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EFFICACY OF NEEM COATED UREA THROUGH NITROGEN USE EFFICIENCY METHODS IN BT COTTON UNDER RAINFED VERTISOLS

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ABSTRACT

A scientific field experiment was conducted during 2017, 2018 and 2019 in kharif season at R.A.R.S, Nandyal, Acharya N.G. Ranga Agricultural University to study Efficacy of Neem coated urea through nitrogen use efficiency methods in Bt cotton. The experiment consisting of seven nitrogen use efficiency treatments with combination of three nitrogen doses viz: No nitrogen, 75% recommended dose of nitrogen, 100% recommended dose of nitrogen, 2 methods of nitrogen application viz: band application and split application and 4 stages of nitrogen top dressing viz: basal, squaring, flowering and boll development stages along with foliar application of 1% urea at squaring, flowering, boll development stage with RBD design and replicated thrice. The results indicated that pooled seed cotton yield (2813 kg/ha), nutrient uptake and cotton economics were higher with spot application 75% recommended dose of nitrogen with 4 split doses of nitrogen along with foliar application of 1% urea at squaring, flowering and boll developmental stage and was on par with spot application of 75% recommended dose of nitrogen with 4 split doses of nitrogen, foliar application of 1% urea at squaring, flowering and boll developmental stage along with incorporation of fodder cowpea before flowering (2681 kg/ ha). Lower seed cotton yield (1637 kg/ ha) was recorded with no nitrogen treatment.

KEY WORDS : Bt cotton, Method of application, Neem coated urea (NCU), Nitrogen use efficiency (NUE), Nutrient uptake, Split application,

INTRODUCTION

Cotton (*Gossypium hirsutum*.L.) crop was an important commercial crop and well known to the farming community as white gold. Small and marginal farmers cultivating under different farming situation since few decades in Andhra Pradesh. Cotton is a versatile crop and agronomically response crop for production technology and leads to farm income in all ecological situation to the farmers. India ranks first (125.84 lakh hectares) with about 37.56% of world cotton area and production of 360 lakh bales of 170kg during 2019-20. Introduction of Bt cotton in India leads to the increase in area, production and farm income but at the same time resource utilization and cost of cultivation increased in 2 folds for the past one decade.

In view of the escalating prices of fertilizers and its ill effects on soil health, there is a need to focus on to increase the nitrogen use efficiency that improves crop production with reduced cost of cultivation and the reduces the amount of fertilizer used and also reduces the ill effects caused by urea. The government of India was also released neem coated urea fertilizer to increase the efficiency of the nitrogen nutrient. So there is very urgent need to study the effect of neem coated urea on growth and yield of Bt cotton and stabilize the method and time application to restore the soil fertility. Keeping in view the present investigation was carried out to determine effect of neem coated urea through quantity, method of application, timing and proportion on seed cotton yield and its economics.

MATERIALS AND METHODS

The present field experiment was carried out for three consecutive years at the research farm of R.A.R.S, ANGRAU, Nandyal, Andhra Pradesh situated at an altitude of 216 m above MSL at 15° 29'19'' N latitude and 78° 29'11'' E longitude during *Kharif* 2017, 2018 and 2019. The experiment consists of 7 nitrogen use efficiency treatments involving various nitrogen management practices in a Randomized Block Design with three replications. The details of treatments were T1: N_0 Control, T2:100 % of recommended dose of nitrogen (band application in 2 split doses at basal and flowering), T3:75 % of recommended dose of nitrogen (band application in 2 split doses at basal and flowering), T4: 75 % of recommended dose of nitrogen + placement (spot application in 2 split doses at basal and flowering), T5: 75 % of recommended dose of nitrogen + placement (spot application in 4 split doses at basal, squaring, flowering, boll development), T6: T5 + foliar application of 1% urea (at squaring, flowering, boll development), T7: T6+raising of fodder cowpea between rows incorporated before flowering.

