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ZERO TILLAGE: A POTENTIAL TECHNOLOGY TO IMPROVE COTTON YIELD

Hafiz Ghazanfar ABBAS[1], Abid MAHMOOD[1] and Qurban ALI[2]

[1]Cotton Research Institute, Ayub Agricultural Research Institute Faisalabad, Pakistan
[2]Centre of Excellence in Molecular Biology, University of the Punjab Lahore, Pakistan

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Zero tillage technology revealed with no use of any soil inverting technique to grow crops. The crop plant seed is planted in the soil directly after irrigation to make the soil soft without any replenishing in soil layers. A study was conducted to evaluate cotton genotypes FH-114 and FH-142 for the consecutive three years of growing seasons from 2013-15. The seed of both genotypes was sown with two date of sowing, 1 March and 1 May of each three years of sowing under three tillage treatments (zero tillage, minimum tillage and conventional tillage) in triplicate completely randomized split-split plot design. It was found from results that significant differences were recorded for tillage treatments, date of sowing, genotypes and their interactions.
Multivariate analysis was performed to evaluate the yield and it attributed traits for potential of FH-114 and FH-142 cotton genotypes. The genotype FH-142 was found with higher and batter performance as compared to FH-114 under zero tillage, minimum tillage and conventional tillage techniques. The traits bolls per plant, boll weight, fibre fineness, fibre strength, plant height, cotton yield per plant and sympodial branches per plant were found as most contributing traits towards cotton yield and production. It was also found that FH-142 gives higher output in terms of economic gain under zero tillage with 54% increase as compared to conventional tillage technique. It was suggested that zero tillage technology should be adopted to improve cotton yield and quality. It was also recommended that further study to evaluate zero tillage as potential technology should be performed with different regions, climate and timing throughout the world.
Keywords: zero tillage, cotton, *Gossypium hirsutum*, multivariate analysis, cotton yield, fibre strength

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Corresponding author: Qurban Ali, Centre of Excellence in Molecular Biology, University of the Punjab Lahore, Pakistan qurban.ali@cemb.edu.pk

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) plays an imperative role in the economy of Pakistan. Cotton is a significant fiber, industrial and cash crop grown throughout the world. It is grown over 12% of the total cultivated area of Pakistan. Cotton contributes about 60% in the shape of raw cotton and its byproducts in total economy of Pakistan. In count to its textile industry uses, edible oil and animal feed is also obtained from cotton seed cake. 60-70% of edible oil is obtained from cotton (KHAN, 2003; KHATTAK *et al*., 2014). It plays a key role in earning of foreign exchange for country. It has share of 1.5% in GDP while 7.1% in total agriculture value of country. The textile industry has fetched USD 10.22 billion foreign exchange during July-March of 2014-15. Pakistan has cotton growing crop area of 2961 thousand hectares with 13.983 million bales which was 9.5% higher as compared with 2806 thousand hectares and production of 12.769 million bales as shown by Economic Survey of Pakistan, 2014-15. The seed cotton of Pakistan is much low as compared to other cotton growing countries of the world. Zero tillage is not any alternative cropping method but it provides an opportunity to improve the yield of crop plants without inverting the soil. The zero tillage provides sustainability to the ecosystem to grow and produce crop plants (SATURNINO *et al*., 2002). The use of appropriate soil management practices is the need to improve crop yield and production. The tillage system did not show the effect on the nutrient contents in plant body tissues but there was a significant effect after the application of fertilizers in the form of N, P and K. the uptake of NPK is increased through the use of different tillage practices (ISHAQ *et al*., 2001). The soil porosity and morphology is much important to improve crop plant hold and ability to grow. The tillage caused to improve soil ability to grow in with healthy and productive crop plants (SHIPITALO and PORTZ, 1987). Zero tillage showed higher amount of variation in cotton-wheat growing systems than conventional tillage. It may be very helpful to farmers to improve crop plant production and potential (SHEIKH *et al*., 2003). Zero tillage reduced soil nutrient losses and erosion of soil. There was an increase in corn yield using zero-tilled field as compared to till-planted field (BAEURMER and BAKERMANS, 1973). The efficiency of cotton and wheat to uptake nitrogen and water is increased through the use of conservation tillage and appropriate irrigation. The conservation tillage caused to improve yield in cotton and wheat as compared to conventional tillage (BRONSON *et al*., 2001).The yield of cotton, sorghum, vetch and rye were highly influenced due to use of zero tillage, strip tillage and chisel tillage. The uptake of nutrients like nitrogen was also affected through the use of tillage techniques and it was concluded that chisel tillage may be used to increase yield of cotton and sorghum (SAINJU *et al*., 2005). Minimum and zero tillage help in water conservation, maintenance of soil organic and inorganic matter and control over soil erosion (PRASADA and POWER, 1991). The strip tillage caused to reduce water evaporation from crop plants and soil to improve water availability to crop plants. The transpiration of water from cotton was recorded lower as compare to wheat (LASCANO *et al*., 1994). Various insects and pest also attack on cotton that get shelter in weeds, through the use of zero tillage these plant enemies can be eradicated from filed. The use of transgenic cotton for tolerance to glyphosate and insect/pest attack may also give an advantage to grow cotton with zero tillage technology (AZAM *et al*., 2013; PUSPITO *et al*., 2015; QAMAR *et al*., 2015ab). The use of mutants or mutation breeding for glyphosate tolerance to avoid weeds may also be used to improve cotton yield and growing under zero tillage (RIZWAN *et al*., 2015). The seed cotton yield as a complex trait, is the product of relationship among its components fixed with unstable environmental conditions. The correlation among various yielding traits may be helpful to improve seed cotton yield (MEENA *et al.*, 2007; SUINAGA *et al.*, 2006; ABBAS *et al*., 2013). Multivariate analysis provides an opportunity to plant breeder for selection among large number of studied traits for the improvement of yield and production (ALI *et al*., 2014; ALI *et al*., 2015; FAWAD *et al*., 2015; NAJAF *et al*., 2014). ABBAS *et al*. (2013); ABBAS *et al*. (2015) reported genetic variability with positive correlation among seed cotton yield and contributing yielding traits in upland cotton. The present study was conducted to evaluate cotton varieties for cotton staple length, fibr fineness, fibre strength and their related traits and to evaluation for the role of zero tillage in improving cotton yield and economic gain.

