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Influence of planting geometry and nutrient management on yield, quality parameters, nutrient uptake and economics of compact cotton (*Gossypium hirsutum* L.) genotypes

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Abstract
A field experiment was conducted during the *Kharif* 2015at Agricultural College farm, Raichur. The results of this experiment revealed that seed cotton yield, quality parameters and economics of Rahc-1011 were statistically par with Rahc-1012. Spacing of 60cm x 30cm recorded significantly higher seed cotton yield, gross returns, net returns and BC ratio((1922kg ha^{-1}, Rs. 86,487, Rs. 54,571 ha^{-1} and 2.70, respectively) as compared to 60cm x 45cm spacing (1566kg ha^{-1}, Rs. 70,475, Rs. 39,023 ha^{-1} and 2.23, respectively) and was on par with 60cm x 15cm spacing (1816kg ha^{-1}, Rs. 84,056, Rs. 51,605 ha^{-1} and 2.58, respectively). Application of 125 per cent RDF recorded significantly higher seed cotton yield (2012kg ha^{-1}), nutrient uptake (115.60, 31.98 and 124.53kg N, P and K ha^{-1}) and BC ratio (2.73) of compact cotton genotypes when compared to 100 per cent RDF (1871kg ha^{-1}, 102.76, 26.47 and 115.12kg N, P and K ha^{-1}, 2.59, respectively), and 75 per cent RDF (1473, 79.65, 18.04 and 89.56kg N, P and K ha^{-1}, 2.19, respectively). The spacing of 60cm x 45cm recorded significantly higher ginning per cent and lint index (35.54% and 4.44) as compared to 60 x 15cm spacing (33.44% and 3.82).

Keywords: Compact genotypes, RDF, planting geometry, nutrient uptake

Introduction
Cotton (*Gossypium hirsutum* L.) is considered as an important fibre crop of India and Karnataka. It is the backbone of textile industries mainly because of its lint. India contributes 85 per cent of raw material to textile industry and it earns about 33 per cent of total foreign exchange (Anon., 2014-15). In India, cotton has an area of 11.97 m ha with a production of 34.22 m bales and productivity of 486kg lint ha^{-1} during 2012-13 as against an area of 5.88 m ha with a production of 3.04 m bales and productivity of 88kg ha^{-1} in 1950-51 (Anon 2014-15). In Karnataka, cotton occupies an area of 5.40 lakh ha with a production of 14.0 lakh bales and with productivity of 434kg lint per ha. The average production is very low when compared to world's average and it is mainly due to 70 per cent of cotton is cultivated as rainfed. Cotton producers are currently faced with rising production cost and declining returns for their commodity. The reason for the low yield is mainly due to non-adoption of precise location specific production packages. Among the various production factors, spacing and fertilization beside climate play significant role. The yield and other yield attributing parameters of cotton vary with planting geometry. In cotton growing areas, imbalanced fertilization of crop also affected vegetative and reproductive growth, thereby causing low productivity. Balanced fertilization is one of the major key factors affecting cotton yields. Optimum planting geometry is one of the most important factor for efficient utilization of available sources. The determination of optimum planting geometry with fertilizer doses for compact cotton is necessary for maximum utilization of various resources viz., light, moisture and CO_2 to augment crop yield. Efficient cotton production packages from modern agronomy of cotton explore the avenues for realizing the potential crop yields. Looking towards increase in area of cotton, it is was felt necessary to conduct experiment to know the effect of planting geometry and nutrient management on yield, quality, nutrient uptake and economics of compact cotton genotypes.

Material and Methods

A field experiment was conducted during the *Kharif*2015 at Agricultural College farm, Raichur, situated on the latitude of $16^{0}12^{1}$ N latitude, $77^{0}20^{1}$ E longitude with an elevation of 389 meters above mean sea level and is located in North Eastern Dry Zone of Karnataka. The experiment was laid out in factorial RCBD with 18 treatments replicated thrice. The studies included two genotypes (G_1: Rahc-1011, G_2: Rahc-1012), three spacings (S_1: 60cm x 15cm, S_2: 60cm x 30cm, S_3: 60cm x 45cm) and three fertilizer levels **(**F_1: 75% RDF, F_2: 100% RDF, F_3: 125% RDF). New compact cotton genotypes (Rahc-1011 and Rahc-1012) were used for sowing. Rahc-1011 is a *Gossypium hirsutum* variety of cotton developed by cotton section, MARS, Raichur. The crop matures in 150-160 days with a yield potential of 25-30 q ha^{-1} under irrigated conditions. Boll size is medium and its average weight is 3-4g with 4-5 locules.Rahc-1012 is a *Gossypium hirsutum* variety of cotton developed by MARS, Raichur. It is suitable for high density planting and it can be grown under irrigated situation. The crop matures in 150-160 days with the yield of 26-30 q ha^{-1}. Bolls size is medium and its average weight is 3-4g. Half the dose of nitrogen and potassium, entire dose of phosphorous in the form of urea, muriate of potash (MOP) and diammonium phosphate (DAP), respectively were band placed as per the treatments. Fertilizers were applied 4-5cm deep and 5cm away from the plant at 30 days after sowing. Remaining half dose of nitrogen and potassium in the form of urea and MOP was top dressed in two equal splits at 60 and 90 days after sowing in the ring formed 5cm away from the plant. The soil of the experimental site was deep black and clay in texture with the available nitrogen (190.00kg ha^{-1}), phosphorus (23.90kg ha^{-1}), potassium (250.00kg ha^{-1}) and organic carbon content (0.68%). The mean fibre length and micronaire values were measured by standard methods.