The field experiment was laid out in medium deep black clay soil with low organic carbon (0.39%) and available nitrogen (186 kg/ha), medium in available phosphorus (22 kg/ha) high in available potassium (474 kg/ha) with pH (8.3), EC(0.09 ds/m). Good viable delinted seeds of 'Jaddoo BG-II' were dibbled with 90 cm between rows and 45 cm apart plant to plant, after receipt of sufficient monsoon rains. The seed rate adopted was 2.5 kg of delinted seeds/ ha. The recommended dose of fertilizer is 150-60-60 kg N-P-K/ha. The treatmental plots were applied with recommended dose of neem coated nitrogen fertilizer as per the treatments. Phosphorus (P_2O_5) and potassium (K_2O) fertilizers doses were uniform for all the treatments. The entire dose of phosphorus was applied as basal in the form of SSP (16% P_2O_5). Nitrogen in the form of neem coated urea (46% N). Potassium (60% K_2O) in the form of muriate of potash were applied in 3 equal split doses at 30, 60 and 90 DAS by pocketing method. A total of 652 mm rainfall in 37 rainy days, 179 mm rainfall in 15 rainy days and 850 mm rainfall in 13 rainy days respectively during 2017, 2018, 2019 years. Plant protection measures were takenup for management of sucking pests. Data pertaining to plant growth parameters of plant height (cm), number of monopodia, number of sympodia and yield attributes like number of bolls/ m^2, boll weight (g) were recorded from randomly selected five plants. Seed cotton yield per ha was estimated from net plot. Three pickings of seed cotton yield were taken from each treatment for recording final yield data. Data were statistically analyzed by standard procedure of Panse and Sukhatme (1967). Cotton nutrient uptake at harvest was estimated duly following standard procedures. Post harvest soil samples were collected, analyzed for available nutrient status immediately after cotton harvest and prepared nutrient balance sheet. Economics was calculated and compared the different treatments.

$$\text{Nitrogen use efficiency formula} = \frac{\text{Seed cotton yield (kg/ha)}}{\text{Amount of nitrogen used (kg/ha)}}$$

RESULTS AND DISCUSSION

Effect on plant growth parameters

The cottonplant height was found to be increased significantly with nitrogen fertilization. Spot application of 75% recommended dose of nitrogen in 4 split doses at basal, squaring, flowering, boll development stage combined with foliar application of 1% urea at squaring, flowering and boll developmental stage (T6) treatment recorded significantly higher plant height (130.5 cm), more number of sympodia per plant (17.0), while lowest plant height (80.2 cm), lower number of sympodia per plant (12.5) was recorded with no nitrogen treatment. Number of monopodial branches did not differ due to different nitrogen use efficiency methods. Higher dry matter production in stem (2051 kg/ha), leaf (1545 kg/ha), reproductive structures (5284 kg/ha) and total dry matter production (8880 kg/ha) was recorded in spot application of 75% recommended dose of nitrogen in 4 split doses at basal, squaring, flowering, boll development along with foliar application of 1% urea at squaring, flowering and boll developmental stage (Table 1).

Effect on yield attributes and yield

The yield attributing parameters like number of bolls per square meter, boll weight (g) and seed cotton yield (kg/ha) differed significantly due to varied nitrogen levels, method of application and split doses. Spot application of 75% recommended dose of nitrogen with 4 split doses of nitrogen along with foliar application of 1 % urea at

squaring, flowering and boll developmental stage (T6) treatment recorded more number of bolls per square meter (53.7) and boll weight (4.6 g) and values were significantly higher than band application of 75% recommended dose of nitrogen with 2 split doses of nitrogen at basal and flowering (T3) treatment. The boll weight differences observed in N split application treatments might be due to higher availability of nitrogen at boll development stages which increased the boll weight. More number of fruiting bodies with splitting of nitrogen has resulted in more number of bolls/ plant ultimately resulting into higher seed cotton yield. These results are in confined with Hallikeri*et al.,* (2010), Deepa and Aladakatti (2016).

The treatment 75% recommended dose of nitrogen significantly superior in terms of method of application and split doses over 100 % recommended dose of nitrogen. Nitrogen splitting resulted in significant increase in seed cotton yield. Band application of 75% recommended dose of nitrogen in 2 split doses at basal and flowering (T3) treatment (2155 kg/ha) recorded 6.9 % increase in yield over 2 splits with placement application (2304 kg/ha). Spot application of 75% RDN with 4 splits at basal, squaring, flowering and boll developmental stage along with foliar application of 1% urea at squaring, flowering and boll developmental stage (2813 kg/ha) recorded 17.2 % increase in yield over spot application of 75% recommended dose of nitrogen with 4 splits at basal, squaring, flowering and boll developmental stage (2400 kg/ha) treatment (T5) on pooled analysis (Table 2). The results indicate that no of bolls per square meter (53.7), boll weight (4.6g) and seed cotton yield (2813 kg/ha) were higher with spot application of 75% recommended dose of nitrogen with 4 split doses at basal, squaring, flowering and boll developmental stage along with foliar application of 1% ureaat squaring, flowering and boll developmental stage (T6) treatment, which was on par with T7(2681 kg/ha).

