Research Article

Investigation of Gardening Patterns Effects on Field Performance of Various *Cucumis sativus* L. Genotypes

Haseeb Khattak[1], Imran Ahmad[1], Abdul Basit[1]*, Izhar Ullah[1,2], Syed Tanveer Shah[1], Humaira Wasila[3], Inayat Ullah[4], Intizar Ahmad[1] and Noman Ahmad[1]

[1]Department of Horticulture, Faculty of Crop Production Sciences, The University of Agriculture Peshawar, 25120, Khyber Pakhtunkhwa, Pakistan; [2]Department of Horticulture, Ondokuz Mayis University, 55200, Samsun-Turkey; [3]Department of Human Nutrition, Faculty of Nutrition Sciences, The University of Agriculture, Peshawar, Khyber Pakhtunkhwa, Pakistan; [4]Department of Agricultural Mechanization, Faculty of Crop Production Sciences, The University of Agriculture, Peshawar, Khyber Pakhtunkhwa, Pakistan.

Abstract | Diverse genotypes of cucumber under different cropping patterns may signify to examine the potential of best and desired selection for quality crop. The study was carried out to evaluate cucumber genotypes (IT-145, Damaz, Yayla, Eva, Chinese Slanger, Poinsett-76, SCM-01 and SCM-03) under various gardening patterns (Horizontal and Vertical) at Vegetable Directorate, HRI, NARC, Islamabad-Pakistan. It was observed that growth and yield parameters of cucumber were effected by genotypes and gardening patterns significantly. Highest female flowers, number of leaves and fruits plant^{-1}, leaf area, fruit length, fruit diameter and total yield were observed under vertical gardening pattern. Data recorded for genotypes observed an increase in total yield and fruits plant^{-1} of Damaz while and increased number of leaves plant^{-1}, leaf area, fruit diameter and length were observed by SCM-01. The interactive response of genotypes and gardening pattern clearly revealed that Damaz grown under vertical gardening produced highest fruit diameter, fruits and yield plant^{-1}. From the above results it was concluded that cultivar Damaz should be grown under vertical gardening for promising growth and yield of cucumber.

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***Correspondence** | Abdul Basit, Department of Horticulture, Faculty of Crop Production Sciences, The University of Agriculture Peshawar, 25120, Khyber Pakhtunkhwa, Pakistan **Email:** abdulbasithort97@gmail.com; mashalhort97@aup.edu.pk
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Introduction

Insects, pests and disease attack are the major problems in cucumber (*Cucumis sativus* L.) when it remains on ground surface. It is a self-support less crop having high water contents, which may rot the crop easily. Therefore, to overcome this problem vertical gardening is preferred to increase its production. In vertical gardening plants are elevated from the ground to prevent the pests and insects attack. Beside this all, there are different advantages of vertical farming as it provides increased air circulation, saves a lot of space, less breaking of the vines, larger yield, easy harvesting, less weeding and less soil preparations (Derek, 2011).

Cucumber belongs to cucurbitaceae family, known as a vegetable grown in a wide range globally. It is thought to have been native to India and has been grown in Iran and China for 2000 years. And then brought from India into China, North Africa, South Europe and other parts of the World by voyagers and travelers. It was brought into tropical Africa by the

Portugues (Grubben and Denton, 2004). Cucumber is grown around the world mostly as a fresh market produce especially in China. In the European and American countries it is used as a fresh market vegetable. In Asia its fruits and shoots are widely used as vegetable and oil is obtained from the seeds. In some countries it is also used to cure disease like sprue which causes swelling of small intestine. In India it is commonly used for curing irresistible ailments in kids (Grubben and Denton, 2004). China is the world largest producer with total production of 54.3 million tons; 73 % of the whole world production, during 2014-2015. That time a total area of 23,268 hectare was recorded under cucumber cultivation with total production of 52,766 tones and mean production of 2.26 tones ha^{-1} in Pakistan (GOP, 2014-2015). Cucumber contains a terpene called cucurbitacin found in its leaves and fruits that prevents cucumber from insect attack (Grubben and Denton, 2004).

