MORPHOLOGICAL AND BIOCHEMICAL STUDY OF EXOTIC PEPPER (Capsicum annuum L.) GERMPLASM

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***ABSTRACT*:** *An experiment to evaluate the morphological and biochemical attributes of exotic germplasm of pepper (Capsicum annum L.) in comparison to local check varieties were carried out under agro-climatic conditions of Rawalakot, Kashmir-Pakistan in cropping season, 2016. The experiment was laid out in Randomized Complete Block (RCB) design replicated thrice. Different morphological and biochemical attributes viz. days to 50% flowering, leaf area (cm^2), leaf weight (g), specific leaf area (cm^2), specific leaf weight (g), plant height (cm), number of brunches $plant^{-1}$, fruit length (cm), fruit diameter (cm), number of fruit $plant^{-1}$, average seeds $fruit^{-1}$, fresh fruit yield (t ha^{-1}), average dry fruit yield (t ha^{-1}), free radical scavenging activity, pH, Vitamin-C, total soluble solids and phenolic content. Results revealed that SPS-14 genotype showed excellent results with highest fresh fruit yield 21.55 t ha^{-1} and highest average dry fruit yield 7.507 t ha^{-1} relating to most of the growth and seed production parameters. On the basis of results obtained the genotype SPS-14 might be considered as an economically dynamic selection on account of growth, yield and seed production, therefore genotype SPS-16 stood 2nd in ranking for yield and seed production and stress tolerance than other selected genotypes and check varieties. So SPS-14 and SPS-16 could be recommended for future improvement, to obtain optimum results and also recommended for growing under agro-climatic conditions of Rawalakot, Kashmir-Pakistan.*

Keywords: Biochemical, *Capsicum annuum*, morphological, pepper.

INTRODUCTION

Peppers grown best in well-drained, sandy or silty loam soil with best soil pH range of 5.5 to 7.0. It has a wide range of cultivation, being grown under both tropical and subtropical conditions. Hot and dry weather is desirable for fruit ripening [1]. Pepper was originated from America and is an important horticultural crop, due to its economic importance, nutritional and medicinal value of its fruit. These are the great sources of natural colors and antioxidants [2]. Peppers contain a wide range of antioxidant vitamins, carotenoids, capsaicinoids and phenolic compounds are present in hot pepper fruits. The intakes of these compounds in food are important health protecting factor by prevention of widespread human diseases. As consumption continues to increase, the hot pepper could provide important amounts of nutritional antioxidants to the human diet. Level of these antioxidants can vary with genotype, stage of harvest, maturity and plant part consumed as well as storage and processing conditions [3, 4].

The total world production of pepper in 2010-11was 50.7 thousand tons which is cultivated at an area of 172.7 thousand hectares [5]. Pepper production in Pakistan fulfills domestic needs and also helps in earning foreign exchange. Pakistan earned GDP of 192.32 million during 2004-05 by exporting red pepper pepper to Middle East, USA and other countries [6]. In Pakistan, yield $hectare^{-1}$ is 1.96 tons as compared to 6.25 tons in other dry pepper pepper producing countries like China [7]. Green fruit yield $plant^{-1}$, fruit size and number of fruit $plant^{-1}$ were found to be mainly genetically controlled characters and less affected by environment that was reported by Arya and Saini [8]. The National Master Agriculture Research Plan 1996-2005 for Pakistan identified hot pepper as a crop requiring research to increase and stabilize yield and quality [9].

Maturation affects synthesis of these compounds which influences hot pepper quality e.g. differences in pepper color, shape and capsaicin level changes continuously during maturation. Important nutrients like ascorbic acid and pro-vitamin "A" increased from the green stage to red stage [10, 11]. Peppers are also used in the medical field with pungency being an important pharmacological property. These are also extremely best sources of many essential nutrients and are richer sources of vitamin A and C. Another major use of pepper is coloring agent in food industry to color a wide variety of processed foods. Pepper is grown for use as a vegetable, spice, condiment, sauce and pickle [12]. Nutritive value of bell pepper is high as it contains 1.29 mg protein, 11 mg calcium, 870 I.U. vitamin A, 17.5 mg ascorbic acid, 0.6 mg thiamin, 0.03 mg riboflavin and 0.55 mg niacin per 100 g edible of fruit. Among pathogenic diseases, more than 45 viruses have been reported infecting pepper worldwide [13].

The current research was conducted to check the performance of exotic peppers genotypes in comparison with check varieties, to establish the nutritional and biochemical status of peppers and to screen out the best genotype of pepper, suitable for getting optimum growth and seed yield in Rawalakot, Kashmir-Pakistan.

