) and significantly lower seed cotton yield was recorded with a wider row spacing of 90 x 60 cm (2472 kg ha^{-1}). Among the different combinations, the genotype SCS-1206 grown at 60 x 10 cm spacing recorded significantly higher seed cotton yield (3096 kg ha^{-1}) and it was found at par with the combination of same genotype at 75 x 60 cm spacing (2949 kg ha^{-1}) and genotype Suraj at same spacing (2923 kg ha^{-1}).

Key words: Compact genotypes, Cotton, Geometry, Nutrient

Introduction

The concept of high density planting system (HDPS) is widely adopted by several countries such as China, Brazil, Uzbekistan, Australia, Argentina and several other countries where in plant population of 1,00,000 to 2,00,000 per hectare is maintained and high seed cotton yield of 40 to 90 quintals per hectare is realized. HDPS is more relevant to India to establish sustainable production system as the productivity of cotton is low in India. Compact cotton type of genotypes have the advantage of short sympodial branches with reduced inter-nodal length giving morphological feature of compressed habit and clustered boll habit on account of low vertical and horizontal growth it occupies minimum space. The HDPS cotton not only provides scope for double cropping and mechanized harvesting but also has the added advantage of requiring few pickings only. Therefore, which inturn reduces the labour cost as well as seed cost as farmers will use the varietal seeds during next sowing season.

Therefore, the present investigation was undertaken to find out the suitable compact cotton genotypes and planting geometry with a view to achieve high yield levels under irrigated ecosystem of North Eastern Dry zone of Karnataka.

Material and methods

A field experiment entitled "Yield, economics and nutrient uptake of compact cotton genotypes in high density planting system under irrigated ecosystem" was conducted at Agricultural College, UAS, Raichur during *Kharif* 2016-17 and 2017-18 on medium black soil, neutral in nature with low available nitrogen, medium phosphorus, rich in potassium. The climatic condition during experimental period was favorable and regular irrigation was provided to crop during both the years at later part of crop growth stages *i.e*, from 60 DAS to till first picking.

The experiment was laid out in split plot design with three compact cotton genotypes *viz*., G_1: SCS-1206, G_2: DSC-99, G_3: Suraj as main plot treatments and three planting geometries *viz*., S_1: 60 x 10 cm (1,66,666 plants ha^{-1}), S_2: 75 x 60 cm (1,33,333 plants ha^{-1}) and S_3: 90 x 10 cm (1,11,111 plants ha^{-1}) as sub plot treatments and it was compared with conventional system of cotton cultivation with Bt cotton hybrid ATM at a recommended spacing of 90 x 60 cm (uneven control)

Results and discussion

Among the different compact cotton genotypes in pooled data G_1: SCS-1206 recorded higher seed cotton yield (2886 kg ha^{-1}) followed by genotype G_3: Suraj (2754 kg ha^{-1}) and which were significantly higher when compared with genotype G_2: DSC-99 (2486 kg ha^{-1}). This difference in seed cotton yield was mainly attributed to significant difference in yield components *viz*., number of bolls per plant (12.82 and 12.12, respectively), boll weight (3.73 and 3.59 g, respectively) and seed cotton yield per plant (25.98 and 24.40 g, respectively) and which was further due to difference in growth attributes. Similar results were also reported by Udikeri and Shashidhara (2017), Ajaykumar *et al*. (2017). Sankarnarayanan *et al*. (2018) reported significantly higher seed cotton yield and boll weight with the genotype Anjali (2513 kg ha^{-1} and 3.4 g, respectively) over C 1412 and CCH 7245 high density planting system.

