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Determining relationships between yield and biochemical traits in pumpkin

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Abstract
The objective of this study was to determine the relationships among fruit yield per plant (Kg), growth and biochemical traits using twenty one genotypes (15 F_1 hybrids and 6 Parents) of pumpkin during three seasons (E_1, E_2, E_3) and pooled analysis worked out. The observations were measured on biochemical traits and fruit yield per plant. The present investigation revealed that the fruit yield per plant had exhibited significant and positive phenotypic correlation with total soluble solids, ascorbic acid and negative and significant correlation with non-reducing sugars during E_1 (*Kharif*, 2015). However during E_2 *Rabi* season, 2015-16 biochemical traits like as dry matter content, total soluble solids, total sugars, reducing and non-reducing sugars, ascorbic acid and β-carotene were positively and significantly associated with fruit yield per plant at phenotypic level. Fruit yield per plant had positive and significant with total soluble solids, ascorbic acid, β-carotene and negative significant correlation with non-reducing sugars during E_3 (*Zaid*, 2016). The pooled analysis revealed that the total soluble solids, ascorbic acid and β-carotene were significantly and positively correlated with fruit yield per plant at phenotypic level.

Keywords: Pumpkin, correlation, fruit yield per plant, biochemical traits

Introduction
Pumpkin (*Cucurbita moschata* Duch. ex. Poir) is one of the most important vegetable crops of family cucurbitaceae grown throughout the world not only for providing better nutrition to the consumers but also higher returns to the farmers. It is originated from central Maxico. Pumpkin is a herbaceous annual, sexually propagated vegetable with chromosome number 2n=2x=40. The word pumpkin was originated from the Greek word *pepon*, which means “large melon", something round and large.
The color of pumpkin is due to the orange pigments. The main nutrients are lutein and both α and β-carotene, the latter of which generates vitamin A in the body. Pumpkins are very versatile in their uses for cooking. Most parts of the pumpkin are edible, including the fleshy shell, seeds, leaves, and even flowers. In the United States and Canada, pumpkin is a popular Halloween and Thanksgiving staple. Pumpkin purée is sometimes prepared and frozen for later use.
Pumpkin is relatively high in energy and carbohydrates and a good source of vitamins, especially high caretenoid pigments and minerals. It may certainly contribute to improve nutritional status of the people, particularly the vulnerable groups in respect of vitamin A requirement. Night-blindness is a serious problem of South Asian countries. Encouraging the mass people to take more pumpkin can easily be solved the problem.
Pumpkin exhibits great variability in its fruit shape, size, colour and yield along with other agronomic attributes (Singh, 2005 and Singh *et al.*, 2005). Like other cucurbits pumpkin is warm season crop and hence it may be cultivated round the year in central and southern states of the country, whereas, in northern parts of the country which face cooler winter months, it is generally cultivated during summer and rainy seasons for which sowing is generally done from January to July. Villagers in north India plant it in month of July-August after onset of monsoon in the mounds or hills in the vicinity of house and the growing plants are trained on thatches, hutments and other abandoned spaces. These genotypes used for planting in the vicinity of household are usually land races traditionally maintained by villagers and locally termed as *Bhadhavaha Kohara* (rainy season type pumpkin). *Bhadhavaha Kohara* is considered relatively tolerant to cool temperature and performs well during rainy season and extends fruiting in offing winter months. Hence, these genotypes are also referred to as winter type pumpkin.

The rainy season or winter season type genotypes produce adequate number of both staminate and pistillate flowers from late August to early September (which happens to be *Bhadrapada* month or *Bhadhau* month of Hindi calendar year) and bear prolific fruits during September-October and also in short days of November-December. If not damaged by frost they may remain productive with very shy bearing in forthcoming January-February.