MATERIAL AND METHODS

To evaluate zero tillage technology of cotton sowing on previous beds of cotton crop against conventional sowing an experiment comprising of three tillage methods and two dates of sowing and two varieties treatments was laid out according to split-split-plot under three replications having a net plot size measuring 6×10m. The crop was sown on two dates 15 March and 01 May 2013-15. The seed rate used was 10kg/ha**.** The cotton variety FH-114 and FH-142 were used as experimental material. The crop was fertilized at the rate of 150:50:50 kg NPK/ha. All the other agronomic and plant protection measures were kept normal and uniform. The data regarding yield and yield components were recorded and got analyzed statistically by using analysis of variance technique (STEEL *et al*., 1997). Multivariate analysis (Proc. Mixed SAS version 9.1 SAS Institute, 2004) principal component analysis and factor analysis were computed. Genotypic and phenotypic correlation (KNOW and TORRIE, 1964) and regression analysis was also computed to access the association of traits among each other.

***Abbreviations of studied traits**: DFB = Days to first bud, FFD = Days to first flower, DFBO = Days to first boll opening, BPP = Bolls per plant, SBP = Sympodial branches per plant, MBP = Monopodial branches per plant, PH = Plant height, PP = Plant population, YPP Cotton yield per plant, BW = Boll weight, GOT = Ginning turn out, SL = Staple length, FF = Fibre fineness, FS = Fibre strength*

RESULTS AND DISCUSSION

The results from statistical analysis of studied traits revealed that significant differences were found among genotypes, date of sowing, treatment (zero tillage, minimum tillage and conventional tillage), interactions of genotypes with treatment (Tables F_1S_1 to F_1S_{14}; F_2S_1 to F_2S_{14}; F_3S_1 to F_3S_{14}; Supplementary material files F_1; F_2; F_3). It was found from results of mean comparison performance that FH-142 was the best one genotype that performed batter under different sowing dates and tillage practice (Supplementary material files F_{1a}; F_{2a}; F_{3a}).

Stepwise regression analysis was performed to find out the traits that were highly contributing towards cotton yield per plant. It was revealed from results (Table 1) that the higher contributing traits were bolls per plant (BPP), days to boll opening (DFBO), plant height (PH), staple length (SL), fibre strength (FS) and days taken to first bud (DFB). The predicted equation for cotton yield per plant was as follow:

$$Y = 18999.7 + (20.09X_1) + (-154.25X_2) + (16.96X_3) + (-236.39X_4) + (-33.88X_5) + (86.00X_6) + (-25.89X_7) + (18.48X_8) + (0.03X_9) + (198.73X_{10}) + (95.76X_{11}) + (-176.69X_{12}) + (2.44X_{13})$$

Genotypic and phenotypic correlation was computed to access the strength of association of traits with respect to genetic and environmental factors. The results from table 2 indicated higher and significant genotypic correlation of cotton yield per plant with days to first flower, fibre strength, GOT, monopodial branches per plant and boll weight. Strong and significant genotypic of GOT was recorded for boll weight, days to first boll opening, days to first flower and fibre strength.

Table 1. Stepwise Regression analysis for cotton yield per plant (Year 2013)

Variable	Coefficients B	Std Error	T	Cumulative R^2	Partial R^2 (%)
BPP (X_1)	20.09	11.80	1.70	0.1027	10.27
BW(X_2)	-154.25	124.34	-1.24	0.2278	22.78
DFB(X_3)	16.96	77.05	0.22	0.8278	82.78
FF(X_4)	-236.39	159.94	-1.48	0.1536	15.36
FFD(X_5)	-33.88	68.66	-0.49	0.2266	22.66
FS(X_6)	86.00	21.50	4.00	0.0006	0.06
GOT(X_7)	-25.89	27.20	-0.95	0.3515	35.15
PH(X_8)	18.48	7.33	2.52	0.0195	1.95
PP(X_9)	0.03	0.02	2.31	0.0307	3.07
SL(X_{10})	198.73	107.55	1.85	0.0781	7.81
DBO(X_{11})	95.76	63.79	1.50	0.1475	14.75
MBP(X_{12})	-176.69	114.84	-1.54	0.1382	13.82
SBP(X_{13})	2.44	17.34	0.14	0.0892	8.92

