Indian Journal of Agricultural Sciences **82** (12): 1039–43, December 2012
https://doi.org/10.56093/ijas.v82i12.26251

Lint yield, fibre quality and its nutrient uptake in *Bt* cotton (*Gossypium hirsutum*)–groundnut (*Arachis hypogaea*) intercropping system using different fertility levels

RAMAN JEET SINGH[1] and I P S AHLAWAT[2]

Indian Agricultural Research Institute, New Delhi 110 012

Received: 24 February 2011 ; Revised accepted: 4 August 2012

ABSTRACT

A field experiment was carried out during the rainy (*kharif*) seasons of 2006 and 2007 at the Indian Agricultural Research Institute, New Delhi to study the lint yield, fibre quality and its nutrient uptake in *Bt* cotton (*Gossypium hirsutum* L.) – groundnut (*Arachis hypogaea* L.) intercropping system using different fertility levels. Intercropping of groundnut with cotton significantly increased the lint yield by 10 % (130 kg/ha) and fibre production efficiency by 8.5 % (0.5 kg/ha-day) over sole cotton. However, it did not influence any of the fibre quality traits and its nutrient uptake except ferrous, manganese and zinc. Substitution of 25 % recommended dose of nitrogen (RDN) by FYM produced additional 180 kg lint /ha over no substitution, whereas substitution of 50 % RDN through FYM reduced lint yield by 150 kg/ha over no substitution. Substitution of 25 % RDN through FYM and 100 % RDN (150 kg/ha) through urea maintained similar uptake of macronutrients (N,P and K) in fibre, but 25 % RDN substitution through FYM recorded significantly higher uptake of micronutrients (Fe, Mn, Zn and Cu) over other treatments. For producing 100 kg lint of *Bt* cotton in fertilized treatments, it accumulated 590 g N, 400 g P, 380 g K, 55 g S, 21 g Fe, 4 g Mn, 2.5 g Zn and 2 g Cu in fibre. Substitution of 25 % RDN through FYM being on par with 100 % RDN recorded higher values of seed index, lint index and micronaire over other treatments. Fibre length and micronaire showed strong correlation with seed weight. Similarly fibre length and micronaire showed strong correlation with fibre N content. Results from this study supports that fibre properties of *Bt* cotton (RCH 134) are highly genetically influenced and least affected by management practices.

Key words: *Bt cotton,* Fertility, Fibre, Groundnut, Lint, Nitrogen, Nutrient uptake

India has emerged as a major global partner in the production, processing and trade of raw cotton and its finished products. The genetically modified *Bt* cotton, containing the *Cry* gene sourced from the soil bacterium *Bacillus thuringiensis* ssp *kurstaki,* providing resistance against bollworms, represents a landmark in cotton research and development. The large scale adoption of *Bt* cotton by Indian farmers in a span of 8 years is the power of this technology (Venugopalan *et al.* 2009). Global demand for cotton is projected at 42.75 million tonnes by 2020. Despite a stiff competition from synthetic fibers, the share of cotton to the global textile pool is 45% (Srinivasan 2009) and this is higher in India (65%). Use of input-responsive cultivars and high-tech production technologies will go a long way to meet the ever-increasing demand for the natural fiber. The increase in productivity alone could not benefit the cotton growers as quality of cotton fibre is primary concern for fetching higher price. The genetic makeup of the cotton plant regulates these fibre traits but the growing conditions determine whether the quality of the fibre reaches the genetic potential. Mineral nutrition is one of the growing conditions that can affect fibre quality. Nitrogen is widely considered one of the major essential nutrients for cotton growth. However, proper N fertilization in cotton often be viewed as more of an art rather than a science. The N requirement uncertainty for optimal cotton yields under different environmental conditions is due to indeterminate growth habit of cotton and the complexity of N cycling in the soil (Rochester 2007). Although the use of chemical fertilizers is the fastest way of counteracting the pace of nitrogen depletion, but the best course is to practice integrated nitrogen management (INM) from technical, economical, logistical and environmental considerations. Wide row spacing of cotton (90–120 cm) provides scope for intercropping short stature and short duration legumes like groundnut for additional produce and returns (Singh and Ahlawat 2011). The effect of groundnut intercropping and nitrogen nutrition on fibre yield, nutrient contents in fibre and quality of *Bt* cotton has not

Based on a part of Ph D thesis of the first author submitted to IARI during 2008

[1]Scientist, (e mail: rdxsingh@gmail.com), Division of Soil Science and Agronomy, CSWCRTI, Dehradun 248 195; [2]Former Head (e mail: ahlawat47@hotmail.com)

been so far well documented in India, hence, the present experiment was carried out under irrigated conditions in sandy loam soils of northern India.

