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Response of biochemical constituents under different sowing periods and their correlation with seed germination in *Gossypium arboreum* L

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Abstract
A two-year field experiment was conducted at the Research Farm of Cotton Section, Department of Genetics and Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Hisar to illustrate the effects of weather parameters on biochemical parameters *viz.* protein content, oil content, sugar content and gossypol content of *desi* cotton varieties HD 123, HD 324 and HD 432 grown in different environmental conditions. Experimental material was planted on 10 April, 15 May and 5 June during 2015 while on 26 April, 5 May and 2 June during 2016 in a Randomized Block Design (RBD) with six replications. The flowering during both the years started from early July and completed by end of September during both the years. Flower were tagged on weekly basis and seed cotton picked from them were ginned separately and thus this seed was used to estimate the biochemical parameters of different sowing dates and their correlation with seed germination. The response of various biochemical constituents differed in different sowing periods. Early sown condition was suitable for the development of biochemical traits in desirable direction. It leads better seed development which resulted in increased the seed. Seed germination with different biochemical parameters showed positive correlation except gossypol content which showed negative correlation.

Keywords: *Desi* cotton and biochemical constituents and sowing periods

Introduction
Cotton plays an important role among the cash crops from the earliest times. It is popularly called as "White Gold" and is the most important renewable natural fibre crop. Cotton plays crucial role in agriculture, industry and economic development of the country. It is grown in an area of 329.49 lakh hectares in 80 countries across the world. India is at top with 1st rank by contribution of one third in total area of the world. During the year 2016-2017 area under cotton in India was 105 lakh hectares with production of 351 lakh bales, while in Haryana it was grown in an area of 5.70 lakh hectares with production 20.4 lakh bales and productivity was 609 kg lint/hectare (Anonymous, 2017). There are total four cultivated species of cotton among these; diploid species (*G. arboreum* L. and *G. herbaceum* L.) are known as old world cotton and tetraploid (*G. hirsutum* L. and *G. barbadense* L) as new world cotton. India is the unique country where all these four cultivated species are grown commercially. Cotton is an indeterminate plant and any weather aberrations during crop season will adversely affect the square, flower and boll setting. It cannot stand continuous wet and overcast weather at any stage like germination and emergence, seedling establishment, leaf-area-canopy development, flowering and boll development and maturation. During the period of fruiting, warm days and cool nights with large diurnal variations are conducive for good boll and seed development (Rathore and Maini, 2008) [17].

Cotton seed is a good source of oil and protein. Cotton seed contains 18-20 % seed oil which is edible after removal of gossypol by hydrogenation (Narayanan *et al.,* 1975) [14] and 17- 23% seed protein by weight. Its seed is the second largest source of vegetable oil in the world. This oil is generally considered as healthy oil. It is cholesterol free and hence termed as "heart oil". It is need of the time to increase the edible oil production locally. Cotton is not only our major fibre crop but also main source of edible oil, however, being ignored as an oilseed crop. Evaluation criteria for a cotton variety only consider its fibre yield and its oil yield is totally ignored. Emphasis is required for the development of cotton varieties with high fibre and oil yield. This will reduce the burden edible oil imports in the country.

After extraction of oil, the cotton seed meal is a protein rich by-product and assumes great importance in feed and fermentation industries. Therefore, cotton seed has an important contribution in helping to animal feed in the future. The annual worldwide cotton seed yield could supply the dietary protein needs of 240 - 350 million people but the sphere of its use in agriculture is limited. Constituting nearly half of a seed's weight, the meal contains 23% high biological-value protein. Limiting its more widespread use is the presence of gossypol which binds with the proteins. The digestibility of the protein is diminished and consequently, is its assimilability in the animal but presence of gossypol is a major deterrent. Therefore a study was made for the improvement of biochemical constituents in cotton seeds by different sowing periods. So that desirable biochemical constituents can be improved and gossypol content can be reduced by manipulating the sowing period.