Results and Discussion

Genotypic Effect

The seed cotton yield of compact genotypes did not differ significantly because of their genetic makeup. However, the Rachc-1012 genotype recorded higher (1816kg ha^{-1}) seed cotton yield but was on par with Rahc-1011 genotype (1754kg ha^{-1}). The probable reason of this might be the variation in the genetic constitution of the variety. These results were in conformity with the finding of Gadade *et al.* (2015) [4]. With respect to quality parameters, significantly higher lint index and ginning percentage (Table.1) was recorded in Rahc-1012 which was superior over than Rahc-1011 except mean fibre length and Micronaire value (Table. 2). Among the two genotypes, Rahc-1012 recorded significantly higher uptake of Nitrogen (101.43kg ha^{-1}), Phosphorous (26.30kg ha^{-1}) and Potassium (111.87kg ha^{-1}) when compared to Rahc-1011(97.24, 24.69 and 107.60 NPKkg ha^{-1}, respectively).

Effect of Planting Geometry

Significantly higher seed cotton yield was obtained with spacing of 60cm x 30cm (1922kg ha^{-1}) over 60cm x 45cm (1566kg ha^{-1}) and which was on par with 60cm x 15cm (1868kg ha^{-1}) which was mainly due to higher plant population per unit area. These results were in close conformity with finding of Bhalerao *et al.* (2010) [2] who reported that significantly higher seed cotton yield was recorded in closer spacing (60cm x 30cm) than wider spacing 60cm x 45cm). Similarly, Tomar *et al.* (2000) [9] found that closer intra row planting gave numerically higher seed cotton yield than wider intra row spaced crop. The data on quality parameter did not differ significantly with respect to spacing except ginning percentage and lint index parameters (Table 1). The spacing of 60cm x 45cm recorded significantly higher ginning per cent and lint index (35.54% and 4.44). This might be due to less attachment of foreign material on lint when compared to closer spacing. Similar results were obtained by Darawesheh *et al*. (2009) [3] and Jahedi *et al.* (2013) [6]. Significantly higher nutrient uptake was noticed with the spacing of 60cm x 15cm when compared to 60cm x 30 and 60cm x 45cm spacing. It is mainly due to the higher plant population per unit area (Manjunath *et al*., 2010) [8]. Economic analysis varied significantly due to different planting geometry. Among the different spacings, 60cm x 30cm recorded significantly higher gross returns, net returns, and benefit cost ratio (Rs. 86,487 ha^{-1}, 54,571 ha^{-1} and 2.70, respectively) compared to 60cm x 45cm (Rs. 70,475 ha^{-1}, 39,023 ha^{-1} and 2.30, respectively) which was on par with closer spacing of 60cm x15cm (Rs. 84,056 ha^{-1}, 51,605 and 2.58, respectively). This is mainly because of higher seed cotton yields per hectare. These results are in consonance with findings of Manjunatha *et al*. (2010) [8] and Darawesheh *et al*. (2009) [3].

