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Clustering Different Greenhouse Pepper Varieties Based on Some Morphological and Fruit Yield

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ABSTRACT

Pepper is one of most important vegetables in the world. Pepper has important role in world vegetable commerce and the worth of its export and import is very high. Selection of better plants is inseparable parts of breeding programs and needs a variable population. So assessment of genetic variation is the first step of breeding programs for this purpose, genetic variation of 22 different varieties of greenhouse pepper was assayed for days to flowering and fruiting, plant height, peduncle length, single fruit weight, fruit yield and fruit length. Descriptive results showed that there was high variation between varieties for earliness, fruit yield and fruit number. Cluster analysis could group varieties into 5 groups that showedthe highest difference for single fruit weight, fruit yield and plant height. Late ripening varieties showed low yield, however varieties with high fruit yield showed high fruit number. Therefore, fruit number had more effect on fruit yield in contrast to single fruit weight. Over all, varieties in different groups could be use in breeding programs with different aims.

Keywords: Cluster analysis, Pepper, Fruit weight

INTRODUCTION

Pepper (*Capsicum annuum* L.) is the world's most important vegetable after tomato and used as fresh, dried or processed products, is spices or condiments (Crosby, 2008). Pepper has important role in world vegetable commerce, and the worth of its export and import (fresh or dried fruit) is very high. The horticultural and biochemical characteristics are important breeding objectives in pepper (Daskalov and Poulos, 1994). Fruit yield, single fruit weight and fruit number per plant are the most important traits in pepper breeding programs. The color type and intensity, fruit uniformity, fruit flavor and quality, fruit shape, size and pericarp thickness and shelf life are also known as other important traits for goals of pepper improvement (Bosland, 1993; Pruthi, 2003). The other objectives of pepper genetic breeding are characteristics such as abiotic stresses (drought, salinity, flooding …) (Singh, 2007). Fruit characters such as fruit color also are important in deletion abnormal plants as selection criteria (Rakita and McCormack, 2005).

Germplasm can be used for plant improvement and also used for determination of phylogenetic relationship and biological and biochemical aspects in pepper (Kang and kole, 2013). Pepper breeders are interested in improving new high fruit yield varieties with other desirable traits. Estimates of the genetic diversity of these traits can assist the design of breeding programs for new varieties. The use of reliable multivariate statistical algorithms such as cluster analysis is an important strategy for classification of germplasm and analysis of genetic relationships among breeding materials (Mohammadi and Prasanna, 2003). Ravindran *et al.* (1997) reported that forty-four cultivars and seven wild black pepper (*Piper nigrum*) accessions (51 Operational Taxonomic Units) based on 22 characters grouped in 11 clusters. Among these, four groups had one cultivar, four had two cultivars, one had four cultivars, one had seven cultivars and one had 28 cultivars each. Therefore, the objective of this study was to classify different pepper varieties based on variable characteristics and to introduce them for breeding goals.

MATERIAL AND METHODS

This research was carried in agricultural research greenhouse of Islamic Azad University of Isfahan (Khorasgan) Branch during 2015-2016 crop seasons. The seeds of 22 greenhouse pepper cultivars (listed in Table 1) were obtained from agricultural inputs sales centers for this trial.

The nursery was watered thoroughly to facilitate seed germination and seedling establishment. Manures and fertilizers were applied as per recommended dose to the roots to enhance active root formation and shoot growth. Before sowing cultural practices such as mold board plowing to a 25 cm depth, disking, and land leveling were also applied.

Seeds were sown on November, 2015 in separate plots. The seedling emerged 8-13 days after sowing. Frothy five days old seedlings were transplanted in lines 0.9 – 1.1 m apart and 0.6-0.7 m between plants, two stem per plant. For all cultivars, eight plants per three replications were cultivated (Occhiuto *et al.*, 2014). Water was applied to the crops using a drip irrigation system. All nutrients were used in combination with irrigation water (fertirrigation) according to the needs of the plants at different stages of growth. Pests such as white flies and trips were controlled using appropriate pesticides. Data recording on single plant were carried out according to International Plant Genetic Resources Institute descriptor (IPGRI, 1995). The variable traits included fruit length (cm), plant height (cm), days to flowering, days to fruiting, single plant yield (g), and single fruit weight (g), peduncle length (cm), were measured.

During growth stages, mean daily and nightly temperatures of greenhouse were 27.5 and 18.5 ° C, respectively and mean relative humidity was %60. The heating and cooling system were hot air and evaporation types, respectively.