Materials and methods

The experimental materials for the present study comprised of six promising and diverse inbreds and varieties of pumpkin selected on the basis of genetic variability from the germplasm stock maintained in the Department of Vegetable Science, N.D. University of Agriculture & Technology, Kumarganj, Faizabad (U.P.) India. The selected parental lines *i.e*. Narendra Upkar (P_1), NDPK-120 (P_2), Narendra Agrim (P_3), NDPK-39-2 (P_4), Kashi Harit (P_5) and NDPK-11-3 (P_6) were raised and crossed in the all possible combinations, excluding reciprocals, during *Zaid*, 2015 to get 15 F_1 hybrid seeds for the study of character association for fourteen quantitative traits. The experiments were conducted in Randomized Block Design (RBD) with three replications to assess the performance of 15 F_1 hybrids and 6 parents. The treatments were planted in rows spaced at 3.0 meters apart with a plant to plant spacing of 0.5 meter. The seeds were sown on 23th July, 2015 and 7th November 2015, 26th March, 2016 for *Kharif*, *Rabi* and *Zaid* crops, respectively. All the recommended agronomic package of practices and plant protection measures were followed to raise good crop.

Biochemical analysis

Ascorbic acid content was estimated at marketable green fruit stage by '2, 6- dichlorophenol-indophenol Visual Titration Method' as described by Ranganna (1979) [5]. Reducing sugars were estimated by Fehling 'A' and 'B' solution method given by Ranganna (1991) [6]. Non-reducing sugars was calculated by deducting the quantity of reducing sugars from total invert sugars and multiplied by factor 0.95. The results were expressed as percent non-reducing sugars.

Total sugars (%)

Total sugars were calculated by adding the quantity of reducing and non-reducing sugars. The results were expressed as total sugars in percent.

$$\text{Total sugars (\%)} = \text{Reducing sugars (\%)} + \text{Non - reducing sugars (\%)}$$

Dry matter content in fruit

The dry matter content in fruit was determined on the fresh weight basis. A quantity of 100 g of fresh fruit was taken, cut into small pieces in oven at 60±2 ˚C for 8-10 hours per day till the complete drying to have constant weight and dry matter percentage was calculated as:

$$\text{Dry matter (\%)} = \frac{\text{Dry matter of fruit (g)}}{\text{Fresh weight of fruit (g)}} \times 100$$

Total soluble solids (TSS) (°B)

Total soluble solids of the juice of fresh fruit of each lines and F_1's were determined with the help of hand refractometer (Erma, Japan) of 0-32 percent range. The values were collected at 20^{0}C and expressed as percent TSS of fresh fruit juice.

β-Carotene (mg/100g)

The β- carotene content was determined in mature fruit sample using the method develoed by Ranganna (1997) [7].

Statistical analysis

Phenotypic and genotypic correlation coefficients were worked out to study the relationship of various pairs of characters as suggested by Al-Jibouri *et al.* (1958) [7].

Results and discussion

Correlation coefficients

Correlation studies provides information that selection for one character will result in progress for all positively correlated characters. Many of the characters are correlated, because of natural association, positive or negative with other characters. As more variables are considered in correlation tables, their indirect correlation becomes more complex.

The phenotypic and genotypic correlation coefficient computed among the fourteen characters under study had been presented in Table 1 and 2 for E_1, 3 and 4 for E_2, 5 and 6 for E_3 and 7 and 8 for pooled. The correlation coefficient analysis revealed that the In general, genotypic correlation values were higher than those at phenotypic levels for most of the traits indicating strong inherent association between various characters studied.

The present investigation revealed that the fruit yield per plant had exhibited significant and positive phenotypic correlation with total soluble solids, ascorbic acid and negative and significant correlation with non-reducing sugars during E_1 (*Kharif*, 2015). However during E_2 *Rabi* season, 2015-16 biochemical traits like as dry matter content, total soluble solids, total sugars, reducing and non-reducing sugars, ascorbic acid and β-carotene were positively and significantly associated with fruit yield per plant at phenotypic level. Fruit yield per plant had positive and significant with total soluble solids, ascorbic acid, β-carotene and negative significant correlation with non-reducing sugars during E_3 (*Zaid*, 2016). The pooled analysis revealed that the total soluble solids, ascorbic acid and β-carotene were significantly and positively correlated with fruit yield per plant at phenotypic level. Pandey *et al.* (2002) [4] reported positive but non-significant association fruit yield per plant with ascorbic acid and β-carotene, Husna *et al*. (2011) [3] also found similar findings in bottle gourd and Akter *et al*. (2013) [1] reported in pumpkin.

