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Full Length Article

Improvement of Cotton Crop Performance by Estimating Optimum Sowing and Picking Time

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Abstract

Performance of seed is determined by interactive component effect of genetics, physiological quality and the environment. Climate change and introduction of Bt genotypes uncertain the conventional sowing time of cotton responsible for low emergence that proceeds to delayed emergence and stand failure. To predict the emergence potential of cotton, Bt (FH-142) and non-Bt (FH-942) genotypes were sown in field with 15 days interval from 15 March to 15 June, 2013. Post planting observations recorded during crop production were morphological and phenological characteristics along with seed cotton picking during September, October and November. Early sowing delayed time to start emergence and sowing of FH-142 at 15 April and FH-942 at 1 June exposed the seed to optimum temperature finally with the quick and maximum emergence percentage. Cotton plants emerged during 15 March to 15 April compensated their delayed emergence by achieving maximum height, more number of bolls, monopodial and sympodial branches as well as early blooming and with higher economic returns for October picking. Thus, sowing from 15 March to 15 April assures high cotton production through good morphological development and subsequently picking during October provide good quality cottonseed.

Keywords: Sowing dates; October picking; Emergence percentage; FH-142

Introduction

The productivity of cotton support Pakistan economy as it contributes 1.5% in GDP and 7.1% in value addition of agriculture thus textile industries seeks US$ 10.22 billion foreign exchange (Federal Bureau of Statistics, 2012).

Genotype expresses its maximum potential in response to optimum planting time as early and delayed sowing enhance the sensitivity of crop towards diseases and pest (Farooq *et al*., 2011). Before introduction of genetically modified Bt varieties in Pakistan, cotton was used to grow in the hottest months i.e., May or June, having maximum daily temperature around >40°C. Seedling emergence followed by establishment is adversely affected by low humidity and high temperature (Nawaz *et al*., 2013; Yuksel *et al*., 2013). Under irrigated conditions, soil temperature is the most important factor affecting either the extent or speed of establishment of crop stand. It is considered that 12ºC is the minimum soil temperature for germination and 32ºC is the optimum (Chu *et al*., 1991). Bolek (2006) recommended 15ºC as lowest temperature and 30ºC as optimum temperature for cotton germination.

In agro-ecological zones temperature can be optimized by adjusting sowing time as it has marked association with expression of genotype agronomic characteristics (Hayes *et al*., 2003) like plant height, height to node ratio, number of direct and alternate fruit bearing branches (Arain *et al*., 2001; Butter *et al*., 2004), number of bolls per plant, seed index and ultimately economic yield. Besides late planting, early planting expressed positive influence on agronomic characteristic of plant as Gormus and Yucel (2002) counted higher number of sympodial branches (Dong *et al*., 2006) more height, more nodes on main stem, higher height to node ratio (Pettigrew, 2002; Hassan *et al*., 2005; Hussain *et al*., 2007). While late planting reduced flower retention ability of plant, produce fewer (Bozbek *et al*., 2006) and lighter bolls (El-Tabbakh, 2002) with less number of seeds (Cathey and Meredith, 1988) that leads to lower seed (Pettigrew, 2002) and lint index (Oad *et al*., 2002).

During picking field environment decide the fortune of seed quality as exposure of humid weather after ripening prove to be detrimental for physiological quality (Williford *et al*., 1995; França-Neto *et al*., 2005; Coblentz, 2010). Early and delayed harvesting carry higher moisture which accelerates the seed deterioration that not only lower the

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germination but also make seed highly susceptible to mechanical damage and insect pest infestation during seed processing and storage (Jyoti and Malik, 2013).

The present study was therefore planned to evaluate the emergence potential and productivity of Bt and non-Bt cotton cultivars through optimizing sowing and picking times.

Materials and Methods

To evaluate the cottonseed quality during development and production, delinted and treated seed of two genotypes (FH-142 and FH-942) with germination percentage ≥65% were collected and sown fortnightly *viz.* 15th March, 1st April, 15th April, 1st May, 15th May, 1st June and 15th June in split plot arrangements at Cotton Research Institute, Ayub Agricultural Research Institute, Faisalabad, ARRI during 2013.

