Environment & Ecology 35 (3C) : 2367—2372, July—September 2017
Website: environmentandecology.com ISSN 0970-0420

Yield Relationship with Plant Geometry, Yield Attributes and Protein-Oil Content

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Received 21 October 2016 ; Accepted 23 November 2016 ; Published online 12 December 2016

Abstract The field experiment was conducted during the *kharif* season of 2015-2016. The main plots treatments consisted of three date of sowing 2nd week of May (D_1), 3rd week of May (D_2) and 1st week of June (D_3) and the sub-plots consisted of three varieties (Pancham 541, SP 7121 and RCH 791). Earlier sown crop and cultivar RCH 791 produced maximum seed cotton yield and yield attributes. Seed cotton yield is highly positive correlated with sympodial, boll wt/ plant, bolls / plant, dry matter and leaf area but not significant correlated with plant height and protein content. Plant height exhibited positive but non-significant correlation with all the yield parameter except leaf area. Highly significant positive correlation (r = 98) was displayed by sympodial bran ches with boll wt/plant, bolls / plant, dry matter which showed that seed cotton yield was greatly influenced by sympodial branches. The coefficient of determination that bolls weight per plant was responsible for 99%, 84% and 93% variation in bolls per plant, dry matter and leaf area. The coefficient of determination (R^2 = .88) revealed 88% of the total variation in dry matter production attributable to the variation in leaf area. Leaf area is significant positive correlated with oil content. Whereas, protein and oil content is negative correlated with each other.

Keywords Cotton, Growing environment, Correlation coefficient, Regression analysis.

Introduction

Cotton, the white gold enjoys a premier position amongst all commercial and fiber crops in India. Cotton is an important raw material supplying about 65% requirement of the Indian textile industry. The primary product lint provides a source of high quality fiber and cotton seed are an important source of oil for human consumption and a high protein meal used as a livestock feed. In India, area under cotton crop was 11.8 million hectares with production of 26.8 m bales in 2015-2016 with an average yield of 0.494 ton/ hectare [1]. It requires a minimum daily air temperature of 15°C for germination, 21–27°C for vegetative growth and above 15°C for crop growth.

The understanding of the correlation of factors influencing yield is a pre-requisite for designing an effective plant breeding program. It helps in the identification of the yield components, yet they do not provide precise information regarding the relative importance of direct and indirect influence of each componential character. Number of sympodial, boll weight and bolls per plant were significantly and

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positively correlated with seed cotton yield per plant [2].

The correlation analysis also reflects correlated response of a particular character with its counterpart and also provides a good index to predict the corresponding change which occurs in one character at the expanse of the proportionate change in the other. Suinaga et al. [3] and Khan et al. [4] studied the stability and adaptability of *Gossypium hirsutum* cultivars and observed varied values for different agronomic, morphological and yield related traits.

The present study of correlation and regression analysis involves interrelationship between yield and other important yield components which could be used as selection criteria in the breeding program.

Materials and Methods

The field experiment was conducted at the research area of the Department of Agricultural meteorology, CCS Haryana Agricultural University, Hisar, during the *kharif* season of 2015-2016. The main plots treatments consisted of three date of sowing and the subplots consisted of three varieties. The twenty seven treatment combinations were tested in random block design with three replications.

Plant height was measured at important phenophases on three tagged plants in each plot. The height was measured from the root-shoot junction to the apical point with a wooden meter scale and mean values were calculated. Three plants were uprooted from each plot and their leaves were used for measuring leaf area per plant (cm^2) with the help of leaf area meter (LI-3000 Leaf Area Meter, LICOR Ltd., Nebraska, USA) at 30, 60, 90, 120 and 150 days after sowing. These samples were oven dried and weighted for dry biomass. Number of detached bolls was counted and mean number of bolls per plant was calculated. Mean weight of bolls per plant was calculated in all the plots. The seed cotton was picked from three randomly selected plants from each plot. The seed cotton yield was calculated on net plot area basis. Cotton lint was removed from cotton seed by ginning and cotton lint weight was taken.

Protein content : Protein content was determined by the following method.

$$\% \text{ Crude protein} = \frac{V \times 0.00014 \times D \times 100 \times 6.25}{W \times A}$$

Where, V = Volume of N/100 H_2SO_4 taken–volume of N/100 NaOH used for titration, D=Dilution factor (volume made in volumetric flask), W=Weight (g) of sample, A = Aliquot taken for distillation.