Effect of Fertilizer Levels

Application of 125 per cent RDF recorded significantly higher seed cotton yield (2012kg ha^{-1}) when compared to 100 per cent RDF (1871kg ha^{-1}) and 75 per cent RDF (1473kg ha^{-1}).It might be due to increase the availability of nutrients which helped the plants to attain its maximum yield potential. Application of 125 per cent RDF recorded significantly higher lint index and ginning percentage (4.39 and 35.34, respectively) over 100 per cent RDF (4.39 and 34.94, respectively) and 75 per cent RDF (3.90 and 33.87, respectively). Significantly higher uptake of nitrogen, phosphorus and potassium (115.6, 31.98 and 124.53kg ha^{-1}, respectively) were recorded with 125 per cent RDF when compared with 100 and 75 per cent RDF (102.76, 26.47 and 115.12kg ha^{-1} and 79.65, 18.04 and 89.56kg ha^{-1}, respectively). These results are in accordance with the findings of Katkar *et al.* (2002) [7]. Application of higher levels of fertilizer (125%) recorded significantly higher gross returns (Rs. 90,536 ha^{-1}), net returns (Rs. 57,381 ha^{-1}) and benefit cost ratio (2.73) when compared to the application of 100 per cent (Rs. 84,217 ha^{-1}, 51,785 $ha^{-1}$and 2.59, respectively) and 75 per cent RDF (Rs. 66,266 ha^{-1}, 36,033 ha^{-1} and 2.19, respectively). The decrease in gross returns, net returns and benefit cost ratios were noticed with decreased levels of fertilize. The higher gross and net returns were mainly due to higher economic yield associated with higher levels of fertilizer applied treatment. These results were in close conformity with reports of Jagvir Singh *et al*. (2012) [5].

Interaction Effects

Interaction effects between spacing and fertilizer levels were found to be significant for seed cotton yield. Spacing of 60cm x 30cm with application of 125 per cent RDF recorded significantly higher seed cotton yield (2196kg ha^{-1}) when compared to other treatments combinations and it was on par with 60cm x 15cm with 125 per cent RDF (2078kg ha^{-1}) and 60cm x 30cm spacing with 100 per cent RDF (2071kg ha^{-1}). Lower seed cotton yield was recorded in 60cm x 45cm spacing with 75 per cent RDF (1283kg ha^{-1}). The differences in seed cotton yield due to planting geometry and fertilizer can be related to their differential responses of growth and

yield contributing characters. None of quality parameters differed due to planting geometry and nutrient application in compact cotton genotypes. The interaction effect between plant spacing and fertilizer levels differed significantly with respect to gross returns, net returns and BC ratio (Table 3). Data indicated that significantly higher gross returns, net returns and BC ratio was recorded with interaction of 60cm x30cm spacing along with 125 per cent RDF (Rs. 98,807 ha^{-1}, 65,894 ha^{-1} and 3.00, respectively) when compared to other treatment combinations and was on par with 60cm x 15cm with 125 per cent RDF (Rs. 93,498 ha^{-1}, 59,820 ha^{-1} and 2.78, respectively) and 60cm x 30cm spacing with 100 per cent RDF (Rs. 93,200 ha^{-1}, 60,615 ha^{-1} and 2.86, respectively). Jagvir Singh *et al*. (2012) [5] reported that under high plant density system with application of fertilizer levels of 125 per cent RDF recorded significantly higher gross monetary returns, net monetary returns and BC ratio over other lower fertilizer levels.

Conclusion

It was concluded that, spacing of 60cm x 30cm along with 125 per cent RDF recorded significantly higher gross returns, net returns and BC ratio compared to other treatment combinations which was on par with 60cm x 15cm with 125 per cent RDF and 60cm x 30cm with 100 per cent RDF.

Table 1: Yield and quality parameters of compact cotton genotypes as influenced by planting geometry and nutrient management

