The Effect of Biofertilizers on Cotton (*Gossypium hirsutum* L.) Development Yield and Fiber Technological Properties

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Abstract: The aim of this study was to determine the effect of biofertilizer application on cotton yield, cotton growth and fiber technological properties. This study was carried out at faculty of agriculture, department of field crops, Siirt University, Turkey during 2017 cotton growing season. The experiment was conducted in randomized complete block design with four replications. Stoneville 468 cotton cultivar was used as plant material. In this experiment Coton Plus and Mega Flu have been used as biofertilizers to increase cotton yield and technological properties as opposed to the utilization of chemical fertilizer. Further, Cotton Plus is mixed microbial fertilizer which contains *Bacillus subtilis*, *Paenibacillus azotofixans* while Mega Flu contains three different genera of bacteria *Bacillus megaterium*, *Pantoea agglomerans* and *Pseudomonas fluorences*. The results of study indicated that there were significant differences between biofertilizers applications in terms of seed cotton yield, lint yield, ginning percentage, the number of monopodial branches, but there were non-significant differences observed in terms of lint quality characteristics except fiber elongation. The best results obtained from the application of biofertilizers at seed + square +flowering +boll formation periods. Comparing with control 1350 kg ha^{-1} higher yield was obtained from Coton-Plus application. Significant seed cotton yield and lint yield obtained by using few times biofertilizers at different growing stages (seed +squaring + flowering +boll forming stages). These findings indicated that yield increasing can be achieved by using biofertilizers few times instead of one time.

Keywords: Cotton, Biofertilizer, Bacillus subtilis, Paenibacillus azotofixans, Bacillus megaterium, Pantoea agglomerans, Pseudomonus fluorences.

1. INTRODUCTION

Cotton is one of the most important commercial crops in Turkey. Turkey is one of the major cotton producing countries with a total of 500.000 ha area of cotton cultivated area and 882.000 tons of total fiber production (Anonymous, 2017). However, because of the local cotton lint production is not sufficient to meet the ever-increasing demands of textile industry, Turkey imports about 800.000 tons of cotton lint per year.

The demand for and supply of food are evidently the results of double increase of human population in the recent decades, in which plant nutrition played an important role. Commercial artificial fertilizers have led to an enormous increase in crop production. The tremendous use of chemical fertilizers has caused several problems in the ecological and agricultural system such as the pollution of air, surface water and ground water as well as deterioration of soil quality, the suppressed ecosystem and biodiversity. In general, plants depend on major nutrients for crop growth and development. Nitrogen and phosphorus are essential minerals strictly required to successfully stimulate plant growth. However, the soil may contain a vast amount of either nutrient, but most of the nitrogen and phosphorus are not absorbed by regular uptake process. Naturally, nitrogen can be lost from crop rhizosphere through volatilization, leaching, crop removal, run off, soil erosion and denitrification (Choudhury and Kennedy, 2005). On the other hand, phosphorus can be lost from agricultural lands through certain chemical and ecological processes.

It was observed that the potassium-mobilizing bacterium *Bacillus edaphicus* promoted the root and shoot growth of seedlings in pot trials of cotton grown in potassium-deficient soil and increased the N and P concentration in plants through root proliferation (Sheng, 2005). Previous researchers explained that the effect of plant growth promoting rhizobacteria (PGPR) inoculation alone as wells as in combination with three levels of nitrogen fertilizer on cotton separately. The bacterium inoculum significantly increased plant height by 5%, seed cotton yield by 21% and microbial population in soil by 41% over their respective controls while boll weight (Anjum *et al*. 2007). It was reported that co-inoculation of fields with *Azospirillum* sp., P-solubilising bacteria and methylotrops significantly enhances root and shoot growth, fibre yield, and, to some extent, fibre quality when used in combination with fertilizers (Dhale *et al*. 2010). Mansoori *et al*. (2013) concluded that the pathogenic fungus *Verticillium dahlia* causes *Verticillium wilt*, one of the most important cotton diseases, *P. fluorescens* and *Bacillus* spp. strains reduce its incidence applied to