Oil content (%) : The oil content was determined by Soxhelt method.

$$\text{Oil (\%)} = \frac{\text{(Weight of sample before extraction– weight of sample after extraction)}}{\text{Weight of sample before extraction}} \times 100$$

Results and Discussion

Seed cotton

Highest seed cotton yield (36.8 g/plant) was observed in RCH 791 followed by SP7121 (26.7 g) and Pancham 541 (22.8 g) with mean average of 14.20 q/ha, 4.66% Standard deviation and 1.55% standard error (Table 1 and Table 2). Seed cotton yield is highly positive correlated with sympodial, boll wt/plant, bolls/plant, dry matter and leaf area but not significant correlated with plant height and protein content. The coefficient of determination (R^2) revealed around 98% of the total variation in seed cotton yield attributable to the variation in sympodial, boll wt/plant, bolls/plant, dry matter and leaf area (Table 3). And lowest 9% of the total variation in seed cotton yield attributed to the variation in protein content. The regression coefficient (b = 2.27) indicated that for a unit increase in sympodial / plant, there would be a proportional increase of 2.27 grams in seed cotton yield per plant. The same findings manifested by Badr [5] and Iqbal et al. [6] who studied the earliness.

Plant height

Highest plant height (128.8 cm) was observed in SP

Table 1. Mean performance of seed cotton, plant height, bolls/plant, sympodia/plant, dry matter, bolls wt/plant, leaf area, protein and oil% of cotton during 2015-2016.

Growing environments	Seed cotton (g)	Plant height (cm)	Bolls/ plant	Sympodial/ plant	Dry matter	Bolls weight/ plant	Leaf area (cm^2)	Protein (%)	Oil (%)
2nd week of May	35.9	127.5	18.0	24	326.1	64.6	7004.3	17.7	19.8
3rd week of May	30.0	124.1	16.0	21	293.4	54.0	6752.3	18.8	17.9
1st week of June	20.5	95.1	11.0	18	257.1	36.8	5562.0	16.5	15.9
CD at 5%	2.6	5.1	1.4	–	9.8	3.1	588.8	1.0	1.0
Pancham 541	22.8	102.7	12.0	19	277.1	41.1	5919.8	18.0	16.1
SP 7121	26.7	128.8	14.0	21	285.1	48.1	6302.3	17.2	17.9
RCH 791	36.8	115.3	19.0	23	314.3	66.3	7096.5	17.8	19.7
CD at 5%	2.6	5.1	1.4	–	9.8	3.1	588.8	NA	1.0

7121 followed by RCH 791 (115.3 cm) and Pancham 541 (102.7 cm) with mean average of 114.2 cm, 21.17% standard deviation and 7.06% standard error (Table 1 and Table 2). Plant height exhibited positive but non-significant correlation with all the yield parameter except leaf area (Table 3). The coefficient of determination (R^2) revealed around 42% of the total variation in plant height attributable to the variation in sympodial, boll wt/plant, bolls/plant, dry matter, oil content and leaf area and very least variation due to oil content. The regression coefficient (b =5.08) indicated that for a unit increase in plant height, there would be a proportional increase of 5.08 gms in oil content per plant. It is therefore, suggested that breeder should very careful in the selection program based on the association of plant height and seed cotton yield. Sevaral authors observed positive correlation between plant height and seed cotton yield and their studies further revealed that characters such as plant height contributed 70% of the total variability for seed cotton yield [7—9].

Sympodial

Highest sympodial / plant (23) was observed in RCH 791 followed by SP 7121 (21) and Pancham 541 (19) with mean average of 24, 4.19% standard deviation and 1.40% standard error (Table 1 and Table 2). Also 2nd week of may produce maximum sympodial and decrease laterward. Highly significant positive correlation (r = 98) was displayed by sympodial branches with boll wt/plant, bolls/plant, dry matter which showed that seed cotton yield was greatly influenced by sympodial branches (Table 3). The coefficient of determination (r^2 = 0.98) revealed 98% variation in the sympodial per plant, due to its relationship with bolls/ plant, dry matter per plant. Regression coefficient (b = 1.12) showed that a unit increase in sympodial branches per plant resulted into a proportional increase of 1.12 units in oil content per plant. And also regression coefficient (b = 0.87) showed that a unit increase in sympodial branches per plant resulted into a proportional increase of 0.87 bolls per plant. The results observed in present study exhibited highly significant positive correlation between sympodial branches and seed cotton yield per plant. This indicates that selection based on sympodial branches per plant will be useful for increasing the seed cotton yield per plant in present material. This fruitful corre-

Table 2. Mean performance, standard deviation and standard error of cotton parameters.