In $E_{1,}$ dry matter content (Table-1) showed positive and significant correlation with total soluble solids, total sugars and reducing sugars at phenotypic level. Total soluble solids showed positive and significant correlation with total sugars and reducing sugars. Total sugars showed positive and significant correlation with reducing sugars and non-reducing sugars at phenotypic level. Non-reducing sugars had significant and negative association with β-carotene at phenotypic level. In E_2, dry matter content (Table-3) showed positive and significant correlation with total soluble solids, total sugars, reducing sugars, non-reducing sugars, ascorbic acid content and β-carotene at phenotypic level. Total soluble solids showed positive and significant correlation with total sugars, reducing sugars, non-reducing sugars, ascorbic acid content and β-carotene. Total sugars showed positive and significant correlation with reducing sugars, non-reducing sugars, ascorbic acid content and β-carotene at phenotypic level. Reducing sugars had significant and positive association with, non-reducing sugars, ascorbic acid and β-carotene at phenotypic level. Non-reducing sugars showed positive and significant association with ascorbic acid content at phenotypic level. In E_3, dry matter content showed (Table-5) positive and significant correlation with total soluble solids, total sugars and reducing sugars at phenotypic level. Total soluble solids showed positive and significant correlation with total sugars, reducing sugars, ascorbic acid content and negative and significant correlation with non-reducing sugars. Total sugars showed positive and significant correlation with reducing sugars and non-reducing sugars at phenotypic level. Non-reducing sugars had significant and negative association with β-carotene at phenotypic level. On the basis of pooled analysis, (Table-7) correlations study revealed that dry matter content showed positive and significant correlation with total soluble solids, total sugars, reducing sugars, ascorbic acid content and β-carotene at phenotypic level. Total soluble solids showed positive and significant correlation with total sugars, reducing sugars and ascorbic acid content. Total sugars showed positive and significant correlation with reducing sugars, non-reducing sugars and ascorbic acid content at phenotypic level. Reducing sugars had significant and positive association with, non-reducing sugars, ascorbic acid and β-carotene at phenotypic level.

Table 1: Estimates of correlation coefficient at phenotypic level for biochemical traits and yield in pumpkin during *Kharif*, 2015 (E_1)

Traits	Total soluble solids	Total sugars	Reducing sugars	Non-reducing sugars	Ascorbic acid	β-carotene	Fruit yield per plant
Dry matter content	0.293**	0.247**	0.394**	-0.124	0.006	0.126	-0.154
Total soluble solids		0.259**	0.492**	-0.190	0.204**	0.042	0.425**
Total sugars			0.723**	0.461**	-0.033	-0.187	-0.113
Reducing sugars				-0.086	0.012	0.026	0.011
Non-reducing sugars					-0.125	-0.311**	-0.230**
Ascorbic acid						0.153	0.258**
β-carotene							0.139

*, ** Significant at 5 percent and 1 percent probability levels, respectively

Table 2: Estimates of correlation coefficient at genotypic level for biochemical traits and yield in pumpkin during *Kharif*, 2015 (E_1)

Traits	Total soluble solids	Total sugars	Reducing sugars	Non-reducing sugars	Ascorbic acid	β-carotene	Fruit yield per plant
Dry matter content	0.325	0.244	0.477	-0.250	-0.002	0.129	-0.180
Total soluble solids		0.261	0.545	-0.316	0.208	0.026	0.446
Total sugars			0.823	0.520	-0.038	-0.250	-0.147
Reducing sugars				-0.155	0.026	-0.010	0.030
Non-reducing sugars					-0.162	-0.393	-0.313
Ascorbic acid						0.156	0.251
β-carotene							0.135

Table 3: Estimates of correlation coefficient at phenotypic level for biochemical traits and yield in pumpkin during *Rabi*, 2015-16 (E_2)

Traits	Total soluble solids	Total sugars	Reducing sugars	Non-reducing sugars	Ascorbic acid	β-carotene	Fruit yield per plant
Dry matter content	0.961**	0.961**	0.892**	0.766**	0.587**	0.437**	0.387**
Total soluble solids		0.999**	0.926**	0.797**	0.602**	0.401**	0.450**
Total sugars			0.932**	0.789**	0.594**	0.402**	0.435**
Reducing sugars				0.515**	0.520**	0.298**	0.328**
Non-reducing sugars					0.540**	0.463**	0.491**
Ascorbic acid						-0.084	0.261**
β-carotene							0.428**