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cotton seeds before planting in *V. dahlia* inoculated soil. Yasmin *et al*. (2013), revealed that under reduced fertilizer conditions, cottonseed inoculated with combined microbial fertilizer which contains *Bacillus fusiformis* S10 and *Pseudomonas aeruginosa* Z5 which isolated from cotton in Pakistan. The results showed that the cotton yield improved by these two bacteria. Two bacterial strains *Pseudomonas chlororaphis* R5 and *Pseudomonas putida* R4 applied to cotton in saline soils it was revealed that were able to suppress abiotic stress case change in concentration of phytohormones level in plant. These great potential strains were further able to produce and regulate (IAA) in the plant and they reduced the cotton root rot which is caused by *Fusarium Solani* (Egamberdieva *et al*. 2015). Perdomo *et al*. (2017), shows that both strains *Azotobacter chroococcum* AC1 and AC2 are capable of producing indole component, fixing nitrogen, synthesizing hydrolytic enzymes and solubilizing phosphorus in cotton. To overcome the environment stresses and to reduce lacking fertilizers in the agricultural lands, biofertilizers can tackle problems despite being an excellent alternative to modify and manipulate agricultural lands.

Therefore, the objective of this study was to determine the effect of biofertilizers on development, yield and fiber technological characteristics of cotton.

2. MATERIAL AND METHOD

2.1. Materials

2.1.1. General Description of Experımental Area

The study was carried out at faculty of agriculture, department of field crops, Siirt University, Turkey during 2017 cotton growing season. The experimental field is located at (37.93'60" N, 41.94'04" E) at 920 m above sea level.

2.1.2. Soil Properties of Experimental Area

The soils of the experimental area are zonal soils which are generally red-brown included in the big soil group having a clayish nature, flat or nearly flat, having very small erosion and deep to medium deep. The soil is low in organic material and phosphorus, has adequate potassium, calcium and high clay content in the 0-150 cm profile.

2.1.3. Climatic Data of Subject Area

The climatical data was given in Figure **1** and Figure **2**.

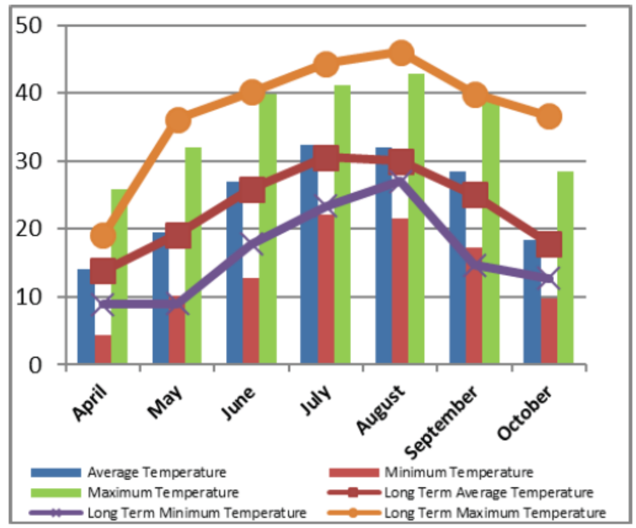

Figure 1: Min. max.and average temperature during investigation and long-term period.

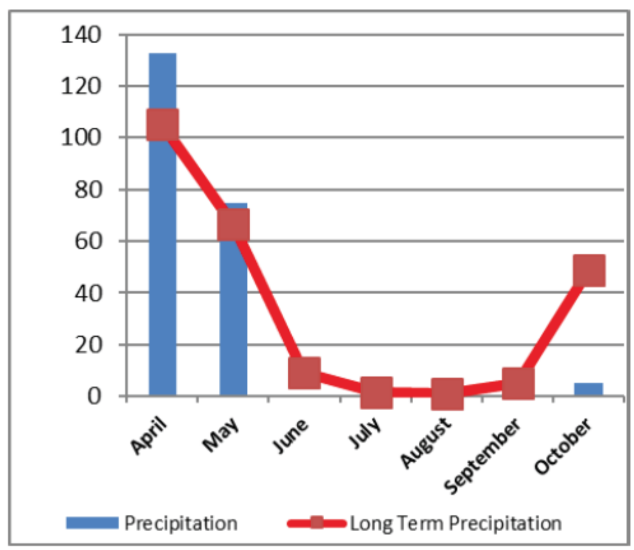

Figure 2: Average precipitation during investigation and long-term period.

