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Effect of fertilizer management and spacing on growth and yield of *kharif* cotton (*Gossypium hirsutum L.*) under lateritic belt of West Bengal

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Cotton (*Gossypium hirsutum*) the most important fibre crop of India plays a dominant role in its agrarian and industrial economy. Cotton the 'King of Fibres' is also called as 'white gold' because of its higher economical value among cultivable crops for quite a long period. It was the superiority of Indian cotton fabrics famed as 'Webs of woven mind' which attracted European countries to seek new trade routes to India. Cotton is the backbone of our textile industry, accounting for 65% of total fibre consumption in textile sector and 33% of the country's export, fetching over 12 billion dollars. Cotton is cultivated in three distinct agro-ecological regions (north, central and south) of the country. India has the largest acreage (95.29 lakh ha) under cotton at global level and has the productivity of 553 kg lint ha^{-1} and ranks second in production (310 lakh bales) during 2007-08.

According to Dr. M. S. Swaminathan, "The greening of agriculture requires the greening of both technology and public policy. Producing more agricultural commodities from less land, water & energy is a task that will call for the integration of the best in modern technology, with the ecological strengths of traditional farming practices". Soil fertility is quantified with available N, P& K content in the soil with improved physiochemical properties. Adequate supply of nutrients would satisfy nutrient demand of crop besides improving the soil fertility. Cotton is a deep rooted crop, voracious feeder of the nutrients and responds well for nitrogen but not with phosphorus & potassium. Cotton requires the constant supply of nutrients; the response was more during flowering and boll development (Srinivasan, 2001) Another point is that modern agriculture relies heavily on the intensive cultivation of crop with the use of high analysis NPK fertilizer resulting in the accelerated depletion of finite reservoirs of secondary & micronutrients demand in soil & are increasingly become major constraints to achieve augmented agricultural production. This evil of excess nitrogen & balance in NPK dosage are still less appreciated in cotton nutrient management. Imbalance in fertilizer application & decreasing soil quality could be one of the reasons for the yield decline. Usually, a balanced optimum nutrient supply ensures optimum growth & ensures plant resistance which leads to depletion of nutrient and minimizing long term mining (Prasad *et al.*, 2005). Since cotton is a wide rowed crop and its yield is very much dependent on the spacing, so the study of optimum spacing in the newly released varieties is an important field of study. In this context, the present investigation was carried out to find out the optimum spacing and nitrogen dose for the cotton variety LRA 5166 in the lateritic belt of West Bengal.

A field experiment was conducted during 2008-09 on sandy loam and lateritic soil at the Rathindra Krishi Vigyan Kendra, Sriniketan, Birbhum which is situated in the western lateritic part of West Bengal under semi arid sub-humid zone in the Western India. The soil was slight acidic in nature, low in organic carbon (0.33%), available nitrogen (121 kg ha^{-1}), medium in available phosphorus (24.2 kg ha^{-1}) and available potassium (134.20 kg ha^{-1}). The experiment was laid out in Randomized Block Design having 2 factors i.e. fertilizer & spacing with 3 replications. The experiment consisted of nine treatment combinations with three levels of spacing (S_1=75cm × 30cm, S_2=60cm × 30cm, S_3=45cm × 30cm) and three levels of nutrient doses (F_1=45:30:30, F_2=60:40:40, F_3=75:50:50 kg N, P_2O_5, K_2O ha^{-1}). LRA-5166 variety was selected for the experiment. The variety was suited for cultivation in *kharif* season in India as well as in West Bengal condition. In this experiment, FYM @ 10 t ha^{-1} were applied in the field before the final land preparation. Here inorganic fertilizer like urea, single super phosphate (SSP) and muriate of potash (MOP) were applied. The crop was raised as per standard package and practices. The analyses of variance method was followed to statistically analyse the various data. The significance of different source of variations was tested by "Error Mean Square Method" of Fisher Snedecor's 'F' test at probability level 0.05. In the tables of result and discussion chapter, the standard error of Mean (SEm $\pm$) and the value of critical difference (CD) to compare the differences between means and coefficient of variance(CV) have been provided.

Growth attributes of cotton

At 150 DAS, the highest plant height of 119.76cm was recorded with 45cm × 30 cm spacing, which was significantly higher than 60 × 30 cm spacing. Meanwhile decrease of row spaces caused plant to grow taller. Similar findings were recorded by Sarkar and Malik (2004) with intermediate plant spacing of 45 cm. In the same growth stage, the highest plant height (115.62 cm) was obtained in the fertilizer dose of 60:40:40 kg N, P_2O_5, K_2O ha^{-1}. The maximum height of the plant were recorded at 150 DAS with the fertilizer dose of 60:40:40 kg N, P_2O_5, K_2O ha^{-1} which was at par with the fertilizer application of 75:50:50 kg N, P_2O_5, K_2O ha^{-1}. So, from the treatment it was found that the treatment combination of 45 cm × 30 cm spacing & 60:40:40 kg N, P_2O_5, K_2O ha^{-1} i.e. S_3F_2 treatment showed the highest plant height.