MATERIALS AND METHODS

The research project was conducted to study the morphological and biochemical attributes of exotic germplasm of pepper (*Capsicum annum* L.) in comparison to local check varieties, at the Research Farm, Faculty of Agriculture, The University of Azad Jammu & Kashmir-Pakistan in cropping season, 2016. The experiment was laid out in accordance with Randomized Complete Block (RCB) design replicated thrice. The germplasm of pepper collected from Spain (Padron). The following genotypes were studied,

along with check varieties i.e. SPS-1, SPS-2, SPS-3, SPS-4, SPS-5, SPS-6, SPS-7, SPS-8, SPS-9, SPS-10, SPS-11, SPS-12, SPS-13, SPS-14, SPS-15, SPS-16, SPS-17, SPS-18, Rawalakot Local and Green Hot.

Sowing and transplanting

The seeds of eighteen genotypes along with two check varieties were sown in well prepared soil followed by planking before nursery rising. Four to six weeks old seedlings were transplanted in well prepared seed beds. There was one row per genotype, in each replication the distance between the rows was kept 45 cm while plant-to-plant distance was kept 30 cm. Standard dose of fertilizers (N:P:K=2700g:1007g:1007g) ws applied in all experimental units to minimize the experimental error. Weeding and hoeing was done manually when required.

Data collection

Data was collected on various morphological attributes like, days to 50% flowering, leaf area (cm^2), leaf weight (g), specific leaf weight (g), specific leaf area (cm^2), plant height (cm) and no. of branches $plant^{-1}$.

Leaf weight (g)

Fresh leaves from the selected plant were taken and brought to the laboratory. The leaves were oven dried at 80ºC for 48 hours and their weight was calculated with electrical balance in grams.

Specific leaf weight (g)

The specific weight of leaf was computed with following formula and average was worked out.

$$SL\ (wt) = \frac{\text{L. wt}}{\text{L. A}}$$

Specific leaf area (cm^2)

The specific leaf area of the leaves of the plant was measured with following formula and average was worked out.

$$SL\ (area) = \frac{\text{L. A}}{\text{L. wt}}$$

FRUIT QUALITY ATTRIBUTES

fruit length (cm), fruit diameter (cm), no. of fruit $plant^{-1}$, average seeds $fruit^{-1}$, fresh fruit yield (t ha^{-1}) and average dry fruit yield (t ha^{-1})

Fresh fruit yield (t/ha)

Green fruit yield was taken from the selected plants at the stage of maturity and average was calculated.

$$Yield/ha = \frac{wt.of\ green\ fruit/plot\ (kg)}{\text{Plot size}\ (m^2)} \times 10000\ (m)^2$$

Average dry fruit yield (t/ha)

Dry fruit yield was taken from the selected plants at the stage of ripening and average was calculated.

$$Yield/ha = \frac{wt.of\ dry\ fruit/plot\ (kg)}{\text{Plot size}\ (m^2)} \times 10000\ (m)^2$$

BIOCHEMICAL ANALYSIS

Determination of the DPPH Radical Scavenging Activity.

The antioxidant activity of the pepper extract was evaluated spectrophotometrically following the DPPH method described by Williams [14].

pH

pH of juice was directly determined by using pH meter as described by Ruck [15].

Vitamin-C

Vitamin-C was determined by using 2, 6, dichlorophenol indophenol dye following the method of Ruck [15].

Total soluble solids (TSS)

Total soluble solids were determined by using hand refractometer.

Total Phenolic content (TPC)

The total phenol content was determined according to the Folin-Ciocalteu method [16].

Statistical analysis

The collected data was analyzed by using the analysis of variance (ANOVA) technique and difference among the treatments means were compared by using Duncan's Multiple Range Test (DMRT) at 5% probability level [17].

RESULTS AND DISSCUSSIONS

Morphological attributes: (days to 50% flowering, leaf area, leaf weight, specific leaf area, plant height, no. of branches $plant^{-1}$)

Parameter, days to 50% flowering of different genotypes were analyzed and its mean square values are presented in table-1, their mean values in table-2. The data indicated the significant differences among various genotypes and check varieties for flower production with respect to number of days to 50% flowering production from the date of transplantation. The minimum days 50.33 for 50% flower production were taken by the genotype SPS-2 followed by the genotypes SPS-3 and SPS-14 in 51.00 days after transplantation. The 50% flower production was completed by the genotypes SPS-1, SPS-6, SPS-9 and SPS-13 with in time duration of 52 days. The maximum time for 50% flower production was taken by the genotype SPS-12 in the time duration of 60.33 days which differed significantly with all genotypes. The check varieties Rawalakot Local and Green Hot took 55 and 56 days respectively for 50% flower production. Check varieties took 5 to 6 more days as compared to genotypes SPS-2, SPS-3 and SPS-14. The genotypes SPS-10 and SPS-18 took 56.67 and 56.33 days to complete 50% flowering respectively. The rest of genotypes SPS-11, SPS-16, SPS-8, SPS-15, SPS-17, SPS-4 and SPS-7 produced 50% flowering with the duration of 53.33 to 55.33 days respectively. The significant difference in flower production between genotypes and check varieties indicated that selected genotypes have best potential of flower production in shorter time duration leading to better economic return. The genotypes SPS-2, SPS-3 and SPS-14 took shortest time 50 to 51 days to emerge 50% flowering as compared to SPS-12 which took 60.33 days for 50% flower production. Variation in flower production with respect to time factor may be occurs because of genetic or environmental influence. These results are supported by Chattopadhyay *et al*.for peppers [18]. Their observation showed minimum 30.33 days for 50% flowering and maximum 109.00 days for 50% flowering.