Cucumber vegetable is known as a warm season crop which even be effected by a very light frost. But, in comparison to melons, it can survive a bit cool weather, thus, can be grown well in a temperature range from 18-24 ^{0}C. Although, in can be cultivated in soil ranges of sandy and clay loamy soil (Pant *et al.*, 2001). It requires high humidity of 60-70% during day time and 70-90% during night, due the greater surface area of its leaves (Arshad *et al.*, 2014). Cucumber crop is of great importance to the economy because of its numerous uses. In Pakistan, large amount of cucumber production is affected due to poor pre-harvest measures annually, which is of serious worry. Proper pre-harvest measures which include efficient growing practices, increasing cultivation area and selecting good varieties are required. It contributes to the basic requirements like high quality yield, disease resistance and maximum storage durability (Dimov *et al.*, 2016). Breeding for disease resistance, use of amended cultural practices tend to stimulate the production of pistil late flowers and increase cucumber yields (Nwofia *et al.*, 2015). Great attention is needed to determine better adopted genotypes for most effective performance of increased yield. To solve this problem an experiment was planned to evaluate the effect of various cucumber genotypes and different gardening patterns on growth and yield of cucumber.

Materials and Methods

This study was conducted at NARC (National Agricultural Research Center) Islamabad during summer 2016, to study the response of various cucumber genotypes to different gardening patterns. Randomized Complete Block Design with two factors and three replications was adopted for evaluation of the experiment. Cucumber genotypes (IT-145, Damaz, Yayla, Eva, Chinese Slanger, Poinsett-76, SCM-01, SCM-03) were planted on different gardening patterns (Horizontal and Vertical). Soil analysis were done before transplantation of the seedlings. Different soil samples from the upper, middle and lower layer of soil were randomly selected for analysis. Each of these sample were analyzed separately and their averages were calculated. The physical and chemical properties of soil are given in Table 1.

Table 1: *Physico-chemical characteristics of the soil sample of the experimental area.*

Soil variables	pH	% O.M	% N	P (mg kg^{-1})	K^+ (mg kg^{-1})
Values	6.5	0. 85	13	6.1	193

Nursery for cucumber seedlings was raised under low plastic tunnel. Pots were used for sowing seeds, which contained a mixture of well decomposed FYM and garden soil in equal amount and were regularly irrigated with sprinkler till germination. The seedling was then ready for transplanting after 4-6 weeks, when it attained height of 15cm and had 3-4 true leaves. Field was then prepared to transplant the cucumber seedlings from the nursery to an open environment. Two plots were prepared on the basis of different gardening patterns in the experimental area. One plot for horizontal gardening pattern and other plot for vertical gardening pattern. Both plots had an area of 108 m^2 (4.30 marlas). 12 cucumber seedlings were used per treatment in each replication. The fertilizers applied were Diammonium phosphate, potash and nitrogen at proportion of 75:60:60 kg ha^{-1}. The plots were ploughed twice; properly leveled and raised beds were prepared. The distance between plants and rows were kept at 0.5 m and 1.5m, respectively. Bamboo sticks were used to stake crop vines in vertical gardening. Four bamboo sticks in each treatment were used one on each corner and net was attached from one stick to other on each row. When the vine grew up to a certain length it was then attached with the net through its tendrils. Whereas, for horizontal gardening raised beds were used.

Single leaf area of the plant was measured with the help of graph paper method with 1cm grid and data

collected were analyzed for each plant. The quantitative parameters i.e. number of leaves, total fruits and female blossoms plant^{-1} were determined by counting leaves, total fruits and blossoms per plant for all plants in each treatment and the data collected was analyzed accordingly. The length and diameter of selected marketable fruits from each treatment was calculated with scale or measuring tape/ Vernier caliper (Basit *et al*., 2019) and their averages were taken. Fruit yield of each plant in a variety was noted by calculating the weight of all the fruits from the plants and the data collected was analyzed accordingly. On the basis of given formula total yield was calculated:

$$Total\ yield\ (tonsha-1) = \frac{Yield\ per\ plot\ (tons)}{Plot\ area\ (ha)} \times 100$$

STATISTIX 8.1 (statistical package), Inc, Tallahassee, FL USA (Basit *et al*., 2018) adopting Randomized Complete Block Design (RCBD) having split plot layout was applied for data analysis calculating ANOVA and LSD value. Means were separated using 5% level of probability (Jan *et al*., 2009).