R^2 = 0.8481 (84.81%), Adjusted R^2 = 0.7584 (75.84%), Standard Deviation = 353.167, Intercept = -18999.7

Table 1a. Stepwise Regression analysis for cotton yield per plant (Year 2014)

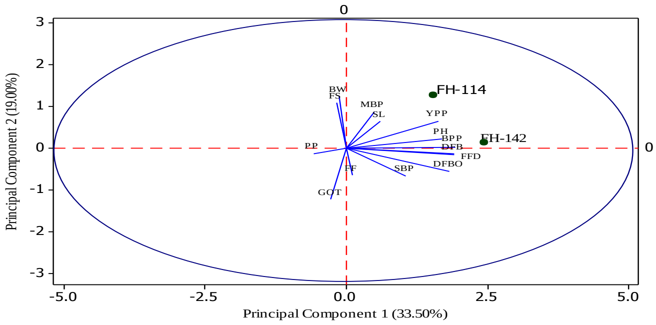
Variable	Coefficients B	Std Error	T	Cumulative R^2	Partial R^2 (%)
BPP (X_1)	16.993	9.457	1.8	0.0861	8.61
BW (X_2)	-136.62	136.796	-1	0.3288	32.88
DFB (X_3)	36.872	63.182	0.58	0.5654	56.54
DFBO (X_4)	122.218	59.453	2.06	0.0519	5.19
FF (X_5)	-223.329	173.895	-1.28	0.2124	21.24
FFD (X_6)	-53.457	59.087	-0.9	0.3754	37.54
FS (X_7)	79.494	24.278	3.27	0.0035	0.35
GOT (X_8)	-18.245	31.328	-0.58	0.5662	56.62
MPB (X_9)	-137.368	128.392	-1.07	0.2963	29.63
PH (X_{10})	15.706	5.689	2.76	0.0114	1.14
PP (X_{11})	0.032	0.016	1.96	0.0631	6.31
SL (X_{12})	227.294	108.821	2.09	0.0485	4.85
SPB (X_{13})	11.782	23.184	0.51	0.0664	6.64

R Squared = 0.8274, Adjusted R^2 = 0.7254, Standard Deviation = 379.310, Intercept = -21005.4

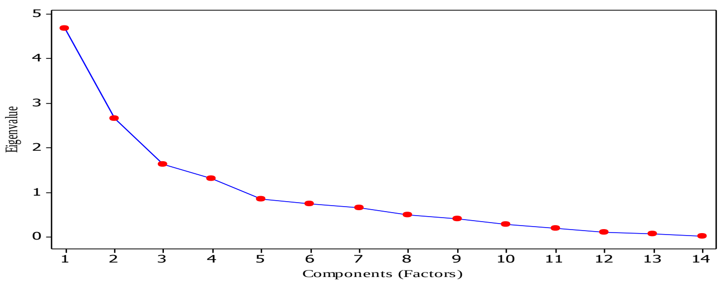
Table 1b. Stepwise Regression analysis for cotton yield per plant (Year 2015)

Variable	Coefficients B	Std Error	T	Cumulative R^2	Partial R^2 (%)
BPP (X_1)	-16.47	18.136	-0.91	0.3736	37.36
BW (X_2)	-50.078	154.651	-0.32	0.4491	44.91
DFB (X_3)	23.053	73.974	0.31	0.2582	25.82
DFBO (X_4)	182.161	66.965	2.72	0.0125	1.25
FF (X_5)	-353.358	215.846	-1.64	0.1158	11.58
FFD (X_6)	-4.74	67.331	-0.07	0.3445	34.45
FS (X_7)	104.182	28.044	3.71	0.0012	0.12
GOT (X_8)	0.353	34.412	0.01	0.0919	9.19
MPB (X_9)	48.991	148.875	0.33	0.2452	24.52
PH (X_{10})	10.142	6.808	1.49	0.1505	15.05
PP (X_{11})	0.01	0.017	0.57	0.5758	57.58
SL (X_{12})	190.006	127.609	1.49	0.1507	15.07
SPB (X_{13})	30.724	45.146	-0.68	0.5033	50.33

R^2 ` 0.7622 (76.22%), Adjusted R^2 = 0.6217 (62.17%), Standard Deviation = 445.222, Intercept = =26128.7



a. Principal component analysis



b. Scree plot

Figure 1:a. Principle component analysis of yield and its attributing traits, b. Scree plot and respective eigen values (Year 2013)