The data regarding leaf area of different genotypes were analyzed and is presented in table-1 for their contrast of means. The data showed significant difference among different genotypes and check varieties for leaf area production. The maximum leaf area (14.25 cm^2) was observed in the plants of genotype SPS-14 which differed

significantly with all genotypes followed by genotypes SPS-12 and SPS-16 with leaf area production 13.67 cm^2 and 13.18 cm^2 respectively showing non-significant difference among each other. The minimum leaf area (9.355 cm^2) was found in the genotype SPS-11. The leaf area of check varieties Green Hot and Rawalakot Local were observed 12.20 cm^2 and 11.20 cm^2 respectively. The difference in leaf area between check varieties was noted significant. However, "Green Hot" performed better than Rawalakot Local with attaining of 0.99 cm^2 more leaf area production. The genotypes SPS-6, SPS-8, SPS-4 and SPS-11 with leaf area production of 11.07 cm^2, 10.59 cm^2, 10.20 cm^2 and 9.355 cm^2 performed poorly to give responsible for this parameter as compared to check varieties. Where as SPS-14, SPS-12, SPS-16, SPS-10, SPS-15, SPS-17, SPS-3 and SPS-13 with the result of 14.25 cm^2, 13.67 cm^2, 13.48 cm^2, 13.24 cm^2, 13.19 cm^2, 13.14 cm^2, 12.91 cm^2 and 12.32 cm^2 exhibited better performance with significant difference for leaf area production as compared to check varieties. Genotypes SPS-14, SPS-12 and SPS-16 had shown greater leaf area production. The significant difference in leaf area production of selected genotypes gave better performance for economic point of view as compared to check varieties. More leaf area of the plants of selected genotypes indicated better production. Leaf area increment may be due to climatic conditions. Similar results were depicted by Ahmed *et al*. for leaf area of different peppers cultivars [19].

The data related leaf weight of different genotypes were analyzed and is summarized in table-1 for their comparison of means. Results revealed the significant difference among various selected genotypes and check varieties for leaf weight. The plant leaves of genotype SPS-14 achieved maximum leaf weight (0.2913 g) which differed significantly with various genotypes followed by genotypes SPS-6 and SPS-16 with leaf weight 0.2820 g and 0.2763 g respectively showing non-significant difference with each other. The minimum leaf weight (0.1350 g) was shown in the genotype SPS-11 followed by SPS-2 and SPS-7 stood at par with 0.1573 g and 0.1593 g leaf weight respectively. The leaf weight of check varieties Green Hot and Rawalakot Local were obtained 0.2387 g and 0.2117 g respectively. Leaf weight between check varieties indicated non-significant difference. Wherever, Green Hot performed fine than Rawalakot Local with attaining 0.027 g is more leaf weight. The genotypes SPS-14, SPS-6, SPS-16 and SPS-12 with their results 0.2913 g, 0.2820 g, 0.2763 g and 0.2523 g showed superior performance with significant difference for leaf weight production as compared to check varieties. Genotypes SPS-14, SPS-6 and SPS-16 exposed larger leaf weight than check varieties. Leaf is important part of plant responsible of food synthesis and supply of carbohydrates to plant for batter growth and development. More leaf area and leaf weight of selected genotypes as compared to check varieties indicated better potential of the selected genotypes for better growth. Difference might be occurred due to genetical variation of genotypes. These results are in harmony with Ziaf *et al*. for leaf area of different peppers cultivars [20].

The data pertaining to specific leaf weight of different genotypes were analyzed and is presented in table-1 for their comparison of means. The data showed non-significant difference among all the selected genotypes and check varieties for specific leaf weight. Due to non-significant results of this parameter comparison of means with DMRT test is not required. Data indicated that genotype SPS-6 attained maximum specific leaf weight (0.026 g) followed by SPS-4, Green Hot and SPS-14 with 0.019 g specific leaf weight respectively. The minimum specific leaf weight was recorded in SPS-7 (0.01 g) followed by SPS-3, SPS-11 and SPS-2 with 0.013 g specific leaf weight. The difference between all genotypes and check varieties exhibited non-significant for this parameter. The results are negatives with Ziaf *et al*., may be due environmental conditions [20].