Variables	Mean	Standard deviation	Standard error
Dry matter	30.81	10.09	3.36
Max. LAI	3.19	0.43	0.14
Seed cotton	14.20	4.66	1.55
Lint	4.73	1.48	0.49
Cotton seed	9.47	3.22	1.07
Oil	17.90	2.67	0.89
Protein	17.67	2.28	0.76
Bolls/plant	22.53	7.39	2.47
Boll Wt/Plant	51.84	16.99	5.66
Plant height	114.22	21.17	7.06
Sympodial	24.44	4.19	1.40

Table 3. Genotypic and phenotypic correlation coefficient between yield and yield components traits in cotton.

	Correlation coefficient	Regression		
		Coefficient	R^2	Slope
Seed Cotton Vs plant height	0.63NS	0.29	0.41	– 3.85
Seed Cotton Vs Plant Sympodial	0.98**	2.27	0.98	– 26.22
Seed Cotton Vs Boll Wt/Plant	0.98**	0.55	0.98	1.09
Seed Cotton Vs Boll/Plant	0.98**	1.99	0.97	– 1.11
Seed Cotton Vs Dry Matter	0.94**	0.26	0.88	– 46.34
Seed Cotton Vs Leaf Area	0.96**	0.01	0.93	– 39.52
Seed Cotton Vs Protein	0.33NS	1.22	0.09	7.29
Seed Cotton Vs Oil	0.77*	2.59	0.53	– 17.54
Plant Height Vs Sympodial	0.58NS	3.17	0.38	37.28
Plant Height Vs Boll Wt/Plant	0.64NS	0.83	0.45	72.04
Plant Height Vs Bolls/Plant	0.64NS	2.88	0.41	70.87
Plant Height Vs Dry Matter	0.64NS	0.43	0.49	– 10.66
Plant Height Vs Leaf Area	0.75*	0.02	0.51	0.89
Plant Height Vs Protein	0.14NS	1.31	0.02	91.04
Plant Height Vs Oil	0.64NS	5.08	0.42	23.41
Sympodial Vs Bolls Wt/Plant	0.98**	0.24	0.97	12.003
Sympodial Vs Bolls/Plant	0.98**	0.87	0.98	11.17
Sympodial Vs Dry Matter	0.98**	0.11	0.88	– 8.47
Sympodial Vs Leaf Area	0.95**	0.01	0.95	– 6.28
Sympodial Vs Protein	0.24NS	0.41	0.05	17.01
Sympodial Vs Oil	0.70*	1.12	0.53	4.27
Bolls Wt/Plant Vs Bolls / Plant	1.00**	3.62	0.99	– 3.81
Bolls Wt/Plant Vs Dry Matter	1.00**	0.45	0.84	– 81.707
Bolls Wt / Plant Vs Leaf Area	0.95**	0.02	0.93	– 73.03
Bolls Wt/Plant Vs Protein	0.29NS	1.97	0.07	15.79
Bolls Wt/Plant Vs Oil	0.73*	4.48	0.49	– 29.29
Bolls/ Plant Vs Dry Matter	1.00**	0.12	0.83	– 21.05
Bolls/Plant Vs Leaf Area	0.95**	0.01	0.93	– 18.78
Bolls/Plant Vs Protein	0.29NS	0.63	0.09	3.89
Bolls / Plant Vs Oil	0.73*	1.17	0.45	– 5.95
Dry Matter Vs Leaf Area	0.95**	0.04	0.88	49.25
Dry Matter Vs Protein	0.29NS	3.08	0.04	237.86
Dry Matter Vs Oil	0.73*	10.26	0.63	108.67
Leaf Area Vs Protein	0.24NS	91.94	0.05	4816.20
Leaf Area Vs Oil	0.74*	245.30	0.58	2053.50
Protein Vs Oil	– 0.06NS	–0.06	0.01	18.68

lation can be helpful in selection program for improvement of cotton varieties towards the yield. Both traits sympodia and bolls per sympodia were found mostly positively correlated with seed cotton yield [7].

Bolls wt / plant

Highest bolls weight per plant was observed in 2nd week of May sown crop and cultivars RCH 791 (66.3 g/plant) followed by SP 7121 (48.1 g/plant) and Pancham 541 (41.1 g/plant) with the mean average of 51.8 g/plant, 17% standard deviation and 5.6% standard error (Table 1 and Table 2). Bolls weight per plant displayed a highly significant positive correlation with bolls per plant, leaf area and dry matter (Table 3). This shows close association of the characters and this meaningful association can be exploited in selection program leading towards the improvement of cotton varieties. The coefficient of determination showed that bolls weight per plant was responsible for 99%, 84% and 93% variation in bolls per plant, dry matter and leaf area. The regression coefficient (b = 4.48) indicated that a unit increase in bolls weight per plant resulted into corresponding increase of 4.48 gms in oil content per plant (Table 3). Wang et al. [10] also evaluated upland cotton varieties and observed positive correlation of bolls per sympodia with seed cotton yield.