Crop Managements during Production

Soil was pre-soaked with irrigation of 10 cm depth. At field capacity soil was cultivated 4 times with tractor mounted cultivator followed by three planking and seed bed of 1 m wide was prepared. On every sowing date seeds were dibbled manually on both sides of beds keeping plant to plant (P×P) distance of 30 cm and row to row (R×R) distance of 75 cm and irrigated immediately to facilitate seed germination (Iftikhar *et al.,* 2010). The cotton seedlings were manually thinned at four leaf stage to maintain required plant population (43575 Plants ha^{-1}) and facilitate efficient input use. For effective early season weed control a pre emergence herbicide was applied (Ali *et al.,* 2013). Crop nutrition was provided with uniform dose of phosphorus (60 kg ha^{-1}) in the form of TSP (triple super phosphate) and potash (60 kg ha^{-1}) in the form of SOP (Sulfate of Potash) at the time of sowing and N (120 kg ha^{-1}) in the form of urea was applied in splits *viz.* 1/3 at time of sowing, squaring and flowering stage (Doli *et al.,* 2015). Through pest scouting, prior to threshold level recommended dose of insecticides were applied to control the sucking insects. During hot and dry days of September, October and November seed cotton was picked from 10:00 to 17:00 h manually.

Observations

After every sowing each plot was observed daily and day of first seedling emergence and number of seedlings emerged in every experimental unit was recorded up to constant emergence to calculate the final emergence percentage (FEP) using following formulae:

$$\text{FEP} = \frac{\text{Maximum seedlings emerged}}{\text{Total number of seeds sown}} \times 100$$

Mean emergence time (MET) was calculated according to the equation of Ellis and Roberts (1981) as follows:

$$Mean\ emergence\ time = \frac{\sum D_n}{\sum_n}$$

Where, 'Dn' is number of seedlings emerged in days 'n' and n is number of days.

After final picking, mean height (cm) of 10 randomly selected plants from each replication was measured from base to top with the help of measuring scale. After emergence, 10 plants were tagged from each replicate and then constantly observed to record the time (days) when first white flower appeared. Retention of maximum bolls on cotton plant gave the estimation of economic yield so mature bolls were counted from each replication. While number of sympodial and monopodial branches were counted on 10 randomly selected plants from each replication.

Seed cotton was picked thrice during the month of September, October and November from each experimental unit manually and weighed to estimate the yield in kg ha^{-1}. After ginning, quality of picked seed was assessed by placing 100 seed with 4 replicated in triple layer "Whatman" filter paper and placed in incubator at 25°C without light. The first count was taken after 4th days and second at 12th day (ISTA, 2016).

Data collected on different variables were analyzed using Fisher's analysis of variance technique computed by statistical package *Statistix-10 USA*. *Tukey's HSD* (Honest significant difference) test at 0.05 probability level (Steel *et al.,* 1997) was used and furthermore standard error was also reported.

Results

Seedling Establishment

Sowing dates (15 March to 15 June) significantly influenced the expression of both genotypes regarding seedling establishment attributes like time to start emergence, final emergence percentage and mean emergence time (Table 1).

The results showed that seeds of both genotypes took maximum time to produced seedling when sown on 15 April (Fig. 1). Maximum emergence percentage (Fig. 2) and mean emergence time (Fig. 3) was calculated for seeds of FH-142 sown on 15 April and of FH-942 on 1 June respectively. Further delay in sowing linearly decreased time to emergence but it negatively affected emergence percentage of both genotypes.

Agronomic and Yield Related Attributes

Plant height, number of bolls per plant, number of sympodial and monopodial branches markedly influenced by interactive effect of sowing dates (SD) and genotypes (G). Days to start flowering and number of bolls significantly varied between G and among SD.