The data concerning specific leaf area of various genotypes were analyzed and is presented in table-1 for their contrast of means. The data showed significant difference among different selected genotypes and check varieties for this parameter. The maximum specific leaf area (74.41 cm^2) was observed in the plants of genotype SPS-7 followed by genotypes SPS-3, SPS-2 and SPS-10 with specific leaf area production 73.11 cm^2, 72.37 cm^2 and 70.79 cm^2 respectively showing non-significant difference amongst each other. Genotype SPS-6 took minimum specific leaf area (37.98 cm^2) which differed significantly with all genotypes. The specific leaf area of check varieties Rawalakot Local and Green Hot were observed 51.20 cm^2 and 50.34 cm^2 respectively. Specific leaf area difference between check varieties was found non-significant however Rawalakot Local achieved more specific leaf area 0.86 cm^2 than Green Hot. The genotypes SPS-5, SPS-16 and SPS-13 with their results 49.92 cm^2, 48.76 cm^2 and 37.98 cm^2 poorly performed with respect to specific leaf area production as compared to check varieties. These results are in line with Gary *et al*., for specific leaf area of tomato [21].

The data collected to plant height of different genotypes of peppers were analyzed and is reviewed in table-1 for their comparison of means. The data indicated significant difference among various genotypes and check varieties for plant height attainment. The maximum plant height (81.23 cm) was measured in the plants of genotype SPS-18 which differed significantly with all genotypes followed by genotypes SPS-10, SPS-16 and SPS-15 with plant height 76.13 cm, 75.27 cm and 75.20 cm respectively. The minimum plant height (53.03 cm) was shown in the genotype SPS-4. Genotypes SPS-16, SPS-15, Green Hot, SPS-8, SPS-17, Rawalakot Local, SPS-14 and SPS-9 located at par with 75.27 cm, 75.20 cm, 74.53 cm, 74.43 cm, 74.23 cm, 74.00 cm, 73.97 cm and 73.33 cm plant height respectively. The plant height of check varieties Green Hot and Rawalakot Local were found 74.53 cm and 74.00 cm respectively. Plant height difference between check varieties was shown non-significant and Green Hot increased more plant height 0.53 cm than Rawalakot Local. However, SPS-18, SPS-10, SPS-16 and SPS-15 showed greater plant height as compared to check varieties. The dissimilarity in plant height production among various selected genotypes and check varieties might be due to genetic characteristic and environmental factors. Such types of results are relevant to Khan *et al.,* and also in accordance with studied about difference in plant height reported by Bosland [22, 23].

The data pertaining to number of branches of different genotypes were analyzed and is described in table-1 for their contrast of means. The data depicted the significant difference among different genotypes and check varieties for the production of number of branches plant^{-1}. Genotype SPS-14 attained maximum number of branches plant^{-1} (7.10) which differed significantly with all genotypes followed by the genotypes SPS-16 and SPS-18 with plant branching of 6.30 and 5.70 respectively. The other genotypes SPS-6, SPS-15, SPS-4, Green Hot, SPS-10 and SPS-17 produced 5.33, 5.30, 5.23, 5.20, 5.10 and 5.10 number of branches plant^{-1} which differ non-significantly with each other. The minimum number of branches plant^{-1} (3.96) was produced by the plants of genotype SPS-11 which differed significantly with all genotypes. The number of branches plant^{-1} of check varieties Green Hot and Rawalakot Local were 5.20 and 4.80 respectively. However, Green Hot performed better than Rawalakot Local with slightly better result in number of branches plant^{-1}. However, the difference in number of branches plant^{-1} among check varieties was noted non-significant. Genotypes SPS-8, SPS-3, SPS-2 and SPS-11 with their results 4.70, 4.40, 4.23 and 3.96 performed poorly with respect to number of branches plant^{-1} as compared to check varieties. Where as SPS-14, SPS-16, SPS-18, SPS-12, SPS-5, SPS-6, SPS-15 and SPS-4 exhibited excellent performance due to production of more number of branches plant^{-1} as compared to check varieties. Selected genotypes produced maximum number of branches plant^{-1} than check varieties by giving better economical yield and quality. These results are corresponding with Green et al., for number of branches plant^{-1} of various peppers genotypes [24].