RESULTS AND DISCUSSION

The mean values of various evaluated characteristics including fruit length (cm), plant height (cm), days to flowering, days to fruiting, single plant yield (g) and single fruit weight (g) are shown in Table 1. Some descriptive statistical parameters of the studied traits are also given in Table 2. This results showed that Ca-301 and Ca-302 were the earliest and latest flowering varieties, respectively. Ca-301 took the shortest period to fruiting, while Car-48 was the latest among the varieties. The highest plant yield was observed for Ca-3010 and the lowest value of this trait was found in Car-48 (Table 1). Ca-3010 had the highest fruit yield, however some of its characteristics such as fruit length and single fruit weight were not high, which suggested the high fruit yield in this cultivar may be considerably due to the high number of fruit number per plant. On the other hand, Car-48 had the lowest fruit yield, highest value of days to flowering and fruiting, thus was scored as the late maturing cultivar with the shortest fruiting duration. The highest and lowest mean values of fruit weight were recorded for Oli-4 and Ca-nas, respectively (Table 1). The highest and lowest plant height were obtained by Oli-4 and Ca-301, respectively. A-270 and Oli-4 had the highest and the lowest values of peduncle length, respectively. In the case of fruit length, Ca-302 had the highest and Ca.Cs had the lowest amount of this trait. Results of descriptive analysis (Table 2) indicated that single fruit weight followed by days to fruiting had the highest rate of standard deviation. This gives us an opportunity to use these quantitative traits to create useful subsets of diverse cultivars for further characterization and breeding works on commercial and agronomic importance traits.

Cluster analysis is very useful in revealing complex relationships among diverse genotypes in a more simplified manner and it is also effective in indicating genetic matters with useful traits belonging to different clusters for breeding goals (Se-Jong *et al*., 2012). The 22 pepper varieties were grouped in to five groups with 5, 3, 8, 3 and 3 genotypes, respectively (Figure 1). Comparing cluster means with respect to studied traits revealed considerable variation among different clusters. In this analysis, the first group had five varieties (Table 3). Fruiting occurred later in these cultivars compared to others. They had the highest single fruit weight and fruit length, while fruit yield had the lowest amount in this group. This negative relation might be due to lower number of fruit which is caused by shorter fruiting duration. Nkansah *et al.* (2017) reported a highly significant negative relationship between fruit yield (tons/ha) and fruit length of sweet pepper.

Table 1. Mean values of evaluated traits in studied pepper varieties

Num.	Accession	Days to flowering	Days to fruiting	Plant height (cm)	Peduncle length (cm)	Single fruit (g) weight	Plant yield (g)	Fruit length (cm)
1	A-270	96	150	137.75	4.89	219.62	1610.53	10.01
2	A-140	98	128	100	4.04	144.35	1610.1	9.34
3	CA-cs	76	114	94.5	3.6	131.03	1895.07	8.89
4	Ca-301	74	96	85.67	3.77	128.18	1673.05	9.02
5	C-3010	98	128	94	3.56	151.06	3625.47	9.2
6	Ca-302	107	129	95	3.84	134.5	3342.3	12.13
7	Ca-310	76	114	97.67	3.3	129.65	1664.2	8.89
8	Ca-nas	98	133	92.5	3.77	127.39	3105.98	11.36
9	Cam-1	84	116	110	3.04	135.66	1474.57	10.69
10	Car-35	76	106	100	4.01	147.52	2096.34	9.96
11	Car-48	107	166	87.5	3.42	132.43	1102.16	9.54
12	Exc13	92	125	116.67	4.42	150.92	1775.96	10.35
13	Exp10	79	129	139.5	3.72	204.13	1735.07	10.71
14	Exp4	84	145	125.5	4.56	217.65	1305.9	11.36
15	Fi-67	84	130	143	4.57	192.18	1350.43	10.84
16	Insp-39	96	156	103	4.75	229.39	1284.6	11.95
17	King	84	116	116.67	3.74	132.29	1909.39	9.17
18	Non50137	79	140	130.4	3.75	202.73	1452.9	9.24
19	Oli-4	90	140	159	3.03	234.38	1552.75	9.36
20	Pel-7	79	99	101.5	3.81	153.38	2265.16	9.59
21	Pi-5	101	157	105.75	4.57	214.27	1157.03	10.56
22	Wiz-44	79	115	111.33	3.22	141.73	1940.08	9.34

Considering these results, it can be stated that earlier cultivars had longer period for fruiting compared to others, so their fruit yield also increased. In contrast, the average value of fruit yield for cultivars in fourth cluster was higher than the total means of all varieties. However, genotypes in this group were in the lowest rate with respect to plant height, so increasing of fruit yield, may be due to a higher number of fruit which might, in turn, be due to a lower internode length in these cultivars. This cluster consisted of Ca-302, Ca-3010- and Ca-nas varieties. The third cluster had the highest number of genotypes having a high value of plant fruit weight after cluster 4. Fruit weight in these two groups was significantly different. Overall, the results of this research showed that the evaluated cultivars had enough diversity for using in further pepper breeding programs.

