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

Anand Alur, AS Halepyati, BM Chittapur, JM Nidagundi and K Narayana Rao

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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 percent 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 (\textit{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 16º12’N latitude, 77º20’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 (G1: Rahc-1011, G2: Rahc-1012), three spacings (S1: 60cm x 15cm, S2: 60cm x 30cm, S3: 60cm x 45cm) and three fertilizer levels (F1: 75% RDF, F2: 100% RDF, F3: 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. 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 a yield potential of 25-30 q ha⁻¹ under irrigated conditions. Boll size is medium and its average weight is 3-4g. Half the dose of nitrogen and potassium, entire dose of phosphorus (23.90kg ha⁻¹), phosphorus (23.90kg ha⁻¹), potassium (250.00kg ha⁻¹) 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, 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 Rahc-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 (115.12kg 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 Bhalarao 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 percentage 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 x 15cm (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 fertilizer. 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 x 30cm spacing along 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.

| 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         | 3.156 | 1989 | 2047 | 1833 | 32.30 | 33.95 | 35.37 | 33.88 | 3.55 | 4.10 | 4.42 | 4.02 | 25.53 | 24.87 | 25.27 | 24.56 |
| S2         | 1.461 | 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         | 1.423 | 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       |    |    |    |      |    |    |    |      |    |    |    |      |    |    |    |      |
| G2         |    |    |    |      |    |    |    |      |    |    |    |      |    |    |    |      |
| S1         | 1.711 | 1890 | 2108 | 1903 | 31.43 | 33.47 | 33.11 | 33.00 | 3.26 | 3.75 | 3.83 | 3.62 | 24.63 | 24.37 | 25.03 | 24.68 |
| S2         | 1.537 | 2080 | 2241 | 1953 | 33.71 | 34.73 | 35.00 | 34.48 | 3.91 | 4.03 | 4.21 | 4.07 | 24.77 | 25.13 | 25.47 | 25.12 |
| S3         | 1.317 | 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 | 25.44 |
| Mean       |    |    |    |      |    |    |    |      |    |    |    |      |    |    |    |      |
| Genotypes (G) |    |    |    |      |    |    |    |      |    |    |    |      |    |    |    |      |
| NS | Non-significant |
| Spacing (S) |    |    |    |      |    |    |    |      |    |    |    |      |    |    |    |      |
| 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       |    |    |    |      |    |    |    |      |    |    |    |      |    |    |    |      |
| 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 | 114.30 | 126.48 | 113.04 |
| S2         | 4.03 | 4.07 | 3.97 | 4.02 | 83.00 | 116.83 | 130.50 | 111.98 | 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       |    |    |    |      |    |    |    |      |    |    |    |      |    |    |    |      |
| Genotypes (G) |    |    |    |      |    |    |    |      |    |    |    |      |    |    |    |      |
| NS | Non-significant |
| Spacing (S) |    |    |    |      |    |    |    |      |    |    |    |      |    |    |    |      |
| 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 3:** Yield and quality parameters of compact cotton genotypes as influenced by planting geometry and nutrient management.
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 |
|------------|--------------------------------|--------------------------|------------------------|-------------------|
|            | F1 | F2 | F3 | Mean | F1 | F2 | F3 | Mean | F1 | F2 | F3 | Mean | F1 | F2 | F3 | Mean |
| G1         |    |    |    |      |    |    |    |      |    |    |    |      |    |    |    |      |
| S1         | 30811 | 32685 | 33456 | 32317 | 70203 | 85102 | 92136 | 82480 | 39392 | 52417 | 58680 | 50163 | 2.28 | 2.60 | 2.75 | 2.55 |
| S2         | 30100 | 32583 | 33188 | 32692 | 65726 | 80102 | 96985 | 85860 | 35626 | 47331 | 55998 | 52417 | 2.18 | 2.50 | 2.65 | 2.46 |
| S3         | 29500 | 31885 | 32356 | 31924 | 64000 | 83489 | 92136 | 81398 | 33913 | 47331 | 54998 | 49933 | 1.91 | 2.30 | 2.40 | 2.15 |
| Mean       | 30137 | 32385 | 33037 | 32026 | 65050 | 83489 | 91769 | 80232 | 37913 | 51104 | 56265 | 50163 | 2.12 | 2.58 | 2.70 | 2.47 |
| G2         |    |    |    |      |    |    |    |      |    |    |    |      |    |    |    |      |
| S1         | 30900 | 32950 | 33900 | 32583 | 76990 | 85044 | 94860 | 85631 | 46090 | 52094 | 60960 | 53048 | 2.49 | 2.58 | 2.80 | 2.62 |
| S2         | 30400 | 32585 | 33025 | 32003 | 69182 | 93600 | 100845 | 87876 | 38782 | 61015 | 67820 | 55872 | 2.28 | 2.87 | 3.05 | 2.73 |
| S3         | 29685 | 31900 | 32890 | 31492 | 59273 | 76190 | 79602 | 71689 | 29588 | 44290 | 46712 | 37849 | 2.00 | 2.39 | 2.42 | 2.27 |
| Mean       | 30328 | 32478 | 33272 | 32026 | 66266 | 84217 | 90536 | 80339 | 36033 | 51785 | 57381 | 49706 | 2.19 | 2.59 | 2.73 | 2.50 |
|            |    |    |    |      |    |    |    |      |    |    |    |      |    |    |    |      |
| S           | 30856 | 32818 | 33678 | 32450 | 73597 | 85073 | 93498 | 84056 | 42741 | 52559 | 59820 | 51605 | 2.38 | 2.59 | 2.78 | 2.58 |
| F1         |    |    |    |      |    |    |    |      |    |    |    |      |    |    |    |      |
| F2         |    |    |    |      |    |    |    |      |    |    |    |      |    |    |    |      |
| F3         |    |    |    |      |    |    |    |      |    |    |    |      |    |    |    |      |
| Mean       |    |    |    |      |    |    |    |      |    |    |    |      |    |    |    |      |

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)

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