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Table 1: Effect of fertilizer management and spacing on growth of cotton

Treatment	Plant height (cm)					Dry matter accumulation (g m^{-2})				
	30DAS	60 DAS	90 DAS	120 DAS	150 DAS	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS
Spacing										
75 cm × 30 cm	14.19	42.27	75.73	88.41	103.83	32.83	75.43	177.85	305.76	446.67
60 cm × 30 cm	15.87	45.89	78.40	92.82	106.78	33.44	85.61	201.33	324.16	458.33
45 cm × 30 cm	16.67	50.78	86.18	103.00	119.76	39.77	111.67	215.62	344.27	489.33
SEm(±)	**0.54**	**2.07**	**1.80**	**2.64**	**3.30**	**0.32**	**1.39**	**3.04**	**2.58**	**3.50**
LSD(0.05)	**1.60**	**NS**	**5.40**	**7.91**	**9.89**	**0.90**	**4.16**	**9.13**	**7.73**	**10.50**
Fertilizer (N: P_2O_5:K_2O kg ha^{-1})										
45: 30: 30	14.27	42.75	76.62	90.80	104.80	33.87	87.11	187.11	309.92	397.67
60 : 40 :40	16.78	49.06	82.27	99.22	115.62	36.37	93.89	205.94	336.96	485.67
75 : 50 : 50	15.57	47.11	81.42	94.24	109.94	35.80	91.71	201.76	327.30	469.00
SEm(±)	**0.54**	**2.07**	**1.80**	**2.64**	**3.30**	**0.32**	**1.39**	**3.04**	**2.58**	**3.50**
LSD(0.05)	**1.60**	**6.20**	**5.40**	**7.91**	**9.89**	**0.90**	**4.16**	**9.13**	**7.73**	**10.50**

Table 2: Effect of fertilizer management and spacing on seed cotton yield, biological yield & harvest index of *kharif* Cotton at harvest

Treatment	Number of flowers m^{-2}			Number of bolls m^{-2}			Seed cotton yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest Index (%)
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS			
Spacing									
75cm × 30cm	5.54	7.15	5.13	8.72	9.51	12.83	616.10	3158.19	19.60
60cm × 30cm	6.01	8.07	5.81	10.01	12.16	14.29	761.73	3546.21	20.75
45cm × 30cm	7.01	8.68	6.71	11.93	15.30	17.51	887.28	4183.62	21.26
SEm(±)	**0.19**	**0.16**	**0.24**	**0.54**	**0.50**	**0.54**	**20.57**	**139.38**	**0.48**
LSD(0.05)	**0.57**	**0.48**	**0.72**	**1.63**	**1.50**	**1.62**	**61.67**	**417.82**	**NS**
Fertilizer (N: P_2O_5:K_2O kg ha^{-1})									
45: 30: 30	5.94	7.78	5.58	9.42	11.67	14.13	722.79	3350.83	21.46
60 : 40 :40	6.58	8.37	6.36	10.88	13.40	15.91	785.34	3728.22	21.12
75 : 50 : 50	6.03	8.11	5.71	10.37	11.89	14.59	756.98	3808.95	19.86
SEm(±)	**0.19**	**0.16**	**0.24**	**0.54**	**0.50**	**0.54**	**20.57**	**139.38**	**0.48**
LSD(0.05)	**0.57**	**0.48**	**0.72**	**NS**	**1.50**	**1.62**	**61.67**	**NS**	**NS**

Prasad *et al.* (2005) found that each excess level of N significantly increased the plant height in cotton and tallest plants were obtained with the application of 60 kg N ha^{-1}. It was observed that at 150 DAS, the highest dry matter accumulation of 489.33g m^{-2} occurred when plants were grown at 45cm × 30cm spacing which was significantly higher than that observed at spacing of 75cm × 30cm & 60cm × 30cm. The same trend was observed in other growth stages. Reduction in dry matter under wider inter-row spacing of 75cm and 60cm can be attributed to inefficient use of radiation, because under wider spacing much of radiation may even be wasted by falling on ground during major part of growing period. Wider inter row spacing decreased plant density which might have resulted in the reduction of dry matter ha^{-1} (Sarkar and Malik, 2004). In case of fertilizer levels, at 150 DAS, the highest value of 485.67 g m^{-2} dry matter accumulation was observed in 60:40:40 kg N, P_2O_5, K_2O ha^{-1} which was statistically at par with that observed at 75:50:50 kg N,P_2O_5,K_2O ha^{-1} but significantly higher than that observed at 45:30:30 kg N, P_2O_5, K_2O ha^{-1}. The same trend was observed in other growth stages. Application of higher amount of K along with N might helped in better uptake of nutrients thereby increasing the dry matter production of cotton. (Srinivasan,2003). The total dry matter production at peak flowering stage and boll bursting stage were highest with the application of recommended level of fertilizer of 60:30:30 kg N, P_2O_5, K_2O ha^{-1} (Srinivasan, 2001).