*, ** Significant at 5 percent and 1 percent probability levels, respectively

Table 4: Estimates of correlation coefficient at genotypic level for biochemical traits and yield in pumpkin during *Rabi*, 2015-16 (E_2)

Traits	Total soluble solids	Total sugars	Reducing sugars	Non-reducing sugars	Ascorbic acid	β-carotene	Fruit yield per plant
Dry matter content	0.995	0.997	0.925	0.788	0.603	0.449	0.414
Total soluble solids		0.999	0.926	0.797	0.617	0.410	0.466
Total sugars			0.931	0.788	0.609	0.411	0.453
Reducing sugars				0.510	0.533	0.300	0.341
Non-reducing sugars					0.550	0.479	0.508
Ascorbic acid						-0.096	0.268
β-carotene							0.447

Table 5: Estimates of correlation coefficient at phenotypic level for biochemical traits and yield in pumpkin during *Zaid*, 2015-16 (E_3)

Traits	Total soluble solids	Total sugars	Reducing sugars	Non-reducing sugars	Ascorbic acid	β-carotene	Fruit yield per plant
Dry matter content	0.297**	0.247**	0.390**	-0.108	0.020	0.126	-0.138
Total soluble solids		0.280**	0.501**	-0.240**	0.226**	0.046	0.441**
Total sugars			0.725**	0.500**	0.010	-0.184*	-0.078
Reducing sugars				-0.101	0.039	0.025	0.038
Non-reducing sugars					-0.067	-0.330**	-0.226**
Ascorbic acid						0.161*	0.274**
β-carotene							0.149*

*, ** Significant at 5 percent and 1 percent probability levels, respectively

Table 6: Estimates of correlation coefficient at genotypic level for biochemical traits and yield in pumpkin during *Zaid*, 2016 (E_3)

Traits	Total soluble solids	Total sugars	Reducing sugars	Non-reducing sugars	Ascorbic acid	β-carotene	Fruit yield per plant
Dry matter content	-0.188	0.434	-0.172	0.010	-0.258	0.245	0.134
Total soluble solids		0.323	0.244	0.480	-0.258	-0.006	0.130
Total sugars			0.248	0.540	-0.312	0.197	0.024
Reducing sugars				0.822	0.592	-0.062	-0.251
Non-reducing sugars					-0.066	0.012	-0.009
Ascorbic acid						-0.088	-0.389
β-carotene							0.149

Table 7: Estimates of correlation coefficient at phenotypic level for biochemical traits and yield in pumpkin over seasons (pooled)

Traits	Total soluble solids	Total sugars	Reducing sugars	Non-reducing sugars	Ascorbic acid	β-carotene	Fruit yield per plant
Dry matter content	0.563**	0.549**	0.584**	0.174*	0.258**	0.240**	0.016
Total soluble solids		0.582**	0.663**	0.122	0.382**	0.177	0.430**
Total sugars			0.807**	0.580**	0.265**	0.046	0.077
Reducing sugars				0.101	0.230**	0.122	0.113
Non-reducing sugars					0.131	-0.082	-0.050
Ascorbic acid						0.061	0.256**
β-carotene							0.221**

*, ** Significant at 5 percent and 1 percent probability levels, respectively

Table 8: Estimates of correlation coefficient at genotypic level for biochemical traits and yield in pumpkin over seasons (pooled)

Traits	Total soluble solids	Total sugars	Reducing sugars	Non-reducing sugars	Ascorbic acid	β-carotene	Fruit yield per plant
Dry matter content	0.586	0.576	0.264	0.275	0.047	0.441	0.198
Total soluble solids		0.542	0.406	0.632	-0.279	0.452	0.355
Total sugars			0.606	0.717	-0.049	0.719	0.292
Reducing sugars				0.842	0.447	0.452	0.129
Non-reducing sugars					-0.144	0.382	0.264
Ascorbic acid						0.190	-0.165
β-carotene							0.313

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