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Full Length Research Paper

Multivariate analysis of quantitative traits in Iranian pumpkin lines (*Cucurbita* spp.)

Mehrab Yadegari[1]*, Ahmad Reza Golparvar[2] and Rahim Barzegar[3]

[1]Department of Agronomy and Plant Breeding, Shahrekord Branch, Islamic Azad University, Shahrekord, Iran.
[2]Department of Agronomy and Plant Breeding, Khorasgan (Isfahan) Branch, Islamic Azad University, Isfahan, Iran.
[3]Department of Agronomy and Plant Breeding, Shahrekord University, Shahrekord, Iran.

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Pumpkin is an important plant, which is one of the oldest domesticated crops of the Neolithic revolution. In this study, seed yield production and its different components fruit length, fruit diameter, fruit length/fruit diameter ratio (FL/FD), diameter of flesh, diameter of seed core, fruit weight, weight of 1000 seed from 24 lines of pumpkin grown in Iran were examined. Twenty five characters in all plant lines were measured by a Descriptor (UPOV) and data were subjected to cluster analysis. Results showed that plant lines were divided in four groups. In all groups, regression comparisons were made for modeling the effect of different characters on seed yield, results also showed that fruit weight and fruit length in all groups had the most direct effect on seed yield. In conclusion, these traits are suggested as the best indirect selection criteria to improve the seed yield genetically in *Cucurbita* spp. genotypes especially in preliminary generation of breeding and selection programs.

Key words: Pumpkin (*Cucurbita pepo),* path analysis, fruit weight, fruit length.

INTRODUCTION

Pumpkin (*Cucurbita* spp) has 5 domestic species and 10 wild species the most important species are *Cucurbita muschata, Cucurbita pepo, Cucurbita maxima* with common names Squash, Pumpkin and Guard, respectively. This plant has many uses in many countries (Robinson and Walters, 1997; Bonebardelli and Morazoni, 1997). *Cucurbita* genus has the 8th place in vegetables and China is the first producer country of it whereas Iran is in the 9th place (FAOSTAT, 2007). Fruit and seeds of *Cucurbita* have many edible and medicinal uses in the world. These plants have much fatty acids, proteins, Se and Zn (Robinson and Walters, 1997). The main nutritionally relevant components of pumpkin seeds are protein and oil. Oil of this plant is very important in many countries. Seeds have many essential oil and protein. Non-saturated oils (linoleic acid, β sytosterol, vitamin E, etc) are used in making many medicinal drugs(Horvath and Bedo, 1988). Seeds of this plant are used for parasitic diseases cure in African countries (Younis et al., 2000).

Pepos have various fruit styles like cylinder, Ellipse, globular, etc from growth form aspect. Pepos are divided to crawly (long stem), shrub (short stem with small internodes), and semi shrub (have intermediated properties) (Paris, 1989). Berenji and Popp (2000) reported that fruits with lower weight were suitable for seed production. Gholipouri and Nazarinejad (2007) showed that by topping of stems, fruit number increased two times than control plants. The various uses of materials and components of yield reported in many projects but the status of components on yield are not listed. This research was conducted in order to assess the relationship among some quantitative traits and yield as well as determination of the best yield components in Iranian pumpkin lines (*Cucurbita* spp.).

MATERIALS AND METHODS

Seed collection

The total of lines is 48 samples, and 28 samples were collected from north provinces and others prepared from Gene bank (Seed

*Corresponding author. E-mail: mehrab_yadegari@yahoo.com.

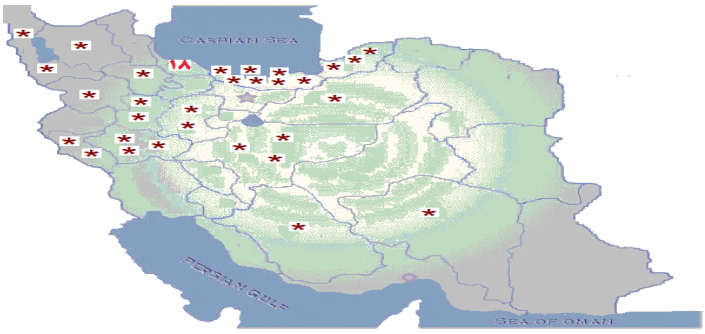

Figure 1. Geographic variation of collected samples.