Source: Turkish State Meteorological Service, 2017, Siirt.

Table 1: Soil Analysis Result of Experimental Area

Deep (cm)	Body Class	PH	Lime ($CaCo_3$) (%)	Total salt (%)	Class	Useful P_2O_5 (kg/da)	Useful K_2O (kg/da)	Organic Matter (%)
0-20	Loamy	7.6	9.5	0.092	Nonsaline	4.00	1.53	1.53

Source: Siirt University Laboratory, 2017, Siirt.

In 2017 both minimum and maximum temperature were lesser than long term period, on the other hand the average temperature was slightly higher than long term period (Figure **1**). From Figure **2** it can be seen that at April and May, which the cotton are sowing months, the amount of rainfall was higher than that of long term period.

2.1.4. Biofertilizers Used in the Study

Two different types of mixed biofertilizers have been used; Coton-plus which contains two different genera of bacteria *Bacillus subtilis* and *Paenibacillus azotofixans*, and Mega-Flu which contains three different genera of bacteria *Bacillus megaterium*, *Pantoea agglomerans*, and *Pseudomonas fluorescens*.

2.2. Method

2.2.1. Experimental Design and Agricultural Cultivation Practices

The experimental design was arranged in Randomized Completely Block design (RCBD) with four replications. The planting was performed with combine cotton drilling machine on 12 May 2017. Each plot consisted of 4 rows each of which having 6 m length of planting. The distance between each two rows was 0.70 m while each two plants in the same row were separated by 0.20 m. All plots received 120 kg ha^{-1} N and 60 kg ha^{-1} P_2O_5. Half of the N and all P_2O_5 were applied during sowing time while the remaining half of N was given during the square stage in the form of urea. Insects were monitored throughout the experiment; however, our determination was that no insect control was necessary during growing season. Experimental plots were irrigated with drip irrigation system. By the maturity was reached, 15 well developed open bolls were cut off by hand randomly from each genotype in each plot to be tested for boll weight and seed cotton weight per boll measurement. Plots were harvested twice by hand on October 4, and November 5 in 2017. The four rows of each plot were harvested to determine lint yield and seed cotton yield. Statistical analysis was performed using JMP 5.0.1 statistical software (SAS Institute Inc. 2002) and the means were grouped with LSD $_{(0.05)}$ test.

2.2.2. Treatments

Totally 9 treatments were performed. The treatments are shown below:

T1: CONTROL (Conventional Chemical Fertilization)

T2: BM-COTON-PLUS as seed dressing.

T3: BM-COTON-PLUS at seed dressing + first squaring stage

T4: BM-COTON-PLUS at seed dressing + first squaring + first flowering stage

T5: BM-COTON-PLUS at seed dressing+ first squ.+ first flow.+ boll formation stage

T6: BM-MEGA FLU as seed dressing.

T7: BM- MEGA FLU at seed dressing + first squaring stage

T8: BM- MEGA FLU at seed dressing + first squaring + first flowering stage

T9: BM- MEGA FLU at seed dressing+ first squ.+ first flow.+ boll formation stage

BM: The abbrevation of Biomarket

3. RESULTS AND DISCUSSION

3.1. Yield Components and Morphological Characteristics

Seed Cotton Yield (kg ha^{-1})