Difference in seed cotton yield due to different planting geometry was evident. In pooled data among different row

Table 1. Yield attributing characters of compact cotton genotypes under high density planting system

Treatments	Number of bolls/plant			Boll weight (g)			Seed cotton yield/plant (g)		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Main plots (G)									
G_1	13.22^{a}	12.42^{a}	12.82^{a}	3.80^{a}	3.66^{a}	3.73^{a}	26.42^{a}	25.55^{a}	25.98^{a}
G_2	11.04^{b}	10.20^{b}	10.62^{b}	3.35^{b}	3.29^{b}	3.32^{c}	22.90^{c}	21.32^{c}	22.11^{c}
G_3	12.56^{a}	11.69^{a}	12.12^{a}	3.64^{a}	3.54^{a}	3.59^{b}	24.97^{b}	23.82^{b}	24.40^{b}
S.Em.±	0.32	0.20	0.24	0.05	0.05	0.03	0.27	0.33	0.16
Sub plots (S)									
S_1	10.42^{c}	9.40^{c}	9.91^{c}	3.36^{c}	3.25^{b}	3.30^{b}	23.18^{c}	21.61^{c}	22.40^{c}
S_2	12.07^{b}	11.29^{b}	11.68^{b}	3.49^{b}	3.44^{b}	3.46^{b}	24.47^{b}	23.39^{b}	23.93^{b}
S_3	14.33^{a}	13.62^{a}	13.98^{a}	3.95^{a}	3.80^{a}	3.88^{a}	26.64^{a}	25.68^{a}	26.16^{a}
S.Em.±	0.21	0.21	0.19	0.03	0.11	0.06	0.35	0.46	0.26
Interactions (G x S)									
G_1S_1	11.13^{e}	10.13^{e}	10.63^{e}	3.58^{bc}	3.41^{a-c}	3.50^{bc}	25.06^{b-d}	23.63^{bc}	24.35^{cd}
G_1S_2	13.07^{b}	12.33^{b}	12.70^{b}	3.71^{bc}	3.69^{ab}	3.70^{ab}	25.94^{bc}	25.40^{ab}	25.67^{bc}
G_1S_3	15.47^{a}	14.80^{a}	15.13^{a}	4.12^{a}	3.89^{a}	4.00^{a}	28.26^{a}	27.6^{a}	27.93^{a}
G_2S_1	9.40^{d}	8.47^{d}	8.93^{d}	3.06^{e}	3.01^{c}	3.03^{d}	21.15^{f}	19.37^{d}	20.26^{f}
G_2S_2	10.73^{c}	9.93^{c}	10.33^{c}	3.27^{de}	3.19^{bc}	3.23^{cd}	22.77^{ef}	21.13^{cd}	21.95^{e}
G_2S_3	13.00^{b}	12.20^{b}	12.60^{b}	3.73^{b}	3.66^{ab}	3.70^{ab}	24.77^{cd}	23.44^{bc}	24.11^{d}
G_3S_1	10.73^{c}	9.60^{c}	10.17^{c}	3.44^{cd}	3.32^{a-c}	3.38^{bc}	23.34^{de}	21.82^{cd}	22.58^{e}
G_3S_2	12.40^{b}	11.60^{b}	12.00^{b}	3.47^{b-d}	3.43^{a-c}	3.45^{bc}	24.68^{c-e}	23.64^{bc}	24.16^{d}
G_3S_3	14.53^{a}	13.8 7^{a}	14.20^{a}	4.02^{a}	3.86^{a}	3.94^{a}	26.89^{ab}	26.00^{ab}	26.45^{b}
S.Em.±	0.37	0.36	0.33	0.08	0.18	0.10	0.60	0.79	0.45
Control	37.07	35.99	36.53	4.32	4.24	4.28	143.45	138.14	140.80
S.Em.±	0.50	0.41	0.43	0.09	0.17	0.08	1.37	0.88	0.77
C.D. (P=0.05)	1.47	1.21	1.26	0.28	0.50	0.24	4.08	2.49	2.29

spacing, a closer spacing of S_1: 60 x 10 cm recorded significantly higher seed cotton yield (2896 kg ha^{-1}) when compared with the medium row spacing of S_2: 75 x 10 cm (2758 kg ha^{-1}) and wider row spacing of S_3: 90 x 10 cm (2472 kg ha^{-1}). Significantly higher seed cotton yield observed was mainly due to higher number of harvested bolls and higher plants population per unit area as supported findings of Alur (2016) and Devi *et al*. (2018).