Table 1. Physical and Chemical characteristics of the experimental farm soil.

pH	O.C (%)	E.C (ds/m)	Zn available (ppm)	Fe availabe (ppm)	Mn availabe (ppm)	Cu availabe (ppm)	K availabe (ppm)	P availabe (ppm)	Total nitrogen (%)	Texture	Depth (cm)
8.33	0.79	0.47	1.136	3.453	9.79	1.108	245	2.8	0.065	Loam	0-30

Table 2. Means and SD of seed yield (kg) in pepo lines and place of collection in Iran.

Line number	Means ± SD	Group	Place of collection
1	86.7 ± 2.3	a	Behshahr (A13)
2	79.02 ± 20.9	ab	Naghadeh (A4)
3	78.5 ± 25.9	ab	Esfahan (A23)
4	67.7 ± 8.4	b	Astaneh (A38)
5	66.1 ± 23.2	ab	Ramian (A55)
6	65.8 ± 13.9	bc	Ilam (A19)
7	65.5 ± 19.6	bc	Astaneh (A51)
8	63.8 ± 16.2	bc	Langroud (A44)
9	63.2 ± 18.5	bc	Astaneh (A26)
10	59.1 ± 20.4	bc	Malayer (A2)
11	58.7 ± 19.3	bc	Tabriz (A7)
12	56.2 ± 22.3	bc	Behshahr (A13)
13	54.5 ± 25.5	bc	Khoram abad (A57)
14	52.6 ± 7.7	bc	Zanjan (A1)
15	47.11 ± 12.2	bc	Astaneh (A33)
16	46 ± 9.2	c	Lasht nesha (A34)
17	44.8 ± 14.1	c	Astaneh (A40)
18	42.7 ± 13.9	c	Astaneh (A36)
19	41.9 ± 14.2	c	Khoram abad (A8)
20	41 ± 18.2	c	Khoram abad (A9)
21	40.9 ± 11.3	c	Amol (A53)
22	38.8 ± 10.5	c	Esfahan (A21)
23	38.5 ± 13.9	c	Astaneh (A45)
24	37.3 ± 8.5	c	Astaneh (A39)
25	34.2 ± 15.6	c	Arak (A56)

and Plant Improvement Institute. In Figure 1, the places that seeds were collected are shown. Most of them were collected from Guilan Province (18 samples).

Experimental conditions

In order to evaluate pumpkin lines in Iran by morphological properties, experiment was conducted at Shahrekord (latitude 50°56' E 32°18' N), located at about 500 km of capital town of Iran during spring and summer 2011. The medial annual rainfall is about 337.2-mm per year. Average annual temperature is 11.2°C. Soil texture was loam. C, N, P and K content, EC, pH and percentage of sand, silt and clay were determined (Table 1). Topsoil of the experimental plot area was kept moist throughout the growing season when necessary. After soil test, the required nutrients were added to soil. Ploughing and other practices were conducted before planting.

Hills were performed by four meter distances from others. This study was prepared by randomized complete block design with three replications and each plot involved three plants. Pre seedling plants were sown in the farm at 22 May. Husbandry practices were done. Fruit length, Fruit diameter, Fruit length/ Fruit diameter ratio (FL/FD), Diameter of Flesh, Diameter of seed core, Fruit weight, Weight of 1000 seed and Seed yield were studied. Statistical analysis was done by SAS and SPSS. Twenty samples were collected from each line and means of three plants in each plot were considered as mean of each plot.

RESULTS AND DISCUSSION

Mean and standard deviation of the traits showed significant difference among pumpkin lines for all the traits (Table 2). The Pearson's correlation analysis also revealed the meaningful interrelationship between traits (Table 3).