Results from the analysis of variance of the seed cotton yield, fiber yield, days to first flowering, plant height and ginning percentage in the experiment is presented in Table **2**. As shown in the Table **2**, it can be seen that there were highly significant ($p<0.01$) differences between treatments for seed cotton yield. According to the Table **2**, seed cotton yield ranged between 4728,60 – 6080,70 kg ha^{-1}. The average seed cotton yield of treatments was 5496,60 kg ha^{-1}. The highest seed cotton yield was obtained from (CP) seed+square+flower+boll as 6080,70 kg ha^{-1}, and the lowest yield was obtained from Control (4728,60 kg ha^{-1}) treatment. The results of this study was compatible with previous studies that indicated Phosphate solubilizing bacteria *Bacillus* sp significantly promoted and increased seed cotton yield (Qureshi *et al*, 2012.,Yao *et al*., 2006., Akhtar *et al*., 2010.).

Fiber Yield (kg ha^{-1})

As shown in the Table **2**, it can be seen that there were highly significant ($p<0.01$) differences between treatments for fiber yield. According to the Tab. 2, fiber yield ranged between 2090,20 – 2706,10 kg ha^{-1}. The average fiber yield of treatments was 2422,90 kg ha^{-1}. The highest fiber yield was obtained from (CP)seed+ square+ flower+ boll as 2706,10 kg ha^{-1}, and the lowest yield was obtained from Control (2090,20 kg ha^{-1}) treatment. Marimuthu *et al*. (2002) revealed a

Table 2: Average values and statistical groups of seed cotton yield, fiber yield, first flowering, plant height and ginning percentage

Treatment	SCY (kg ha^{-1})	FY (kg ha^{-1})	FF (day)	PH (cm)	GP (%)
Control	**4728,60 d**	**2090,2 d**	64,25	94,45	**44,20** c
(CP)seed	5382,70 bc	2392,90 bc	64,75	95,75	44,45 abc
(CP)seed+square	5640,50 ab	2501,40 ab	64,00	98,55	44,35 bc
(CP)seed+square+flower	5775,60 ab	2579,30 ab	63,00	95,45	44,65 ab
(CP)seed+square+flower+boll	**6080,70 a**	**2706,10 a**	63,50	92,80	44,50 abc
(MF)seed	4816,30 cd	2153,20 cd	64,25	93,65	**44,70 a**
(MF)seed+square	5523,80 ab	2410,70 bc	62,50	98,90	43,65 d
(MF)seed+sq.+flower	5706,60 ab	2437,50 bc	63,50	94,90	42,70 e
(MF)seed+sq.+flower+boll	5814,90 ab	2535,30 ab	64,00	96,80	43,60 d
Mean	**5496,60**	**2422,90**	63,75	95,70	**44.09**
C.V (%)	**8,00**	**8,15**	1,86	7,60	**0,48**
LSD $_{(0,05)}$	**64,18****	**28,82****	ns	ns	**0,31****

* and **, Significant at 0.05 and 0.01 level of probability, respectively; SCY: Seed Cotton Yield (kg ha^{-1}); FY: Fiber Yield (kg ha^{-1}); FF: First Flowering (Day); PH: Plant Height (cm); GP: Ginning Percentage (%).

synergistic effect of the combined application of Azospirillum and Pseudomonas fluorescens in reduction of root rot incidence and enhancement of plant growth and cotton yield under field conditions. The results of this study is comply with that of Marimuthu *et al*. 2002.

First Flowering (day)

Result from the analysis of variance of first flowering in the experiment is presented in Table **2**. The differences between the treatments with respect to first flowering date were non-significant. According to the Tab. 2, first flowering date ranged between 62,50 – 64,75 days. The average first flowering date of treatments were 63,75. The highest days to first flowering values were obtained from (CP)seed (CP - S) as 64,75, and the lowest first flowering values were obtained from (MF)seed+square (SS) treatment as 62,50 days.