Strength and significant phenotypic correlation of fibre fineness was recorded for days to first bud, monpodial branches per plant and sympodial branches per plant. KOTB, (2012) found higher and significant correlation between fibre length and fibre strength. ABBAS *et al*. (2013) reported that the significant correlation among cotton yield, bolls per plant, fibre fineness and sympodial branches per plant may be used for the development of higher yielding cotton genotypes. ALI *et al*., (2016) found that significant correlation of yield and its attribute traits may help plant breeders to develop higher yielding synthetic and hybrids in crop plants to improve yield and production. Principal component analysis was performed to screen the genotypes for best performing traits form large number of studied traits, as it helps to explore total variation in the germplasm. Four PCs (Principal Components), PC1, PC2, PC3 and PC4 were recorded as shown in table 3 also the respective Eigenvalue was more than 1 (Figure 1b). Higher variation was recorded for traits days to first bud, days to first flower, days to first boll opening, bolls per plant, and cotton yield per plant. The proportion variation of four PCs was PC1 (33.50%), PC2 (19.00%), PC3 (11.60%) and PC4 (9.30%). FAWAD *et al*. (2015) and ALI *et al*. (2016) working on maze suggested that principal component analysis helps in selecting genotypes on the basis of large number of studied traits.

Table 2. Genotypic (Bold values) and phenotypic correlation among different traits of cotton (Year 2013)

	BPP	BW	DFB	DFBO	FF	FFD	FS	GOT	MPB	PH	PP	SL	SPB
BW	-0.07												
	0.686*												
DFB	0.713*	-0.127											
	-0.089	0.462*											
DFBO	0.038	-0.26	-0.015										
	-0.024	0.126	0.933*										
FF	0.717*	-0.144	0.99*	-0.01									
	0.002	0.402*	0.087	0.952*									
FFD	-0.062	0.396	-0.152	0.083	-0.168								
	0.72*	0.017	0.377*	0.633*	0.329*								
FS	-0.087	-0.433*	-0.156	0.266	-0.136	-0.585*							
	0.615*	0.008	0.363*	0.117	0.43*	-0.081							
GOT	0.703*	0.078	0.484*	0.069	0.512*	-0.035	-0.001						
	-0.086	0.652*	-0.003	0.69*	0.001	0.839*	0.997*						
MPB	-0.415*	0.073	-0.076	-0.145	-0.058	-0.143	0.034	-0.279					
	0.012	0.673*	0.66*	0.401*	0.736*	0.404*	0.846*	0.1					
PH	0.191	0.366*	0.323*	-0.335*	0.296	-0.147	-0.199	0.162	0.011				
	0.265	0.028	-0.055	0.046	0.08	0.393*	0.244	0.346*	0.949*				
PP	0.638*	0.193	0.542*	-0.094	0.536*	0.356*	-0.394*	0.694	-0.105	0.234			
	0.001	0.26	0.001	0.586*	0.001	-0.033	-0.018	-0.009	0.544*	0.17			
SL	0.663*	-0.236	0.712*	0.174	0.709*	-0.319	0.134	0.679*	-0.17	-0.007	0.514*		
	-0.084	0.166	0.001	-0.31	-0.004	0.058	0.438*	0.007	0.321*	0.968*	0.001		
SPB	0.275	0.285	0.009	-0.039	0.028	0.221	-0.239	0.441*	-0.226	0.177	0.241	0.039	
	0.104	0.092	0.957*	0.82*	0.87*	0.195	0.16	-0.034	0.186	0.301*	0.158	0.821*	
YPP	0.445*	-0.195	0.408	0.245	0.393*	-0.105	0.128	0.143	-0.01	-0.062	0.271	0.505*	-0.238
	0.007	0.554*	0.013	0.151	0.018	0.544*	0.456*	0.406*	0.954*	0.719*	-0.11	0.002	0.162

***** = Significant at 5% probability level

Table 2a. Genotypic (Bold values) and phenotypic correlation among various traits of cotton (Year 2014)

	BPP	**BW**	**DFB**	**DFBO**	**FF**	**FFD**	**FS**	**GOT**	**MPB**	**PH**	**PP**	**SL**	**SPB**
BW	-0.009												
	0.396*												
DFB	0.588*	-0.129											
	-0.037	0.452*											
DFBO	0.491*	-0.236	0.704*										
	0.002	-0.166	0.075										
FF	-0.03	-0.26	-0.009	0.174									
	0.864*	0.126	0.957*	0.31*									
FFD	0.599*	-0.133	0.985	0.712*	-0.009								
	0.053	0.441*	-0.234	-0.089	0.959*								
FS	0.039	0.396*	-0.15	-0.319	0.083	-0.162							
	0.822*	0.017	0.383*	0.058	0.633*	0.347*							
GOT	-0.183	-0.433*	-0.144	0.134	0.266	-0.153	-0.585*						
	0.286	0.008	0.402*	0.438*	0.117	0.374*	0.087						
MPB	0.409*	0.239	-0.031	0.095	0.039	0.01	0.281	-0.191					
	0.013	-0.161	0.859*	0.583*	0.823*	0.955*	-0.097	0.264					
PH	0.425*	0.108	0.452	0.634*	0.081	0.491*	0.125	-0.051	0.437				
	0.01	0.529*	0.006	0.088	-0.064	0.002	0.469*	0.768*	0.008				
PP	-0.41	0.073	-0.057	-0.17	-0.145	-0.081	-0.143	0.034	-0.304	-0.302			
	0.013	0.673*	0.743*	0.321*	0.401*	0.638*	0.404*	0.846*	0.071	0.073			
SL	0.164	0.366*	0.32*	-0.007	-0.335*	0.307*	-0.147	-0.199	0.029	0.03	0.011		
	0.341*	0.028	0.057	0.968*	0.046	0.068	0.393*	0.244	0.869*	0.863*	-0.049		
SPB	0.53	-0.021	0.575*	0.546*	0.04	0.563*	0.078	-0.303*	0.036	0.367*	0.001	0.146	
	0.001	0.906*	-0.081	0.001	0.818*	-0.043	0.652*	0.073	0.837*	0.028	0.997*	0.395*	
YPP	0.535*	0.208	0.549*	0.511*	-0.107	0.539*	0.377*	0.403*	0.266	0.671*	-0.095	0.219	0.607*
	0.001	0.424*	0.001	0.001	0.534*	0.501*	0.523*	0.615*	0.517*	-0.007	0.582*	0.199	-0.087