The maximum seed cotton yield with regard to method and split nitrogen applications seems due to more number of boll and boll weight in that treatment. The boll development has coincided with the split dose application of nitrogen which might have been increased the plant nutrients uptake due to slow release of neem coated urea ultimately resulting in higher number of bolls per plantand higher single boll weight which contributed to higher seed cotton yield. Similarly Anjum *et al.,* (2000) and Tang *et al*., (2012) reported that higher cotton yields with 3 splits application of nitrogen.

Table 1. Growth parameters of Bt cotton as influenced by different nitrogen use efficiency methods.

Treatments	Plant height (cm)	No. of mono Podia/ plant	No. of sym Podia/ plant	Dry matter production (kg/ha)			
				Stem	Leaf	RS*	Total
T1: N_0 Control	80.2	1.0	12.5	1193	909	3060	5166
T2: 100 % of RDN (band application in 2 split doses at basal & flowering)	111.1	1.0	14.6	1530	1153	3943	6626
T3: 75 % of RDN (band application in 2 split doses at basal & flowering)	116.9	1.1	15.2	1571	1183	4048	6802
T4: 75 % of RDN +placement (spot application in 2 split doses at basal & flowering)	115.3	1.1	15.4	1680	1266	4327	7273
T5: 75 % of RDN + placement (spot application in 4 split doses at basal, squaring, flowering, boll development)	115.5	1.0	15.1	1750	1318	4508	7576
T6: T5+foliar application of 1% urea (3 times: squaring, flowering, boll development)	126.5	1.2	17.0	2051	1545	5284	8880
T7: T6+Raising of fodder cowpea between rows incorporated before flowering	115.9	1.0	16.1	1954	1472	5037	8463
SE m+	7.9	0.1	0.4	23.5	26.2	35.3	51.6
CD(P=0.05)	24.3	NS	1.2	65	78	103	148

RS* : Reproductive structres

Table 2. Yield attributes and seed cotton yield of Bt cotton as influenced by different nitrogen useefficiencymethods.

Treatments	No. of Bolls/ m^2	Boll weight (g)	Seed cotton Yield (kg/ha)			
			2017	2018	2019	Pooled mean
T1: N_0 Control	36.2	3.4	2111	1296	1571	1637
T2: 100 % of RDN (band application in 2 split doses at basal & flowering)	41.3	4.5	2623	1624	2044	2099
T3: 75 % of RDN (band application in 2 splits doses at basal & flowering)	42.3	4.5	2694	1730	2043	2155
T4: 75 % of RDN +placement (spot application in 2 split doses at basal & flowering)	46.7	4.4	2925	1821	2168	2304
T5: 75 % of RDN + placement (spot application in 4 split doses, basal, squaring, flowering, boll development)	47.5	4.4	2987	1954	2259	2400
T6: T5+foliar application of 1 % urea (3 times: squaring, flowering, boll development)	53.7	4.6	3383	2384	2674	2813
T7: T6+Raising of fodder cowpea between rows incorporated before flowering	52.0	4.6	3261	2248	2536	2681
SE m+	2.8	0.13	201	110	125	79
CD(P=0.05)	8.7	0.4	620	341	386	242

However, Sankat *et al.* (2013) concluded 5 split doses of nitrogen application were beneficial to harvest higher seed cotton yield.

Effect on fiber quality parameters

Cotton quality parameters like fiber length, fiber strength and micronaire value, maturity ratio, tenacity and fiber elongation parameters were not significantly affected by nitrogen use efficiency methods (Table 3). These results are inconformity with the findings of Hallikeri (2008), Bhati and Manpreet (2015). However, improvement in fiber qualitywith better nutrient management was reported by Amboti and Soniya (2012) and Thimmareddy *et al.,* (2013).