Treatments		Seed cotton yield (kg)				Ginning percentage				Lint index				Mean fibre length (mm)			
		F1	F2	F3	Mean	F1	F2	F3	Mean	F1	F2	F3	Mean	F1	F2	F3	Mean
G1	S1	1560	1891	2047	1833	32.30	33.95	35.37	33.88	3.55	4.10	4.42	4.02	23.53	24.87	25.27	24.56
	S2	1461	2062	2150	1891	35.22	36.35	36.04	35.87	4.13	4.47	4.63	4.41	24.17	25.90	26.20	25.42
	S3	1249	1613	1756	1539	36.03	35.97	36.02	36.01	4.40	4.55	4.75	4.57	24.93	25.17	25.07	25.06
	Mean	1423	1855	1984	1754	34.52	35.42	35.81	35.25	4.02	4.38	4.60	4.33	24.21	25.31	25.51	25.01
G2	S1	1711	1890	2108	1903	31.43	33.47	34.11	33.00	3.26	3.75	3.83	3.62	24.63	24.37	25.03	24.68
	S2	1537	2080	2241	1953	33.71	34.73	35.00	34.48	3.91	4.03	4.21	4.05	24.77	25.13	25.47	25.12
	S3	1317	1693	1769	1593	34.52	35.18	35.51	35.07	4.15	4.27	4.52	4.31	24.60	25.37	26.33	25.43
	Mean	1522	1888	2039	1816	33.22	34.46	34.87	34.18	3.77	4.02	4.19	3.99	24.67	24.96	25.61	25.08
S1		1635	1891	2078	1868	31.86	33.71	34.74	33.44	3.41	3.92	4.13	3.82	24.08	24.62	25.15	24.62
S2		1499	2071	2196	1922	34.46	35.54	35.52	35.17	4.02	4.25	4.42	4.23	24.47	25.52	25.83	25.27
S3		1283	1653	1762	1566	35.27	35.57	35.77	35.54	4.27	4.41	4.64	4.44	24.77	25.27	25.70	25.24
Mean		1473	1871	2012	1785	33.87	34.94	35.34	34.72	3.90	4.20	4.39	4.16	24.44	25.13	25.56	25.04
		S. Em.±		C.D. (0.05)		S.Em.±		C.D. (0.05)		S.Em.±		C.D. (0.05)		S.Em.±		C.D. (0.05)	
Genotypes (G)		23		NS		0.34		0.97		0.04		0.12		0.25		NS	
Spacing (S)		28		79		0.41		1.19		0.05		0.15		0.31		NS	
Fertilizers (F)		28		79		0.41		1.19		0.05		0.15		0.31		NS	
G at same/different level of S		39		NS		0.59		NS		0.07		NS		0.44		NS	
G at same/different level of F		39		NS		0.59		NS		0.07		NS		0.44		NS	
S at same/different level of F		48		137		0.72		NS		0.09		NS		0.53		NS	
G x S x F		68		NS		1.01		NS		0.13		NS		0.75		NS	

NS: Non-significant

G1: Rahc-1011 G2: Rahc -1012

F1: 75% RDF (60:40:40 NPK kg ha^{-1}) S1: 60 cm x 15 cm (1, 11, 111 plants ha^{-1})

F2: 100% RDF (80:50:50 NPK kg ha^{-1}) S2: 60 cm x 30 cm (55,555 plants ha^{-1})

F3: 125% RDF (100:50:50 NPK kg ha^{-1}) S3: 60 cm x 45 cm (37,037 plants ha^{-1})

Table 2: Micronaire value and nutrient uptake of compact cotton genotypes as influenced by planting geometry and nutrient management.

Treatments		Micronaire value				Nitrogen				Phosphorus				Potassium			
		F1	F2	F3	Mean	F1	F2	F3	Mean	F1	F2	F3	Mean	F1	F2	F3	Mean
G1	S1	4.03	4.23	4.17	4.14	79.56	102.11	120.00	100.56	18.72	24.58	32.75	25.35	92.04	111.57	122.82	108.81
	S2	4.10	4.13	4.03	4.09	77.43	117.50	125.40	106.78	17.53	30.31	34.40	27.41	88.39	126.81	133.30	116.17
	S3	4.10	4.30	4.20	4.20	72.44	85.50	95.20	84.38	14.99	22.58	26.34	21.30	81.19	101.62	110.63	97.81
	Mean	4.08	4.22	4.13	4.14	76.48	101.70	113.53	97.24	17.08	25.83	31.16	24.69	87.21	113.33	122.25	107.60
G2	S1	4.00	4.10	4.00	4.03	88.97	104.20	126.00	106.39	20.53	26.46	33.73	26.91	99.24	113.40	126.48	113.04
	S2	4.03	4.07	3.97	4.02	83.00	116.83	130.50	110.11	19.98	31.20	38.10	29.76	92.22	128.96	138.94	120.04
	S3	4.07	4.03	4.17	4.09	76.50	90.40	96.50	87.80	16.46	23.70	26.54	22.23	84.29	108.35	114.99	102.54
	Mean	4.03	4.07	4.04	4.05	82.82	103.81	117.67	101.43	18.99	27.12	32.79	26.30	91.92	116.90	126.80	111.87
S1		4.02	4.17	4.08	4.09	84.27	103.16	123.00	103.47	19.63	25.52	33.24	26.13	95.64	112.48	124.65	110.92
S2		4.07	4.10	4.00	4.06	80.22	117.17	127.95	108.44	18.76	30.76	36.25	28.59	90.31	127.89	136.12	118.10
S3		4.08	4.17	4.18	4.14	74.47	87.95	95.85	86.09	15.73	23.14	26.44	21.77	82.74	104.99	112.81	100.18
Mean		4.06	4.14	4.09	4.10	79.65	102.76	115.60	99.34	18.04	26.47	31.98	25.49	89.56	115.12	124.53	109.73
		S. Em.±		C.D. (0.05)		S.Em.±		C.D. (0.05)		S. Em.±		C.D. (0.05)		S. Em.±		C.D. (0.05)	
Genotypes (G)		0.04		NS		0.97		2.78		0.31		0.89		1.09		3.14	
Spacing (S)		0.05		NS		1.19		3.41		0.38		1.09		1.34		3.84	
Fertilizers (F)		0.05		NS		1.19		3.41		0.38		1.09		1.34		3.84	
G at same/different level of S		0.07		NS		1.68		NS		0.54		NS		1.89		NS	
G at same/different level of F		0.07		NS		1.68		NS		0.54		NS		1.89		NS	
S at same/different level of F		0.09		NS		2.05		5.90		0.66		1.89		2.31		6.65	
G x S x F		0.13		NS		2.91		NS		0.93		NS		3.27		NS	