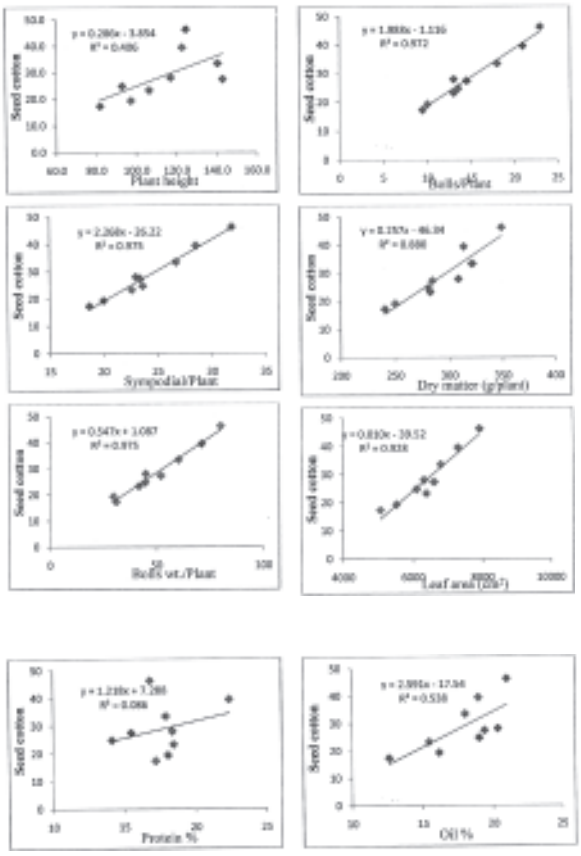

Fig. 1 (a, b). Graphical presentation of correlation and regression coefficient of different yield and morphological traits of cotton during 2015-2016.

Bolls / plant

Highest bolls per plant was observed in 2nd week of May sown crop and cultivars RCH 791 (19) followed by SP 7121 (14) and Pancham 541 (12) with the mean average of 22 bolls, 7.39% standard deviation and 2.47% standard error (Table 1 and Table 2). It is clear from Table 3 that bolls per plant exhibited strong positive association with dry matter and leaf area. The coefficient of determination ($r^2 = 0.93$) revealed 93% of the total variation dry matter attributable to the variation in number of bolls per plant. The regression coefficient (b =1.17) indicated that for a unit increase in bolls per plant, there would be a proportional increase of 1.17 units in protein content in seed cotton yield per plant.The present experimental study revealed that there had been positive and highly significant association between bolls per plant and seed cotton yield per plant. This exhibited that selection for high seed cotton yield per plant based on bolls per plant would be beneficial. Meena et al. [11] also evaluated the *Gossypium hirsutum* cultivars and hybrids, and observed varied values for bolls per plant. Copun [12] also compared the yield and yield

components of cotton cultivars and showed significant differences for these traits.

Dry matter

Maximum dry matter production (314.3 g/plant) was observed in RCH 791 followed by SP7121 (285.1 g/plant) and Pancham 541 (277.1 g) with mean average of 30.81 q/ha, 10.09% standard deviation and 3.36% standard error. Also earlier sown crop produced more dry matter and decreases laterward. Dry matter production is highly positive correlated with leaf area but not significant correlated with protein content. The coefficient of determination (R^2 = .88) revealed 88% of the total variation in dry matter production attributable to the variation in leaf area. The regression coefficient (b = 10.26) indicated that for a unit increase in dry matter, there would be a proportional increase of 10.26 units in oil content production.

Leaf area, protein and oil content

Maximum leaf area was observed in earlier sown crop and cultivars RCH 791 (7096.5 cm^2) followed by SP7121 (6302.3 cm^2) and Pancham 541 with the mean average of 3.91 LAI. Oil content in seed cotton yield is also higher in earlier sown crop and RCH 791 followed by SP7121 and Pancham 541. The mean average of protein content was 17.90% with standard deviation of 2.67% and 0.89% standard error. Whereas, protein content is higher is 3rd week of May sown crop and cultivar Pancham 541 followed by RCH 791 and SP 7121. The mean average of protein content is 17.67% with standard deviation of 2.28% and 0.76% standard error. Leaf area is significant positive correlated with oil content. Whereas, protein and oil content is negative correlated with each other. The coefficient of determination (R^2 = .58) revealed 58% of the total variation in protein content attributable to the variation in leaf area. The regression coefficient (b=245.30) indicated that for a unit increase in oil content, there would be a proportional increase of 245.30 units in leaf area production.

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