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EFFECT OF FERTIGATION REGIMES AND LATERAL SPACING ON NUTRIENT MOVEMENT AND UPTAKE IN COTTON

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Abstract

Optimization of water and nutrients in cotton under drip fertigation is important for semiarid regions of south Tamil Nadu, where drip fertigation is new for cotton. This study investigates the combined effect of water and nitrogen for cotton dry matter production and N uptake. Two levels of water and nitrogen namely; adequate input (100% of crop evapotranspiration + 120 kg N ha^{-1}) and deficit input (75% of crop evapotranspiration + 90 kg N ha^{-1}) were tested during winter 2001 and summer 2002 at Madurai Agricultural College Central farm, Tamil Nadu, India. The two treatments studied were part of a larger experiment with different combinations in a factorial randomized design. Adequate and deficit input produced 3293 and 2561 kg ha^{-1} seed cotton. The rate of dry matter production was slow until 60 days after seeding. Adequate and deficit input produced 74% and 82% of the total seasonal dry matter in an eight week period from 60 to 120 days after seeding. Although an increase in water and nitrogen increased the dry matter production, the relative proportion of the plant fractions exhibited a little variation between the treatments. Mature plants contained 187 and 140 kg N ha^{-1}.Peak N uptake occurred between 60 and 90 days after seeding and was 46 and 60 % of total seasonal N uptake for cotton receiving adequate and deficit input. The accumulation of N in adequate treatment followed that of dry matter production, whereas in deficit treatment N reached a peak at 120 after seeding and then decreased. Earliness was induced in deficit treatment.

Introduction

Most cotton in semiarid regions of Tamil Nadu, India is grown under furrow irrigation and there has been much local research with regard to irrigation and fertilization of cotton under these conditions (Sundar Singh et al*.,* 1980; Subramanian, 1988; Solaiappan et al*.*, 1993). In recent years field experiments (Muthusamy et al*.*, 1993; Veeraputhiran, 2001) have shown the advantage of drip fertigation while using similar or less quantities of water and nitrogen. Among other factors, improved understanding of cotton growth, development and nutrient uptake under drip fertigation may contribute to modifications in management strategies resulting in different levels of production inputs especially water and nitrogen. Earlier, Bassett et al. (1970) and Halevy et al. (1976) studied the dry matter production and nutrient uptake under irrigated condition. Several workers at various environments have identified the interactive effect of water and nitrogen on cotton growth and nutrient uptake under drip irrigation (Constable and Hearn, 1981; Halevy and Karmer, 1986; Constable et al., 1990; Mussaddak Jant and Somi, 2001). In Tamil Nadu, Veeraputhiran (2001) studied the effect of water and N on cotton yield under drip but information on dry matter partitioning and nutrient uptake was lacking, which is important for efficient input designing. The objective of the present work was to study and compare the combined effect of water and nitrogen on growth and N uptake in cotton under drip fertigation.

Materials and Method

Field experiments were performed during winter 2001 and summer 2002 at Madurai Agricultural College Central farm, Tamil Nadu, India, on a field containing fine loamy kaolinite. The two combined treatments of water and nitrogen (adequate input - 100% of crop evapotranspiration + 120 kg N ha^{-1} and deficit input - 75% of crop evapotranspiration + 90 kg N ha^{-1}) where part of a drip fertigation study in factorial randomized block design replicated thrice. Plots were 9.6m in length and consisted of eight rows of cotton planted in raised beds on 1.2m row spacing. Laterals were placed for each cotton row with 8 lps drippers for every 60cm. Plots were planted to RCH-2 cotton to maintain a plant population of 13,300 plant ha^{-1}. Applied water quantity (crop evapotranspiration) was calculated by Doorenbos and Pruitt (1977) criteria using class A pan evaporation and appropriate crop coefficients. The deficit input treatment received 75% of water and nitrogen applied to that considered adequate. Equal amount (60 kg ha^{-1}) of phosphorous and potash was applied to both the treatments. Among the nutrients, N and K were applied through drip system and phosphorous was applied basally in band. Of the total nitrogen and potash 20 % N was given at germination phase, 50% N and 39% K was given at vegetative phase, 25 % N and 44 % K at flowering phase and 5 % N and 17 % K was given at maturity phase. The irrigation and fertigation was scheduled once in 3 and 9 days. Rainfall, pan evaporation, crop evapotranspiration and amount of water applied during the growing season are shown in Table 1. Effective rainfall was calculated using the method of Dastane (1974). Plant samples were collected at 30, 60, 90, 120 days after seeding and at harvest. Six plants were randomly collected from each plot and divided in to parts and dried as described by Bassett et al. (1970). Plant parts were ground and analyzed for nitrogen by micro kjeldhal digestion as described by Humphries (1956).