Interaction effect of compact cotton genotypes and planting geometries were found significant. Among the different combinations, interaction of genotype G_1: SCS -1206 with a row spacing of S_1: 60 x 10 cm recorded significantly higher seed cotton yield (3096 kg ha^{-1}) when compared to rest of the treatment combinations. However, it remained at par with the combination of G_1: SCS-1206 with a row spacing of S_2: 75 x 10 cm (2949 kg ha^{-1}) and genotype G_3: Suraj with a row spacing of S_1: 60 x 10 cm (2923 kg ha^{-1}). Further, cotton grown under conventional system with Bt cotton hybrid ATM at a recommended spacing of 90 x 60 cm recorded significantly lower seed cotton yield (2314 kg ha^{-1}) when compared with all the treatment combinations of cotton grown under HDPS except with the combination of genotype G_2: DSC-99 with a row spacing of S_2: 75 x 10 cm (2525 kg ha^{-1} on pooled basis) and genotype G_2: DSC-99 with a row spacing of S_3: 90 x 10 cm (2263 kg ha^{-1}, on pooled basis). The results are in line with the findings of Parlawar *et al*. (2017) who reported that genotype AKH-081 produced significantly higher seed cotton yield (2356 kg ha^{-1}) at a higher population density of 2,22,222 plants^{-1}. Similar result was also reported by Tuppad (2015).

In pooled data among the different compact cotton types, genotype G_1: SCS-1206 and G_3: Suraj recorded significantly higher net returns (₹ 81,346 and 75,434 ha^{-1}, respectively) and BC ratio (2.73 and 2.60, respectively). While the genotype G_2: DSC-99 recorded significantly lower net returns (₹ 63,508 ha^{-1}) and BC ratio (2.35). Among different planting geometries, a closer row spacing of S_1: 60 x 10 cm recorded significantly higher net returns (₹ 80,865 ha^{-1}) and BC ratio (2.69) and it was found at par with medium row spacing of S_2: 75 x 10 cm (₹ 75,732 ha^{-1} and 2.61, respectively). While, wider row spacing of S_3: 90 x 10 cm recorded significantly lower net returns and BC ratio (₹ 63,692 ha^{-1} and 2.38, respectively). Among different interactions of cotton grown under HDPS, a combination of genotype G_1: SCS-1206 with row spacing of S_1: 60 x 10 cm recorded significantly higher net returns and BC ratio (₹ 89,736 ha^{-1} and 2.87, respectively) and found on par with combination of genotype G_1: SCS-1206 with a spacing of S_2: 75 x 10 cm (₹ 84,263 ha^{-1} and 2.80, respectively) and genotype S_3: Suraj with a row spacing of S_1: 60 x 10 cm (₹ 82,064 ha^{-1} and 2.71, respectively). Significantly lower net returns and BC ratio (₹ 54,379 ha^{-1} and 2.18, respectively) was observed with combination of genotype G_2: DSC-99 with a row spacing of S_3: 90 x 10 cm. Cotton grown under conventional system with Bt cotton hybrid ATM with a recommended spacing of 90 x 60 cm recorded significantly lower economic values (₹ 53,522 ha^{-1} and 2.09, respectively) when compared with the cotton grown under HDPS. This result was supported by findings of Tuppad (2015) and Udikeri (2017) who also reported significantly higher economic values with the combination of high yielding genotypes with the closer spacing.

Table 2. Yield and economics of compact cotton genotypes under high density planting system