Table 1: Analysis of variance (ANOVA) for mean square value of time to start emergence, final emergence (%) of two Cotton genotypes to fortnight sowing from 15 March to 15 Jun

SOV[a]	DF[b]	Time to start emergence (days)	Final emergence (%)	Mean emergence time (days)
Sowing Date (SD)	6	28.139***	29.442**	0.788***
Genotype (G)	1	80.095***	684.054***	0.35NS
SD×G	6	1.929**	143.861***	0.772***

a SOV- Source of variation, b DF= Degree of freedom, NS= non-significant, * = Significant at P≤0.05, ** = Significant at P≤0.01, *** = Significant at P≤0.001

Table 2: Analysis of variance (ANOVA) for mean square values of yield related traits, seed yield and germinating potential of different (September, October and November) pickings of two cotton genotypes (FH-142 and FH-942) in response to fortnight sowing from 15 March to 15 June

SOV[a]	DF[b]	Plant height (cm)	No of sympodial Branches	No of monopodial Branches	Days to start flowering	No of bolls per plant	DF[b]	Seed cotton yield (kg ha^{-1})	Germination (%)
Sowing Date (SD)	6	50469.0***	191.825***	3.151**	201.722***	319.312***	6	937504***	1285.58***
Genotype (G)	1	3152.9***	2828.881***	1.167***	859.524***	758.625***	1	44428**	3126.74***
SD×Gn	6	607.0NS	10.381**	0.056NS	0.690NS	33.764**	6	10668*	14.11NS
Picking (P)	-	-	-	-	-	-	2	4148365***	6296.35***
SD×P	-	-	-	-	-	-	12	111606***	27.13***
G×P	-	-	-	-	-	-	2	29632***	195.92***
SD×G×P	-	-	-	-	-	-	12	3940**	28.82***

a SOV- Source of variation, b DF= Degree of freedom, NS= non-significant, * = Significant at P≤0.05, ** = Significant at P≤0.01, *** = Significant at P≤0.001

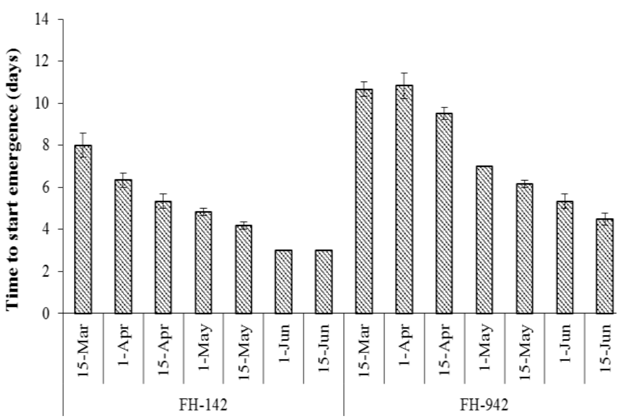

Fig. 1: Time to start emergence of two cotton genotypes (FH-142 and FH-942) when sown on different sowing dates (15 March to 15 June). Values are means ± standard error

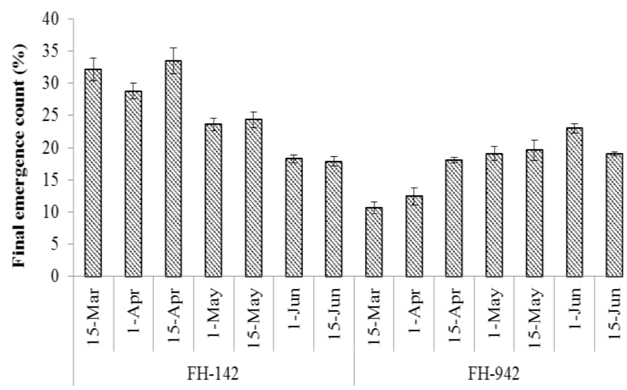

Fig. 2: Final emergence count of two cotton genotypes (FH-142 and FH-942) when sown on different sowing dates (15 March to 15 June). Values are means ± standard error

Furthermore, association of SD, G and picking time (P) significantly influenced economic yield and germination percentage of harvested cottonseed lot (Table 2).

