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Studies on Growth and Yield of Bt Cotton under Conservation Tillage, Crop Residues and Supplemental Irrigation in Dryland

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Field experiments were carried out during 2011-12 and 2012-13 at Agricultural Engineering College and Research Institute, Kumulur, Tamil Nadu, India on sandy loam soils to evaluate different tillage practices, crop residues and supplemental drip irrigation methods on growth and yield of Bt cotton. The experiments were laid out in a strip plot design with three replications. The main plot treatments were conventional tillage, minimum tillage without crop residue, minimum tillage with crop residue @ 5 t ha^{-1} and minimum tillage with crop residue @ 10 t ha^{-1}. Sub plot treatments were without irrigation (control), supplemental drip irrigation 4, 6, 8 and 10 times during the cropping period. The results revealed that minimum tillage with crop residue @ 10 t ha^{-1} + supplemental drip irrigation 10 times had recorded significantly higher growth, yield components and yield.

Key words: Bt cotton, Tillage, Crop residue, Supplemental irrigation, Yield

Dryland areas are one of the hot-spots of poverty, malnutrition, water scarcity, severe land degradation, and poor physical and financial infrastructure. The unsustainable crop production in the drylands is a resultant of large degree of heterogeneities in terms of soils, quantity and distribution of rainfall. The prime factor of this unstable production is high variability in the spatial and temporal rainfall distribution. India ranks first among the dryland agriculture both in terms of extent and value of produce. Nearly, 60 per cent of our population still continue to depend on dryland agriculture.

A proper tillage can alleviate soil-related constraints, while improper tillage leads to a decline in soil structure, accelerated erosion, depletion of soil organic matter (SOM) fertility and disruption of the nutrient cycle (Mohanty *et al*., 2007). Continuous use of conventional farming practices with conventional tillage (CVT) and burning crop residues has degraded the soil resource base (Montgomery, 2007) and intensified soil degradation by about 67% with concomitant decreases in crop production capacity (World Resources Institute, 2000). Soil loss is expected to be a critical issue for global agricultural production under conventional farming practices. For instance, Montgomery (2007) estimated that global erosion rates from conventionally ploughed agricultural fields averaged one to two orders of magnitude greater than erosion under native vegetation, long-term geological erosion and rates of soil production. Conservation tillage systems improve land productivity by way of improved soil physical properties, reduce soil loss and enhance soil organic C (Nyakatawa *et al.,* 2001).

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Oweis and Hachum, (2006) reported that supplemental irrigation (SI), using a limited amount of water, if applied during the critical crop growth stages, would result in substantial improvement in yield and water productivity. Therefore, SI is an effective response to alleviate the adverse impact of soil moisture stress during dry spells on the yield of rainfed crops.

Cotton is an important commercial crop, contributing to 65 per cent requirement of Indian Textile Industries. In India, cotton is currently cultivated in 9.37 million ha with the production of 29.0 million bales and the productivity is 526 kg ha^{-1} (CCI, 2012). Keeping this in view, the present investigation was undertaken to study the combined effect of tillage, crop residue and supplemental irrigation through drip on the growth, nutrient uptake and yield of Bt cotton in the central region of Tamil Nadu.

Materials and Methods

Field experiments were conducted during 2011-12 and 2012-13 at Agricultural Engineering College and Research Institute, Kumulur, Tamil Nadu. The experimental site is geographically situated at 10'56^{o} North latitude and 78'49^{o} East longitudes and at an altitude of 78 m above MSL. The soil was sandy loam in texture with pH 7.71. The fertility status of the soil was low, medium and high in available N, P_2O_5, and K_2O with the values of 212, 20 and 575 kg ha^{-1}. The main plot treatments were conventional tillage (M_1), minimum tillage without crop residue (M_2), minimum tillage with crop residue 5 t ha^{-1} (M_3) and minimum tillage with crop residue 10 t ha^{-1} (M_4). Sub plot treatment were no irrigation (control) (S_1), supplemental drip irrigation 4 (S_2), 6 times (S_3), 8 times (S_4) and 10 times (S_5) during the cropping period. The experiments were laid out in a strip plot design with three replications during both the years.

Conventional tillage included one pass of mouldboard plough to a depth of 15 cm and was followed by two passes of disk harrowing. Minimum tillage included only one pass of disk harrowing. The treatments were carried out on the same plots during 2011-12 and 2012-13. In both the growing seasons, one of the most commercial Bt cotton RCH 2 was sown manually on paired row spacing of 120 + 30 x 60 cm (totally there were two rows per plot). Before sowing, a uniform fertilizer schedule was followed at the rate of 90:45:45 kg of N, P_2O_5 and K_2O ha^{-1}. Nitrogen was applied in three splits as 25: 50: 25 per cent as basal, at 35 and 55 DAS, respectively. The entire dose of phosphorus was applied basally. The potassium was applied in two equal split doses *viz*., basal and at 55 DAS. Pendimethalin @ 1.0 kg a.i ha^{-1} was also applied for weed control after sowing of cotton seed. During the growing season, the insecticides and fungicides were applied according to recommendations by the state agricultural university (SAU). All other necessary operations except those under study were kept normal and uniform for all the treatments.