MATERIALS AND METHODS

Field experiments were conducted in sandy loam soil with *p*H 7.8 and 8.1(1:2.5 soil to water) containing 0.42 and 0.46% organic carbon, 227 and 207 kg/ha available N, 12.8 and 13.6 kg/ha available P, and 270 and 282 kg/ha available K in 0–30 cm soil layer in 2006 and 2007 respectively at the research farm of Indian Agricultural Research Institute, New Delhi. The total rainfall received during the cropping period was 629.5 mm in 2006 and 489.0 mm in 2007. Eight treatments comprising combination of two cropping systems (sole cotton and cotton + groundnut) and four fertility levels (control (0 N), 100 % recommended dose of N (RDN) through urea, 25% RDN substitution through FYM and 50% RDN substitution through FYM) to cotton were laid out in a randomized block design with three replications. In cotton, 150 kg N/ha was used as RDN. Well decomposed farmyard manure (FYM) was uniformly incorporated into the soil seven days before sowing as per treatments. FYM on dry weight basis contained 0.5–0.2–0.5 % N-P-K respectively and 32 ppm zinc, 150 ppm Mn, 8 ppm Cu, 15 ppm boron and 220 ppm iron. The quantity of P and K being variable owing to differential quantities of FYM addition. As per treatment, 50% N each through urea was applied at sowing and square initiation stage. A uniform dose of 26 kg P/ha through single super phosphate (SSP) was applied at sowing. Cotton RCH-134 *Bt* was sown by dibbling with 120 cm × 60 cm geometry on 17 June in 2006 and 2 June in 2007. In intercropped cotton, 3 rows of groundnut Punjab Groundnut 1 were planted in between two cotton rows. Groundnut was harvested in last week of October. Cotton was harvested in 2 pickings up to last week of November. For assessing the quality parameters (except ginning percentage, seed index and lint index) a high volume instruments (HVI, Statex-Fibrotex model) was used. Fibre quality index (FQI= LT/ vM, where L, 2.5 % span length (mm); T, fibre strength (g/tex); and M, micronaire value), count (C= 0.196FQI-16) and count strength product (CSP= 1.740FQI+1600) were also worked out. Fibre productivity efficiency (FPE) was calculated based on unit day productivity (lint yield / 180 phenological days). The pooled analysis for lint yield was carried out after homogeneity test. At harvest lint samples of cotton were analysed for total N using a micro-Kjeldahal method, while total P, K and S were determined using sulphuric-nitric-perchloric acid digest as per procedures described by Prasad *et al.* (2006). All the cationic micronutrients like Fe, Mn, Zn and Cu were analysed by using 0.005 M DTPA as an extractant (Lindsay and Norvell 1978) with the help of Atomic Absorption Spectrophotometer (model Perkin Elmer Analyst 100).

RESULTS AND DISCUSSION

Lint yield and ginning percentage

Intercropping of groundnut with cotton significantly increased the lint yield by 10% (130 kg/ha) and fibre production efficiency by 8.5% (0.5 kg/ha-day) over sole cotton (Table 1). Groundnut as an intercrop with short and compact stature did not offer competition to cotton. The positive impact of inclusion of groundnut as an intercrop owing to its ability of biological N_2 fixation and reducing weed menace in between cotton rows favoured development of yield attributes in cotton, leading to higher lint yield. These results are in close agreement with the findings of Singh and Ahlawat (2011). Ginning percentage was not influenced by groundnut intercropping.