Plant Height (cm)

The differences between the treatments with respect to plant height were non-significant. According to the Tab. 2, plant height ranged between 92,80 – 98,90 cm. The average plant height of treatments was 95,70 cm. The highest plant height values were obtained from (MF)seed+square (MF - SS) as 98,90 cm, and the lowest plant height values were obtained from (CP)seed+square+flower+boll treatment as 92,80 cm. Based on the above results, we can conclude that as to plant height, we did not have any significant increase despite using chemical fertilizer added to soil and biofertilizers by foliar spray in four different stages of growth. While Gomathy *et al*. (2008) has obtained significant increase in the plant height by using chemical fertilizers together with biofertilizer (Azophosmet) used through drip irrigation. Erdogan and Benlioglu (2010) used four strains of *Pseudomonas,* these strains together with the known biocontrol agent *Serratia plymuthica* (HRO-C48) were tested under greenhouse conditions. The treatment of cotton seed with the *Pseudomonas* strains and HRO-C48 increased the plant height. The difference between our results and those of previous studies are due to environmental conditions, soil types and features or materials used throughout the study.

Ginning Percentage (%)

The differences between the treatments with respect to ginning percentage were highly significant ($p<0.01$). According to the Tab. 2, ginning percentage ranged between 42,70 - 44,70 %. The average ginning percentage of treatments was 44.09%. The highest ginning percentage were obtained from (MF) seed (MF - S) as 44,70 %, and the lowest ginning percentage were obtained from (MF)seed+square+flower (42,70 %) treatment. Combined Biofertilizers and macro elements have been used in cotton field, added to soil together with foliar spray to BT cotton. The results show that ginning percentage and lint index (g) were highly significantly increased and positively affected by biofertilizers (Laxman *et al*. 2017). While, according to our results, ginning percentage was higher than that obtained by Laxman *et al*. 2017. The way we conducted our experiment is different from that of Laxman *et al*. 2017 in that we performed the inoculation of Stoneville 468 with biofertilizer as foliar spray together with chemical fertilizer applied to soil. In Laxman the experiment has been conducted in a reverse manner, *i.e*. chemical fertilizer has been applied through foliar spray while biofertilizers have been applied to the underlying soil. However, Laxman yielded higher ginning percentage than that of its predecessors although ours was even more.

Results from the analysis of variance of the Number of Monopodial Branches, The Number of Sympodial Branches, Number of Bolls Per Plant, Boll Weight and Single Boll Seed Cotton Weight in the experiment is presented in Table **3**.

The Number of Monopodial Branches (Number / Per Plant)

As shown in the Table **3**, it can be seen that there were significant ($p<0,05$) differences between treatments for number of monopodial branches. According to the Tab. 3, number of monopodial branches ranged between 3,50 – 4,80 per plant^{-1}. The average number of monopodial branches of treatments were 4,30 per plant^{-1}. The highest number of monopodial branches were obtained from (MF)seed+square+flower+boll (MF-SSFB) as 4,80 per plant^{-1}, and the lowest number of monopodial branches were obtained from Control (3,50 per plant^{-1}) treatment.

Combination of plant growth promoting rhizobacteria (PGPR) applied to the soil together with its foliar spray, compost tea and biosol has been tested. On the other hand, PGPR has been used by applying to the underlying soil together with its foliar spray as well as compost tea. Both experiments led to a significant increase in the number of monopodial and sympodial branches as well as plant height (Zewail and Ahmed, 2015). In our results the monopodial branches increased significantly. Therefore (Zewail and Ahmed, 2015) corroborates our results.

The Number of Sympodial Branches (Number / Per Plant)

As shown in the Table **3**. it can be seen that there were non-significant differences between treatments for number of sympodial branches. According to the Tab. 3, number of sympodial branches ranged between 10,00 – 11,10 per plant. The average number of sympodial branches of treatments were 10,59 per plant. The highest number of sympodial branches values were obtained from (CP)seed+square (CP - SS) as 11,10, and the lowest the number of sympodial branches values were obtained from (CP)seed+square+flower+boll treatment as 10,00 number per plant.

