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Effect of Subsurface Drip Irrigation-Fertigation Regimes on Yield and Economics of Compact Cotton in Sodic Soil

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A B S T R A C T

A field experiment was conducted at Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirapalli during winter season of 2019 to study the effect of subsurface drip irrigation- fertigation regimes on stalk yield, seed cotton yield and economics of high density cotton cultivation in sodic soil. The experiment was laid out in factorial randomized block design with three replications. The treatments consisted of combination of two factors *viz*., four subsurface drip irrigation levels (I_1 – 0.4 Epan,I_2 – 0.6 Epan, I_3 – 0.8 Epan and I_4– 1.0 Epan) and three fertigation levels (N_1 – 100% RDF, N_2 – 125%, RDF and N_3– 150% RDF). The results revealed that subsurface drip irrigation level of 1.0 Epan registered higher stalk yield as well as seed cotton yield and this was found comparable with 0.8 Epan for seed cotton yield alone. Among fertigation levels 150% RDF registered higher stalk yield but the seed cotton yield was found higher under fertigation of 125% RDF. Among interaction, combination of 1.0 Epan + 125% RDF recorded higher gross return, net return and B:C ratio. The study shows that subsurface drip irrigation-fertigation of 1.0 Epan + 125% RDF may be recommended for compact cotton varieties for better productivity and profitability in sodic soil condition.

Introduction

Cotton (*Gossypium hirsutum* L.) is one of major cash crop of India, supporting the country's largest organized industry, textile industry and recognised as "White Gold" for its contribution to the national economy in terms of foreign exchange earnings and employment generation. In India cotton is cultivated in an area of 126 lakh hectare with the production and productivity of 337 lakh bales and 451 kg ha^{-1} respectively. Cotton production in India cannot be measured without taking into account salt-affected soils, but increasing productivity in these soils is a difficult task. India contributes around 52 m ha of salt affected land (Mandal *et al.,* 2018).It is placed in the moderately salt tolerant group of plant species with the salinity threshold level of 7.7 ds m^{-1}. Its growth and development was severely reduced at high salinity levels. Salinity of agricultural lands and irrigation water is the major constraint for crop growth and development in study area.

Over the last three years, cotton production has been declining. The use of subsurface drip irrigation and precise nutrient application through fertigation can aid in increasing cotton productivity. Subsurface drip irrigation (SSDI) is one such tried and true process where it increases the productivity of water as well as nutrients. Cotton production is one of the largest usages of SSDI around the world, with its lower water use it can be an excellent crop in water-short areas when coupled with SSDI. According to Lamm (2016), combining irrigation and fertilization with subsurface drip irrigation will reduce nutrient and water requirements compared to regional fertilization practices. Application of fertilizers by subsurface drip irrigation lowers the production costs which also reduce groundwater contamination, avoiding ecosystem disruptions and health threats caused by nitrate leaching and accumulation in deeper layers. When fertilizer is applied through drip, it is observed that 30 per cent of the fertilizer could be saved as compared to broadcast or band placement. Keeping these considerations in view the present study was undertaken to estimate the effect of subsurface drip irrigation and fertigation regimes on yield and economics of compact cotton under high density planting system.

Materials and Methods

A field experiment was conducted at Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirapalli during winter season of 2019. The soil type was sandy clay loam with initial N, P_2O_5 and K_2O of the soil were 216 kg ha^{-1}, 14.8 kg $ha^{-1}$and 245.6 kg ha^{-1}respectively. Factorial randomized block design was adopted with three replications. The treatments consisted of combination of two factors *viz.,* four irrigation levels (I_1 – 0.4 Epan,I_2 – 0.6 Epan, I_3 – 0.8 Epan and I_4– 1.0 Epan) and three fertigation levels (N_1 – 100% RDF, N_2 – 125%, RDF and N_3– 150% RDF). The cotton variety Co 17 was sown during 2019 by hand dibbling of seeds at 60 x 10 cm spacing. The observations were recorded at the time of harvest stage. The data collected from the experimental field were analyzed statistically following the procedure as described by Gomez (1984).