Fruits attributes: (fruit length, fruit diameter, no. of fruit plant^{-1}, average seeds fruit^{-1}, fresh fruit yield, average dry fruit yield)

The data for the parameter fruit length of different genotypes of peppers were analyzed and is presented in table-1 for their comparison of means. The data exhibited significant difference among various genotypes and check varieties for fruit length. In genotype SPS-14 maximum fruit length (9.500 cm) was recorded. SPS-14 attained superiority from the parameter and differed significantly with all selected genotypes and check varieties. This was followed by SPS-4 and SPS-2 with 9.300 cm and 9.200 cm fruit length respectively having non-significant difference with each other. The genotype SPS-9 and check variety Rawalakot Local with 8.800 cm stood at par. The minimum fruit length (6.500 cm) was recorded by the plants of genotype SPS-11 which differed significantly with all genotypes. Fruit length of check varieties Green Hot and Rawalakot Local was 9.067 cm and 8.800 cm respectively. The fruit length of check varieties shown significant difference with each other but Green Hot produced 0.267 cm more fruit length than Rawalakot Local. The genotypes SPS-14, SPS-4 and SPS-2 produced greatest fruit length as compared to check varieties and other selected genotypes. The significant difference in fruit length production between genotypes and check varieties pointed out that selected genotypes have better capability of fruit length production and leads to superior economic return. Difference in fruit length due to genetic make-up and might be due to moderate affect of environmental conditions [8, 25].

The data regarding fruit diameter of different genotypes were analyzed and is described in table-1 for their contrast of means. The data indicated significant difference among various genotypes and check varieties for fruit diameter. The selected genotype SPS-2 attained superiority by gaining the maximum fruit diameter (3.037 cm) and differed significantly with all genotypes and check varieties followed by SPS-6 with 2.962 cm diameter showing significant difference between each other. Genotypes SPS-3, Green Hot, SPS-7 and SPS-10 stood at par with obtained 2.863 cm, 2.857 cm, 2.850 cm and 2.847 cm fruit diameter respectively. The minimum fruit diameter (2.387 cm) was observed in genotype SPS-16 and the measurement also differed significantly with all genotypes and check varieties by attaining low fruit diameter. In check varieties fruit diameter measurement was 2.857 cm and 2.567 cm in Green Hot and Rawalakot Local respectively. The variety Green Hot performed well by attaining 0.29 cm more fruit diameter than Rawalakot Local by giving significant difference amongst each other. The genotypes SPS-13, SPS-17, SPS-11, SPS-1 and SPS-16 with their results 2.557 cm, 2.507 cm, 2.447 cm, 2.437 cm and 2.387 cm showed less fruit diameter as compared to check varieties. Where as the plants of genotypes SPS-2, SPS-6 and SPS-3 produced greatest fruit diameter as compared to check varieties. A variation occurred due to genetic characteristics and might be less affected by environmental conditions [8].

Statistically analyzed data from the parameter number of fruits plant^{-1} of different genotypes of peppers is presented in table-2 for their comparison of means. The data indicated the significant difference among various genotypes and check varieties for number of fruits plants^{-1}. In genotype SPS-14 maximum numbers of fruits plant^{-1} (11.60) were observed, which statistically differed significantly with all the genotypes. This was followed by SPS-16 and SPS-18 by attaining 10.57 and 10.03 fruits plant^{-1} respectively. The minimum numbers of fruits plant^{-1} (5.867) were recorded in the genotype SPS-11. The fruit production in check varieties Green Hot and Rawalakot Local were observed 8.867 and 8.167 fruits plant^{-1} respectively. The variation in number of fruits plant^{-1} among check varieties was noted significant. However Green Hot produced more number of fruits plant^{-1} better than Rawalakot Local. The genotypes SPS-12, SPS-7, SPS-5 and SPS-11 with their results 7.700, 7.533, 7.133 and 5.867 respectively carried out poor production with respect to number of fruits plant^{-1} than check varieties. The greater fruit producing selected genotypes SPS-14, SPS-16 and SPS-18 had shown the better potential of a greater number of fruits production. The variation among genotypes for fruit production might be genetic. More numbers of fruits lead to greater fruit yield and more economical for the formers. These results are comparable with Dasgan and Abak, in pepper [26]. They recorded 9.06 highest numbers of fruits plant^{-1} and 5.00 less numbers of fruits plants^{-1}.