Results and Discussion

Leaf area (cm^2)

There was a significant difference for leaf area among genotypes and gardening patterns except their interaction genotypes and gardening patterns with no significant influence on leaf area (Table 2). The maximum leaf area (175.16cm^2) was measured in SCM-01, while genotype Eva had minimum leaf area (104.66 cm^2) (Figure 1). Maximum leaf area per plant was noticed in genotypes grown by vertical gardening method (147.25 cm^2), while minimum leaf area was measured in genotypes grown by horizontal method (141.12cm^2) (Figure 2). The increase in leaf area of SCM-01 genotype could be due to the genetic makeup of specific cultivar or may be because of greater chlorophyll amount. Due to more light penetration in vertical gardening the leaf area was increased, which in return might have good effect on its absorption than plants in horizontal gardening. Vigorous growth and better nutrient uptake also play key role in larger leaf area of a plant. Present results are in accordance with Queiroga and Pauttai (2008) who evaluated the quantitative and qualitative characteristics of watermelon regarding no of leaves and fruits.

Number of leaves per plant

The present results revealed a significant difference for number of leaves of cucumber genotypes and gardening pattern, however, their interaction was found non-significant (Table 2). The genotypes, SCM-01 had highest number of leaves (51.33), while minimum leaves (33.66) were recorded in genotype Chinese Slanger (Figure 1). The genotypes grown by vertical method produced maximum leaves plant^{-1} 44.58, while the genotypes grown by horizontal method produced minimum leaves plant^{-1} 42.25 (Figure 2). Initiation of highest number of leaves in genotype SCM-01 could be due to climatic adaptability, more leaf buds and more nutrient uptake. This increase in number of leaves of cucumber genotype may be because of its genetic makeup that enhanced its vegetative growth and suitability of the genotype to the agro-climatic status of the study area. Increased number of leaves under vertical gardening

Table 2: *Mean Square value of growth and yield related attributes of cucumber as influenced by genotypes and gardening patterns.*

		Mean Square (MS)							
SOV	DF	LA	NOLPP	TNFFPP	NOFPP	FL	FD	FYPP	TY
Replication	2	75.25^{ns}	6.08^{ns}	0.89^{ns}	0.36^{ns}	0.43^{ns}	0.02^{ns}	0.01^{ns}	2.89^{ns}
Gardening patterns (P)	1	450.18*	65.33*	44.08^{ns}	3.67*	22.68*	1.05^{ns}	1.24*	292.34*
Error 1	2	0.75	2.08	4.52	0.037	0.062	0.17	0.03	1.69
Genotypes (G)	7	3512.02*	205.95*	108.22*	6.18*	17.47*	1.30*	0.97*	108.74*
P×G	7	5.37^{ns}	13.14^{ns}	11.94^{ns}	0.57*	0.54^{ns}	0.68*	0.24*	7.86^{ns}
Error II	28	6.97	5.86	5.56	0.25	0.464	0.21	0.08	4.15
Total	47								

P≤0.05; ns: Non-significant; LA: Leaf area; NOLPP: Number of leaves plant^{-1}; TNFFPP: Total number of female flowers plant^{-1}; NOFPP: Number of fruits plant^{-1}; FL: Fruit length; FD: Fruit diameter; FYPP: Fruit yield plant^{-1}; TY: Total yield.