Combination of plant growth promoting rhizobacteria (PGPR) applied to the soil together with its foliar spray, compost tea and biosoal has been tested in cotton field. On the other hand, PGPR has

Table 3: Average Values and Statistical Groups of The Number of Monopodial Branches, The Number of Sympodial Branches, Number of Bolls Per Plant, Boll Weight and Single Boll Seed Cotton Weight

Treatment	MB (n plant^{-1})	SB (n plant^{-1})	NB (n plant^{-1})	BW (g)	SBSCW (g)
Control	**3,50 c**	10,40	21,15	6,32	4,70
(CP)seed	4,00 bc	11,05	21,20	6,58	5,02
(CP)seed+square	4,15 abc	11,10	**18,70**	6,55	4,92
(CP)seed+square+flower	4,15 abc	10,10	**23,50**	6,78	5,13
(CP)seed+square+flower+boll	4,70 ab	10,00	21,35	6,45	4,82
(MF)seed	4,35 ab	10,20	20,30	6,58	4,97
(MF)seed+square	4,50 ab	10,90	19,60	**6,35**	4,90
(MF)seed+sq.+flower	4,35 ab	10,70	21,10	6,85	5,15
(MF)seed+sq.+flower+boll	**4,80 a**	10,85	20,40	6,80	5,08
Mean	**4,30**	10,59	**20,81**	**6,58**	**4,96**
C.V (%)	6,52	7,93	12,63	5,77	**5,77**
LSD $_{(0,05)}$	0,75*	ns	ns	ns	ns

* and **, Significant at 0.05 and 0.01 level of probability, respectively; MB: Number of Monopodial Branches (number per plant); SB: Number of Sympodial Branches (number per plant); NB: Number of Bolls (number per plant); BW: Boll Weight (g); SBSCW: Single Boll Seed Cotton Weight (g)

been used by applying to the underlying soil together with its foliar spray as well as compost tea. Both experiments led to a significant increase in the number of monopodial and sympodial branches as well as plant height (Zewail and Ahmed, 2015). In our experiment the cotton seed inoculated with COTON PLUS and MEGAFLU except for the control. At the same we sprayed all parts of the plant with foliar spray and applied chemical fertilizers to the underlying soil. Yet no significant results are achieved among treatments. Nonetheless, in (Zewail and Ahmed, 2015) sympodial branches were positively affected by all fertilizers.

Number of Boll Per Plant (Number / Per Plant)

As shown in the Table **3**. it can be seen that there were non-significant differences between treatments for number of boll per plant. According to the Tab. 3, number of boll per plant ranged between 18,70 – 23,50. The average number of boll per plant of treatments were 20,81. The highest number of boll per plant values were obtained from (CP)seed+ square+ flower (CP-SSF) as 23,50, and the lowest number of boll per plant values were obtained from (CP)seed+square (CP-SS) treatment as 18,70. The results of Patil *et al*. (2011) indicated that boll weight and number of bolls was significantly increased with inoculation of *Azospirillum* surat strain. But, our findings did not show any significant differences between treatments.

Boll Weight (g)

It can be seen that there were non-significant differences between treatments for boll weight. According to the Tab. 3, boll weight ranged between 6,32– 6,85 g. The average boll weight of treatments was 6,58 g. The highest boll weight values were obtained from (MF)seed+ square+ flower (MF-SSF) as 6,85 g, and the lowest boll weight values were obtained from Control treatment as 6,32 g. Sawan, (2016) indicated that, the application of (PGPR's) Cycocel and Alar in two stages of cotton growth (square and boll setting stages). The recorded data showed that boll weight increased significantly. However, in our experiment seed cotton dressed with biofertilizers and they applied as foliar spray in four different stages of growth along with chemical fertilizers added to soil but, our findings did not show any significant differences between treatments.

Single Boll Seed Cotton Weight (g)

As shown in the Table **3**, it can be seen that there were non-significant differences between treatments for single boll seed cotton weight. According to the Table **3**, single boll seed cotton weight ranged between 4,70 – 5,15 g. The average single boll seed cotton weight of treatments was 4,96 g. The highest single boll seed cotton weight values were obtained from (MF)seed+square+flower (MF - SSF) as 5,15 g, and the lowest single boll seed cotton weight values were obtained from Control 4,70 g.