Application of RDN (150 kg/ ha) irrespective of its source significantly enhanced lint yield and fibre production efficiency (470 kg lint/ha and 2.6 kg lint/ha-day) over unfertilized crop. Within fertilized treatments, application of 75% RDN through urea and rest 25% by FYM produced significantly the highest lint yield and fibre production efficiency (1 300 kg lint/ha and 7.2 kg lint/ha-day). It showed that substitution of 25% RDN by FYM produced extra 180 kg lint /ha over no substitution, but 50% substitution of RDN through FYM reduced lint yield by 150 kg/ha over no substitution. This could be attributed to prolonged supply of N and other nutrients owing to slow mineralization of FYM coupled with minimum losses of mineral N as it binds with FYM particles reducing leaching and other losses. Thus supply of N matching with the crop needs led to development of more yield attributes (data not reported here) and nutrient uptake. However, substitution of 50% fertilizer N through FYM proved counterproductive to some extent as this level of substitution drastically altered the N supply to the crop. The rate of mineralization of FYM failed to release the required N at critical periods of development of yield attributes. This is in line with the findings of Rathinakumari *et al.* (2004). Substitution of 25 % RDN by FYM resulted in significantly higher ginning percentage over control, but other treatments were on par.

Nutrient uptake in fibre

Intercropping of groundnut with cotton did not influence nutrient uptake in fibre, except ferrous, manganese and zinc (Table 1). Higher lint yield in intercropped cotton maintained higher ferrous, manganese and zinc uptake, however the content of these micronutrients was similar in both the cropping systems. Recommended dose of N irrespective of its source significantly enhanced nutrient uptake over unfertilized crop. For producing 100 kg lint in fertilized treatments, it accumulated 590 g N, 400 g P, 380 g K, 55 g S, 21 g Fe, 4 g Mn, 2.5 g Zn and 2 g Cu in fibre (Rochester 2007). Substitution of 25 % RDN through FYM and no substitution recorded similar uptake of macronutrients (N, P, K and S) in fibre, however, the former had higher uptake of micronutrients (Fe, Mn, Zn and Cu) over other treatments. Treatments involving FYM had significantly higher amount of all the nutrients in fibre over 100 % RDN through urea due to considerable amount of nutrients present in FYM because of its high CEC and chelating properties.

Fibre quality traits

Cropping system had no effect on any of the fibre quality traits (Table 2) as groundnut supplied adequate but not excessive N to cotton hence did not alter fibre quality parameters (Bouquet *et al.* 2004). Moreover, fibre quality is

Table 1 Effect of cropping system and fertility level on lint yield, fibre production efficiency, ginning percentage and nutrient uptake in fibre of *Bt* cotton (mean of 2006 and 2007)

Treatment	Lint yield* (kg/ha)	Fibre production efficiency (kg/ha-day)	Ginning (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	S (g/ha)	Fe (g/ha)	Mn (g/ha)	Zn (g/ha)	Cu (g/ha)
Cropping system											
Sole cotton	960	5.4	37	5.1	3.6	3.5	420.2	186.7	45.1	20.1	18.9
Cotton + Groundnut (1:3)	1 070	5.9	37.4	5.9	4	4.1	592.1	217.1	38.6	24.5	21.7
SEm +	24.22	0.12	0.52	0.67	0.21	0.41	67.11	4.97	2.05	0.66	1.34
CD (*P* = 0.05)	70.14	0.37	NS	NS	NS	NS	NS	15.07	6.21	2	NS
Recommended dose of nitrogen (150 kg/ha)											
Control (0 N)	660	3.7	35.8	2.1	1.9	2.2	162.7	80.9	27.3	5.1	6.8
100 % urea	1 120	6.2	37.4	7.3	4.8	4.1	387.4	173.8	36.1	14.8	13.5
75 % urea + 25 % FYM	1 300	7.2	39.1	8.1	5	5.3	587.5	310.5	57.5	35.9	34.3
50 % urea + 50 % FYM	970	5.4	36.4	4.7	3.7	3.6	887.2	242.5	46.5	33.3	26.6
SEm ±	34.22	0.17	0.73	0.96	0.31	0.57	94.9	7.03	2.89	0.93	1.89
CD (*P*=0.05)	99.12	0.52	2.21	2.87	0.91	1.72	287.84	21.31	8.78	2.83	5.73

Interaction between cropping system and RDN was not significant

* pooled data of two years

Table 2 Effect of cropping system and fertility level on fibre quality parameters of *Bt* cotton (mean of 2006 and 2007)