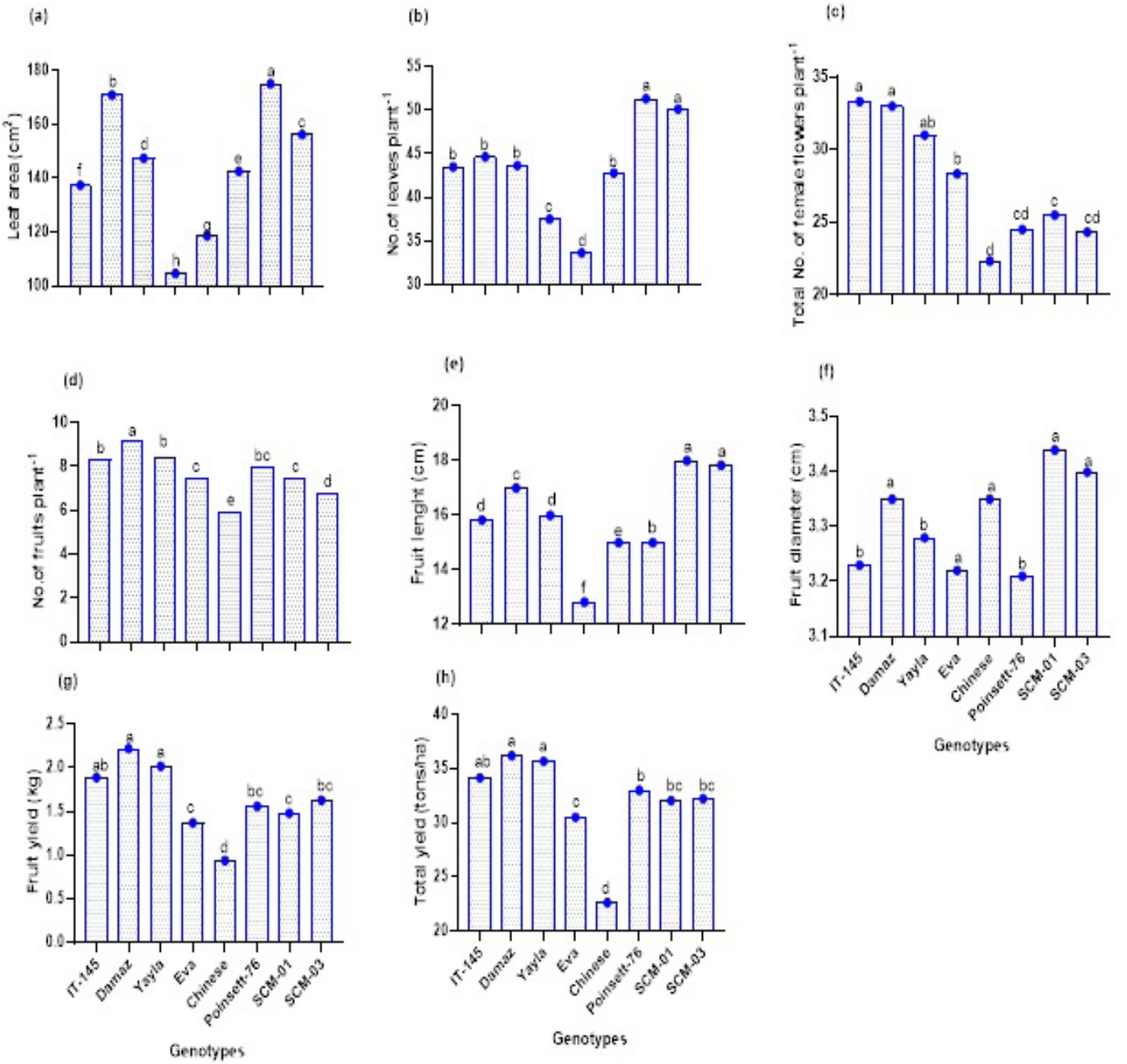

Figure 1: *Growth and yield related attributes as influenced by cucumber genotypes.*

might be due to more vine length and high chlorophyll content, which boosted the vegetative growth. Hikosaka and Hirose (1997) reported that the plants with vertical leaves canopy has more photosynthetic capacity than plants with horizontal leaves, because in vertically elevated leaves maximum amount of light passes and reaches deeper layers of leaves, and hence resultantly maximum light disseminates with in plants canopy. Better nutrient availability and easy uptake of nutrients is also the cause of increase in number of leaves. Similar results were also found by Mona *et al*. (2011) in eggplant, who observed that through application of organic fertilizers the number of leaves significantly increased.