***** = Significant at 5% probability level

Factor analysis provides an opportunity to select the genotypes for most contributing traits which falls in factor 1 (Table 4), in our study the most contributing traits were days to first bud, days to first flower, days to fist boll opening, bolls per plant, plant height and cotton yield per plant.

The results from Table 1a revealed that the traits, bolls per plant, days to first bud, days to first boll opening, fibre strength, plant height, staple length and sympodial branches per plant were the highly contributing traits. The predicated regression equation was as follow:

$Y = 21005.4 + (16.993X_1) + (-136.62X_2) + (36.872X_3) + (122.218X_4) + (-223.329X_5) + (-53.457X_6) + (79.494X_7) + (-18.245X_8) + (-137.368X_9) + (15.706X_{10}) + (0.032X_{11}) + (227.294X_{12}) + (11.782X_{13})$

Table 2b. Genotypic (Bold values) and phenotypic correlation among various traits of cotton (Year 2015)

	BPP	BW	DFB	DFBO	FF	FFD	FS	GOT	MPB	PH	PP	SL	SPB
BW	-0.039												
	0.821*												
DFB	-0.288	-0.129											
	0.089	0.452*											
DFBO	-0.206	-0.236	0.704*										
	-0.227	-0.166	-0.020										
FF	-0.140	-0.260	-0.009	0.174									
	0.415*	0.126	0.957*	0.310*									
FFD	-0.241	-0.133	0.985*	0.712*	-0.009								
	-0.156	0.441*	-0.023	0.120	0.959*								
FS	0.016	0.396*	-0.150	-0.319	0.083	-0.162							
	0.927*	0.017	0.383*	-0.058	0.633*	-0.347*							
GOT	0.141	-0.433*	-0.144	0.134	0.266	-0.153	-0.585*						
	0.414*	0.008	0.402*	0.438*	0.117	-0.374*	0.040						
MPB	0.452*	-0.245	0.028	-0.123	-0.127	0.048	-0.411*	0.302*					
	-0.006	0.151	0.871*	0.476*	0.459*	0.783*	0.013	0.074					
PH	0.659*	0.018	-0.325	0.020	-0.089	-0.284	-0.002	0.155	0.051				
	-0.034	0.917*	0.053	0.908*	0.605*	0.094	0.990*	0.367*	0.769*				
PP	-0.112	0.073	-0.057	-0.170	-0.145	-0.081	-0.143	0.034	-0.023	0.055			
	0.514*	0.673*	0.743*	-0.321*	0.401*	0.638*	0.404*	0.846*	0.896*	0.750*			
SL	-0.092	0.366	0.320*	-0.007	-0.335*	0.307	-0.147	-0.199	0.116	-0.160	0.011		
	0.595*	-0.028	0.057	0.968*	0.046	0.068	0.393*	-0.244	0.501*	0.352*	0.949*		
SPB	0.483*	-0.070	-0.174	0.002	-0.276	-0.140	-0.142	0.166	0.222	0.620*	0.159	-0.163	
	-0.003	0.684*	0.312*	0.991*	-0.103	0.417*	0.408*	0.334*	-0.193	-0.200	0.354*	0.343*	
YPP	-0.166	0.208	0.549*	0.511	-0.107	0.539*	0.377*	-0.403*	-0.325	0.062	-0.095	0.219	-0.080
	0.334*	0.424*	0.001	0.001	0.534*	-0.001	0.523*	-0.015	0.053	0.720*	0.582*	0.599*	0.643*

* = Significant at 5% probability level

The results about the genotypic and phenotypic correlation among different traits of cotton during 2014 year of study (Table 2a), indicated that there was recorded a significant genotypic correlation of cotton yield per plant with boll weight, fibre fineness, GOT, fibre strength, days to first flower, monopodial branches per plant and plant population. Fibre fineness as an important traits was significantly and positively correlated with bolls per plant, days to first bud, days to first flower opening, days to first flower, monopodail branches per plant, sympodial branches per plant, fibre strength and plant population. Significant phenotypic correlation of cotton yield per plant was found for bolls per plant, days to first bud, days to first boll opening, GOT, fibre strength, monopodial branches per plant and plant height. The large number of bolls per plant, higher boll weight, more sympodial branches per plant, fibre strength and fibre fineness indicated that the improvement in these traits may be fruitful to enhance cotton yield and production.