Yield attributes

Among different growth stages, the highest number of flowers/m^2 was observed at 90 DAS with the spacing of 45 cm × 30 cm. In case of fertilizer dose, the highest value was observed in 60:40:40 kg N, P_2O_5, K_2O ha^{-1} vtreatment which was at par with the treatment of 75:50:50 kg N, P_2O_5, K_2O ha^{-1} fertilizer application. At all the growth stages, spacing of 45 cm × 30 cm also showed the highest number of bolls m^{-2} which was significantly higher than 75 cm × 30 cm spacing. The highest number of bolls m^{-2} was observed with 60:40:40 kg N, P_2O_5, K_2O ha^{-1} which was significantly higher than the fertilizer doses of 45:30:30 kg N, P_2O_5, K_2O ha^{-1} but statistically at par with the fertilizer doses of 75:50:50 kg N, P_2O_5, K_2O ha^{-1}. Sawan (1986) reported that number of bolls $plant^{-1}$ was increased with increasing N doses. Prasad *et al.* (2005) showed that the significant increase in bolls $plant^{-1}$ was obtained only with an application of 60 kg N ha^{-1}. Kasap and Killi (2004) reported similar findings. The application of 45cm × 30 cm produced significantly higher quantity of seed cotton yield (887.28 kg ha^{-1}) than all other treatment. The increase in seed cotton yield with the spacing of 45 cm × 30 cm was 44% &16.4% respectively over the value of 75 cm × 30 cm & 60 cm × 30cm spacing. The results confirm the findings of Yadav *et al.* (1992). Such increase in the yield with the row spacing of 45 cm × 30 cm can be attributed to improvement in ancillary characters/plant of cotton owing to optimum utilization of spaces, soil & environmental resources available for the individual plant coupled with optimization of population stand. The decrease of cotton yield with wider spacing may be attributed to less number of bolls m^{-2} as well as lower plant population per unit area. The widely spaced plants probably could not utilize fully the available moisture & nutrients from the inter-veining large gaps between plants (Sarkar & Malik, 2004). In fertilizer levels, treatment with 60:40:40 kg N, P_2O_5, K_2O ha^{-1} showed the highest response in respect to seed cotton yield which was at par with 75:50:50 kg N, P_2O_5, K_2O ha^{-1}. The increase in the seed cotton yield was 8.6% compared to the fertilizer application of 45:30:30 kg N, P_2O_5, K_2O ha^{-1}. Prasad & Prasad (1996) reported good response of cotton up to 60 kg N ha^{-1}. Elshinawy and Mohad (1985) indicated that the effect of nitrogen doses on yield was significant. Satao *et al.* (1984) reported significant increase in yield with changes in nitrogen doses. The yield response may have occurred due to cumulative effect of higher number of bolls $plant^{-1}$, boll weight and continued availability of nutrients in the treatments, which ultimately helped in better boll retention and development.The treatment of spacing showed a significant response to the biological yield of cotton. The highest biological yield of 4183.62 kg ha^{-1} was obtained from the spacing of 45cm × 30cm. The biological yield in fertilizer treatment was not significant. The highest biological yield (3808.95) was obtained with the fertilizer doses of 75:50:50 kg N, P_2O_5, K_2O ha^{-1}. The spacing and fertilizer applied in this *kharif* experiment on cotton did not respond significantly among themselves with respect to harvest index. However, the results obtained from this field trial confirmed that the sowing with 45 cm × 30 cm spacing showed higher harvest index in respect to all other treatments. Among the fertilizer treatments use of 45:30:30 kg N, P_2O_5, K_2O ha^{-1} exhibited higher harvest index (21.46%) followed by 60:40:40 kg N, P_2O_5, K_2O ha^{-1} & 75:50:50 kg N, P_2O_5, K_2O ha^{-1} respectively.

Thus among the different fertilizer doses, the treatment 60:40:40 kg N, P_2O_5, K_2O ha^{-1} proved superior and from yield point of view the spacing of 45cm × 30 cm was found to be better in terms of growth, yield and income.

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