Total number of female flowers per plant

Data recorded for total female flowers per plant, Results revealed a significant difference among the cucumber genotypes studied, however gardening pattern and the interaction between cucumber genotypes and gardening pattern were discovered non-significant (P≤0.05) (Table 2). The genotype IT-145 plants resulted in highest number of female flowers (33.33), followed by genotype Damaz (33.00), while the genotype Chinese Slanger produced minimum female flowers (22.33) see (Figure 1). The difference in total female flowers per plant for studied genotypes might be attributed to genetic variation at same environmental conditions. Our results are in line with

(Pal *et al.*, 2017; Khan *et al.*, 2015; Ranjian *et al.*, 2015) who also noted that genetic variation significantly assorted number of flowers plant^{-1}. Many plant growth regulators like auxins are responsible for altering the physiology of plants and particularly flowering and sex proportion. The proportion of male flowers and female flowers are directly regulated through sum of gibberellin and auxin; the formation of female flowers increases as the sum of auxin increases, in contrast the formation of male flowers increases as the production of gibberellin increases (Surendranath and Rao, 1981). Similarly, George (1985) reported that plants in long day length and more light intensities resulted high male flowers formation, while plants under short day length and low light intensities having more female flowers formation.

No. of fruits plant^{-1}

Results revealed that cucumber genotypes significantly affected number of fruits per plant, gardening pattern and their interaction at P≤0.05 (Table 2). Present findings revealed that genotype Damaz produced maximum fruits plant^{-1} (9.16), while genotype Chinese Slanger (5.94) produced minimum fruits plant^{-1} i.e. 5.94 (Figure 1).

Plants grown under vertical gardening technique attained maximum fruits per plant (7.98) compared to horizontal gardening that produced minimum fruits per plant (7.42) (Figure 2). The interaction between genotypes and growing patterns (Figure 1) showed that genotype Damaz under vertical gardening pattern produced highest number of fruits per plant (9.88) compared to genotype Chinese Slanger grown under horizontal gardening pattern (5.88) (Figure 3).

