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Enhancing nitrogen use efficiency by application methods and nitrogen scheduling in cotton

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Abstact: A field experiment was conducted for three years in *kharif*, 2017 to 2019 at Cotton Research Station, JAU, Junagadh to study enhancing nitrogen use efficiency in cotton under irrigated condition. The result revealed that the treatment T6 (spot application in 4 split: Basal, Squaring, flowering, boll development) + foliar application of (1%) urea (3 times: squaring, flowering, boll development) is significantly higher in all growth parameters, yield attributes as well as cotton stalk yield (5881 kg/ha) and seed cotton yield (2448 kg/ha). However, this was statistically *at par* with T_7 (T_6 + raising of Sunhemp between rows incorporated before flowering) in all the three year and pooled results. Significantly higher nutrient uptake, maximum nitrogen use efficiency (12.55) and apparent NUE (29.23 %) were reported in T_6.

Key word: Application methods, cotton, nitrogen scheduling, nitrogen use efficiency

Progressive nutrient (Macro and Micro) depletion occurs due to continuous repeated cultivation of high nutrient consuming hybrids on the same soils, without replenishing nutrients appropriately. The source sink relationship gets affected because of repeated hybrid cultivation. Cotton hybrids utilize more nutrients to yield more. Therefore the soils are getting progressively depleted and need more nutrient refurbishment, which is not done properly in many farms. The most commonly used fertilizer in cotton production is nitrogen because of its high demand by the plant and its low availability in the soil. In general, nitrogen is prescribed on the basis of soil type, variety, duration of growing period and target yield. Nirogen application plays inducible role in plant photosynthesis activities, canopy development and reproductive growth. In contrast, surplus N application encourages excessive vegetative growth, resulting in poor boll setting, higher pest incidence and delayed maturity. The principles of fertilizers use are straight forward but efficient use is complicated, involving the correct choice of type and amount of fertilizer with correct decisions on timing and method of application. The balanced supply of nutrients is a key to efficient crop management. Nitrogen is one of the decisive as well as expensive input, which is applied for increasing the crop production. It shows quickest effect on plant growth. Over fertilization results in excessive vegetative growth, increased wilt disease incidence, delay in maturity which may results in immature fiber, adversely affects lint yield and fiber quality (Main *et al.*, 2011). It is, therefore, necessary to study the influence of nitrogen application method with its schedule. Nitrogen is applied through different methods at different rates. Mostly split application at PPA (Pre plant application), FBA (First bloom application) and PBA (Peak bloom application) with different rates according to soil and plant condition are in practice by farmers. Many organic and inorganic sources of nitrogen are available with different properties. NUE is affected by different factors like genotype, cropping system, soil, volatilization and leaching, N amount application and fertilizer timing. Different methods like soil testing, tissue testing, Leaf area index (LAI), normalize difference vegetation index (NDVI) and satellite imagery are suggested to improve NUE. Many researches proved that proper management of itrogen increase farmers profit and NUE. (Nangial Khan *et al.*, 2019)

MATERIALS AND METHODS

A three years experiment was conducted on *Bt* cotton hybrid (GTHH-49, BG-II) at Cotton Research Station, Junagadh Agricultural University, Junagadh under irrigated condition. Nitrogen management treatment (7) viz: T_1: control; T_2: (100%) RDN (Band application in 2 splits at basal and flowering); T_3: (75%) RDN (Band application in 2 splits at basal and flowering); T_4: (75%) RDN + placement (Spot application in 2 splits at basal and flowering); T_5: (75%) of RDN + placement (Spot application in 4 split: basal, squaring, flowering, boll development); T_6: T_5 + foliar application of (1%) urea (3 times: squaring, flowering, boll development); T_7: T_6 + raising of sunhemp between rows incorporated before flowering. The experiment was conducted in RBD design along with three replications. Sowing was done by dibbling method on well prepared soil with row to row spacing of 120 cm and plant to plant spacing of 45cm. Gap filling and thinning was done to keep the good crop stand. Basal application fertilizers of 60 kg/ha nitrogen, 50 kg/ha P_2O_5 and 75 kg/ha K_2O were applied 15 Days before sowing, remaining 75 kg/ha K_2O were applied at 45 DAS and nitrogen top dressings given as per treatment at squaring, flowering and boll development stage of cotton crop. Three to four irrigations were given by flood irrigation method in three years depend on soil moisture demand. All the recommended package of practices was followed to raise a health crop. All the observations were recorded as per standard procedures.