NS: Non-significant

G_1: Rahc-1011 G_2: Rahc -1012
F_1: 75% RDF (60:40:40 NPK kg ha^{-1}) S_1: 60 cm x 15 cm (1, 11, 111 plants ha^{-1})
F_2: 100% RDF (80:50:50 NPK kg ha^{-1}) S_2: 60 cm x 30 cm (55,555 plants ha^{-1})
F_3: 125% RDF (100:50:50 NPK kg ha^{-1}) S_3: 60 cm x 45 cm (37,037 plants ha^{-1})

Table 3: Economics of compact cotton genotypes as influenced by planting geometry and nutrient management

Treatments		Cost of cultivation (Rs. ha^{-1})				Gross returns (Rs. ha^{-1})				Net returns (Rs. ha^{-1})				Benefit Cost ratio			
		F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
G_1	S_1	30811	32685	33456	32317	70203	85102	92136	82480	39392	52417	58680	50163	2.28	2.60	2.75	2.55
	S_2	30100	32585	32800	31828	65726	92799	96768	85098	35626	60214	63968	53269	2.18	2.85	2.95	2.66
	S_3	29500	31885	32856	31414	56220	72565	79002	69262	26720	40680	46146	37849	1.91	2.28	2.40	2.20
	Mean	30137	32385	33037	31853	64050	83489	89302	78947	33913	51104	56265	47094	2.12	2.58	2.70	2.47
G_2	S_1	30900	32950	33900	32583	76990	85044	94860	85631	46090	52094	60960	53048	2.49	2.58	2.80	2.62
	S_2	30400	32585	33025	32003	69182	93600	100845	87876	38782	61015	67820	55872	2.28	2.87	3.05	2.73
	S_3	29685	31900	32890	31492	59273	76190	79602	71689	29588	44290	46712	40197	2.00	2.39	2.42	2.27
	Mean	30328	32478	33272	32026	68482	84945	91769	81732	38154	52466	58497	49706	2.25	2.61	2.76	2.54
S_1		30856	32818	33678	32450	73597	85073	93498	84056	42741	52255	59820	51605	2.38	2.59	2.78	2.58
S_2		30250	32585	32913	31916	67454	93200	98807	86487	37204	60615	65894	54571	2.23	2.86	3.00	2.70
S_3		29593	31893	32873	31453	57747	74378	79302	70475	28154	42485	46429	39023	1.95	2.33	2.41	2.23
Mean		30233	32432	33155	31940	66266	84217	90536	80339	36033	51785	57381	48400	2.19	2.59	2.73	2.50
		-		-		-		-		S.Em.±		C.D. (0.05)		S.Em.±		C.D. (0.05)	
Genotypes (G)		-		-		-		-		942		NS		0.03		NS	
Spacing (S)		-		-		-		-		1154		3316		0.04		0.10	
Fertilizers (F)		-		-		-		-		1154		3316		0.04		0.10	
G at same/different level of S		-		-		-		-		1632		NS		0.05		NS	
G at same/different level of F		-		-		-		-		1632		NS		0.05		NS	
S at same/different level of F		-		-		-		-		1999		5744		0.06		0.18	
G x S x F		-		-		-		-		2827		NS		0.09		NS	

NS: Non-significant
G_1: Rahc-1011 G_2: Rahc -1012
F_1: 75% RDF (60:40:40 NPK kg ha^{-1}) S_1: 60 cm x 15 cm (1, 11, 111 plants ha^{-1})
F_2: 100% RDF (80:50:50 NPK kg ha^{-1}) S_2: 60 cm x 30 cm (55,555 plants ha^{-1})
F_3: 125% RDF (100:50:50 NPK kg ha^{-1}) S_3: 60 cm x 45 cm (37,037 plants ha^{-1})

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