Seed yield

For omission of ineffectiveness traits or less effectiveness

Table 3. Correlation between yield components in pepo lines.

Yield components	Fruit length	Fruit diameter	FL/FD	Diameter of flesh	Diameter of seed core	Weight of fruit	Weight of 1000 seed	Seed yield
Fruit length	1	-0.45**	0.88**	0.03	-0.53**	0.2**	-0.02	0.07
Fruit diameter		1	-0.77**	0.52**	0.96**	0.72**	0.48**	0.51**
FL/FD			1	-0.26**	-0.79**	-0.22	-0.25**	-0.22**
Diameter of flesh				1	0.27**	0.68**	0.39**	0.4**
Diameter of seed core					1	0.59**	0.41**	0.44**
Weight of fruit						1	0.51**	0.65**
Weight of 1000 seed							1	0.42**
Seed Yield								1

Significant in α=5% and ** significant in α=1%.

Table 4. Path analysis of seed yield.

Path	Direct effect	Indirect effect	Total correlation
FL/FD			
Direct effect	-0.48**		
Indirect effect by diameter of flesh		0.3	-0.63
Indirect effect by weight of fruit		-0.165	
Indirect effect by weight of 1000 seed		-0.02	
Diameter of flesh			
Direct effect	-0.14**		
Indirect effect by FL/FD		0.12	0.53
Indirect effect by weight of fruit		0.51	
Indirect effect by weight of 1000 seed		0.04	
Weight of fruit			
Direct effect	0.75**		
Indirect effect by FL/FD		0.1	0.81
Indirect effect by diameter of flesh		-0.09	
Indirect effect by weight of 1000 seed		0.05	
Weight of 1000 seed			
Direct effect	0.11**		
Indirect effect by FL/FD		0.12	0.56
Indirect effect by diameter of flesh		-0.05	
Indirect effect by fruit weight		0.38	

traits in step to step regression model, forward and backward regression was conducted. Therefore, forward regression was the best for detection. In path analysis, this character followed forward model. In general, between separate comparisons between lines this character is dependent on all components with exception to Fruit diameter and Fruit length. Length / Diameter ratio of fruit is significant but in separated comparisons between lines this character was not significant. In both tests (all data and separated lines), the fruit weight was the most important character that seed yield depended on it. Results of seed yield components path analysis are shown in Table 4. Direct effects of four traits (weight of 1000 seed, Fruit weight, Diameter of Flesh and L/TF) have the positive and direct effect. The regression formula that was obtained is:

Yield= 51.88 + 0.05 weight of 1000 seed + 12.07 Fruit weight – 0.43 Diameter of Flesh – 12.39 FL/FD (R=0.45)

Chretien and Loy (2000) reported that seed yield per fruit was positively correlated with fruit size (r=0.68). In a

Table 5. Path analysis of fruit length.

Path	Direct effect	Indirect effect	Total correlation
Diameter of fruit			
Direct effect	-0.13**		-0.45**
Indirect effect by FL/FD		-0.68	
Indirect effect by Weight of fruit		0.36	
FL/FD			
Direct effect	0.89**		0.88**
Indirect effect by fruit diameter		0.1	
Indirect effect by weight of fruit		-0.11	
Weight of fruit			
Direct effect	0.51**		0.23**
Indirect effect by diameter of fruit		-0.09	
Indirect effect by FL/FD		-0.19	

similar fashion, seed size was positively correlated with fruit size (r = 0.58).

On the other hand, the highest seed yield indices (SYI) were obtained in fruit weighing between 0.5 and 1.5 kg index and seed yield index are highly correlated with seed yield. Bidgoli et al. (2006) in a study of safflower reported that one of the characters that correlated with seed yield was 1000-seed yield. In Bambara groundnut (*Vigna subterranea*), number of leaves was more important in determining seed yield in the bunch types, but leaf size was rather more important in the spreading types (Ofori, 1996).