3.2. Fiber Technological Characteristics

Result from the analysis of variance of fiber fineness, length, strength, elongation, uniformity and spinning consistency index in the experiment is presented in Table **4**.

Fiber Fineness (Micronaire)

Result from the analysis of variance of fiber fineness (mic.) in the experiment is presented in Table **4**. As shown in the Table, it can be seen that there were non-significant differences between treatments for mic. values. The values ranged between 4,11 – 4,38 mic. The average micronaire values of treatments were 4,26 mic. The highest values were obtained from (MF)seed+square+flower (MF - SSF) as 4,38 mic., and the lowest values were obtained from (CP)seed+square+flower (CP-SSF) treatment as 4,11 mic. Based on the above results, we did not see any significant improvement in the quality of micronaire. Similarly, in (Laxman *et al*. 2017) who reported that there is no significant quality improvement for micronaire despite chemical and mixed microbial fertilizers.

Fiber Length (mm)

As shown in the Table **4**, it can be seen that there were non-significant differences between treatments for fiber length. Fiber length ranged between 28,55 – 29,73 mm. The average fiber length of treatments was 28,99 mm. The highest fiber length values were obtained from (CP)seed (CP- S) as 29,73 mm, and the lowest fiber length values were obtained from (MF)seed+square and (MF)seed+square+flower treatment as 28,55 mm. Previous results showed significant differences between treatments to upper half mean length (UHML) (Zewail and Ahmed, 2015).

Fiber Strength (g tex^{-1})

As shown in the Table **4**, it can be seen that there were non-significant differences between treatments for fiber strength. According to the Tab. 4, fiber strength ranged between 30,20 – 33,95 g/tex. The average fiber strength of treatments was 32,08 g/tex. The highest fiber values were obtained from

Table 4: Average Values and Statistical Groups of Fiber Fineness, Fiber Length, Fiber Strength, Fiber Elongation, Fiber Uniformity and Spinning Consistency Index

Treatment	FF (mic)	FL (mm)	FS (g tex^{-1})	FE (%)	FU	SCI
Control	4,32	29,53	33,13	7,05 ab	84,90	144,00
(CP)seed	4,14	29,73	33,15	**7,20 a**	85,08	151,50
(CP)seed+square	4,17	28,94	31,53	7,05 ab	84,78	143,75
(CP)seed+square+flower	**4,11**	28,57	30,70	6,78 bc	83,53	135,75
(CP)seed+square+flower+boll	4,24	29,39	**33,95**	6,95 ab	85,28	152,75
(MF)seed	4,32	29,01	33,50	**6,55 c**	84,46	146,50
(MF)seed+square	4,42	28,55	31,28	7,00 ab	84,80	140,25
(MF)seed+sq.+flower	**4,38**	28,55	**30,20**	6,98 ab	84,05	134,25
(MF)seed+sq.+flower+boll	4,21	28,60	31,33	6,98 ab	83,98	139,00
Mean	4,26	28,99	32,08	6,95	84,53	143,08
C.V (%)	4,88	3,25	6,17	3,19	1,34	7,60
LSD $_{(0,05)}$	ns	ns	ns	0,32**	ns	ns

* and **, Significant at 0.05 and 0.01 level of probability, respectively; FF: Fiber Fineness (micronaire) FL: Fiber Length (mm); FS: Fiber Strength (g tex^{-1}); FE: Fiber Elongation (%); FU: Fiber Uniformity (%); SCI: Spinning Consistency Index.

(CP)seed+square+flower+boll as 33,95 g/tex, and the lowest values were obtained from (MF)seed+square+flower treatment as 30,20 g/tex (Tab. 4). According to (Zewail and Ahmed, 2015), the strength of fibers increased by applying Biosoal extract lonely and in another case using Biosol extract together with PGPR and Compost Tea. While in this experiment, two types of biofertilizers tested on cotton seed and applied as foliar spray during three stages of growth with chemical fertilizers added to soil, the strength of fibers was not affected significantly.