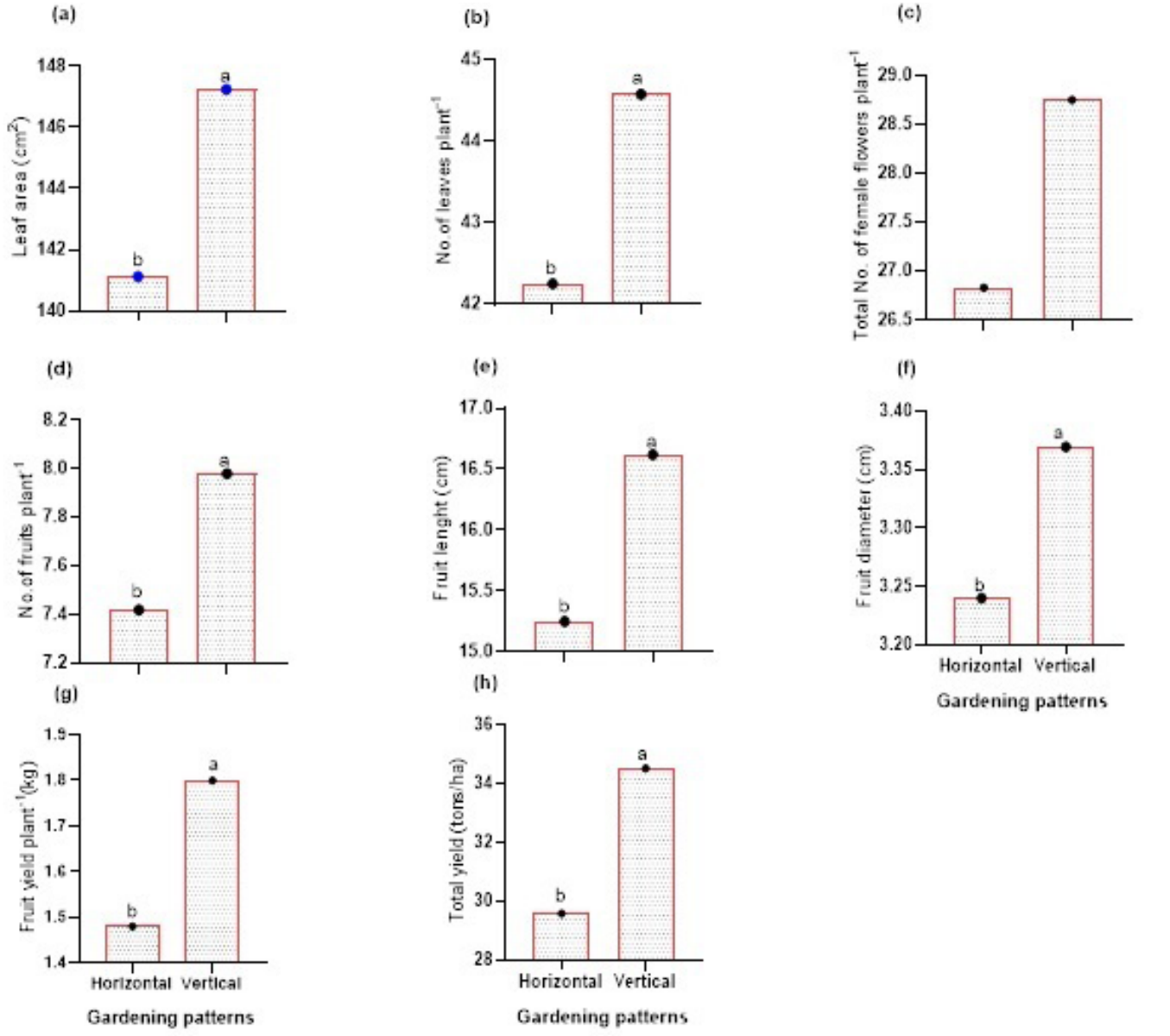

Figure 2: *Growth and yield related attributes as influenced by different gardening pattern.*

Increase in number of fruits per plant by all genotypes grown by vertical pattern might be due to more lateral branches which produced high number of flowers that produced more fruits per plant. Maximum fruits plant^{-1} in genotype Damaz may be because of better genetic variability and less time to edible maturity which results in more production. Similarly, Hakim *et al.* (1999) revealed that different varieties of cucumber show significant difference in chilling sensitivity.

Fruit length (cm)

Fruit length differed significantly among gardening patterns and genotypes except their interaction that had non-significant difference (P≤0.05) among gardening patterns and genotypes (Table 2). The genotype, SCM-01 produced maximum fruit length (18cm) and minimum fruit length (12.83cm) was observed in genotype Eva (Figure 1). Regarding gardening patterns, maximum fruit length (16.62cm) were observed in all genotypes grown by vertical method, while horizontal gardening pattern attained minimum fruit length (15.25cm) (Figure 2). Differences in above results are due to varied gardening patterns because vertically grown plants have more space to grow. Differences in varieties may be possibly due to the difference among genetic makeup of selected varieties. Our results are also supported by Resende (1999) who recorded maximum fruit length with elevated marketable value of cultivars Colonia, Ginga, Tamor, AG-77, Indaial and Score.