Fruit length

For omission of ineffectiveness traits or less effectiveness traits in step to step regression model, forward and backward regression was conducted, and therefore forward regression was the best for detection. In path analysis, this character followed the forward model. In path analysis this character followed forward model and was dependent on fruit weight, fruit diameter and fruit length/ fruit diameter (Table 5). Our data showed that the effect of these 3 traits were direct and significantly positive. The effectiveness of fruit weight from indirect effect on fruit diameter was positive and on FL/FD was negative. The regression formula that was obtained is:

Fruit diameter = 2.98 + Diameter of seed core + 0.2 Diameter of Flesh (R= 0.95)

Khan et al. (2009) showed that Fruit length had positive correlation with single fruit weight, pulp seed ratio, number of fruits per plant and yield of fruit per hectare.

On the other hand, negative correlation with Fruit weight per plant. Saha et al. (1992) reported also similar results in respect of fruit length in pumpkin. Number of fruits per plant had positive significant correlation with Fruit weights per plant (0.915**) and yield of fruit (0.813**) which indicates that yield per plant will be increased with the increase in fruit number. These results are in line with the findings of Singh (1983) and Singh et al. (1993), in pointed gourd, Panwar et al. (1977) in sponge gourd and Rana (1982) in Pumpkin. In that research, Fruit weights per plant had positive significant correlation with yield of fruit (0.890**) which indicates that yield per plant will be increased with the increase in fruit number. Similar findings were noticed by Singh et al. (1986) and Singh and Prasad (1989). Khan et al. (2009) in a study reported that fruit breadth had positive direct effect (1.348) on yield per plant, but it showed negative indirect effect on yield through days to first flower, number of node at first harvest, fruit length, fruit weight, and pulp seed ratio, number of fruits per plant and fruit weight per plant. Fruit weight had considerable direct and positive effect (0.331) on fruit yields per plant.

Fruit diameter

In path analysis, this character followed the backward model and dependent to the weight of 1000 seed, Fruit Length/ Fruit Diameter, Fruit Weight and diameter of seed core. In regression result, more of these character, Fruit length and Diameter of flesh were effective too (by very small regression coefficient) (Table 6). Data analysis showed that the effectiveness of diameter of flesh and diameter of seed core from indirect effects on even traits was positive and on Fruit diameter was significantly positive. The regression formula that was obtained is:

Fruit diameter = 2.98 + Diameter of seed core + 0.2 Diameter of Flesh

Table 6. Path analysis of fruit diameter.

Path	Direct effect	Indirect effect	Total correlation
Diameter of flesh			
Direct effect	0.28633**		0.524**
Indirect effect by diameter of seed core		0.2386	
Diameter of seed core			
Direct effect	0.88382**		0.961**
Indirect effect by diameter of flesh		0.0773	

Table 7. Path analysis of Fruit length/Fruit diameter.

Path	Direct effect	Indirect effect	Total correlation
Fruit length			
Direct effect	0.7737**		0.88**
Indirect effect by diameter of fruit		0.135	
Indirect effect by diameter of flesh		-0.001	
Indirect effect by fruit weight		-0.028	
Diameter of fruit			
Direct effect	-0.3**		-0.77**
Indirect effect by fruit length		-0.348	
Indirect effect by diameter of flesh		-0.017	
Indirect effect by weight of fruit		-0.101	
Diameter of Flesh			
Direct effect	-0.03**		-0.26**
Indirect effect by fruit length		0.023	
Indirect effect by diameter of fruit		-0.156	
Indirect effect by fruit weight		-.096	
Fruit weight			
Direct effect	-0.14**		-0.22**
Indirect effect by fruit length		0.154	
Indirect effect by diameter of fruit		-0.216	
Indirect effect by diameter of flesh		-0.0204	