Fiber Elongation (%)

Result from the analysis of variance of the fiber elongation in the experiment is presented in Table **4**, as shown in the table, it can be seen that there were significant (p<0,01) differences between treatments for fiber elongation. Fiber elongation values ranged between 6,55 – 7,20. The average fiber elongation of treatments were 6,95. The highest fiber elongation value were obtained from (CP)seed (CP-S) as 7,20, and the lowest fiber elongation value were obtained from (MF)seed (MF-S) 6,55 treatment. Zewail and Ahmed (2015), corroborates our findings as to the elongation ratio of the fibers which used PGPR, Biosol, Compost tea all together to cotton. The results of Zewail and Ahmed (2015) shows significant increase in the ratio of elongation of fibers. While in Laxman *et al*. (2017) the inoculation of BT cotton with mixed microbial fertilizers did not show any significant results in fiber elongation.

Fiber Uniformity (%)

As shown in the Table **4**, it can be seen that there were non-significant differences between treatments for fiber uniformity percentage. Values ranged between 83,53 – 85,28 %. The average fiber uniformity percentage of treatments were 84,53%. The highest values were obtained from (CP)seed+square+flower+boll as 85,28 %, and the lowest values were obtained from (CP)seed+square+flower treatment as 83,53 % (Tab. 4). The results on uniformity percentage show significant increase in Laxman *et al*. (2017) while in ours we do not have any significant data due to environmental conditions, soil type and features or materials used.

Spinning Consistency Index (SCI)

Result from the analysis of variance of SCI in the experiment is presented in Table **4**. As shown in the Table **4**, it can be seen that there were non-significant differences between treatments for Spinning Consistency Index (SCI).

According to the Tab. 4, SCI values-ranged between 134,25 – 152,75. The average SCI value of treatments were 143,08. The highest SCI values were obtained from (CP)seed+square+flower+boll as 152,75, and the lowest SCI values were obtained from (MF)seed+square+flower treatment as 134,25. Our present results reveal that inoculating cotton seeds with biofertilizer did not increase the spinning consistency index (SCI) significantly. Although we have some observable degree of variance in the data. Meanwhile, the results of Bilalis *et al*. (2015) which treated cotton with organic and chemical fertilizers (organic and conventional) farming systems show otherwise. The experimental data of SCI for three consecutive years show significant increase for organic farming system.

RESULTS AND RECOMMENDATIONS

The results of variance analysis showed that seed cotton yield, fiber yield, ginning percentage and number of monopodial branches per plant significantly affected from different biofertilizer applications. On the other hand, the lint quality parameters not affected from biofertilizer applications except fiber elongation. The highest yield obtained from the application of biofertilizer at seed + square +flowering +boll formation periods.

The best results obtained from the application of biofertilizers at seed + square +flowering +boll formation periods. Comparing with control 1350 kg ha^{-1} higher yield was obtained from Coton-Plus application. Significant seed cotton yield and lint yield obtained by using few times biofertilizers at different growing stages (seed +squaring + flowering +boll forming stages). This indicated that yield increasing can be achieved by using biofertilizers few times instead of one time.

The results of this study showed that not only Coton-Plus but also MegaFlu biofertilizers had significant effect on yield. The number of monopodial branches increased by using biofertilizers few times at different growing stages. In addition, ginning percentage increased by using biofertilizers. The highest ginning percentage values obtained from MF seed (44.70%) and CP seed +square + flower (44.65%) treatments.

These kinds of investigations should be carried as long term studies within particular rotation system. Considering the negative effects of chemical fertilizers on soil and environment, the amount of biofertilizer researches should be increased and it must be determined the alternativeness of biofertilizers to the chemical fertilizers by supporting with economic analysis. First flowering date, plant height, the number of sympodial branches, number of nodes for first fruiting branch, number of boll per plant, boll weight, single boll seed cotton weight and first picking percentage was not effected from application of biofertilizer.

In conclusion, although it is the result of one year, biofertilizers increased yield of cotton and it can be recommended for using in cotton production.

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