The data collected on number of seeds fruit^{-1} of different genotypes of peppers were analyzed and is expressed in table-2 for their comparison of means. The data indicated the significant differences among various genotypes and check varieties for number of seeds fruit^{-1}. The maximum numbers

of seeds fruit^{-1} (299.3) were obtained by the genotype SPS-18. This genotype attained superiority for seed production on all genotypes and check varieties was followed by genotypes SPS-6 and SPS-13 with the number of seeds fruits^{-1} 285.7 and 271.7 which differed significantly among each other and also with all genotypes of peppers. Among the check varieties the Green Hot produced 265.9 seeds fruit^{-1} and stood 4th in ranking with all selected genotypes and check Local Rawalakot. The smallest seeds production (179.6) seeds fruit^{-1} were noted in SPS-11. Variation in number of seeds fruit^{-1} between Green Hot and Rawalakot Local was shown significant, but Green Hot fruits produced 68.3 more number of seeds fruit^{-1} as compared to Rawalakot Local. The genotypes SPS-1, SPS-15 and SPS-11 with their results 195.9, 188.3 and 179.6 produced the lowest number of seeds fruit^{-1} as compared to check varieties and genotypes SPS-18, SPS-6 and SPS-13 gave performance in seed production with significant difference for number of seeds fruit^{-1} as compared to check varieties. Variations in number of seeds fruit^{-1} may be a varietal characteristic. The above results are supported by the Ahmed *et al*., who obtained 400.2 maximum numbers of seeds fruit^{-1} and 220.2 minimum numbers of seeds fruit^{-1}[27].

The data concerning to **a** fresh fruit yield of different genotypes were analyzed and is presented in table-2 for their contrast of means. The data revealed the significant difference among different genotypes and check varieties for fresh yield. The plants of genotype SPS-14 gained maximum fresh yield (21.55 t/ha) and yield data statistically differed significantly with all other selected genotypes and check varieties. This was followed by the genotypes SPS-16 and SPS-18 with the fresh fruit yield of 20.20 t/ha and 19.48 t/ha respectively. The minimum avg. green yield (11.56 t/ha) was attained by the plants of genotype SPS-11 which also statistically differed significantly with all genotypes by giving the lowest green fruit yield of pepper. The fresh yield of the plants of check varieties Green Hot and Rawalakot Local was observed 17.13 t/ha and 15.12 t/ha respectively which showed significant differences between each other. Where as the plants of Green Hot produced better yields than Rawalakot Local with attaining 1.02 t/ha added avg. green yield. While the plants of genotypes SPS-2, SPS-5 and SPS-11 showed poorly performance with respect to fresh yield production as compared to check varieties Green Hot and Rawalakot Local. The plants of selected genotypes have better potential for producing more fresh yield than check varieties which leads to better economical yield of crop. Difference in yield in various genotypes may be due to genetic variation. The SPS-14, SPS-16 and SPS-18 selected genotypes have shown the prominent affect on yield and yield related traits. As a result of continues selection process the dominant alleles of the selected plants have shown significant effect on the progeny and resultantly increase of the yield of these line. This may be useful for further plants selection and improvement from these selected lines. Similar results were concluded by Chattopadhyay *et al*. and Khokhar *et al*., who observed maximum fresh yield 44.26 t/ha and lowest yield 10.97 t/ha of peppers cultivars [18, 25].

Statistically analyzed data from the parameter average dry yield of different genotypes of peppers were summarized in table-2 for their comparison of means. The data expressed the significant difference among various genotypes and check varieties for average dry yield. The selected genotype SPS-14 attained superiority for (7.507 t/ha) average dry fruit yield of crop. This yield increase statistically differed significantly from all selected genotypes and check varieties. SPS-16 stood 2nd in ranking for a dry fruit yield of crop with 6.490 t/ha. SPS-18, SPS-15 and SPS-17 gave the dry fruit yield of 5.893 t/ha, 5.870 t/ha and 5.663 t/ha respectively, showing non-significant difference for dry fruit yield among each other. The minimum average dry yield was obtained by the plants of genotype SPS-11 which gave (3.810 t/ha) average dry yield. The plants of check varieties Green Hot and Rawalakot Local gained average dry yield 5.363 t/ha and 4.257 t/ha respectively. The difference in average dry yield between check varieties was shown significant but Green Hot plants produced 1.106 t/ha extra average dry yield than the plants of Rawalakot Local. The plants of genotypes SPS-7 and SPS-11 with dry yield 4.170 t/ha and 3.810 t/ha weakly performed and produced less yield than check varieties. The plants of selected genotypes showed good potential than check varieties. These results were inline with the Khan *et al*., and Chattopadhyay *et al*., both showed that different cultivars of peppers give different average dry yield [22, 18].

Biochemical attributes: (DPPH, pH, Vitamin-C, TSS, TPC)

The data regarding to DPPH of different genotypes were analyzed and is reviewed in table-2 for their contrast of means. The data offered the significant difference among different genotypes and check varieties for DPPH. The genotype SPS-16 attained the highest position of maximum DPPH (26.53) antioxidant activity percentage which statistically differed significantly with all selected genotypes and check varieties. This was followed by the genotypes SPS-1, SPS-11, SPS-10 and SPS-6 by giving antioxidant activity 24.03%, 23.60%, 23.26% and 23.06% DPPH respectively. The minimum DPPH (16.46%) was found in the genotype SPS-12. The check varieties Green Hot and Rawalakot Local 21.05% and 18.30% DPPH and differed significant with each other. However Green Hot obtained largest position with 2.75% DPPH more than Rawalakot Local. While genotypes SPS-13, SPS-14, SPS-15 and SPS-12 with DPPH concentration 18.20%, 18.13, 17.52 and 16.46% showed poor positions as compared to check varieties. The genotypes SPS-16, SPS-1 and SPS-11 achieved greater range of DPPH than check varieties and other selected genotypes. Antioxidant activity enhanced in following genotypes due to promotion of leaf pigments [28]. These results are followed by Materska and Perucka for DPPH of different peppers genotypes varieties [29].