Results and Discussion

Stalk yield (kg ha^{-1})

The subsurface drip irrigation and fertigation levels had significant influence on stalk yield (Table 1). Among irrigation levels 1.0 Epan significantly recorded higher stalk yield of 5416 kg ha^{-1} was followed by 0.8 Epan (4949 kg ha^{-1}). This was perhaps due to increased available moisture content along the crop growth resulted in cell elongation and turgidity under subsurface drip irrigation as suggested by Cetin (2020). Among fertigation levels 150% RDF significantly recorded higher stalk yield and was followed by 125% RDF. This may be due to application of higher amount of fertilizers through subsurface drip fertigation, which gradually increases growth and development resulted in higher stalk yield.

The interaction was found significant (Table 2). Higher stalk yield was obtained under the combination of 1.0 Epan + 150% RDF (6712 kg ha^{-1}).This was followed by 0.8 Epan + 150% RDF (5785 kg ha^{-1}). This may be due to continuous availability of requisite soil moisture and nutrients near the root zone resulted in higher nutrient uptake, greater cell division and elongation as indicated by Govindan and Grace (2012).

Seed cotton yield (kg ha^{-1})

The seed cotton yield was significantly influenced by subsurface drip irrigation and fertigation regimes as depicted in Table 1. Irrigation level of 1.0 Epan recorded higher seed cotton yield of 2446 kg ha^{-1} and was found comparable with 0.8 Epan (2361 kg ha^{-1}). This was followed by 0.6 Epan with a yield of 2172 kg ha^{-1}.This could be due to better growth as a result of optimum soil moisture with lower EC throughout the life cycle associated with subsurface drip irrigation without any stress period which increased the assimilates from source to sink for both 1.0 and 0.8 Epan as reported by Sorensen *et al.*, (2004).Among fertigation levels, 125% RDF registered significantly higher seed cotton yield of 2478 kg ha^{-1} followed by 150% RDF (2156 kg ha^{-1}) and the lower seed cotton yield was obtained under 100% RDF (1942 kg ha^{-1}). The higher fertigation of 150% RDF recorded lower seed cotton yield, due to higher vegetative growth and reduce yield parameters with imbalanced source sink relationship. This is in confirmation with Gormus *et al.*, (2016). The interaction effect was found significant (Table 2). Higher seed cotton yield was obtained under the combination of 1.0 Epan + 125% RDF (2805 kg ha^{-1}) and was comparable with 0.8 Epan + 125% RDF (2698 kg ha^{-1}).This may be due to superior performance of all yield attributing parameters at better availability of soil moisture with optimum nutrients which was reflected in seed cotton yield. These findings are in close conformity with Shivakumar *et al.*, (2010).

Harvest index (HI)

Harvest index was significantly influenced by subsurface drip irrigation and fertigation levels (Table 1). The subsurface drip irrigation level of 0.8 Epan recorded higher harvest index of 0.33 and was found comparable with 1.0 Epan (0.32) and 0.6 Epan (0.32). Among fertigation levels 125% RDF registered higher harvest index (0.35) and was followed by 100% RDF. Similar result was reported by Venugopalan (2019), who reported that the cotton planted under HDPS needs an additional fertilizer of 25 percent above the recommendation, which will increase the nutrient absorption under high density planting condition which was reflected in higher seed cotton yield. Interaction was found significant (Table 3). The combination of 1.0 Epan + 125% RDF registered higher harvest index of 0.36 and was found comparable with 0.8 Epan + 125% RDF (0.36), 0.6 Epan + 125% RDF (0.35), I_4N_1 (0.34) and I_3N_1 (0.34). This may be due to higher seed cotton yield obtained under the combination of 1.0 Epan + 125% RDF.

Economic analysis

It is evident from data that subsurface drip irrigation level of 1.0 Epan recorded higher cost of cultivation (Rs. 62201),gross return (Rs. 1,29,627), net return (Rs. 67,426) and B:C ratio (2.08). This may be due to increased moisture content under subsurface drip irrigation which boosted the plant growth and resulted in higher seed cotton yield which is reflected in the net return and B:C ratio.

Among fertigation levels150% RDF registered higher cost of cultivation (Rs. 62555) while the gross return (Rs. 1,31,342), net return (Rs. 69,741) and B:C ratio (2.13) were found higher at 125% RDF. This may be due to balanced application of essential nutrients from vegetative stage to boll formation stage in split doses through subsurface drip irrigation increased the seed cotton yield which is responsible for higher economic benefit. These confirmations are in agreement with Basavanneppa and Biradar (2003).