Fruit length / fruit diameter

In path analysis this character followed the forward model and was dependent on fruit length, fruit diameter, Fruit weight and Fruit diameter (Table 7). Results of Fruit length/ Fruit diameter ratio path analysis are shown in Table 7. The direct effect of fruit length was significantly positive and other (Fruit diameter, Fruit weight, Diameter of Flesh) were significantly negative. Both effectiveness of the diameter of flesh and fruit weight on the other and on FL/FD was significantly negative. The regression formula that was obtained is:

FL/FD = 0.94 + 0.07 Fruit length – 0.05 Fruit diameter – 0.004 Diameter of Flesh – 0.089 Fruit weight (R=0.99)

Fruit length:diameter (L:D) is considered a yield component, since it determines marketable yield. For example, U.S. processing cucumbers must have an L:D of 2.9 to 3.3 to be commercially acceptable (Staub and Bacher, 1997). Although important for marketable yield, L:D is generally associated with lower fruit number per plant, r = -0.98 (Serquen et al., 1997a); r = -0.27 to -0.36, (Fazio, 2001).

Diameter of flesh

In path analysis, this character followed the forward model and was dependent on Fruit weight, Diameter of seed core and Fruit diameter. In the result of regression,

Table 8. Path analysis of diameter of flesh.

Path	Direct effect	Indirect effect	Total correlation
Diameter of seed core			
Direct effect	-3.08**		0.27**
Indirect effect by diameter of fruit		3.3504	
Diameter of fruit			
Direct effect	3.49**		0.52**
Indirect effect by diameter of seed core		-2.9568	

Table 9. Path analysis of Diameter of seed core.

Path	Direct effect	Indirect effect	Total correlation
Diameter of fruit			
Direct effect	1.13**		0.96**
Indirect effect diameter of flesh		-0.156	
Diameter of flesh			
Direct effect	-0.3**		0.27**
Indirect effect by diameter of fruit		0.5876	

Fruit weight was not significant (Table 8). The direct effect of diameter of seed core on diameter of flesh was negative and on Fruit diameter was significantly positive. Indirect effect of diameter of seed core on Fruit diameter was negative and Fruit diameter on diameter of seed core from indirect effect was positive. The regression formula that was obtained is:

Diameter of Flesh = -5 Diameter of seed core + 5 Fruit diameter (R= 0.99)

Diameter of seed core

In path analysis this character followed the backward model and was dependent to weight of 1000 seed, Fruit length, FL/FD and Fruit weight. In regression result, more of these character, Fruit diameter and Diameter of flesh were significant too (by a very small regression coefficient). Diameter of seed core path analysis is shown in Table 9. Direct effect of Fruit diameter on seed core diameter was significantly positive and flesh diameter effect on seed core diameter was significantly negative. Indirect effect of flesh diameter on fruit diameter was negative. Fruit diameter effect of flesh diameter was positive. Correlations of bouth traits on seed core diameter were significantly positive. The regression formula that was obtained is:

Diameter of seed core = Fruit diameter – 0.2 Diameter of Flesh (R=0.99)

Fruit weight

In path analysis, this character followed the forward model and was dependent on Fruit length, Fruit diameter, and Diameter of flesh and FL/FD. The direct effect of fruit diameter, fruit length, and flesh diameter were significantly positive and the effect of FL/FD ratio on fruit weight was significantly negative (Table 10). The regression formula that was obtained is:

Fruit weight = -4.38 + 0.12 Fruit length + 0.21 Fruit diameter – 0.39FL/FD + 0.031 Diameter of Flesh (R=0.95)

Mishra et al. (1990) reported that fruit weight was one of the most important characters contributing towards fruit yield. The results of the present experiment also suggest that selection for fruit weight would increase fruit yield of this crop. Khan et al. (2009) showed that Fruit weight per plant had positive indirect effect on yield via fruit length, fruit breadth and number of fruits per plant. As evident from correlation studies, the fruit length and fruit weight, pulp seed ratio, number of fruits per plant and Fruit weights per plant were important for pointed gourd yield, which showed moderate and positive relationship with yield, selection could be effective for breeding about the improvement of pointed gourd. A similar result was found in pointed gourd (Singh et al., 1993).