	Seed index (g)	Lint index	Bartlett's index	2.5% span length (mm)	50% span length (mm)	Fibre strength (g/tex)	Fibre elongation (%)	Micro-naire	Uniformity ratio (%)	Fibre quality index (FQI)	Count	Count strength product
Cropping system												
Sole cotton	8.2	4.8	0.87	26.4	14	21.4	6	4.7	53.1	259.7	34.9	2 052
Cotton + groundnut (1:3)	8.3	5	0.87	26.8	14.1	21.7	6	4.8	52.7	264.2	35.8	2 060
SEm ±	0.03	0.11	0.008	0.31	0.154	0.2	0.06	0.08	0.62	3.71		
CD (*P*=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS		
Recommended dose of nitrogen (150 kg/ha)												
Control (0 N)	8	4.5	0.91	25.8	13.6	21.1	6	4.5	52.9	256	34.2	2 045
100 % urea	8.4	5	0.85	26.8	14.3	21.6	6.1	4.9	53.1	262.5	35.4	2 057
75 % urea + 25 % FYM	8.5	5.4	0.86	27.2	14.4	22.3	6.1	5.1	52.9	268.1	36.6	2 067
50 % urea + 50 % FYM	8.2	4.7	0.86	26.5	14	21.4	6	4.7	52.6	261	35.2	2 054
SEm ±	0.04	0.16	0.012	0.43	0.22	0.29	0.08	0.11	0.87	5.26		
CD (*P*=0.05)	0.13	0.48	0.036	NS	NS	NS	NS	0.34	NS	NS		

Interaction between cropping system and RDN was not significant

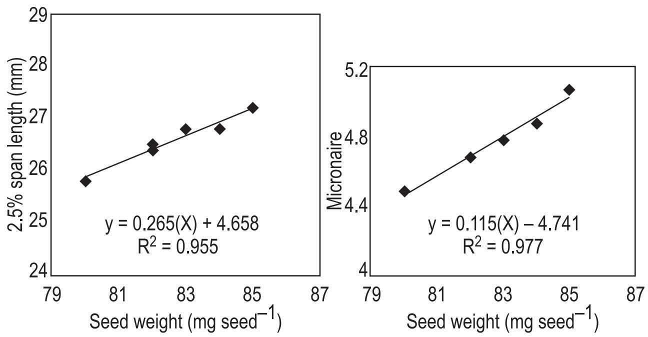

Fig 1 Relationship between seed weight with 2.5 % span length and micronaire of *Bt* cotton

a genetic character and it does not change by cultivation practices (Blaise *et al.* 2005). Fertility levels affected seed index, lint index, Bartlett's index and micronaire values only. Substitution of 25 % RDN through FYM being on par with 100 % RDN through urea recorded higher values of seed index, lint index and micronaire over other treatments. This could be attributed to availability of micronutrients with FYM application along with the major nutrients (P, K, Ca, Mg and S) and growth promoting substances (Blaise *et al.* 2005). Numerically, the highest FQI (268) was noticed with 25 % RDN substitution followed by 100 % RDN through urea (262.5). Similar trend was observed for spinnable count and count strength product, which are normally used to indicate the spinning value of cotton (Sankranarayanan *et al*. 2010). Bauer and Roof (2004) also observed lower lint quality, including fiber length, length uniformity and fiber strength in plots that did not receive N fertilization.

Regression analysis

Fibre length and micronaire showed strong correlation with seed weight (Fig 1). Larger seeds produced longer fibers with greater micronaire than smaller seeds. Because cotton fibers develop from epidermal cells of the ovule, the amount of lint produced per seed should depend on the size of the fully mature seed. This relationship implies that factors that limit growth and development of the seed should limit the amount of lint produced as well as fibre length and fineness (Tewolde and Fernandez 2003). Likewise, fibre length and micronaire showed strong correlation with fibre N content (Fig 2). Higher N content in fibre produced longer fibers and greater micronaire than the fibre containing less N since optimum N supply is an essential requirement for the process of secondary wall lengthening (Girma *et al*. 2007).