Fruit diameter (cm)

Results presented in Table 2 shows that genotypes and their interaction among genotypes and gardening pattern significantly influenced fruit dimeter of cucumber, while gardening pattern had no significant influence on fruit diameter at P≤0.05. Maximum fruit diameter was produced by genotype Eva (5.33cm) which was statistically at par with fruit diameter of genotype SCM-01 (5.29cm), while the lowest fruit diameter was noted in genotype Yayla (4.19cm) (Figure 1). The interaction between genotypes and growing patterns (Figure 3) showed that highest fruit diameter was noted in Damaz (5.50cm) under vertical gardening and lowest fruit diameter was recorded under horizontal gardening in IT-145 (3.52cm) (Figure 3). Differences in fruit diameter among all cultivars are due to the different categories and growing method. Cucumbers are divided into different 3 types i.e. slicing, pickling and gherkins according to their size, skin and other physical attributes. Slicing, prickling and burpless are the main existing varieties of cucumber. Within these varieties, several different cultivars have emerged. Many cucumber varieties exist with different shapes carotene content and skin color (Simon, 1992). Tokatli *et al.* (1999) reported that pickling type of cucumber when grown on vertical wires had different fruit diameters. Genetic make-up of all the cultivars is also the cause of differences in height of plants, leaf area, no of branches fruit production (Sajjan *et al.*, 2002).

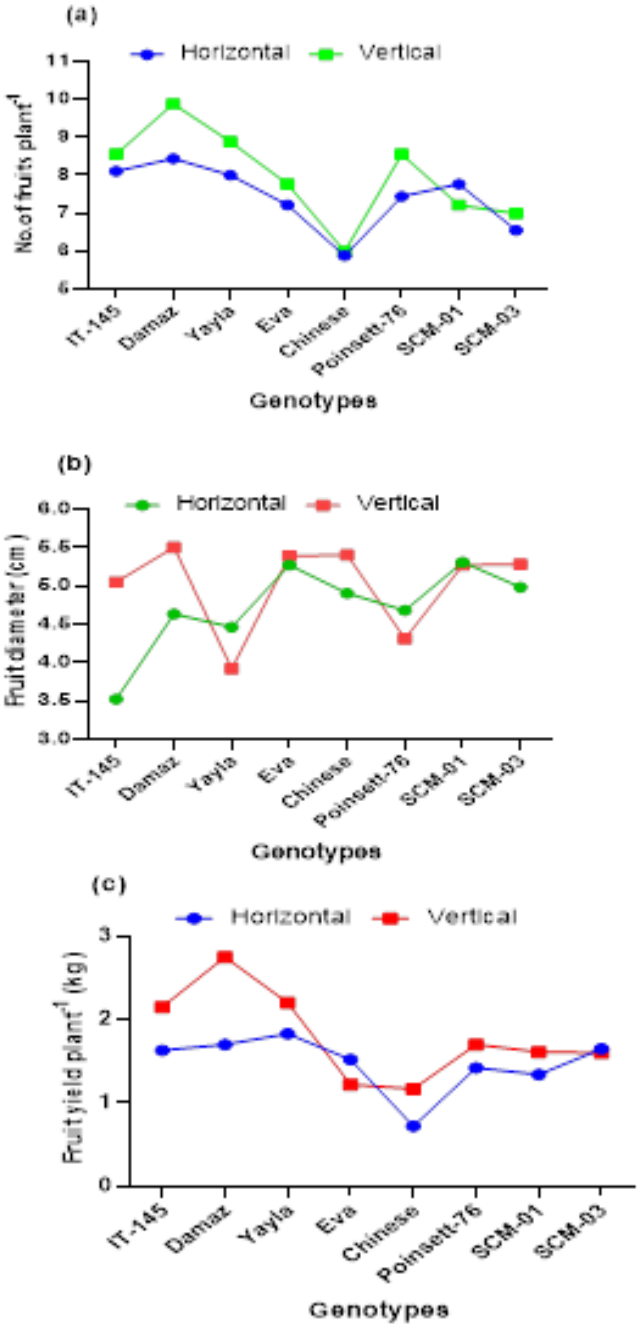

Figure 3: *No. of fruits plant^{-1}, fruit diameter and fruit yield plant^{-1} as influenced by interaction of cucumber genotypes and gardening patterns.*