Effect on nitrogen use efficiency

Higher nitrogen use efficiency (11.3) was recorded with spot application of 75% recommended dose of nitrogen with 4 split doses at basal, squaring, flowering and boll developmental stages along with foliar application of 1% urea at squaring, flowering and boll developmental stage (T6) treatment, where as lower nitrogen use efficiency (6.3) was noticed with band application of 100 % recommended dose of nitrogen with 2 split doses at basal and flowering

Table 3. Cotton fiber quality parameters as influenced by Nitrogen use efficiency methods.

Treatments	2.5% span length (mm)	Uniformity ratio (%) (mg $inch^{-1}$)	Micronaire value	Maturity ratio	Tenacity (g/tex) (%)	Fiber elongation
T1	33.88	46.17	3.25	0.73	25.67	5.69
T2	33.72	46.31	3.26	0.72	25.78	5.68
T3	33.89	46.22	3.24	0.74	25.69	5.67
T4	33.92	46.58	3.25	0.74	25.65	5.72
T5	33.93	46.44	3.29	0.73	25.94	5.72
T6	33.96	46.51	3.28	0.72	25.83	5.70
T7	33.84	46.64	3.30	0.73	25.83	5.64
SE m±	0.24	0.47	0.06	0.02	0.31	0.04
CD(P=0.05)	NS	NS	NS	NS	NS	NS

stages and the same trend was observed in all the years (Table 4).

Nutrient Uptake

Nutrient uptake by cotton stem, leaf and reproductive structures and total uptake was presented in Table 5. Results showed that the uptake was significantly influenced by nitrogen doses, method of application and split application.

Mean total nutrient uptake was maximum with the spot application of 75% recommended dose of nitrogen in 4 splits at basal, squaring, flowering and boll developmental stage along with foliar application of 1% urea at squaring, flowering and boll developmental stage (T6). The same treatment recorded highest uptake of nitrogen, phosphorus and potassium in stem (10.3, 6.2 and 12.3 kg/ha) leaf (18.5, 7.7 and 16.7 kg/ha), reproductive structures (137.4, 42.3 and 142.7kg/ha) and total uptake (166.2, 56.2 and 171.7 kg/ha) respectively followed by T7 treatment. Foliar application significantly altered the nutrients uptake of Bt cotton on 90 DAS and at harvest (Saravanan *et al.*, 2013). No nitrogen treatment recorded lower values of available nitrogen, phosphorus and potassium uptake during three years of study.

Post harvest soil status

The outline of balance sheet indicated that available nitrogen as in positive side because of mineral nitrogen nitrification process is under gone so that nitrogen balance sheet is maintained in all the treatments (Table 6, 7, 8). Phosphorus balance sheet is in negative side and indicated that available phosphorus was converted into unavailable form due to fixation by clay minerals as the cotton crop is cultivated under black cotton soils, however potassium balance sheet was positive side as the soils are rich in potassium.

Economics

Spot application of 75% recommended dose of nitrogen in 4 splits (at basal, squaring, flowering and boll developmental stage) + foliar application of 1% urea at squaring, flowering and boll developmental stage (T6) recorded highest gross returns (Rs 135022/-), net returns(Rs 83291/-) and B: C ratio(2.6) overband placement of 75% recommended dose of nitrogen with 2 splits at basal and flowering stages and zero nitrogen treatments. Spot application of 75% recommended dose of nitrogen with 4 splits recorded additional monetary benefit of Rs 29,762/- over band

Table 4. Nitrogen use efficiency and economics (pooled) as influenced by nitrogen use efficiency methods in Bt cotton

Treatments	Nitrogen Use Efficiency				Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net Return (Rs/ha)	B:C Ratio
	2017	2018	2019	Pooled mean				
T1	0	0	0	0	48838	78576	29738	1.6
T2	8.0	4.9	6.2	6.3	50671	100656	49985	2.0
T3	11.0	7.1	8.4	8.8	49911	103440	53529	2.1
T4	12.0	7.4	8.8	9.4	50175	110592	60417	2.2
T5	12.2	8.0	9.2	9.8	50942	115200	64258	2.2
T6	13.5	9.6	10.7	11.3	51733	135022	83291	2.6
T7	13.0	9.0	10.1	10.7	52197	128688	76491	2.4

Cottonmarket value: Rs 50 per kg

Table 5. Nutrient uptake (Kg/ha) of Btcotton as influenced by nitrogen use efficiency methods.