However seed germination in cotton is a major problem under North Indian conditions particularly during 2013 and 2014. It remains below the normal seed standards because of poor seed development. Cotton seed quality is very much affected by environmental factors. Sometimes seed germination in cotton may be reduced as low as 10% due to adverse environmental conditions and exact reasons for poor development of seed are still unknown. Therefore understanding the association between seed germination and biochemical constituents is of paramount importance for making the best use of these relationships in selection. The correlation and regression analysis also reflects the correlated response of a particular trait with its counterpart and also provides a good index to predict the corresponding change which occurs in one trait at the expense of the proportionate change in the other. The correlation coefficient provides a reliable measure of association among the traits and helps to differentiate vital associates useful in breeding from those of the non vital ones. Since the total cultivable area is decreasing due to over growing population, the increased agricultural productivity is the only option.

Material and Methods

The study was conducted at the Research Farm of Cotton Section, Department of Genetics and Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Hisar. It is situated in the semi arid zone at an elevation of 215.2 m with a longitude of $75^0 46'$ E and latitude of $29^0 10'$N. The experimental material for the present study comprised of 3 varieties of *Desi* cotton *i.e.* HD 123, HD 324 and HD 432. All the experimental material was grown in six environments (Table 1) which comprised of two years (2015 and 2016) and three different sowing periods (early, normal and late). All the varieties were grown in a Randomized Block Design (RBD) with six replications. There were eight rows of each genotype of six meter length spaced 67.5 cm apart and plant to plant distance was kept 30 cm. The observation were taken weekly from flowering initiation to boll opening. As and when flowering started, opened flowers were tagged. The flowering tagging during both the years started from early July to mid of September during 2015 and 2016. From each seed lot of all the three varieties of different sowing dates, biochemical parameters were worked out to find out the their role and correlation with seed germination (%). Total nitrogen (N) was estimated by micro-Kjedahl method (AOAC, 1990) and protein content was calculated as 6.25 x N concentration. The oil content was determined by Soxhelt method. Gossypol content was determined by the method of Bell, 1967 and total sugar estimation was done as per method of Du Bois *et al.* (1956) [10]. Correlations were computed by using the formula given by Al-Jibouri *et al*. (1958) [2].

Results and Discussion

Accumulation of desirable biochemical constituents is responsible for proper seed development and it also reflects its quality also. It has been observed to be variable under different environmental condition and sowing period of cotton seems important role for seed quality and hence it was analyzed. Data in Table 2 revealed that protein content differed significantly in different sowing conditions. It was found highest in early sown conditions (24.72 mg/100g of seed) whereas lower in late sown conditions (21.36 mg/100g of seed). During 2016 maximum protein content was found in early sown conditions (28.40 mg/100g of seed) whereas it was minimum (25.95 mg/100g of seed) in late sown conditions. Among varieties, maximum protein (22.98 mg/100g of seed) was found in the variety HD 324 and minimum (22.68 mg/100g of seed) in the variety HD 123 in the year 2015. While in 2016 it was found to be non-significant in all sowing conditions. Beevers and Poulson (1974) also reported that varying amounts and types of protein deposited in maturing seeds. Results of present study are in conformity with the earlier findings of Cherry (1974) [8] in peanut and Basha *et al*. (1976) [4] in groundnut.

Maximum sugar content (2.61 %) was found in early sown conditions while minimum (1.24 %) in late sown conditions in the year 2015 (Table 3). Similarly during second year (2016) sugar content was found maximum under early sown conditions (3.79 %) while minimum in late sown conditions (2.87 %). Among varieties sugar content was found non-significant in both the seasons. Higher sugar content in early sown conditions may be due to that experimental material under such condition gets longer period for accumulation of more sugar content compared to late sown conditions. Results were in conformity in cotton by Ackerson and Richard (1981) [1] and Damodaran *et al.* (2010) [9].