The supplemental irrigation was given to the crop at the time of moisture stress period, which was determined based on the visual symptom (Wilting of plants). In study period four, six, eight and ten supplemental irrigations were given at various time period during 2011-12 and 2012-13. The water was pumped by motor from farm pond and supplied to crops through drip irrigation system at a depth of 3 cm.

Irrigation water was pumped using 3.5 HP motor and conveyed to the main line of 63 mm OD (outer diameter) PVC (Poly vinyl chloride) pipes after filtering. From the main, sub mains of 40 mm OD PVC pipes were drawn. From the sub main, laterals of 12 mm linear low density polyethylene (LLDPE) pipes were installed at an interval of 1.50 m. Each lateral was provided with individual tap control for imposing respective irrigation schedules. Along the laterals, inline drippers with a discharge capacity of 4 lph were spaced at 0.6 m. Single lateral was used for a paired row of cotton. Sub mains and laterals were closed at the end with end cap. After installation, trial run was conducted to assess mean dripper discharge and uniformity co-efficient. This was taken into account while fixing the irrigation water application time. During the irrigation period an average of 90 to 95 per cent uniformity was observed.

During first year (2011-12) chopped maize stalks as crop resides were mixed to the soil with the help of a mould board plough, while during 2012-13 cotton stalks were used.

Observations on growth characters such as plant height, leaf area index and dry matter production were recorded at 40, 80, 120 DAS and at harvest The data on yield parameters and yield were also recorded.

Results and Disscussion

Effect of rainfall on crop

Variations in amount and distribution of rainfall resulted in significant year-to-year variations. Without supplemental irrigation in the year 2011-12, higher yield was recorded which was probably due to normal (628 mm) and well distributed (34 rainy days) rainfall (Table 1). But, during the second year (2012), total rainfall (436 mm) received was less and distributed in less number of rainy days (25). Further, it was received only during the early stages of the crop growth; at later stages, crop utilized only supplemental irrigation. Thus, the crop experienced water stress due to intermittent drought due to uneven distribution of rainfall and terminal drought.

Table 1. Rainfall (mm) received during the cropping seasons

Months	2011-12			2012-13	
	Rainfall	Rainy day		Rainfall	Rainy day
September	134.2	10	September	108.7	6
October	166.1	9	October	151.7	12
November	222.1	12	November	78.0	3
December	56	2	December	0	0
January	0	0	January	0	0
February	0	0	February	0	0
Total	628.1	34		436.0	25

Effect of treatments on growth parameters

The growth parameters of Bt cotton at 120 DAS and harvest were significantly influenced by tillage and crop residue with supplemental drip irrigation.

Plant height

Among the treatments, minimum tillage with crop residue 10 t ha^{-1} recorded significantly taller plants (Table 2) (128, 143 cm and 112, 127 cm at 120 DAS and at harvest during 2011-12 and 2012-13, respectively). Regarding irrigation practices, supplemental irrigation at 10 times recorded taller plants than control.

With regard to interaction effect, in a given tillage with crop residue treatment and supplemental drip irrigation, minimum tillage with crop residue 10 t ha^{-1} + supplemental drip irrigation 10 times registered distinctly higher plant height at 120 DAS and at harvest during both the years.

Leaf area index

Among tillage and crop residue treatments, minimum tillage with crop residue 10 t ha^{-1} recorded significantly higher leaf area index (Table 2) (3.75, 3.17 cm and 3.46, 3.16 at 120 DAS and at harvest

Table 2. Effect of tillage, crop residue and supplemental drip irrigation on growth attributes of Bt cotton

Treatments	Plant height (cm)				Dry matter production (kg ha^{-1})				Leaf area index			
	2011-12		2012-13		2011-12		2012-13		2011-12		2012-13	
	At 120 DAS	Harvest	At 120 DAS	Harvest	At 120 DAS	Harvest	At 120 DAS	Harvest	At 120 DAS	Harvest	At 120 DAS	Harvest
T_1	110	120	98.3	114	4359	4763	4585	4682	3.14	2.83	3.11	2.87
T_2	112	127	98.2	114	4584	4929	4523	4781	3.07	2.79	2.95	2.73
T_3	118	137	104.5	121	4639	5084	4843	4926	3.61	3.01	3.30	2.95
T_4	128	143	111.9	127	4966	5278	5053	5279	3.75	3.17	3.46	3.16
SEd	4	3	3.1	4	150	134	124	147	0.09	0.08	0.07	0.07
CD (P = 0.05)	9	8	7.6	9	368	328	304	361	0.22	0.20	0.18	0.18
S_1	107	120	94.8	106	4353	4637	4369	4501	2.85	2.83	2.92	2.57
S_2	113	128	98.3	113	4420	4916	4600	4699	3.18	2.79	3.01	2.73
S_3	118	132	101.8	118	4610	5019	4740	4852	3.41	2.86	3.18	2.92
S_4	121	136	106.1	124	4756	5115	4925	5090	3.68	3.19	3.33	3.11
S_5	126	141	115.1	133	5044	5380	5121	5442	3.84	3.42	3.58	3.30
SEd	3	4	3.4	4	153	158	147	178	0.09	0.11	0.09	0.09
CD (P = 0.05)	8	8	8.0	9	353	368	338	409	0.21	0.26	0.23	0.22
Interaction	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**