Plant height, monopodia/plant, sympodia/plant, bolls/plant, average boll weight of five tagged plants and seed cotton yield in each plot was recorded. As per standard procedures N, P, K was analyzed from plants and soil before sowing and after harvesting of crop.

RESULTS AND DISCUSSION

All the treatments have significantly higher growth and yielding characters over control. The significantly higher plant height (131 cm), monopodia/plant (1.78), sympodia/plant (15.38), boll/sq m (86.43) and boll weight (4.26 g) were recorded in treatment No. T_6 *i.e* (75%) RDN + placement (Spot application in 4 split: basal, squaring, flowering, boll development) + foliar application of (1%) urea (3 times: squaring, flowering, boll development). But this treatment was at par with treatment No. T_7 (T_6 + raising of sunhemp between rows incorporated before flowering) in all the growth and yielding characters. This might be due to timely availability of nitrogen in adequate amount for the cell division and elongation as nitrogen is one of the major component for the growth of plant. Similar results have been reported by Jagvir Singh *et al.*, (2003), Bibi *et al.*, (2011) and Devi *et al.*, (2021).

The dry matter accumulation is one of the most important parameter that reflects the crop growth. Method of application and N scheduling had a significant influence on the dry matter accumulation at all the crop growth stages. The significantly highest cotton stalk yield (5881 kg/ha) was recorded in treatment No T_6 (75 %) RDN + placement (Spot application in 4 split: basal, squaring, flowering, boll development) + foliar application of (1 %) urea (3 times: squaring, flowering, boll development). Higher stalk yield might be due to nitrogen fertilization made at right time with suitable method, helps the plants more efficient in photosynthetic activity by enhancing the carbohydrate metabolism resulting in increased dry matter accumulation. Similar results have been reported by Sisidia and Khamparia (2007).

The effect of different treatments of enhancing nitrogen use efficiency was found significant on seed cotton yield in individual year

Table 1. Plant growth characters, seed cotton yield attributes and cotton stalk yield as influenced nitrogen use efficiency methods in cotton (Three years pooled)

Treatments	Plant height (cm) at harvest	Monopodia at harvest	Sympodia at harvest	Bolls /sqm metre	Boll weight (g)	Cotton stalk yield (kg/ha)
T_1 - Control	104	1.38	12.09	61.80	3.63	4085
T_2 -(100 %) RDN (Band application in 2 splits at Basal and Flowering)	117	1.64	13.96	79.27	3.90	5027
T_3 - (75 %) of RDN (Band application in 2 splits at Basal and Flowering)	111	1.56	13.00	73.58	3.80	4917
T_4 - (75 %) of RDN + Placement (Spot application in 2 splits at Basal and Flowering)	115	1.69	13.62	71.80	3.84	4812
T_5 - (75 %) of RDN + Placement (Spot application in 4 Split: Basal, Squaring, Flowering, Boll development)	123	1.62	14.20	80.71	3.79	5320
T_6 - T_5 + Foliar application of (1%) urea (3 times: Squaring, Flowering, Boll development)	131	1.78	15.38	86.43	4.26	5881
T_7 - T6 + raising of Sunhemp/fodder cowpea between rows incorporated before flowering	128	1.71	14.96	81.74	3.89	5052
S.Em.±	3.89	0.06	0.44	2.77	0.10	185
CD (p = 0.05)	11.17	0.17	1.26	7.96	0.28	531
CV (%)	9.87	11.11	9.51	10.87	7.62	11
	Year					
S.Em.±	2.54	0.04	0.28	1.81	0.06	121
CD (p = 0.05)	7.31	0.11	0.83	5.21	0.18	347
	Y X T					
S.Em.±	6.74	0.10	0.76	4.80	0.17	320
CD (p = 0.05)	NS	NS	NS	NS	NS	NS