Fruit yield plant^{-1}

Results presented in Table 2 revealed a significant

difference among gardening patterns and genotypes as well as their interaction for fruit yield per plant at P≤0.05. Highest fruit yield plant $^{-1}$ was noted in genotype Damaz (2.22kg), while it was lowest for genotype Chinese Slanger (0.94kg) (Figure 1). Regarding gardening pattern, the maximum fruit yield per plant (1.80kg) was observed in genotypes grown under vertical gardening, while lowest fruit yield was noted in genotypes grown by horizontal gardening (1.48kg) (Figure 2). The interaction between genotypes and growing patterns revealed that highest fruit yield plant^{-1} was noted in Damaz (2.75kg) under vertical gardening and lowest fruit yield plant^{-1} was recorded under horizontal gardening in Chinese Slanger (0.72kg) (Figure 3). Growing methods are prime responsible for the improvement of the yield components of a crop. Plant grown with vertical support reduces loss of the produce by minimizing risks of fruit rotting, pests and insects attack, vine breaking and other hazards. Varietal differences is another factor which affects the yield. Vertical cropping techniques provides favorable conditions and increase the production by increasing number of fruits plant^{-1}, healthy leaves and plants consistency, stimulating the source-sink stability as per productive requirements (Papadopoulos, 1994).

Total yield (tons.ha^{-1})

The analysis of the data revealed significant differences among gardening patterns and genotypes, while their interaction had no considerable influence on total yield of cucumber at P≤0.05 (Table 2). The significant findings of genotypes indicated that Damaz gave maximum (36.20 tons ha^{-1}) total yield followed by Yayla (35.69 tons ha^{-1}). While minimum total yield (22.63tons ha^{-1}) was observed in Chinese Slanger (30.52 tons ha^{-1}) (Figure 1). The highest total yield (34.53tons ha^{-1}) was recorded in genotypes grown by vertical method, while genotypes cultivated by horizontal pattern attained lowest total yield (29.59 tons ha^{-1}) (Figure 2). More production (tons ha^{-1}) by all genotypes cultivated by vertical method may be due to less rate of fruit loss and more space. Cultivation in an open field could also be the cause of more production. Sharma *et al.* (2000) also found that cucumber plants grown in green house produced more yield as compared to those grown in open field. Increase in the total yield by cultivar Damaz is because of maximum fruit number and weight plant^{-1}, and higher adoptability to environmental conditions. The variation among yield of cucumber cultivars may be because of distinct genetic structure, mineral composition and potential to move photosynthates inside plants (Clark *et al.*, 1997). Training the plants vertically provides easier application of chemical, improves the ventilation in plants, equally supply of sunlight to the plant parts and enhances plants density, thus maximizing number of fruits per plant (Martins *et al.*, 1999).

Conclusions and Recommendations

The results obtained from the present study indicated that the vertical growing pattern performed better with respect as number of leaves per plant, leaf area, fruit diameter, fruit length, fruits per plant, fruit yield per plant and total yield of cucumber. The genotype Damaz performed better performance with respect to growth and yield related attributes. It is concluded from the above results that "Damaz" grown in vertical gardening pattern improved growth and yield attributes of cucumber under agro-climatic condition of Islamabad.

Novelty Statement

All the varieties studied observed an increased effect to gardening patterns and are of great economic importance. On the other hand, these varieties can be grown and tested in the agro-climatic conditions of Islamabad and its surrounding for better production and survival. All the studied traits reported growth success and better yield of the tested varieties to various gardening patterns.

Author's Contribution

Haseeb Khattak and Imran Ahmad: Conceived and designed the study.
Imran Ahmad and Abdul Basit: Performed the experiment.
Haseeb Khattak, Syed Tanveer Shah and Izhar Ullah: Analyzed the data.
Noman Ahmad, Izhar Ullah, Intizar Ahmad and Humaira Wasila: Contributed the chemical, materials and analysis tools.
Abdul Basit: Wrote and reviewed the original manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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