Results and Discussion

Dry Matter Production

The equivalent two year average for total dry matter were 9042 and 7113 kg ha^{-1}, for adequate and deficit inputs respectively (Table 2 and Fig.1). Adequate input produced 29.5% higher lint than the deficit treatment. Increase in total dry matter with increase in water and nitrogen under drip were indicated by Constable and Hearn (1981) and Mussaddak Jant and Somi (2001). At the last sampling date plants from adequate treatment were composed of 25.5% stems, 22% leaves, 16% burs, 23.5% seed, and 13% lint. In comparison plants from the deficit treatment were composed of 25.3% stems, 21.6% leaves, 17% burs, 23.3% seeds and 12.8% lint. Distribution of dry matter within cotton plants from both the treatments was within the range reported by other workers (Bassett et al., 1970 and Halevy, 1976). Although an increase in water and nitrogen increased the dry matter production, the relative proportions of the plant fractions exhibited a small variation between the two treatments. Constable and Hearn (1981) also reported that despite large differences in total dry weight between irrigation and nitrogen treatments (500 – 900 g m^{-2}), the dry matter distribution among the matured plant parts varied little among the treatments. In both the treatments the dry weight of leaves was unstable, with about 60% at the first stage and decreased to 22% at harvest. Whereas the dry weight of stem was more or less stable with 37% at the fist stage and 25% at harvest. The growth of the reproductive parts was very rapid. At 60 days it was only 3% of the total dry matter, whereas by the last sampling it was around 53% for both the treatments.

In both the treatments the growth was slow until 60d followed by a rapid acceleration. This rapid acceleration was nearly constant for eight weeks, until 120d (116 – 106 kg ha^{-1} day^{-1}) in the adequate treatment, producing about 74% of the total dry matter. But the accelerated higher growth was not constant in deficit treatment. In the first four weeks (60-90d) the rate was 113 kg^{-1} ha^{-1} day^{-1} with accumulation of 48% of total seasonal dry matter and during 90-120d the rate was 81 kg ha^{-1} day^{-1} with accumulation of 34% of total seasonal dry matter. In the eight week period (60-120d) deficit treatment accounted for 82% of total seasonal dry matter. The difference being due to the fact that earliness was induced in deficit treatment. Mussaddak Jant and Somi (2001) also indicated earliness in nitrogen deficit cotton plants under drip fertigation. Many workers (Bassett et al., 1970; Fritschi et al., 2003) at different situations have reported that two-thirds of the total seasonal dry matter was produced in a six to eight week period (between early square and peak bloom).

Olson and Bledsoe (1942) reported that dry matter production was confined to the bolls at 120d or more after planting. In the present study practically all of the dry matter produced at 120d after seeding was in the bolls for cotton grown with deficit inputs. In the adequate input only 80 percent of the dry matter produced after 120d was confined to bolls.

Nitrogen Uptake

Average N uptake influenced by the treatments was given in Table 2 and Fig. 2. The N uptake pattern was similar to that of dry matter accumulation curve, but with an interesting difference, i.e., the highest accumulation for deficit treatment was at 120d after which the total N uptake diminished. The reduction in total N after 120d was due to greater N loss by leaf abscission compared to N gained by bolls in deficit treatment. The leaf abscission after 120d was 23% in deficit treatment and 12% in adequate treatment. Bassett et al., (1970) reported a leaf dropping of 20% in irrigated cotton. But higher leaf abscission with higher N rate (168 ka ha^{-1}) compared to lower N rate (84 kg ha^{-1}) at the same moisture level was indicated by Boquet and Breitenbeck (2000).

