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Plant geometry engineering with wider lateral spacing for low cost drip system in cotton

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ABSTRACT : Plant geometry engineering with wider lateral spacing is one of the options for reducing the initial cost in drip irrigation system. This should be done without reducing the optimum crop yield. With this hypothesis, two field experiments were conducted to study the effect of plant geometry related to lateral spacing and plant density and drip irrigation fertigation regimes on yield and economics of hybrid cotton at Agricultural College and Research Institute, Madurai. Rectangular geometry (wider lateral spacing – 240cm and high plant population – 18518 plants/ha) and normal geometry (every row lateral spacing – 120 cm and low plant population – 13889 plants/ha) with drip irrigation fertigation of 100 per cent ETc + 100 per cent N recorded comparable higher seed cotton yield and gross income. Rectangular geometry with drip irrigation fertigation of 100 per cent ETc + 100 per cent N registered higher net income, B: C ratio and lower pay back period with a saving of Rs. 34600 on capital investment on drip irrigation system. Thus rectangular geometry with wider lateral spacing – 240cm and high plant population – 18518 plants/ha may be recommended as a low cost drip irrigation system design for cotton farming.

Key words : Capital investment, cotton, density, drip irrigation, irrigation fertigation regimes, plant geometry

Cotton continues to be a major agricultural commodity in India. For past three decades research has been intensified in India on drip-cotton farming and yield increase with quality improvement have been proved in addition to 53 per cent water saving. But the area under drip cotton farming has not registered the expected increase. The main reason for the relatively restricted use of drip irrigation by Indian farmers in crop such as cotton is the high initial cost. The only option to encourage farmers to adopt drip-cotton is providing them a low cost drip irrigation unit.

Possible solution for reducing the drip irrigation system cost includes wider spacing of laterals, as it constitutes 45 per cent of the total investment. A modification in drip lateral spacing for hybrid cotton entails altering or engineering plant geometry for matching the minimum wetted zone with the crop root zone without reducing plant density or with higher plant density for controlling yield. This modification also warrants a change in water and nitrogen requirement.

Hence with the above background the present study was carried out to design a low cost drip irrigation system by investigating the effects of plant geometry related to lateral spacing and density and drip irrigation-fertigation regimes on yield and economics of drip irrigated hybrid cotton.

MATERIALS AND METHODS

Field experiments were conducted at Agricultural College and Research Institute, Madurai during winter 2001-2002 and summer 2002 to study the effect of plant geometry related to lateral spacing and density and drip irrigation-fertigation regimes on the yield and economics of hybrid cotton under drip irrigation system. The soil of the experimental field was clay loam with a pH of 7.1 and EC of 0.20 and the annual rainfall 893 mm in 45 rainy days. Intra-specific cotton hybrid RCH 2 maturing in 150 - 165 days was used in the study under factorial randomized block design with three replications. Treatments consist of combination of five plant geometry influenced by lateral spacing and plant density and two drip irrigation-fertigation regimes. The plant geometry treatments were, P1 - Normal geometry (every-row lateral spacing + low plant density) with a spacing of 120 x 60 cm. P2 - Paired row geometry (wider lateral spacing + low plant density) with a spacing of (180+60) x 60 cm. P3 - Intra row increased geometry (every row lateral spacing + high plant density) with a spacing of 120 x 90 cm with 2 plants/hill. P4 - Triple row geometry (wider lateral spacing + high plant density) with a spacing of (180 + 60) x 45/90 cm. P5-Rectangular geometry (wider lateral spacing + high plant density) with a spacing of 240 x 90 (60x40) cm. The lateral spacing in every-row was 120 cm (normal and intra row increased geometry) and wider was 240 cm (paired row, triple row and rectangular geometry). The plant density in low was 13889 plants/ha and high was 18518 plants/ha respectively. The two irrigation and fertigation regimes were, F1 - 100 per cent ETc + 100 per cent N and F2 - 75 per cent ETc + 75 per cent N. The amount of nitrogen applied in 100 per cent N plots corresponds to 120 N kg/ha and 75 per cent N plots corresponds to 90 kg N/ha. All plots received 60 kg/ha of phosphorus and potash. Irrigation was scheduled using the criteria as indicated below;

ETc = Eo x Kp x Kc

Where; ETc = crop evapotranspiration (mm/day); Eo = pan evaporation (mm/day); Kp= pan coefficient (0.8); Kc = crop coefficient

The irrigation was scheduled once in 3 days. Irrigation was given at two levels, 75 and 100 per cent of ETc. Irrigation was applied on area basis. All the plots under each irrigation regime were supplied with equal quantity of water irrespective of lateral spacing. The economics of cotton production including the capital investment on drip irrigation system was worked out based on the prevailing market rate for inputs and produce. The life of drip system was assumed to be 10 seasons. Interest on capital invested was taken as 12 per cent per annum. Pay back period, time period required for a project to recover capital investment was computed using the formulae;

$$\text{Payback period} = \frac{\text{Capital investment}}{\text{Seasonal net income}}$$

The data on seed cotton yield was statistically analysed.