The result of the present experiment revealed (Table 11) that a wide variability existed among the collected pointed gourd accessions. Also, there was correlation of

Table 10. Path analysis of fruit weight.

Path	Direct effect	Indirect effect	Total correlation
Fruit length			
Direct effect	0.7894**		
Indirect effect by diameter of fruit		-0.355	0.2**
Indirect effect by FL/FD		-0.221	
Indirect effect by Diameter of Flesh		0.005	
Diameter of fruit			
Direct effect	0.7968**		
Indirect effect by fruit length		-0.355	0.72**
Indirect effect by FL/FD		0.193	
Indirect effect by diameter of Flesh		0.086	
FL/FD			
Direct Effect	-0.2512**		
Indirect effect by fruit length		0.694	-0.22**
Indirect effect by diameter of fruit		-0.613	
Indirect effect by diameter of Flesh		-0.043	
Diameter of flesh			
Direct effect	0.1666**		
Indirect effect by fruit length		0.023	0.68**
Indirect effect by diameter of fruit		0.414	
Indirect effect by FL/FD		0.065	

Table 11. Results of cluster analysis and lines of each cluster and their properties.

Cluster	Code	Fruit shape in length	FL/FD
Cluster 1	A1, A2, A4, A7, A19	oval	1.2-1.7
Cluster 2	A23, A33, A45, A55	globular	0.9-1.1
Cluster 3	A38, A51, A40, A26, A44, A33, A39	Ellipse	<0.85
Cluster 4	A8, A9, A13, A21, A36, A53, A56, A57	cylinder	>1.9

Table 12. Correlation between characters in first cluster (oval fruits).

Character	Seed yield	Fruit length	Fruit diameter	FL/FD	Flesh diameter	F/DF	Fruit weight	1000 Seed weight
Seed yield	1							
Fruit length	0.31**	1						
Fruit diameter	0.60**	0.07^{ns}	1					
FL/FD	-0.17^{ns}	0.67**	-0.65**	1				
Flesh diameter	0.34**	0.44**	0.49**	-0.04^{ns}	1			
F/DF	-0.18^{ns}	0.37**	-0.40**	0.56**	0.58**	1		
Fruit weight	0.647**	0.64**	0.79**	-0.11^{ns}	0.70**	-0.01^{ns}	1	
1000 seed weight	0.51**	0.50**	0.58**	-0.05^{ns}	0.63**	0.11^{ns}	0.78**	1

different yield components with the yield of pointed gourd. Lannes et al. (2007) working with *Capsicum chinense* showed a positive linear correlation between fruit weight and fruit wall thickness and it is important for the

Table 13. Correlation between characters in second cluster (globular fruits).

Character	Seed yield	Fruit length	Fruit diameter	FL/FD	Flesh diameter	F/DF	Fruit weight	1000 seed weight
Seed yield	1							
Fruit length	0.752**	1						
Fruit diameter	0.584**	0.44**	1					
FL/FD	0.15^{ns}	0.54**	-0.50**	1				
Flesh diameter	0.387**	0.43**	0.61**	-0.14^{ns}	1			
F/DF	-0.09^{ns}	0.13^{ns}	-0.25*	0.39**	0.59**	1		
Fruit weight	0.745**	0.698**	0.90**	-0.17^{ns}	0.683**	-0.06^{ns}	1	
1000 seed weight	0.31**	0.26*	0.28**	0.00^{ns}	0.30**	0.07^{ns}	0.32**	1

Table 14. Correlation between characters in third cluster (ellipse fruits).

Character	Seed yield	Fruit length	Fruit diameter	FL/FD	Flesh diameter	F/DF	Fruit weight	1000 seed weight
Seed yield	1							
Fruit length	0.46**	1						
Fruit diameter	0.54**	0.58**	1					
FL/FD	0.11^{ns}	0.70**	-0.16*	1				
Flesh diameter	0.343**	0.55**	0.65**	0.08^{ns}	1			
F/DF	0.00^{ns}	0.20*	0.04^{ns}	0.19^{ns}	0.77**	1		
Fruit weight	0.587**	0.81**	0.91**	0.19^{ns}	0.72**	0.19*	1	
1000 seed weight	0.521**	0.44**	0.44**	0.14^{ns}	0.38**	0.13^{ns}	0.494**	1

Table 15. Correlation between characters in fourth cluster (cylinder fruits).