Table 2. Some descriptive parameters of studied varieties

Traits	Mean	Range	Standard deviation	Minimum	Maximum
Days to flowering	88.04	33	0.59	74	107
Days to fruiting	128.73	70	8.71	96	166
Plant height (cm)	111.22	73.33	0.07	85.67	159
Peduncle length (cm)	3.88	1.86	0.54	3.03	4.89
Single fruit weight (g)	166.11	106.99	38.86	127.39	234.38
Plant yield(g)	1860.41	2523.31	9.36	1102.16	3625.47
Fruit length(cm)	10.06	3.24	1.00	8.89	12.13

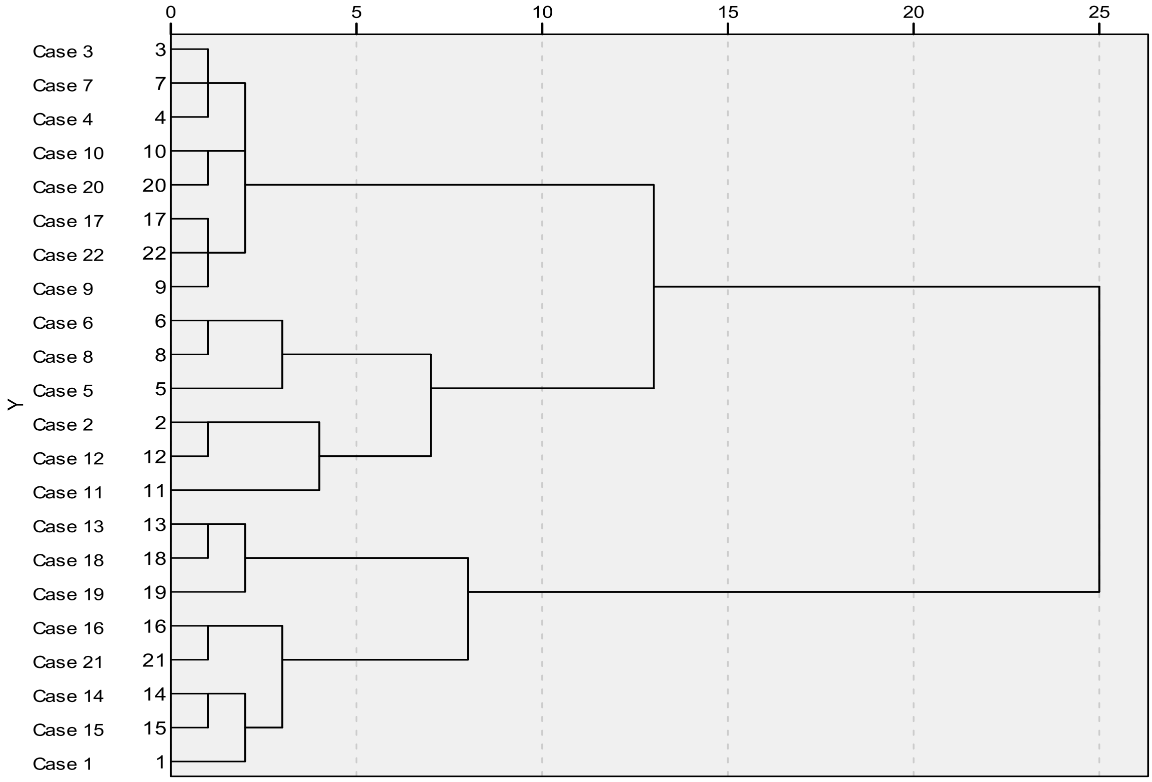

Figure 1. Cluster diagram of 22 pepper cultivars based on evaluated traits using Ward method (the name of varieties are based on Table 1)

Table 3. Mean comparison between groups based on cluster analysis in primary parents

Traits	Mean Square	Group 1	Group 2	Group 3	Group 4	Group 5
Days to flowering	441.36**	92.2 a	99a	78.5 b	*101 a*	82.68 b
Days to fruiting	1318.95**	147.6 a	139.67 a	136.3 a	130 a	109.5 b
Plant height	1392.41**	123 a	101.39 b	102.17 b	93.83 b	142.97 a
Pedicle length	1.11**	4.67 a	3.96 b	3.56 b	3.72 b	3.5 b
Single fruit weight	7311.98**	214.62 a	142.57 b	137.43 b	137.65 b	213.75 a
Fruit yield per plant	2176687**	1341.7 c	1496.1 bc	1864.7 b	3357.9 a	1580.2 bc
Fruit length	2.41**	10.94 a	9.74 ab	9.44 b	10.89 a	9.77 ab

Means followed by the same letter were not significantly different at 0.05 probability level using LSD test.
**: F-test significant at p<0.01

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