RESULTS AND DISCUSSIONS

Seed cotton yield : During both the seasons of experimentation, plant geometry and drip irrigation fertigation regimes had significant influence on seed cotton yield and given in Table 1.

Normal geometry (every row lateral spacing and low plant population) recorded higher seed cotton yield (2859 in winter and 2969 kg/

Table 1. Effect of plant geometry and drip irrigation fertigation regimes on seed cotton yield

Treatments	Seed cotton yield (kg/ha)					
	Winter 2001-2002			Summer 2002		
	Irrigation fertigtion regimes			Irrigation fertigation regimes		
	F1 100 per cent	F2 75 per cent	**Mean**	F1 100 per cent	F2 75 per cent	**Mean**
Plant geometry						
P1. Normal	3042	2677	**2859**	3237	2701	**2969**
P2. Paired row	2897	2447	**2672**	3030	2549	**2790**
P3. Intra row increased	2490	2356	**2423**	2756	2442	**2599**
P4. Triple row	2686	2446	**2566**	2949	2504	**2727**
P5. Rectangular row	2953	2638	**2796**	3126	2670	**2898**
Mean	**2814**	**2513**		**3020**	**2573**	
	P	F	P x F	P	F	P x F
SEd	43	27	60	47	30	67
CD (p=0.05)	90	57	127	99	63	140

ha in summer) and was comparable with rectangular geometry (wider lateral spacing and high plant population) (2796 in winter and 2898 kg/ha in summer) during both seasons. Thus normal geometry under uniform spatial distribution of plants with slightly higher and consistent available soil moisture and nutrients at the proximity of root zone due to every row spacing of laterals resulted in higher seed cotton yield. Rectangular geometry also produced comparable seed cotton yield with normal geometry. This happened despite a wider lateral spacing which slightly decreased the available water in the proximity of the root zone. Higher plant density associated with rectangular geometry probably made up for this variation in /plant performance caused by wider lateral spacing. Thus comparable seed cotton yields can be generated through suitable manipulation of geometry for lateral spacing and plant density as indicated by Sorensen *et al.,* (2011).

Drip irrigation-fertigation of 100 per cent ETc + 100 per cent N (2814 and 3020 kg/ha) significantly enhanced the seed cotton yield compared to 75 per cent ETc + 75 per cent N (2513 and 2573 kg/ha) during winter and summer seasons respectively as indicated by Jayakumar *et al.,* (2014), Dougherty *et al.,* (2009) and Veeraputhiran *et al.,* (2002). Drip irrigation-fertigation of 100 per cent ETc + 100 per cent N resulted in higher nutrient uptake due to increased availability of water and nutrients in the soil compared to lower drip irrigation fertigation regime. Thus increased uptake of nutrients and water and subsequent accumulation of source material increased the seed cotton yield as revealed by Mussadak Jant and Somi (2001).

Interaction effect was significant during both the years. Normal geometry combined with drip irrigation fertigation of 100 per cent ETc + 100 per cent N registered higher seed cotton yield (3042 and 3237 kg/ha) and was on par with the combined effect of rectangular geometry and 100 per cent ETc + 100 per cent N (2953 and 3126 kg/ha) during both the seasons. This indicated an additive interaction effect wherein the individual superior level of each variable retained their significance in combination also as indicated by Himanshu *et al.,* (2014).

Table 2. Capital investment (cost of drip irrigation system) influenced by lateral spacing in hybrid cotton

Particulars	Lateral spacing (cm)					
	120			240		
	Quantity	Unit cost (Rs)	Amount (Rs)	Quantity	Unit cost (Rs)	Amount (Rs)
Main line – PVC (63 mm)	50 m	26.33	1317	50 m	26.33	1317
Sub main – PVC (40 mm)	100 m	20	2000	100 m	20	2000
Laterals – 13 mm	8340 m	3.9	32526	4170 m	3.9	16263
Drippers – 4lph	13900 Nos	2.6	36140	6985 Nos	2.6	18161
GTO (83 x 2)	166 Nos	3.13	520	83 Nos	3.13	260
End cap (83 x 2)	166 Nos	1.19	197	83 Nos	1.19	99
Screen filter	1 No	2900	2900	1 No	2900	2900
Venturi unit	1 No	5500	5500	1 No	5500	5500
PVC fittings and accessories			500			500
Installation charges			1000			1000
Total			**82600**			**48000**

Economics : Capital investment on the drip irrigation system was influenced by lateral spacing and given in Table 2. The capital investment was higher for plant geometry with every-row lateral spacing (120 cm - normal and intra row increased geometry with 2 plants/hill) compared with plant geometry with wider lateral spacing (240cm – rectangular, paired row and triple row geometry). A lateral quantity of 8340 m was required for every row lateral spacing whereas it was only 4170 m in wider lateral spacing. This difference makes a saving of Rs. 34600 /ha in capital investment on the drip irrigation system.