Oil content under different sowing periods differed significantly (Table 4). Maximum oil content (18.83 %) was found in early sown conditions and minimum (16.48 %) in late sown conditions in the year 2015. Similarly during second year oil content was maximum under early sown conditions (17.69 %) whereas minimum (13.86 %) under late sown conditions. Among different varieties oil content and interaction between different sown periods and varieties were found to be non-significant during both the years. Similarly higher oil content was found in early sown conditions and in subsequent sowings it reduces gradually, may be due lesser time availability for accumulation of oil content in late sown conditions. Decrease in oil and protein content in seed was observed with sowing date by Kohel and Cherry (1983) [12] in cotton.

Perusal of Table 5 showed that gossypol content under different sowing periods differed significantly. Minimum gossypol content (0.48 %) was found in early sown conditions while maximum (0.67 %) in late sown conditions. Among varieties minimum gossypol content (0.53 %) was recorded in the variety HD 432 while maximum (0.64 %) in the variety HD 324 during 2015. Same trend was observed during 2016 and its content was minimum in early sown conditions (0.23 %) whereas maximum under late sown conditions (0.26 %). Interaction between different varieties and sown periods were found to be non-significant. All the biochemical constituents except gossypol content were higher during 2016. The

gossypol content was found minimum in early sown conditions and increased gradually under late sown conditions showed that more suitability of cotton seed of early sown conditions because cotton oil is mainly used as vegetable oil for human consumption. Gossypol is an alkaloid and undesirable for human consumption. Beyond a maximum permissible limit, it has to be removed from oil by different means which deteriorates its quality and resulting in increased cost. These results were in broad agreement with the finding of Meredith *et al.* (2012) [13], Chakrabarty *et al.* (2002) [7] and Percy *et al.* (1996). The results obtained over years showed the variation in gossypol content. Similar results were reported by Pons *et al.* (1953) [16] in cotton.

Differences in biochemical constituents under different sowing periods may help to increase the seed germination, so it was necessary to study the correlation of various biochemical constituents affecting seed development during their critical development phase and results are presented Table 6. The standard seed germination of the variety HD 123 showed positive and highly significant association with protein content (0.960**), sugar content (0.940**) and oil content (0.916**) while it showed highly significant negative association with gossypol content (-0.963**). Similarly, standard germination in the variety HD 324 showed positive and highly significant association with protein content (0.965**), sugar content (0.957**) and oil content (0.970**) while it showed significant negative association with gossypol content (-0.877**). Same trend was observed in case of variety HD 432. It showed positive and highly significant association with protein content (0.970**), sugar content (0.975**) and oil content (0.956**) while showed significant negative association with gossypol content (-0.896**). The correlation study among various parameters except gossypol content showed significant positive association while gossypol showed negative significant association which is desirable indicating possibility of improving seed germination by improving biochemical parameters in desirable direction by manipulating sowing periods. Similar results have been reported by Chakrabarty *et al.* (2002) [7] in maize, Pons *et al.* (1953) [16] in cotton and Freitas *et al*. (2002) [11] in cotton.

Table 1: Description of environments

Environment		Date of Sowing	Environment Designation
Year	**Sowing period**		
2015	Early	April 10, 2015	E_1
	Normal	May 15, 2015	E_2
	Late	June 5, 2015	E_3
2016	Early	April 26, 2016	E_4
	Normal	May 5, 2016	E_5
	Late	June 2, 2016	E_6

Table 2: Effect of sowing periods on protein content (mg/100g of seed)

	2015				2016			
Varieties	**Early**	**Normal**	**Late**	**Mean**	**Early**	**Normal**	**Late**	**Mean**
HD 123	24.86	21.96	21.20	22.68	27.72	26.49	25.24	26.49
HD 324	24.59	22.84	21.52	22.98	28.36	27.04	26.08	27.16
HD 432	24.71	22.23	21.35	22.76	29.13	28.64	26.52	28.09
Mean	24.71	22.35	21.36	22.81	28.40	27.39	25.95	27.25
CD at 5%	D-1.83 V- 0.75 V x D-NS				D-1.39 V- NS V x D- NS			
SE (m)	D-0.61 V-0.61 V x D-1.06				D-0.47 V-0.47 V x D-0.81			