In general the N uptake in leaves, burs and stems decreased after 120d, as N concentration decreased due to maturity. There were no comparable differences between the treatments for N concentration throughout the sampling period expect for leaves. After 90d the N concentration of leaves in deficit treatment was low, compared to adequate treatment. Plant factors associated with low N concentration of leaves in deficit treatment are, damage in root growth, limiting water and nutrient uptake, due to stress as suggested by Radin et al., (1989) and competition within plant parts for nutrients as reported by Eaton and Joham (1944). Mullins and Burmester (1990) also indicated redistribution of nutrients from vegetative parts to fruits as the season progressed. The total N uptake was 184 and 140 kg ha^{-1}. Constable and Hearn (1981) observed higher N uptake (80-100 kg ha^{-1}) in different water and nitrogen treatments up to 150kg N ha^{-1}. At the last sampling, N within the plants was distributed as 12.4% stems, 33.7% leaves, 7.7% bur and 44.3% seeds in the adequate and 11.5% stems, 31.6% leaves, 9.4% bur and 46% seeds in the deficit treatment. The distribution was similar as indicated by Mullins and Burmester (1990). The daily N uptake by supplying adequate and deficit inputs reached a peak of 2.8 kg ha^{-1} day^{1} at 60-90d after seeding, during which 46.4 and 60% of total seasonal N was accumulated. The peak intervals for N uptake correspond to the same peak intervals of dry matter production. Halevy (1976) specified higher N uptake between 84 and 98 days in cotton cultivar Acala 1517-C at Israel.

Conclusion

The cotton growth and N uptake was affected by adequate and deficit input of water and nitrogen under drip fertigation. There was a comparable variation between the treatments in the quantities of dry matter and N generated but not in their distribution among the plant parts. Adequate and deficit treatment accumulated 74% and 82% of the total seasonal dry matter in an eight week period (60-120d). The rate was constant for the entire eight week under adequate treatment. In deficit treatment the rate was high in the first four week generating 48% of the total seasonal dry matter. The peak N uptake for both the treatments was during 60-90 days. There was no variation in the rate of uptake, but the percentage to the total seasonal production varied. During the period (60-90d), adequate and deficit treatment generated 46% and 60% of total seasonal nitrogen. The rate of dry matter production and N uptake in the peak period was 113 – 116 kg ha^{-1} day^{-1} and 2.8 kg ha^{-1} day^{-1}. The highest N accumulation for deficit treatment was at 120d, after which the total uptake diminished. In this region cotton should be tested with higher N rate (>120 kg ha^{-1}) under drip fertigation.

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Table 1. Rainfall and irrigation amount during crop growth period.

Parameter	Winter 2001		Summer 2002	
	Adequate	Deficit	Adequate	Deficit
Growth period	Sep 5 – Feb 27	Sep 5 – Feb 20	Mar16 - Aug 24	Mar16 –Aug 14
Rainfall (mm)	508	508	214	214
Pan evaporation (mm)	643	621	869	819
Estimated ETc (mm)	470	352	645	462
Applied water (Irrigation + Effective rainfall) (mm)	550	428	645	462

ETc = crop evapotranspiration

Table 2. Dry matter production and nitrogen uptake influenced by adequate (A) and deficit (D) input.

Parameter	Growth period, days after seeding									
	0-60		60-90		90-120		120-Har		0-Har	
	A	D	A	D	A	D	A	D	A	D
	Dry matter production									
Kg ha^{-1}	1180	785.9	3503	3391	3192	2449	1167	487	9043	7114
%, of total	13	10.9	38.7	47.8	35.3	34.4	12.89	6.8		
Rate, kg ha^{-1} day^{-1}	39.3	26.5	116.8	113	106.4	81.6	20.84	12.3		
	Nitrogen uptake									
Kg ha^{-1}	37.85	24.73	86.5	84.6	53.86	43.01	9.1	-11	187	140
%, of total	20.14	17.45	46.33	60.4	28.65	30.46	4.88	0		
Rate, kg ha^{-1} day^{-1}	1.262	0.824	2.88	2.82	1.78	1.4	0.263	0		