Treatments	Nitrogen uptake				Phosphorous uptake				Potassium uptake			
	Stem	Leaf	RS*	Total	Stem	Leaf	RS	Total	Stem	Leaf	RS	Total
T1	6.0	2.9	80	88.9	3.6	5.5	24.5	33.6	7.2	9.9	82.6	99.7
T2	7.7	13.8	102.5	124.0	4.6	5.8	31.5	41.9	9.2	12.7	106.5	128.4
T3	7.9	14.2	105.2	127.3	4.7	5.9	32.4	43.0	9.4	13.0	109.3	131.7
T4	8.4	15.2	112.5	136.1	5.0	6.3	34.6	45.9	10.1	13.9	116.8	140.8
T5	8.8	15.8	117.2	141.8	5.3	6.6	36.1	48.0	10.5	14.5	121.7	146.7
T6	10.3	18.5	137.4	166.2	6.2	7.7	42.3	56.2	12.3	16.7	142.7	171.7
T7	9.8	17.7	131	158.5	5.9	7.4	40.3	53.6	11.7	16.2	135.9	163.8

*RS- -Reproductive structures

Table 6. Balance sheet of soil available nitrogen (Kg/ha)as influencedby nitrogen use efficiency methods after Bt cotton crop harvest.

Treatments	Initial soil nitrogen (kg/ha)	Nitrogen added through fertilizer*	Total available nitrogen	Total Nitrogen uptake by crop	Expected balance	Actual balance	Net gain or loss (±)
T1	145	0	145	88.9	56.1	148	+91.9
T2	145	150.0	295	124.0	171.0	195	+24.0
T3	145	112.5	257.5	127.3	130.2	191	+60.8
T4	145	112.5	257.5	136.1	121.4	185	+63.6
T5	145	112.5	257.5	141.8	115.7	188	+72.3
T6	145	112.5	257.5	166.2	91.3	185	+94.0
T7	145	112.5	257.5	158.5	99.0	187	+88.0

Table 7. Balance sheet of soil available phosphorus (Kg/ ha) as influenced by nitrogen use efficiency methods after Bt cotton crop harvest.

Treatments	Initial soil Phosphorus (kg/ha)	Phosphorus added through fertilizer	Total available Phosphorus	Total Phosphorus uptake by crop	Expected balance	Actual balance	Net gain or loss (±)
T1	47	60	107	33.6	73.4	52	-21.4
T2	47	60	107	41.9	65.1	52	-13.1
T3	47	60	107	43.0	64.0	52	-12.0
T4	47	60	107	45.9	61.1	51	-10.1
T5	47	60	107	48.0	59.0	49	-10.0
T6	47	60	107	56.2	50.8	48	-2.8
T7	47	60	107	53.6	53.4	49	-4.4

Table 8. Balance sheet of soil available potassium (Kg/ ha) as influenced by nitrogen use efficiency methods after Bt cotton crop harvest.

Treatments	Initial soil Potassium (kg/ha)	Potassium added through fertilizer	Total available potassium	Total Potassium uptake by crop	Expected balance	Actual balance	Net gain or loss (±)
T1	474	60	534	99.7	434.3	478	+43.7
T2	474	60	534	128.4	405.6	475	+69.4
T3	474	60	534	131.7	402.3	477	+74.7
T4	474	60	534	140.8	393.2	476	+82.8
T5	474	60	534	146.7	387.3	475	+87.7
T6	474	60	534	171.7	362.3	467	+104.7
T7	474	60	534	163.8	370.2	465	+94.8

application of 75% recommended dose of nitrogen with 2 splits at basal and flowering on pooled basis. Similar results were also reported by Srinivasan (2003). Higher gross and net returns as well as B: C ratios were obtained with split application of nutrients to Bt cotton was noted by Solunke *et al.,* (2009), Pawar *et al.,* (2010) and Bhalerao *et al.,* (2012)(Table 3).

Based on the three years experimental results, it was concluded that spot application of 75 % recommended dose of nitrogen through neem coated urea with 4 splits at basal, squaring, flowering and boll developmental stage along with foliar application of 1% urea at squaring, flowering and boll developmental stage was found to be optimum to relies higher seed cotton yield and higher net returns. The fibre quality parameters of Bt cotton were not significantly influenced either by the nutrient levels, method of application and split application of nitrogen.