Table 3. Principal component analysis for different traits of cotton (Year 2013)

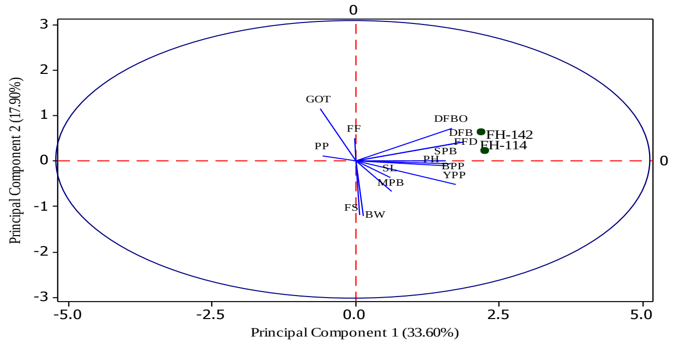
Eigenvalue	4.6896	2.6603	1.6227	1.3002
Proportion	0.335	0.19	0.116	0.093
Cumulative	0.335	0.525	0.641	0.734
Variable	PC1	PC2	PC3	PC4
DFB	0.406	-0.055	0.215	0.139
FFD	0.406	-0.063	0.207	0.119
DFBO	0.387	-0.207	-0.04	-0.024
BPP	0.414	0.008	-0.107	-0.09
SBP	0.224	-0.249	-0.037	0.399
MBP	0.103	0.327	-0.241	-0.45
PH	0.361	0.086	-0.175	-0.296
PP	-0.123	-0.05	0.434	0.301
YPP	0.347	0.245	-0.069	0.189
BW	-0.029	0.463	0.105	0.014
GOT	-0.061	-0.464	-0.024	-0.357
SL	0.127	0.238	0.471	-0.243
FF	0.022	-0.245	-0.492	0.135
FS	-0.039	0.406	-0.373	0.422

Table 3a. Principal component analysis for different traits of cotton (Year 2014)

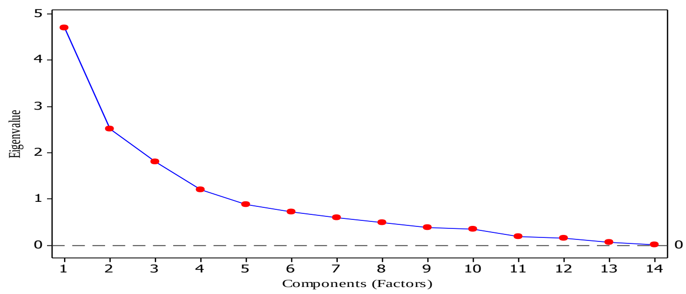
Eigenvalue	4.7004	2.5057	1.8057	1.1997
Proportion	0.336	0.179	0.129	0.086
Cumulative	0.336	0.515	0.644	0.729
Variable	PC1	PC2	PC3	PC4
YPP	0.372	-0.201	0.003	0.177
PP	-0.12	0.047	-0.421	0.406
MPB	0.136	-0.27	0.379	-0.366
BPP	0.356	-0.025	0.118	-0.208
FFD	0.399	0.168	-0.182	0.032
PH	0.334	-0.038	0.256	-0.102
SBP	0.337	0.006	-0.093	0.336
DFBO	0.358	0.289	0.079	0.014
DFB	0.394	0.169	-0.205	0.06
BW	0.015	-0.477	-0.158	-0.138
GOT	-0.13	0.465	0.138	-0.256
SL	0.129	-0.143	-0.46	-0.422
FF	-0.003	0.203	0.443	0.308
FS	0.028	-0.486	0.24	0.375

Table 3b. Principal component analysis for different traits of cotton (Year 2015)

Eigenvalue	3.9321	3.251	2.1723	1.5282
Proportion	0.281	0.232	0.155	0.109
Cumulative	0.281	0.513	0.668	0.777
Variable	PC1	PC2	PC3	PC4
SPB	0.22	0.022	0.291	-0.051
MPB	-0.39	-0.1	0.265	0.228
PH	0.325	0.013	-0.345	-0.232
BPP	-0.225	0.101	-0.354	0.33
YPP	0.381	-0.149	-0.33	-0.037
PP	0.269	0.167	0.324	-0.245
FFD	0.195	-0.436	0.148	0.306
DFBO	0.153	-0.505	-0.093	-0.031
DFB	0.203	-0.433	0.14	0.311
BW	0.188	0.356	0.295	0.081
GOT	-0.393	-0.176	0.024	-0.254
SL	0.227	-0.017	0.229	-0.300
FF	-0.208	-0.233	-0.215	-0.550
FS	0.195	0.29	-0.388	0.258