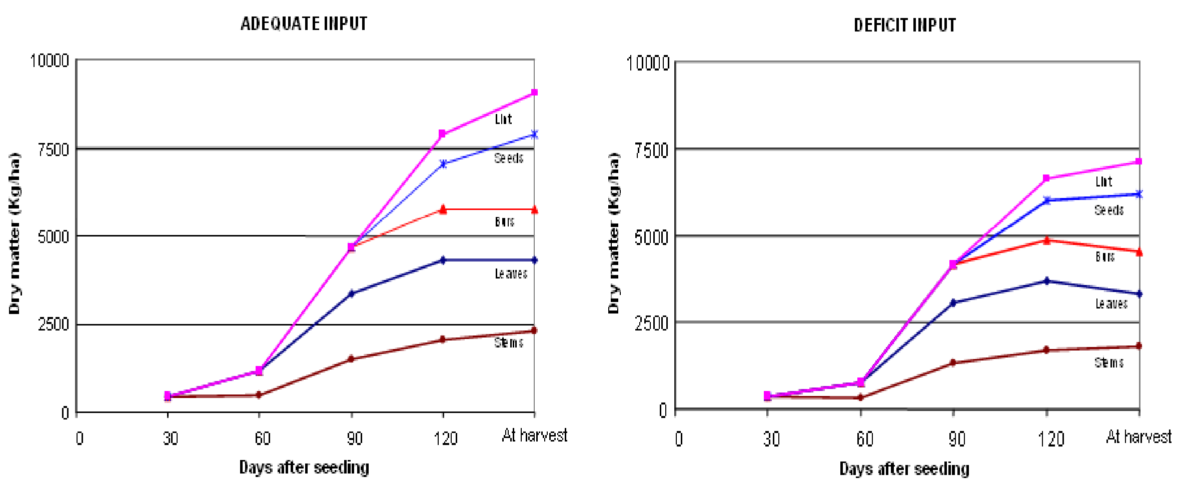

Figure 1. Dry matter production in adequate and deficit input.

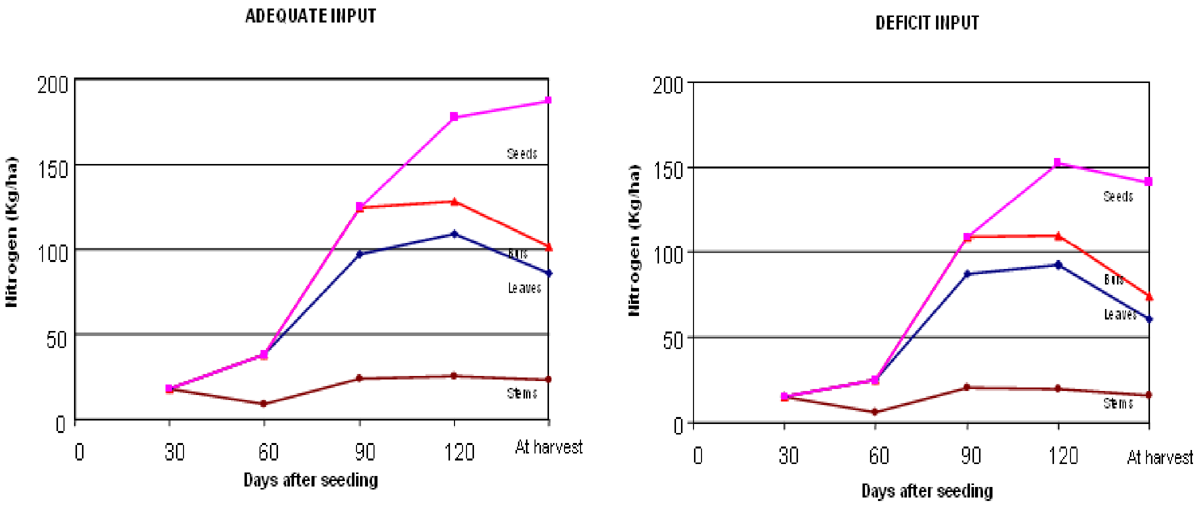

Figure 2. Nitrogen uptake in adequate and deficit input.