Results showed that both G produced tallest plants, took more days to start flowering and monopodial branches when sowing was done on either 15 March or 1 April, while further delay in sowing was not in favor of these attribute thus minimum value was recorded for sowing on 15 June (Table 3).

Genotype FH-142 had more sympodial branches and number of bolls when sown on 15 March and was statistically at par with the sowing on 1 April and 15 April respectively. Further delay in sowing linearly reduced values and minimum sympodial branches and number of bolls counted when sown on 15 June. Similarly, FH-942 also had more number of sympodial branches and number of bolls when sown on 15 March while minimum values of these attributes were observed when sowing delayed till 15 June (Table 4). Moreover, maximum seedcotton (Fig. 4) with higher germination potential (Fig. 5) was found with picking collected during month of October and crop sown on 15 April and response was statistically at par with sowing of 15 March or 1 April, respectively. Likely, further delay in sowing and early or late picking gradually decreased seed cotton yield and minimum value of these attribute was found for November picking from crop sown on 15 June.

Table 3: Influence of sowing date on plant height (cm), Number of bolls and Number of sympodial branches of two cotton genotypes (FH-142 and FH-942) in response to fortnight sowing from 15 March to 15 June

Sowing date/cotton genotypes	Plant height (cm)			Number of monopodial branches			Time to start flowering (days)		
	FH-142	FH-942	Means	FH-142	FH-942	Means	FH-142	FH-942	Means
15-Mar	183.67	210.92	197.29 A	1.67	2.34	2.00 A	45.33	54	49.67 A
1-Apr	182.33	204.67	193.50 A	1.67	2.00	1.84 A	42.00	54.67	46.84 A
15-Apr	171.00	188.06	179.53 AB	1.34	1.63	1.50 AB	36.33	46.34	41.34 B
1-May	162.13	174.57	168.35 B	1.00	1.34	1.17 BC	35.67	44.67	40.17 BC
15-May	132.83	156.47	144.65 C	0.67	1.00	0.84 CD	31.00	39.67	35.34 CD
1-Jun	116.33	118.98	117.66 D	0.34	0.67	0.50 DE	33.00	41.00	37.00 B-D
15-Jun	93.17	109.11	101.14 D	0.00	0.00	0.00 E	29.67	39.00	34.33 D
Means	148.78 B	166.11A		0.952 B	1.29 A		36.14 B	45.19 A	

Table 4: Influence of sowing date on number of monopodial branches and time to start flowering (days) of two cotton genotypes

Sowing dates/cotton genotypes	Number of sympodial branches			Number of bolls per plant		
	FH-142	FH-942	Means	FH-142	FH-942	Means
15-Mar	21.33 a	15.00 d	18.17	29 a	22.33 a-c	25.65
1-Apr	20.33 ab	13.33 ef	16.83	28 a	19.33 b-d	23.67
15-Apr	18.00 c	12.00 f	15.00	26 ab	15.33 c-e	20.67
1-May	15.67 cd	7.67 gh	11.67	24.33 ab	12.33 d-f	18.33
15-May	12.33 ef	6.33 h	9.33	20.33 a-d	7.34 ef	13.83
1-Jun	6.33 h	4.33 ij	5.33	11.67 d-f	4.00 f	7.83
15-Jun	4.00 jk	3.00 k	3.50	7.67 ef	5.17 f	6.42
Means	14	8.18		148.78	166.11	

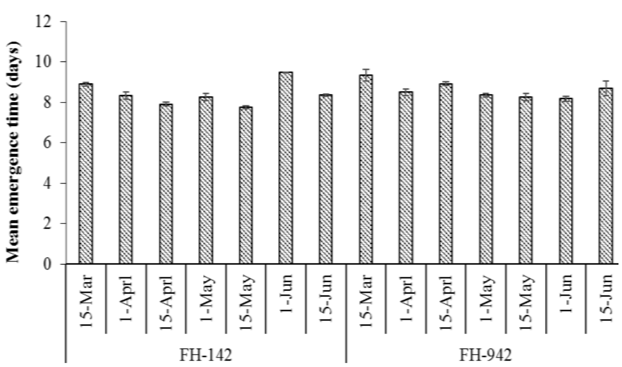

Fig. 3: Mean emergence time of two cotton genotypes (FH-142 and FH-942) when sown on different sowing dates (15 March to 15 June). Values are means ± standard error