REFERENCES

Amboti, R. R. and Soniya, T. K. 2012. Effect of nutrient management on FUE, red leaf, fiber properties of Bt hybrid cotton (*Gossypium hirsutum*). *Indian Journal of Agronomy.* 57(4): 390-396.

Anjum, F. H., Tanveer, A., Ahmad, R., Ali, A., Nadeem, M. A. and Tahir, M. 2000. Response of cotton (*Gossypium hirsutum* L.) to split application of nitrogen and weed control method. *Indian Journal of Agricultural Sciences.* 77(4): 224-229.

Bhalerao, P. D., Deshmukh. P.W., Gaikwad, G. S. and Imade, S. R. 2012. Response of *Bt* cotton to spacing and fertilizer levels under rainfed condition. *Indian Journal of Agronomy.* 57(2): 176-179.

Bhati, A. S. and Manpreet, S. 2015. Effect of split application of nitrogen and potassium on yield, nutrient uptake and nutrient use efficiency in Bt cotton. *Annals of Plant and Soil Research.* 17(1): 71-73.

Blaise, D. and Prasad, R. 2005. Integrated plant nutrient supply: An approach to sustained cotton production. *Indian Journal of Fertilizers.* 1 : 37-46.

Deepa, G. S. and Aladakatti, Y. R. 2016. Effect of nutrient levels and split application of nitrogen and potassium on yield, economics and fiber quality parameters of interspecific *Bt* cotton. *Journal of Farm Sciences.* 29(2): 203-207.

Hallikeri, S. S. 2008. *Effect of sowing time, nitrogen and irrigation levels on yield, fibre quality and Cry protein concentration in Bt-cotton,* Ph. D. Thesis, University of Agricultural Sciences, Dharwad, Karnataka.

Hallikeri, S. S., Halemani, H. L., Patil, V. C., Palled, Y. B., Patil, B. C. and Katageri, L. S. 2010. Effect of nitrogen levels, split application of nitrogen and detopping on seed cotton (*Gossypium hirsutum* L.) yield and fiber quality in Bt cotton. *Karnataka Journal of Agricultural Sciences.* 23 (3) : 418-422.

Pawar, S. U., Gitte, A.N., Bhosle, G. P. and Suryawanshi, S. B. 2010. Effect of fertilizer levels and plant densities on yield, gross and net monetary returns of Bt cotton hybrids. *Journal of Cotton Research and Development.* 24(2) : 182-185.

Sankat, K, B., Usdadia, V. P., Patel, J. G., Sutaria, C. M. and Kumar, V. 2013. Precision application of irrigation and fertilizers to Bt cotton (*Gossypium hirsutum* L.) and effect on productivity and input use efficiency in vertisols of south Gujarat. In proceedings of *National Convention on Indian Cotton: "Gearing up for Global Leadership"*. Main Cotton Research Station, N. A. U, Surat. pp 64,

Saravanan, M., Venkitaswamy, R. and Rajendran, K. 2013. Growth, yield, nutrient uptake and economics of Bt cotton as influenced by foliar nutrition. *Madras Agricultural Journal*. 100 (1-3): 160-162.

Solunke, P. S., Thokale, J. G. and Barve, U. S. 2009. Influence of foliar feeding of different micronutrients on yield andeconomics of hybrid cotton. *Nationional Symposium on Bt cotton : Opportunities and Prospects*. Central Institute on Cotton Research, Nagpur, Maharastra, pp. 5917-19.

Srinivasan, G. 2003. Response of cotton (*Gossypium hirsutum*) to split application of major nutrients. *Indian Journal of Agronomy.* 48(1) : 59-61.

Tang, H. Y., Yang, G., Zhang, X. L. and Siddique, K. 2012. Improvememt of fertilizer N recovery by allocating more N for later application in cotton (*Gossypium hirsutum* L.). *International Journal of Basic Applied Sciences.* 12 : 32-37.

Thimmareddy, K., Desai, B. K. and Vinoda Kumar, S. N. 2013. Uptake of NPK, availability of NPK and quality parameters of Bt cotton (*Gossypium hirsutum* L.) as influenced by different bio-fertilizers and in-situ green manuring under irrigation. *International Journal of Agricultural Environmemt and Biotechnology.* 6(4) : 623-628.