Treatments	Seed cotton yield (kg ha^{-1})			Net returns (₹ ha^{-1})			BC Ratio		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Main plots (G)									
G_1	2962^{a}	2811^{a}	2886^{a}	84064^{a}	78629^{a}	81346^{a}	2.81^{a}	2.64^{a}	2.73^{a}
G_2	2584^{b}	2388^{b}	2486^{b}	67407^{b}	59609^{b}	63508^{b}	2.45^{b}	2.24^{b}	2.35^{b}
G_3	2842^{a}	2666^{a}	2754^{a}	78764^{a}	72104^{a}	75434^{a}	2.70^{a}	2.51^{a}	2.60^{a}
S.Em.±	55.58	52.77	53.73	2445	2375	2390	0.06	0.05	0.05
Sub plots (S)									
S_1	2974^{a}	2819^{a}	2896^{a}	83661^{a}	78068^{a}	80865^{a}	2.77^{a}	2.60^{a}	2.69^{a}
S_2	2841^{b}	2675^{b}	2758^{b}	78840^{a}	72624^{a}	75732^{a}	2.71^{a}	2.52^{a}	2.61^{a}
S_3	2573^{c}	2371^{c}	2472^{c}	67734^{b}	59650^{b}	63692^{b}	2.49^{b}	2.27^{b}	2.38^{b}
S.Em.±	42.38	43.68	42.87	1865	1966	1908	0.03	0.05	0.03
Interactions (G x S)									
G_1S_1	3156^{a}	3035^{a}	3096^{a}	91669^{a}	87803^{a}	89736^{a}	2.94^{a}	2.80^{a}	2.87^{a}
G_1S_2	3020^{ab}	2879^{ab}	2949^{ab}	86706^{ab}	81819^{ab}	84263^{ab}	2.88^{a}	2.71^{a}	2.80^{ab}
G_1S_3	2711^{cd}	2518^{cd}	2615^{cd}	73816^{cd}	66265^{cd}	70041^{cd}	2.62^{b-d}	2.41^{bc}	2.52^{cd}
G_2S_1	2761^{cd}	2579^{cd}	2670^{cd}	74304^{cd}	67283^{cd}	70793^{cd}	2.57^{cd}	2.38^{bc}	2.48^{cd}
G_2S_2	2621^{d}	2428^{d}	2525^{d}	69180^{d}	61524^{d}	65352^{d}	2.50^{d}	2.29^{cd}	2.39^{d}
G_2S_3	2368^{e}	2157^{e}	2263^{e}	58739^{e}	50020^{e}	54379^{e}	2.29^{e}	2.06^{d}	2.18^{e}
G_3S_1	3005^{ab}	2842^{ab}	2923^{ab}	85010^{ab}	79118^{ab}	82064^{ab}	2.80^{ab}	2.62^{ab}	2.71^{ab}
G_3S_2	2882^{bc}	2717^{bc}	2799^{bc}	80634^{bc}	74529^{bc}	77582^{bc}	2.75^{a-c}	2.56^{a-c}	2.65^{bc}
G_3S_3	2639^{cd}	2438^{d}	2539^{d}	70648^{cd}	62665^{d}	66657^{cd}	2.55^{d}	2.33^{c}	2.44^{d}
S.Em.±	73.40	75.65	74.25	3230	3404	33.05	0.07	0.08	0.06
Control	2419	2208	2314	57848	49195	53522	2.19	1.98	2.09
S.Em.±	77	78	75	3383	3488	3331	0.07	0.07	0.07
C.D. (P=0.05)	228	230	222	10052	10364	9898	0.22	0.22	0.21

Table 3. Uptake of major nutrients (kg ha^{-1}) by cotton as influenced by genotypes and planting geometries under high density planting system