Statistically analyzed data from the parameter pH of different genotypes of peppers is depicted in table-2 for their comparison of means. The data indicated the significant difference among various genotypes and check varieties for pH level. The maximum pH level was recorded in the

genotype SPS-16 which obtained 5.117. This was followed by the check variety Rawalakot Local with a level of pH 5.017. SPS-16 and Rawalakot Local check variety stood at par statistically showing non-significant difference among each other. The genotype SPS-2 showed minimum pH level 3.897. The pH level of other check variety Green Hot observed 4.367. The difference in pH level between check varieties found significant. However, Rawalakot Local showed level of pH greater than Green Hot. Where as the genotype SPS-16 observed highest pH level as compared to check varieties and selected genotypes. The pH of fruit refers to its acidity and alkalinity, pH below 7 indicates increase acidity and above 7 indicates increase alkalinity. In bell pepper pH level decrease from transfer unripe green to red stage. The pH value did not affect taste, flavor and consumer preference. These results are approaches to Sobhi *et al*., [30]. They observed maximum pH level 6.33 and minimum pH level 4.02 and Antoniali *et al*., was check pH level on yellow bell peppers in different ripeness stages [31].

The data from the parameter Vitamin 'C' of different genotypes was analyzed and is presented in table-2 for their comparison of means. The data showed that non-significant difference among all the selected genotypes and check varieties for vitamin 'C'. Due to non-significant result of the data DMRT test was not applied, however original mean comparisons have because present in table-16 for the interest of viewers. Data indicated the difference in various genotypes and check varieties for Vitamin-C contents of fruits, however, the difference was statistically non-significant. The maximum vitamin C contents were observed in SPS-3 which was followed by SPS-14 and SPS-6. The low contents of vitamin C were found in SPS-12, SPS-4 and SPS-15. The red peppers contain large amount of vitamin C while green peppers contain lower amount of vitamin C. The results are negatives with Ashrafuzzaman *et al*., may be due environmental conditions [32].

The data pertaining to total soluble solids (TSS) of different genotypes were analyzed and is described in table-2 for their contrast of means. The expressed the significant difference among different genotypes and check varieties for total soluble solids. The genotype SPS-2 took maximum level of total soluble solids 4.200% followed by the genotypes SPS-7 and SPS-10 with total soluble solids 4.067% and 4.033% which differed non-significant with each other respectively. The minimum total soluble solids level 2.800% taken by the genotype SPS-13. The genotypes SPS-9, SPS-1, SPS-6 and SPS-11 are at par with each other. The check varieties Rawalakot Local and Green hot were observed total soluble solids 3.200% and 2.933% respectively. The level difference of total soluble solids between check varieties indicated significance and the check variety Rawalakot Local obtained 0.267% more total soluble solids concentration as compared to Green Hot. The genotypes SPS-14 and SPS-13 with total soluble solids level 2.900% and 2.800% which was less than with respect to total soluble solids levels as compared to check varieties. The total soluble solids increase in ripening stage of the pepper fruit increased due to the greater degradation of polysaccharides and the accumulation of sugar. These results are corresponding with Antoniali *et al*., for total soluble solids of yellow bell peppers in different ripeness stages [31].