Discussion

Sowing at suboptimal conditions affect plant right from emergence to maturation (Bange and Milroy, 2004). Planting at 15 March (Ahmad, 1999) exposed the seed to low temperature (<18°C) which delayed and reduced emergence count. Similarly, Tuck *et al.* (2010) also reported late and minimum emergence when temperature during sowing fell to 14°C (Pereira *et al.,* 2005; Gipson *et al*., 2006). Conversely, planting during June exposed the seed to highest temperature (>30°C) which assure quick emergence (Kittock *et al*., 1987) but low emergence count. Awan *et al.* (2011) found that 25th April provided optimum temperature (26ºC) which declared as most suitable sowing time for cotton planting in favor of early emergence and maximum emergence count because it provided optimum temperature (25ºC) to germinating seed (Fig. 6).

Cotton plant architecture with maximum plant height, more boll count, more number of sympodial and monopodial branches, early blooming, high seed cotton yield and seed index (Farzana *et al*., 2005) are linked with selection of genotype and early sowing (Norfleet *et al*., 1997; Wrather *et al*., 2008). Therefore, during experiment performance of Bt genotypes (FH-142) surpassed non-Bt genotypes (FH-942; Wang *et al*., 2004) and early sowing (15 April to 15 June) enabled plant to utilize maximum heating units (Boman and Lemon, 2005) while late planting of cotton crop showed haphazard vegetative growth and poorly shifted resources to economic parts and ultimately lowered seed cotton yield (Ali *et al*., 2009).

The performance of genetically pure genotype can be improved by optimizing sowing time in favor of optimum metrological parameters to influence the timing of all subsequent phenological events (Siebert and Ewert, 2012). The growth and yield attributes of FH-142 coincide with the research work of Mustafa *et al*. (2014) where maximum plant height, number of boll, number of sympodial and monopodia branches and seed cotton yield because this genotype exhibits broader genetic variability for wide range adaptability, resistance against insect, viruses and higher yield potential.

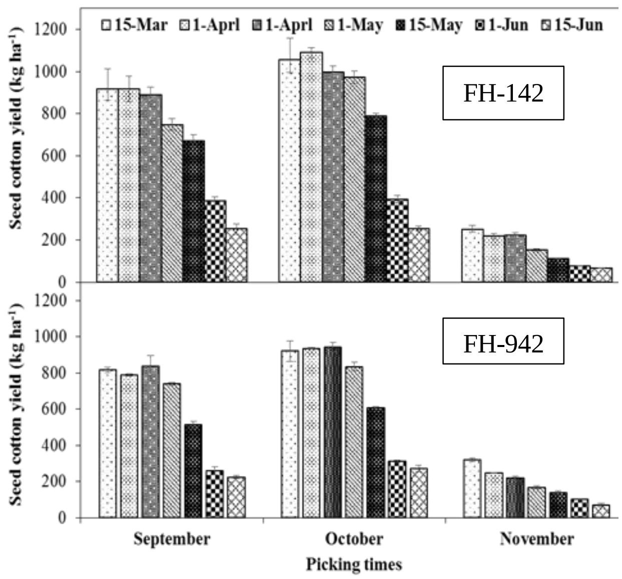

Fig. 4: Variation in seed cotton yield of two cotton genotypes (FH-142 and FH-942) at different picking times. Values are means ± standard error