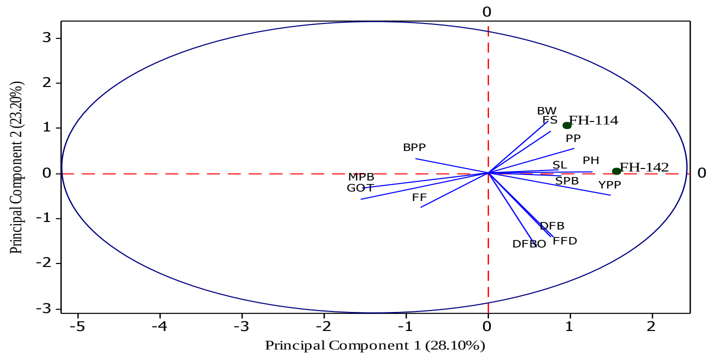


a. Principal component analysis

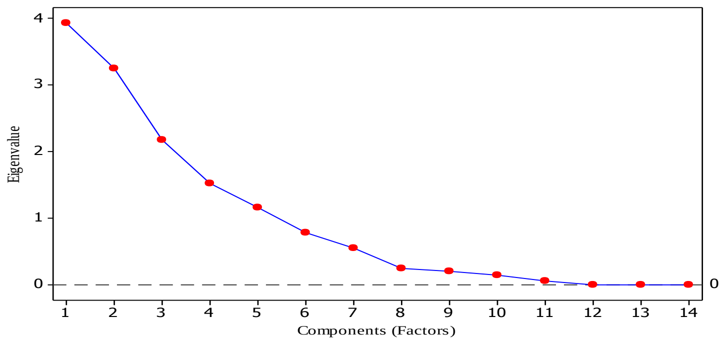


b. Scree plot

Figure 2:a. Principle component analysis of yield and its attributing traits, b. Scree plot and respective Eigenvalues (Year 2014)



a. Principal Component Analysis



b. Scree plot

Figure 3:a. Principle component analysis of yield and its attributing traits, b. Scree plot and respective Eigenvalues (Year 2015)

Our results were similar in accordance the finding reported by ABBAS *et al*. (2015); MEENA *et al.* (2007); SUINAGA *et al.* (2006) and SAJJAD *et al*. (2015). TAOHUA and HAIPENG (2006); ABBAS *et al*. (2015) and IQBAL *et al*. (2003) suggested that the genotypes with higher number of bolls per plant, boll weight, sympodial branches per plant and GOT are the traits may be used for the development of higher yielding cotton genotypes for early maturing with less number of days taken to first bud, first flower, first boll opening. Four principal components PC1, PC2, PC3 and PC4 were recorded from data of study year 2014 (Table 3a), the PCs showed Eigen value more than 1 as shown in figure 2b. It was found that the total proportion contribution of PC1 (33.60%), PC2 (17.90%), PC3 (12.90%) and PC4 (8.60%) was recorded for studied traits as shown in table 3a and figure 2a. The cotton yield per plant, bolls per plant, first flower days, plant height, days to first boll opening, sympodial branches per plant and days to first bud showed higher contribution towards increasing in cotton yield. From factor analysis, it was found that the traits fall in factor 1 which contributed 48.60% of total variation were days to first bud, days to first flower, days to first boll opening, plant height, sympodial branches per plant and cotton yield per plant. The cumulative variation was 89.40% (Table 4a).

Table 4. Factor loadings of yield attributing morpho-physiological and agronomic traits (Year 2013)

Variables	Loadings	% of total communality
Factor 1		53.50
DFB	0.878	
FFD	0.879	
DFBO	0.838	
BPP	0.896	
PH	0.782	
YPP	0.752	
Factor 2		19.00
SBP	-0.607	
MBP	-0.534	
GOT	-0.756	
BW	-0.755	
Factor 3		11.60
PP	0.553	
FF	0.555	
FS	0.671	
SL	0.600	
Cumulative variance		84.10

Table 4a. Factor loadings of yield attributing morpho-physiological and agronomic traits (Year 2014)

Variables	Loadings	% of total communality
Factor 1		48.60
DFB	0.855	
FFD	0.864	
DBO	0.776	
BPP	0.771	
PH	0.724	
SBP	0.731	
YPP	0.806	
Factor 2		27.90
MBP	-0.527	
GOT	-0.737	
FS	-0.769	
BW	-0.755	
Factor 3		12.90
PP	0.565	
FF	0.596	
SL	0.619	
Cumulative variance		89.40

Table 4b. Factor loadings of yield attributing morpho-physiological and agronomic traits (Year 2015)

Variables	Loadings	% of total communality
Factor 1		45.30
MBP	0.685	
FFD	0.859	
DFBO	0.655	
BPP	0.571	
SBP	0.746	
YPP	0.683	
DFB	0.879	
Factor 2		18.60
GOT	-0.702	
FS	-0.785	
BW	-0.695	
Factor 3		14.60
PP	0.365	
FF	0.601	
SL	0.345	
PH	0.105	
Cumulative variance		78.20

Table 5. Average economic gain percentage for consecutive three years of study

Treatments	Date. of sowing	Yield kg/ha		Average Yield kg/ha	Net profit (Rs/ha)	Tillage treatment average	% increase over conventional
		FH-114	FH-142				
Zero -tillage	15-03-2013/14/15	2842a	3870a	3356a	1,59,569	1,20,420	54
	30-04-2013/14/15	2034d	2321e	2177d	81,271		
Minimum tillage	15-03-2013/14/15	2738b	3338b	3038b	1,33,249	92,825	18.72
	30-04-2013/14/15	1434f	2217f	1825f	52,401		
Conventional tillage	15-03-2013/14/15	1731e	2597d	2164e	56,584	78,185	
	30-04-2013/14/15	2127c	3084c	2605c	99,786		