Character	Seed yield	Fruit length	Fruit diameter	FL/FD	Flesh diameter	F/DF	Fruit weight	1000 seed weight
Seed yield	1							
Fruit length	0.334**	1						
Fruit diameter	0.51**	0.50**	1					
FL/FD	-0.09^{ns}	0.63**	-0.35**	1				
Flesh diameter	0.30**	0.37**	0.57**	-0.10^{ns}	1			
F/DF	-0.10^{ns}	-0.01^{ns}	-0.23*	0.20*	0.66**	1		
Fruit weight	0.569**	0.777**	0.85**	0.08^{ns}	0.65**	0.01^{ns}	1	
1000 seed weight	0.20*	0.33**	0.35**	0.04^{ns}	0.24*	-0.01^{ns}	0.36**	1

selection of varieties more appropriate for fresh market sale, since fruits with thicker wall are more resistant to wounding during post harvest handling and subsequent shipping.Ramalho et al. (2011) in a study of pepper showed that major fruit width, fruit weight and fruit dry matter were the only fruit traits with positive correlation with yield. Plant width, height, first bifurcation height and fruit set were positively correlated between them and with yield. Maggs-Kölling and Christiansen (2003) in a study of watermelon showed that there was a positive correlation between yield and fruit weight for all groups, except the seed melon type, as well as for yield and fruit number for all groups (Table 12).

For the two groups with the widest variation in fruit weight (Table 13), that is the cooking melons and the commercial varieties, there was a significant difference in the correlation between fruit weight and total yield (Table 14). The cooking melons responded strongest to increasing fruit number (yield (t/ha) = –20.19685 + 18.20625× fruit weight) and the commercial varieties more moderately (yield (t/ha) = 4.132195 + 6.221633 × fruit weight). A significant difference was found in the correlation between number of fruit and total yield between the cooking melons and the local watermelon subgroups (Table 15). A strong response was found for the cooking melon types (yield (t/ha) = -31.04031

Table 16. Results of regression analysis of seed yield in groups of *C. pepo*.

Group	Characters input in model	Regression coefficient	R^2
Oval fruits	Fruit weight	12.25	0.419
	Flesh diameter	-0.62	0.444
Seed yield= 44.76+12.25 (fruit weight) – 0.62(flesh diameter)			
Globular fruits	Fruit length	2.88	0.565
	Fruit weight	10.98	0.668
	Flesh diameter	-0.71	0.679
Seed yield= -10.29+10.98 (fruit weight)+ 2.88 (fruit length) -0.71(flesh diameter)			
Ellipse fruits	Fruit weight	7.7	0.344
	1000 seed weight	0.11	0.416
	Flesh diameter	-0.51	0.432
Seed yield= 25.21+7.7 (fruit weight)+0.11 (1000seed weight) -0.507(flesh diameter)			
Cylinder fruits	Fruit weight	16.57	0.323
	Fruit length	-0.8	0.353
Seed yield= 34.45+16.57(fruit weight) – 0.8 (fruit length)			

+76.29279 × fruit number), whereas the yield increase with increasing fruit number in the local watermelons was less pronounced (yield (t/ha) = 0.590602 +18.10914 × fruit number).

Weight of 1000 seed

In path analysis, this character followed the forward model and was dependent on Fruit diameter and Fruit weight but in the regression result, this character was only affected by Fruit diameter. The regression formula that was obtained is:

Weight of 1000 seed = 88.4 + 3.03 Fruit diameter (R=0.28)

In wheat cultivars, yield dependent to weight of 1000 seed (Khayatnejad et al., 2011; Ehdaie and Waines, 1989).