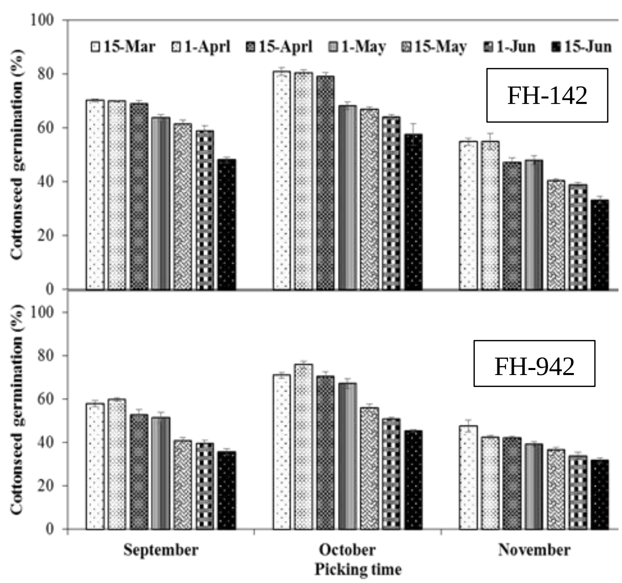

Fig. 5: Variation in cottonseed germination of two cotton genotypes (FH-142 and FH-942) at different picking times. Values are means ± standard error

When this genotype was sown early i.e. between 15 March to 15 May, 2013 established plant availed optimum environmental condition in field (Norfleet *et al*., 1997; Linderholm, 2006) and keep boll unaffected from insects (Saeed *et al*., 2014), carry maximum number of monopodial (Butter *et al*., 2004), sympodial branches (El-Shahawy, 1999) and higher yield (Dounias *et al*., 2002; Mohammed *et al*., 2003; Yeats *et al*., 2010). Because early emerged plants stay long in field to utilize high summer temperature and

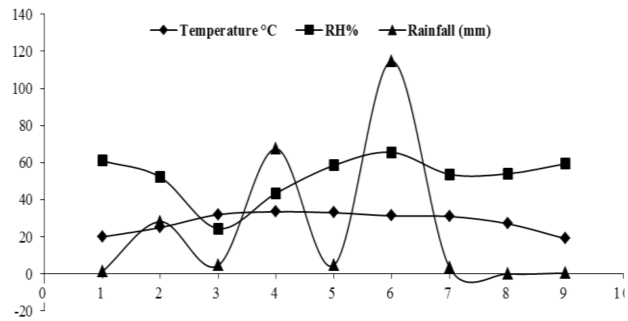

Fig. 6: Weather data of Year 2013 during experiment (Available online on. http://uaf.edu.pk/downloads/10%20met.%20data%20Oct-13.pdf)

accumulate maximum heating units for blooming and boll opening as well as, synthesize higher photosynthates and reserves for developing seeds and lint. Contrarily, late sowing push the flowering and boll development (Gormus and Yucel, 2002) into cooler weather and reduces the final yield (Braunack *et al*., 2012).

In present study, the better performance of early sown plants can be explained by quantitative impact of temperature in association with sowing date that every 1°C rise in monthly temperature shortened phenological periods by 2.17–4.76 days with exception of delay sowing by 2.49–3.35 days (Deng *et al*., 2008; Huang and Feng, 2015). But extreme heat in late sown plots also results in photosystem inhibition (Schrader *et al*., 2004), low biomass accumulation (Reddy *et al*., 1995) and male sterility which cause more flower and boll shedding (Fisher, 1975). Picking time also showed significant importance regarding cotton quality (Deho *et al*., 2012) as found for cottonseed picked during September and October with good quality and exhibit maximum germination potential i.e., 90.93 and 94.23% respectively.

The high quantity of seed found during mid-October, 2013 can be supported by field environment during picking as shown with relative humidity of 46% and no rainfall (Fig. 6) during October. Thus the optimum temperature for cotton is 20–30 (Zhao, 1981) that can be easily attained by adjusting planting time which assure normal phenological phase shifting, increase resistance against insect (Gormus and Yucel, 2002) and picking during hot and humid weather (Deho *et al*., 2012) ensured higher quantity of seedcotton and high quality cottonseed.

Conclusion

Cottonseed with good quality can be picked during October by planting seed between 15th March to 15th April which nevertheless delayed emergence but seems appropriate by shifting cotton canopy and seed development in optimum environment for high economic returns.

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