The results from table 1b revealed that the traits, days to first bud, days to first boll opening, fibre strength, GOT, plant height, staple length and sympodial branches per plant were the highly contributing traits. The predicated regression equation was as follow:

$Y = 26128.7 + (-16.47X_1) + (-50.078X_2) + (23.053X_3) + (182.161X_4) + (-353.358X_5) + (-4.74X_6) + (104.182X_7) + (0.353X_8) + (48.991X_9) + (10.142X_{10}) + (0.01X_{11}) + (190.006X_{12}) + (30.724X_{13})$

The cotton yield per plant was significantly and positively correlated with bolls per plant, boll weight, fibre fineness, fibre strength, plant height, plant population and sympodial branches per plant at genotypic level. Bolls per plant showed strongly genotypic correlation for fibre strength and boll weight. Fibre strength also showed strong genotypic correlation with plant height and bolls per plant. Strong phenotypic correlation was found for days to first bud with days to first flower and days to first boll opening (Table 2b). MEENA *et al*. (2007) and KOTB (2012) suggested that the correlation analysis may be helpful to improve the yield traits to enhance yield and productivity of crop plants. AHMAD *et al*. (2008) and WANG *et al*. (2004) found significant fibre strength and fibre fineness and regards these traits as the main traits to improve cotton quality.

Four principal components were recorded (Fig. 3a and Table 3b); the proportion percentage for variation was 28.1% (PC1), 23.20% (PC2), 15.50% (PC3) and 10.90% (PC4) also showed in figure 3b as the Eigen value was higher than 1. Maximum variation in PC1 was recorded for plant height, cotton yield per plant, plant population, days to first bud and staple length. From factor analysis, 45.30% variation was found for factor 1. The traits monopodial branches per plant, days to first flower, days to first boll opening, bolls per plant, sympodial branches per plant, days to first bud and cotton yield per plant (Table 4b). The early of lass time in days taken to first flower, first bud, first boll opening and early maturing indicated that the genotypes may be select to develop early maturing and higher yielding cotton genotypes (AMIR *et al*., 2012). BHUTTA *et al.* (2015) reported that the late maturing is usually caused due to environmental stress which caused damage of plant tissues ultimately reduce plant potential.

The aim of our study was to evaluate zero tillage as potential agronomic practice to improve yield and production of crop plant. The results from table 5 indicated that FH-142 performed batter for cotton yield per plant under zero, minimum and conventional tillage practices. Maximum cotton yield was recorded for 15 March sowing under zero tillage followed by minimum tillage. The net profit was found higher under zero-tillage as compared with minimum and conventional tillage. The net increase in economic gain from zero tillage was 54% over conventional tillage whereas; minimum tillage showed 18.72% increase over conventional tillage.

CONCLUSION

The present study was conducted to evaluate cotton genotypes for cotton yield potential under zero tillage technology. Multivariate analysis was performed to evaluate the yield and it attributed traits for potential of FH-114 and FH-142 cotton genotypes. The genotype FH-142 was found with higher and batter performance as compared to FH-114 under zero tillage, minimum tillage and conventional tillage techniques. The traits bolls per plant, boll weight, fibre fineness, fibre strength, plant height, cotton yield per plant and sympodial branches per plant were found as most contributing traits towards cotton yield and production. It was also found that FH-142 gives higher output in terms of economic gain under zero tillage with 54% increase as compared to conventional tillage technique. It was suggested that zero tillage technology should be adopted to improve cotton yield and quality.

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NULTA OBRADA ZEMLJIŠTA: POTENCIJALNA TEHNOLOGIJA U UNAPREĐENJU PRINOSA PAMUKA

Hafiz Ghazanfar ABBAS[1], Abid MAHMOOD[1] and Qurban ALI[2]

[1]Cotton Research Institute, Ayub Agricultural Research Institute Faisalabad, Pakistan
[2] Centre of Excellence in Molecular Biology, University of the Punjab, Lahore, Pakistan

Izvod

Cilj istraživanja je bio ocena potencijala genotipova pamuka za prinos u uslovima ninimalne obrade zemljišta. Korišćenjem multivariantne.analize izvršena je evaluacija i osobina koje su vezane za prinos kod FH-114 i FH-142 genotipova pamuka. Utvrđeno je da je genotip FH-142 imao bolje osobine kada se uporedi sa genotipom FH-114 u uslovima nulte i minimalne obrade u poređenju sa konvencijalnim tehnikama. Dobijeni rezultati su pokazali da su osobine kao broj po biljci,, težina glave, finoća vlakana, pravilnosti vlakana, visina biljke pamuka, prinos po biljci i simpodijalne grane po biljci najviše doprinele prinosu i proizvodnji pamuka. Genoptip FH-142 je ekonomski dao bolje rezultate u uslovima nulte obrade u poređenju sa konvencionalom tehnikom.

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