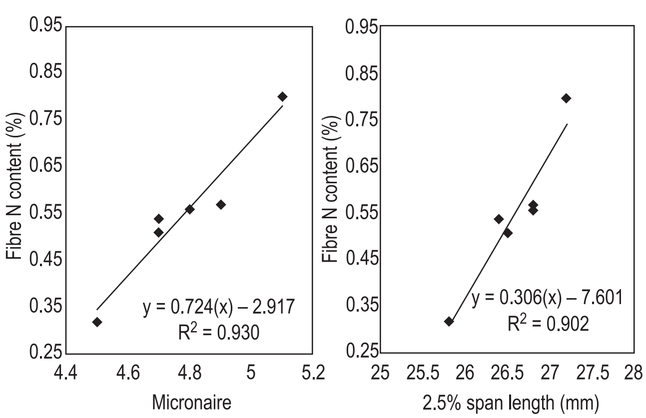

Fig 2 Relationship between fibre N content with micronaire and 2.5 % span length of *Bt* cotton

The results of this study show that new transgenic cultivars have removed bollworm pressure and substantially changed the yield potential consequently enhancing the nutrient uptake, especially N. This requires redevelopment of nutrient management practices for sustainable cotton production. The findings of the present investigation also showed that transgenic cultivars produce fibre quality acceptable for the industry without any discount. The data presented here is a resource for planning research in cotton producing areas of India which emphasize that management strategies may also need to be re-examined.

ACKNOWLEDGEMENT

The authors greatly acknowledge the Indian Agricultural Research Institute, New Delhi for providing financial assistance to conduct this study.

REFERENCES

Bauer P J and Roof M E. 2004. Nitrogen, aldicarb, and cover crop effects on cotton yield and fiber properties. *Agronomy Journal* **96**: 369–76.

Blaise D, Majumdar, G and Tekale K U. 2005. On farm evaluation of fertilizer application and conservation tillage on productivity of cotton + pigeonpea strip intercropping on rainfed Vertisol of central India. *Soil and Tillage Research* **84**: 108–17.

Bouquet D J, Hutchinson R L and Breitnbeck G A. 2004. Long term tillage, cover crop and nitrogen rate effects on cotton: Yield and fibre properties. *Agronomy Journal* **96**: 1436–42.

Girma K, Roger K T, Freeman K W, Boman R K and William R.2007. Cotton lint yield and quality as affected by applications of N, P, and K fertilizers. *Journal of Cotton Science* **11**: 12–9.

Prasad R, Shivay Y S, Kumar D and Sharma S N. 2006. *Learning by Doing Exercises in Soil Fertility (A Practical Manual for Soil Fertility).* Division of Agronomy, Indian Agricultural Research Institute, New Delhi.

Rathinakumari S, Subbaravamma P and Nariji Reddy A. 2004. Response of cotton to farmyard manure in deep black cotton soils under rainfed conditions. (*in*) *National Symposium on Changing World Order-Cotton Research, Development and Policy in Context*, ANGRAU, Hyderabad, 10–12 August 2004.

Rochester Ian. 2007. Nutrient uptake and export from an Australian cotton field. *Nutrient Cycling in Agroecosystem* **77**(3): 213–23.

Sankaranarayanan K, , Prahraj C S, Nalayini P, Bandyopadhay K K and Gopalkrishnan N. 2010. Effect of magnesium, zinc, iron and boron application on yield and quality of cotton. *Indian Journal of Agricultural Sciences* **80** (8): 699–703.

Singh Raman Jeet and Ahlawat I P S. 2011. Productivity, competition indices and soil fertility changes of *Bt* cotton (*Gossypium* *hirsutum*) – groundnut (*Arachis hypogaea*) intercropping system using different fertility levels. *Indian Journal of Agricultural Sciences* **81** (7): 606–11.

Sreenivasan S. 2009. Technology Interventions in cotton for enhancing its diversified use. (in) *International Conference on Emerging Trends in Production, Processing and Utilization of Natural Fibers*. Book of Papers, pp 208–15.

Tewolde H and Fernandez C J. 2003. Fibre quality response of Pima cotton to nitrogen and phosphorus deficiency. *Journal of Plant Nutrition* **26** (1): 223–35.

Venugopalan M V, Sankaranarayanan K, Blaise D, Nalayini P, Prahraj C S and Gangaiah B. 2009. Bt cotton in India and its agronomic requirements. *Indian Journal of Agronomy* **54** (4): 343–60.