Table.1 Effect of irrigation and fertigation regimes on stalk yield (kg ha^{-1}), seed cotton yield (kg ha^{-1}) and harvest index

Treatments	Stalk yield (kg ha^{-1})	Seed cotton yield (kg ha^{-1})	Harvest index
Irrigation regimes			
I_1 – 0.4 Epan	4038	1790	0.30
I_2 – 0.6 Epan	4530	2172	0.32
I_3 – 0.8 Epan	4949	2361	0.33
I_4 – 1.0 Epan	5416	2446	0.32
SEd	188	53	0.009
CD (p=0.05)	389	110	0.02
Fertigation regimes			
N_1 – 100% RDF	4140	1942	0.32
N_2 – 125% RDF	4659	2478	0.35
N_3 – 150% RDF	5400	2156	0.29
SEd	162	45	0.007
CD (p=0.05)	337	95	0.02
Interaction	S	S	S

Table.2 Interaction of irrigation and fertigation regimes on stalk and seed cotton yield (kg ha^{-1})

Treatments	Stalk yield (kg ha^{-1})				Seed cotton yield(kg ha^{-1})			
Irrigation regimes	**Fertigation regimes**				**Fertigation regimes**			
	N_1 – 100% RDF	N_2 – 125% RDF	N_3 – 150% RDF	**Mean**	N_1 – 100% RDF	N_2 – 125% RDF	N_3 – 150% RDF	**Mean**
I_1 – 0.4 Epan	3979	4021	4113	4038	1627	1901	1843	1790
I_2 – 0.6 Epan	4091	4508	4992	4530	1864	2508	2145	2172
I_3 – 0.8 Epan	4164	4899	5785	4949	2109	2698	2275	2361
I_4 – 1.0 Epan	4327	5209	6712	5416	2170	2805	2362	2446
Mean	4140	4659	5400		1942	2478	2156	
I x N	**I**	**N**	**IxN**		**I**	**N**	**IxN**	
SEd	188	162	325		53	45	91	
CD (p=0.05)	**389**	**337**	**675**		**110**	**95**	**189**	

Table.3 Interaction effect of irrigation and fertigation regimes on harvest index

Treatments	**Harvest index**			
Irrigation regimes	**Fertigation regimes**			
	N_1 – 100% RDF	N_2 – 125% RDF	N_3 – 150% RDF	**Mean**
I_1 – 0.4 Epan	0.29	0.32	0.30	0.30
I_2 – 0.6 Epan	0.31	0.35	0.30	0.32
I_3 – 0.8 Epan	0.34	0.36	0.29	0.33
I_4 – 1.0 Epan	0.34	0.36	0.27	0.33
Mean	0.32	0.35	0.29	
I x N	**I**	**N**	**IxN**	
SEd	0.009	0.007	0.016	
CD (p=0.05)	**0.02**	**0.02**	**0.03**	

Table.4 Effect of irrigation and fertigation regimes on economics

Treatments	**Cost of cultivation (Rs.)**	**Gross return (Rs.)**	**Net return (Rs.)**	**B:C**
I_1N_1	60049	86231	26182	1.44
I_1N_2	61001	100753	39752	1.65
I_1N_3	61955	97679	35724	1.58
I_2N_1	60449	98792	38343	1.63
I_2N_2	61401	132924	71523	2.16
I_2N_3	62355	113685	51330	1.82
I_3N_1	60849	111830	50981	1.84
I_3N_2	61801	143011	81210	2.31
I_3N_3	62755	120575	57820	1.92
I_4N_1	61249	115010	53761	1.88
I_4N_2	62201	148683	86482	2.39
I_4N_3	63155	125190	62035	1.98
Irrigation regimes				
I_1 – 0.4 Epan	61001	94887	33886	1.55
I_2 – 0.6 Epan	61401	115133	53732	1.87
I_3 – 0.8 Epan	61801	125138	63336	2.02
I_4 – 1.0 Epan	62201	129627	67426	2.08
Fertigation regimes				
N_1 – 100% RDF	60649	102965	42316	1.69
N_2 – 125% RDF	61601	131342	69741	2.13
N_3 – 150% RDF	62555	114282	51727	1.82

The interaction between irrigation and fertigation regimes found economically benefit with the combination of 1.0 Epan + 125% RDF (Table 4) due to the enhanced yield as reported by Soni and Asoka (2017).

From the results of the experiment it was concluded that the subsurface drip irrigation and fertigation of 1.0 Epan + 125% RDF may be recommended for higher productivity and profitability under high density cotton cultivation with compact cotton varieties in sodic soil condition.

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