Treatments	Nitrogen (kg ha^{-1})			Phosphorus (kg ha^{-1})			Potassium (kg ha^{-1})		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Main plots (G)									
G_1	132.8^{a}	127.5^{a}	130.1^{a}	31.3^{a}	28.2^{a}	29.8^{a}	145.4^{a}	141.6^{a}	143.5^{a}
G_2	123.3^{b}	118.6^{b}	121.0^{b}	25.4^{b}	22.1^{b}	23.8^{b}	134.2^{c}	132.1^{c}	133.1^{c}
G_3	129.5^{a}	124.5^{a}	127.0^{a}	29.3^{a}	26.6^{a}	27.9^{a}	141.0^{b}	138.3^{b}	139.7^{b}
S.Em.±	0.98	1.08	1.02	0.70	0.67	0.69	0.88	0.77	0.82
Sub plots (S)									
S_1	132.8^{a}	127.5^{a}	130.1^{a}	31.7^{a}	28.5^{a}	30.1^{a}	143.3^{a}	140.2^{a}	141.8^{a}
S_2	129.3^{b}	124.2^{b}	126.7^{b}	29.1^{b}	26.1^{b}	27.6^{b}	140.7^{b}	137.8^{b}	139.3^{b}
S_3	123.5^{c}	118.9^{c}	121.2^{c}	25.2^{c}	22.3^{c}	23.7^{c}	136.6^{c}	134.0^{c}	135.3^{c}
S.Em.±	1.10	1.00	1.05	0.78	0.76	0.77	0.78	0.71	0.71
Interactions (G x S)									
G_1S_1	136.8^{a}	131.3^{a}	134.0^{a}	34.1^{a}	30.9^{a}	32.5^{a}	148.3^{a}	144.3^{a}	146.3^{a}
G_1S_2	133.6^{ab}	128.2^{ab}	130.9^{ab}	31.8^{ab}	28.7^{ab}	30.2^{ab}	146.0^{ab}	142.1^{ab}	144.0^{ab}
G_1S_3	128.0^{bc}	123.1^{b-d}	125.5^{bc}	28.0^{bc}	25.1^{b-d}	26.5^{bc}	142.0^{b}	138.4^{bc}	140.2^{bc}
G_2S_1	127.8^{bc}	122.8^{b-d}	125.3^{bc}	28.7^{bc}	25.3^{b-d}	27.0^{bc}	137.6^{cd}	135.3^{cd}	136.5^{cd}
G_2S_2	124.0^{c}	119.2^{d}	121.6^{c}	25.9^{cd}	22.5^{de}	24.2^{c}	134.7^{d}	132.6^{d}	133.6^{d}
G_2S_3	118.1^{d}	113.7^{e}	115.9^{d}	21.7^{d}	18.5^{e}	20.1^{d}	130.2^{e}	128.5^{e}	129.3^{e}
G_3S_1	133.7^{ab}	128.4^{ab}	131.0^{ab}	32.2^{ab}	29.4^{ab}	30.8^{ab}	144.0^{ab}	141.1^{ab}	142.6^{ab}
G_3S_2	130.2^{bc}	125.2^{bc}	127.7^{bc}	29.8^{a-c}	27.0^{a-c}	28.4^{a-c}	141.6^{bc}	138.9^{bc}	140.2^{bc}
G_3S_3	124.5^{c}	119.8^{cd}	122.2^{c}	25.8^{cd}	23.3^{cd}	24.5^{c}	137.5^{cd}	135.0^{cd}	136.2^{cd}
S.Em.±	1.91	1.74	1.82	1.36	1.31	1.33	1.34	1.22	1.27
Control	101.6	98.7	100.2	23.3	22.2	22.8	121.2	118.9	120.1
S.Em.±	1.9	1.8	1.8	1.3	1.3	1.3	1.5	1.4	1.4
C.D. (P=0.05)	5.6	5.3	5.4	3.9	3.7	3.8	4.4	4.0	4.2

Genotype SCS-1206 recorded significantly higher uptake of nitrogen, phosphorus and potassium (130.1, 29.8 and 143.5 kg ha^{-1}, respectively) and significantly lower uptake was recorded with DSC-99 (121.0, 23.8 and 133.1 kg ha^{-1}, respectively). Among different row spacings, significantly higher uptake of nitrogen, phosphorus and potassium

(130.1, 30.1 and 141.8 kg ha^{-1}, respectively) was observed with the closer row spacing of 60 x 10 cm over medium and wider row spacings. It was mainly attributed to higher number of plant population per unit area. Among the interactions, a combination of genotype SCS-1206 at 60 x 10 cm spacing recorded significantly higher uptake of nitrogen, phosphorus and potassium (134.0, 32.5 and 146.3 kg ha^{-1}, respectively) followed by combination of same genotype at 75 x 10 cm spacing and Suraj at 60 x 10 cm spacing. Cotton grown under conventional system recorded significantly lower uptake of nitrogen, phosphorus and potassium (100.2, 22.8 and 120.1 kg ha^{-1}, respectively). The results are in conformity with the findings of Tuppad (2015) and Udikeri (2017) who found significantly higher NPK uptake under higher plant population level of 2,22,222 plants ha^{-1}.

Conclusion

Among the genotypes, SCS-1206 resulted higher seed cotton yield, economics and NPK uptake followed by Suraj. Among the row spacings, a closer row spacing of 60 cm x 10 cm resulted in higher seed cotton yield, economics and NPK uptake. A combination of genotype SCS-1206 at a closer row spacing of 60 cm x 10 cm resulted in higher seed cotton yield, economics and NPK uptake. This combination was found most effective and ideal for increasing cotton productivity.

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