Table 2. Seed cotton yield (kg/ha) as influenced by nitrogen effect methods in cotton Treatments Seed cotton yield (kg/ha)

Treatments	2017-2018	2018-2019	2019-2020	**Pooled**
T_1 - Control	1734	1552	1706	**1664**
T_2 - (100%) of RDN (Band application in 2 splits at Basal and Flowering)	2109	1883	2143	**2045**
T_3 - (75%) of RDN (Band application in 2 splits at Basal and Flowering)	2018	1750	2169	**1979**
T_4 - (75%) of RDN + Placement (Spot application in 2 splits at Basal and Flowering)	2086	1837	2096	**2006**
T_5 - (75%) of RDN + Placement (Spot application in 4 Split: Basal, Squaring, Flowering,Boll development)	2101	2123	2391	**2205**
T_6 - T5 + Foliar application of 1 % urea (3 times: Squaring, Flowering, Boll development)	2456	2411	2478	**2448**
T_7 - T6 + raising of Sunhemp/fodder cowpea between rows incorporated before flowering	2343	2298	2121	**2254**
S.Em.±	111	141	131	**74**
CD (p = 0.05)	343	435	403	**213**
CV (%)	9.08	12.35	10.50	**10.66**
	Year			
S.Em.±	-	-	-	**49**
CD (p = 0.05)	-	-	-	**139**
	Y X T			
S.Em.±	-	-	-	**128**
CD (p = 0.05)	-	-	-	**NS**

Table 3. Nutrient uptake (kg/ha), nitrogen APR (%) and nitrogen use efficiency as influenced by nitrogen effect methods in cotton. (Three years pooled)

Treatments	Initial N (kg/ha)	N uptake by plant (kg/ha)	P uptake by by plant (kg/ha)	K uptake by plant (kg/ha)	NAPR (%)	NUE
T1 - Control	203	81	11.45	56.43	-	-
T2 - (100 %) RDN (Band application in 2 splits at Basal and Flowering)	260	116	15.19	79.49	14.58	8.52
T3 - (75 %) RDN (Band application in 2 splits at Basal and Flowering)	246	102	15.19	73.89	11.67	10.99
T4 - (75 %) RDN + Placement (Spot application in 2 splits at Basal and Flowering)	247	103	16.55	74.41	12.22	11.14
T5 - (75 %) RDN + Placement (Spot application in 4 Split: Basal, Squaring, Flowering, Boll development)	242	125	17.65	89.33	24.44	12.25
T6 - T5 + Foliar application of (1%) urea (3 times: Squaring, Flowering, Boll development)	244	138	23.69	101.59	29.23	12.55
T7 - T6+raising of Sunhemp/fodder cowpea between rows incorporated before flowering	252	126	16.75	82.54	23.08	11.56
S.Em.±	8.20	3.81	1.31	4.70	-	-
CD (p = 0.05)	23.53	10.94	4.04	14.49	-	-
CV (%)	10.16	10.10	14.23	11.77	-	-
Year						
S.Em.±	5.37	2.49	0.86	3.08	-	-
CD (p = 0.05)	15.40	NS	2.64	9.49	-	-
Y X T						
S.Em.±	14.20	6.60	1.37	5.41	-	-
CD (p = 0.05)	NS	NS	3.92	15.54	-	-

* Nitrogen amount of sunhemp is not added for calculation of NUE.