Table 3: Effect of sowing periods on sugar content (%)

	2015				2016			
Varieties	**Early**	**Normal**	**Late**	**Mean**	**Early**	**Normal**	**Late**	**Mean**
HD 123	2.90	1.65	1.47	2.01	3.98	3.55	3.10	3.55
HD 324	2.37	1.45	0.72	1.52	3.82	3.34	2.87	3.34
HD 432	2.57	1.88	1.53	1.99	3.58	3.29	2.64	3.17
Mean	2.61	1.66	1.24	1.84	3.79	3.39	2.87	3.35
CD at 5%	D-0.66 V- NS V x D-NS				D-0.44 V- NS V x D-NS			
SE (m)	D-0.215 V- 0.215 V x D-0.373				D-0.15 V-0.146 V x D-0.25			

Table 4: Effect of sowing periods on oil content (%)

	2015				2016			
Varieties	**Early**	**Normal**	**Late**	**Mean**	**Early**	**Normal**	**Late**	**Mean**
HD 123	18.29	16.21	15.83	16.78	19.02	16.23	13.64	16.29
HD 324	18.74	17.43	16.54	17.57	17.86	15.74	14.81	16.14
HD 432	19.46	17.58	17.05	18.03	16.21	15.13	13.12	14.81
Mean	18.83	17.07	16.48	17.46	17.69	15.70	13.86	15.75
CD at 5%	D-1.42 V- NS V x D- NS				D-1.85 V- NS V x D- NS			
SE (m)	D-0.47 V-0.473 V x D-0.82				D- 0.62 V- 0.62 V x D-1.07			

Table 5: Effect of sowing periods on gossypol content (%)

	2015				2016			
Varieties	**Early**	**Normal**	**Late**	**Mean**	**Early**	**Normal**	**Late**	**Mean**
HD 123	0.46	0.66	0.68	0.60	0.23	0.24	0.26	0.24
HD 324	0.54	0.64	0.73	0.64	0.22	0.24	0.25	0.23
HD 432	0.44	0.55	0.61	0.53	0.23	0.23	0.26	0.24
Mean	0.48	0.62	0.67	0.59	0.23	0.24	0.26	0.24
CD at 5%	D-0.75 V- 0.75 V x D-NS				D-NS V-NS V x D-NS			
SE (m)	D-0.25 V-0.25 V x D-0.43				D-0.01 V-0.01 V x D-0.02			

V = Variety, D = Sowing period, V × D = Variety × Sowing period

Table 6: Correlation coefficients (r) of seed germination with biochemical parameters in *Desi* cotton varieties

HD 123	**SG**	**PC**	**GC**	**SC**	**OC**
SG	1				
PC	0.960**	1			
GC	-0.963**	-0.970**	1		
SC	0.940**	0.927**	-0.915**	1	
OC	0.916**	0.923**	-0.888**	0.896**	1
HD 324	SG	PC	GC	SC	OC
SG	1				
PC	0.965**	1			
GC	-0.877**	-0.940**	1		
SC	0.957**	0.979**	-0.962**	1	
OC	0.970**	0.976*	-0.880**	0.963**	1
HD 432	SG	PC	GC	SC	OC
SG	1				
PC	0.970**	1			
GC	-0.896**	-0.909**	1		
SC	0.975**	0.982**	-0.910**	1	
OC	0.956**	0.965**	-0.865**	0.965**	1

*Significant at 5% (p = 0.05), **Significant at 1% (p = 0.01)
SG= Standard germination, PC= Protein content, GC= Gossypol content, SC= Sugar content, OC= Oil content

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