S – Significant **, NS –** Non Significant

during 2011-12 and 2012-13, respectively) Regarding irrigation practices, supplemental irrigation at 10 times recorded higher leaf area index (3.84, 3.42 and 3.58, 3.30 at 120 DAS and at harvest during 2011-12 and 2012-13, respectively) and it was comparable with supplemental irrigation at 8. The least leaf area index was received under control without supplemental irrigation.

With regard to interaction effect, minimum tillage with crop residue 10 t ha^{-1} + supplemental drip irrigation 10 times registered lucidly higher leaf area index at 120 DAS and at harvest during both the years.

Dry matter production

Among treatments, minimum tillage with crop residue 10 t ha^{-1} recorded significantly higher dry matter production (4966, 5278 kg ha^{-1} and 5053, 5279 kg ha^{-1}) at 120 DAS and at harvest during 2011-12 and 2012-13, respectively (Table 2). Among irrigation practices, supplemental irrigation at 10 times recorded higher dry matter production in respective stages during both the seasons and it was comparable with supplemental irrigation at 8 times which also recorded higher dry matter production than that without supplemental irrigation.

Table 3. Effect of tillage, crop residue and supplemental drip irrigation on yield attributes and yield

Treatments	Sympodial branches plant^{-1}		Number of bolls plant^{-1}		Yield (kg ha^{-1})	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
T_1	18.3	17.7	49.1	48.4	1993	1988
T_2	19.4	18.0	51.2	52.0	2076	2193
T_3	19.5	19.5	54.6	56.2	2301	2271
T_4	21.3	21.2	57.1	58.2	2547	2436
SEd	0.5	0.5	1.6	1.5	87	84
CD(P = 0.05)	1.3	1.2	3.9	3.6	213	204
S_1	18.3	17.0	40.1	38.7	1891	1930
S_2	19.5	18.2	50.7	51.8	2097	2094
S_3	19.8	19.1	55.0	56.2	2269	2218
S_4	19.8	20.1	57.8	59.0	2381	2314
S_5	20.9	21.1	61.4	62.7	2508	2514
SEd	0.6	0.7	1.8	1.8	105	107
CD(P = 0.05)	1.4	1.7	4.2	4.1	242	248
Interaction	S	S	S	S	S	S

S – Significant **, NS –** Non Significant

With regard to interaction effect, minimum tillage with crop residue 10 t ha^{-1} + supplemental drip irrigation 10 times registered significantly higher dry matter production at 120 DAS and at harvest during both the years of study. Interaction effect was not significant at 120 DAS during 2011-12.

Yield attributes and yield

Yield attributes like number sympodial branches per plant and number of bolls per plant and yield of Bt cotton was significantly influenced by tillage, crop residue and supplemental irrigation through drip system.

Among tillage and crop residue treatments, minimum tillage with crop residue 10 t ha^{-1} recorded significantly higher sympodial branches per plant and number of bolls per plant and yield (Table 3) (21.3 branches plant^{-1}, 57.1 bolls plant^{-1}, 2436 kg ha^{-1} and 21.2 branches plant^{-1}, 58.2 bolls plant^{-1}, 2547 kg ha^{-1} during 2011-12 and 2012-13, respectively) Regarding irrigation practices, supplemental irrigation at 10 times recorded higher sympodial branches per plant and number of bolls per plant and yield (20.9 branches plant^{-1}, 61.4 bolls plant^{-1}, 2514 kg ha^{-1} and 21.1 branches plant^{-1}, 62.7 bolls plant^{-1}, 2508 kg ha^{-1} during 2011-12 and 2012-13, respectively).

With regard to interaction effect, minimum tillage with crop residue 10 t ha^{-1} + supplemental drip irrigation 10 times registered higher sympodial branches per plant, number of bolls per plant and yield during both the years.

This might be due to the reason that the minimum tillage plots had more main stem nodes, numbers of fruiting sites than those on conventional tillage. Consequently, the number of bolls retained was greater under the minimum tillage than under the conventional tillage system. Enhanced boll retention in the minimum tillage treatments could be due to other factors such as less competition from weeds, differences in nutrient supply and conserved soil moisture. Greater boll numbers on the minimum tillage plots contributed to yield improvements compared to the conventional tillage (Blaise, 2011). Tolessa Debele (2011) concluded that minimum tillage with residue retention increased yield particularly when crop faced terminal drought.

From these experiments, it is concluded that practicing of minimum tillage and application of crop residue at 10 t ha^{-1} + supplemental drip irrigation 10 times will be the promising agronomic practice for enhancing growth and productivity of Bt cotton under dry land situation.

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