Conclusion

There was a significant correlation in all clusters between fruit diameter with seed yield, the most correlation was in oval fruits and the least in cylinder fruits. In all clusters except globular fruits, correlation between fruit diameter with seed, yield more than fruit length with seed yield. The most important character in all groups, which correlated with seed yield, was fruit weight. The most correlation was in globular fruit. In all groups, correlation between 1000 seed weight and fruit weight was significant then by increasing of fruit weight, seed size and 1000 seed weight was increased. The most correlation was between fruit weight and 1000 seed weight (0.78) in the first cluster and the least correlation was in the second cluster (0.32). In all groups, correlation between fruit diameter and fruit weight was more than correlation between fruit length and fruit weight.

In ellipse fruits, 1000 seed weight and fruit weight (by positive index) and flesh diameter (by negative index) were most important characters on seed yield. Results from path analysis (Table 16) in oval fruits showed that fruit weight has more direct effect than flesh fruit but by negative indirect effect of fruit flesh, correlation between seed yield and fruit weight less than direct effect. However there was negative direct effect for flesh diameter but by positive indirect effect of fruit weight, correlation between seed yield and flesh diameter was positively significant. Path analysis in globular fruits showed that the fruit weight has the most direct effect and positive indirect effect from fruit length and negative indirect effect from fruit flesh on seed yield. Because there was positive indirect effect of fruit length on fruit weight, correlation between fruit length and seed yield more than correlation between fruit weight and seed yield. In this group, the direct effect of flesh diameter was negative too but by positive indirect effects of flesh diameter on fruit weight and fruit length, correlation between flesh diameter and seed yield was positively significant.

In ellipse and cylinder fruits, fruit weight had the most direct effect too. Fruit weight had negative indirect effect on fruit length in cylindrical fruits and then correlation between fruit weight and seed yield was less than the direct of it. The direct fruit length was negative, but indirect of it on fruit weight caused that correlation

Table 17. Results of path analysis of seed yield in various clusters

Cluster	Character	Path	Path coefficient
1	Fruit weight	Direct effect	0.802**
		Indirect effect from fruit flesh	-0.153
		Total correlation	0.647**
	Fruit flesh	Direct effect	-0.221**
		Indirect effect from fruit weight	0.561
		Total correlation	0.34**
	Residual error		0.746
2	Fruit length	Direct effect	0.435**
		Indirect effect from fruit flesh	-0.084
		Indirect effect from fruit weight	0.4
		Total correlation	0.752**
	Fruit weight	Direct effect	0.573**
		Indirect effect from fruit length	0.304
		Indirect effect from fruit flesh	-0.132
		Total correlation	0.745**
	Flesh diameter	Direct effect	-0.194*
		Indirect effect from fruit length	0.188
		Indirect effect from fruit weight	0.391
		Total correlation	0.387**
	Residual error		0.567
3	Fruit weight	Direct effect	0.566**
		Indirect effect from fruit flesh	-0.132
		Indirect effect from 1000 seed weight	0.153
		Total correlation	0.587**
	1000 seed weight	Direct effect	0.312**
		Indirect effect from fruit weight	0.279
		Indirect effect from flesh diameter	-0.07
		Total correlation	0.521**
	Flesh diameter	Direct effect	-0.183
		Indirect effect from fruit weight	0.407
		Indirect effect from 1000 seed weight	0.119
		Total correlation	0.343**
	Residual error		0.753
4	Fruit weight	Direct effect	0.781**
		Indirect effect from fruit length	-0.212
		Total correlation	0.569**
	Fruit length	Direct effect	-0.273**
		Indirect effect from fruit weight	0.606
		Total correlation	0.344**
	Residual error		0.8

between fruit length and seed yield to be positive. By positive indirect effect of flesh diameter, correlation between flesh diameter and seed yield was significantly positive (Table 17). Except the second cluster, the

residual effect of other clusters showed that other characters for example fruit number in each plant, pollination ratio, properties of growth etc must be considered.

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