Cost of cultivation, gross and net return, benefit cost ratio and pay back period were influenced by the plant geometry and drip irrigation fertigation regimes and given in Table 3. The cost of cultivation was also higher for 120cm lateral spacing, with the highest for intra row increased geometry + 100 per cent ETc + 100 per cent N combination (P3F1 – Rs. 32148 and 31148) and was lower for 240 cm lateral spacing with the lowest for paired row geometry + 75 per cent ETc + 75 per cent N (P2F2 – Rs. 27556 and 26556) during both the season. Higher gross income was recorded by normal geometry combined with drip irrigation-fertigation of 100 per cent ETc + 100 per cent N (P1F1-Rs. 69966 and 72833). It was followed by rectangular geometry (P5F1-Rs. 67919 and 70335) with the same higher drip irrigation fertigation regime during both the seasons. Rectangular geometry combined with drip irrigation fertigation of 100 per cent ETc + 100 per cent N accounted for higher net income (P5F1-Rs. 39420 and 42656) followed by normal geometry (P1F1-Rs.38189 and 42056) and higher benefit cost ratio (P5F1- 2.368 and 2.541), followed by paired row (P2F1- 2.354 and 2.497) with the same drip irrigation-fertigation regimes as the former during both the season. Pay back period was higher with 120cm lateral spacing. Lower pay back period was accounted for plant geometry with 240cm lateral spacing and the lowest with the combination of rectangular geometry and drip irrigation-fertigation regime of 100 per cent ETc + 100 per cent N (P5F1 – 1.211 and 1.123 seasons) during both the seasons.

Therefore a sum of Rs. 34600 on capital investments can be saved under wider lateral

Table 3. Effect of plant geometry and drip irrigation - fertigation regimes on economics of cotton (Rs/ha)

Treatments	Cost of cultivation		Gross Income		Net Income		Benefit cost ratio		Pay back period (seasons)	
	Winter 2001-2002	Summer 2002	Winter 2001-2002	Summer 2002	Winter 2001-2002	Summer 2002	Winter 2001-2002	Summer 2002	Winter 2001-2002	Summer 2002
P1F1	31777	30777	69966	72833	38189	42056	2.202	2.366	2.163	1.964
P1F2	31025	30025	61570	60773	30545	30748	1.985	2.024	2.704	2.686
P2F1	28308	27308	66631	68175	38323	40867	2.354	2.497	1.25	1.172
P2F2	27556	26556	56281	57353	28725	30797	2.042	2.16	1.668	1.556
P3F1	32148	31148	57270	62010	25122	30862	1.781	1.991	3.288	2.676
P3F2	31396	30396	54188	54945	22792	24549	1.726	1.808	3.624	3.365
P4F1	28679	27679	61780	66353	33101	38673	2.154	2.397	1.447	1.239
P4F2	27927	26927	56253	56340	28325	29413	2.014	2.092	1.691	1.629
P5F1	28679	27679	67919	70335	39240	42656	2.368	2.541	1.221	1.123
P5F2	27927	26927	60674	60075	32747	33148	2.173	2.231	1.463	1.445

spacing (rectangular geometry) compared with every row lateral spacing (normal geometry) with higher net income, benefit cost ratio and lower pay back period. Similar findings have been reported by Enciso *et al.,* (2005).

CONCLUSION

Change in plant geometry for widening lateral spacing in this study was intended to reduce cost of the system without affecting yield. This objective was realized in this study. Rectangular geometry (wider lateral spacing – 240cm + high plant population – 18472 plants/ ha) + 100 per cent ETc + 100 per cent N recorded comparable yield and gross income with normal geometry (every-row lateral spacing – 120cm + low plant population – 13889 plants/ha) + 100 per cent ETc + 100 per cent N, with lesser capital cost on system layout. Also higher net income, B: C ratio and lower pay back period were registered by rectangular geometry with a saving of Rs. 34600 on capital investment on drip irrigation system. Thus wider lateral spacing (240 cm) with increased plant population (18472 plants/ha) arranged in rectangular geometry may be recommended as a low cost drip irrigation system design for hybrid cotton.

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