Table 4. Economics of different treatment

Treatments	Gross return (Rs/ha)	Cost of cultivation (Rs/ha)	Net income (Rs/ha)	B:C
$\mathbf{T_1}$ - Control	89208	51065	38142	1.75
$\mathbf{T_2}$ - (100 %) RDN (Band application in 2 splits at Basal and Flowering)	109621	57148	52473	1.92
$\mathbf{T_3}$ - (75 %) RDN (Band application in 2 splits at Basal and Flowering)	106117	55926	50191	1.90
$\mathbf{T_4}$ - (75 %) RDN + Placement (Spot application in 2 splits at Basal and Flowering)	107506	56064	51442	1.92
$\mathbf{T_5}$ - (75 %) RDN + Placement (Spot application in 4 Split: Basal, Squaring, Flowering, Boll development)	118155	58248	59907	2.03
$\mathbf{T_6 - T_5}$ + Foliar application of (1%) urea (3 times: Squaring, Flowering, Boll development)	131185	61234	69951	2.14
$\mathbf{T_7 - T_6}$ +raising of Sunhemp/fodder cowpea between rows incorporated before flowering	120598	62651	57947	1.92

Price :-

Seed cotton price	3358 Rs/ha	MOP	Rs 875 per 50 kg
Sunhemp seed	975 Rs/ha	SSP	Rs 390 per 50 kg
Urea	Rs 267 per 45 kg	Sunhemp incorporate	600 Rs/ha
Seed	Rs 3358/ha	Labour charge	Rs 250/day
Irrigation	Rs 320/ha per irrigation	Total pesticide cost	Rs 3758/ha
Cotton picking cost	Rs 10/kg seed cotton	Cotton uprooting	Rs 900/ha

as well as pooled results. The significantly highest seed cotton yield (2456, 2411, 2478 and 2448 kg/ha) was recorded in treatment T_6 (75 % of RDN + placement (Spot application in 4 split: basal, squaring, flowering, boll development) + foliar application of (1%) urea (3 times: squaring, flowering, boll development) in all the three years and pooled results. However this was at par with treatment No. T_7 (T_6+ raising of sunhemp between rows incorporated before flowering) in all the year and pooled results. The above results are also corroborated by the findings of Jat *et al.*, (2014). There is significantly higher nutrient uptake under treatment T_6 (75%) RDN + placement (Spot application in 4 split: basal, squaring, flowering, boll development) + foliar application of (1%) urea (3 times: squaring, lowering, boll development)) in the *Bt* cotton. Maximum nitrogen use efficiency (12.55) and nitrogen apparent use efficiency (29.23%) also reported under this treatment. This might be due to optimum availability of nutrients in soil it was reflected in the improvement in various growth characters ultimately enhance production of photosynthetic, dry matter, seed cotton yield/ plant, biological yield and finally reflected in the higher uptake of N, P, and K by cotton similar results reported by Gache *et al.*, (2018).

The different treatments of enhancing nitrogen use efficiency in *Bt* cotton economics revealed that treatment T_6 *i.e.* (75%) of RDN + placement (Spot application in 4 split: basal, squaring, flowering, boll development) + foliar application of (1%) urea (3 times: squaring, flowering, boll development) produce higher and profitable gross return (Rs.131185/ha) and net return (Rs. 69951/ha) as well as B:C ratio (2.14).

CONCLUSION

The nitrogen management in the soil at sufficient level is fundamental to *Bt* cotton growth and yield. The effect of different enhancing nitrogen use efficiency was also found significant on seed cotton yield. The result revealed that the nitrogen spot application in 4 equal split at basal, squaring, flowering, boll development stage along with foliar application of (1%) urea (3 times: squaring, flowering, boll development) is significantly the highest in yield attributes, seed cotton yield, nutrient uptake, maximum nitrogen use efficiency and apparent nitrogen use efficiency.

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