The data regarding total phenolic content of different genotypes were analyzed and is offered in table-2 for their contrast of means. The data showed that significant difference among various genotypes and check varieties for total phenolic content. The maximum total phenolic content 29.87 (mg GAE/g) was showed by the genotype SPS-10 followed by the genotypes SPS-7 and SPS-1 with phenol content 29.22 (mg GAE/g) and 28.42 (mg GAE/g) which differed significantly with other genotypes. The minimum phenolic content was found in the check variety Green Hot with phenol content 21.81 (mg GAE/g) which differed significantly with all genotypes respectively. The other genotypes SPS-16, SPS-14, SPS-12, SPS-11 and SPS-17 with phenol content 25.39 (mg GAE/g), 25.35 (mg GAE/g), 25.00 (mg GAE/g), 24.95 (mg GAE/g) and 24.91 (mg GAE/g) showed non-significant difference respectively. The chick varieties Rawalakot Local and Green Hot observed total phenolic content 27.12(mg GAE/g) and 21.81 (mg GAE/g) which differed significantly with each other. However, Rawalakot Local expressed more total phenol content than Green Hot with attaining of 5.31 (mg GAE/g) are further total phenolic content. The genotypes SPS-10, SPS-7, SPS-1, SPS-3, SPS-2 and SPS-2 with total phenolic content from 27.14-29.87 (mg GAE/g) more produced as compared to check varieties. Where as genotypes SPS-4, SPS-26, SPS-14, SPS-12, SPS-11, SPS-17, SPS-5, SPS-6, SPS-13, SPS-8, SPS-15, SPS-18 and SPS-9 shown with total phenolic content from 22.80-26.69 (mg GAE/g) are poorly performed than check variety Rawalakot Local but better than check variety Green Hot. Phenolic content increased with salinity level in red fruit and slightly decreased in green fruit [33]. These results are in line with Prasath and Ponnuswami for phenolic content of different peppers genotypes [34].

Table-1 Show MS values:

S.O.V	D.F	Days to 50% flowering	Leaf area (cm^2)	Leaf Weight (g)	Specific Leaf weight (g)	Specific Leaf area (cm^2)	Plant height (cm)	Number of branches	Fruit Length (cm)	Fruit diameter (cm)
Replications	2	123.717**	1.101*	0.000	0.000	29.886*	9.883	0.201	0.153**	0.005**
Treatments	19	18.536**	4.736**	0.005**	0.000	294.598**	135.491**	1.462**	2.529**	0.101**
Error	38	1.962	0.239	0.000	0.000	7.946	3.120	0.118	0.004	0.000
CV%	---	**2.60**	**4.06**	**2.16**	**7.15**	**4.81**	**4.81**	**6.67**	**0.76**	**0.07**

S.O.V	D.F	Fruits $plant^{-1}$	Seeds $fruit^{-1}$	Green fruit yield (t/ha)	Dry fruit yield (t/ha)	DPPH	pH	Vitamin C (mg/100g)	TSS (Brix)	TPC
Replications	2	0.040	46.667**	1.253*	1.243**	5.505**	0.046	0.257	0.018	0.047
Treatments	19	4.722**	2995.433**	17.759**	2.212**	19.739**	0.360**	8.048	8.566**	16.012**
Error	38	0.122	0.032	0.206	0.039	0.290	0.037	0.605	0.015	0.178
CV%	---	**3.93**	**0.08**	**2.62**	**3.80**	**2.60**	**4.45**	**12.43**	**3.41**	**1.66**

SOV= source of variation, DF= degree of freedom, pH= power of hydrogen ions, TSS= total soluble solids, TPC= total phenolic content

Table-2 Shows mean values of days to 50% flowering, leaf area, leaf weight, specific leaf weight, specific leaf area, plant height, number of branches, fruit length and fruit diameter:

Genotypes	Days to 50% flowering	Leaf area (cm^2)	Leaf Weight (g)	Specific Leaf weight (g)	Specific Leaf area (cm^2)	Plant height (cm)	Number of branches	Fruit Length (cm)	Fruit diameter (cm)
SPS-1	52.00 efg	11.73 efgh	0.1710 fgh	0.01500	68.73 b	57.87 f	4.700 fgh	8.100 h	2.437 l
SPS-2	50.33 g	11.39 fghi	0.1573 gh	0.01367	72.37 ab	63.13 e	4.233 hi	9.200 b	3.037 a
SPS-3	51.00 fg	12.91 bcd	0.1767 efgh	0.01367	73.11 ab	72.30 cd	4.400 ghi	7.700 j	2.863 c
SPS-4	53.33 cdef	10.20 j	0.1937 cdefgh	0.01900	52.63 efgh	53.03 g	5.233 cdef	9.300 b	2.697 g
SPS-5	51.33 efg	11.83 efgh	0.2370 abcde	0.01867	49.92 gh	62.83 e	5.400 cde	7.300 k	2.627 i
SPS-6	52.00 efg	11.21 ghi	0.2820 ab	0.02600	37.98 i	69.77 d	5.333 cdef	8.500 f	2.967 b
SPS-7	53.33 cdef	11.86 efgh	0.1593 gh	0.01333	74.41 a	72.17 cd	5.000 defg	6.700 m	2.850 c
SPS-8	55.33 bc	10.59 ij	0.1863 defgh	0.01700	56.82 cde	74.43 bc	4.700 fgh	8.900 de	2.807 de
SPS-9	52.33 defg	11.29 fghi	0.2063 cdefg	0.01800	54.75 defg	73.33 bc	4.700 fgh	8.800 e	2.797 e
SPS-10	56.67 b	13.24 b	0.1870 defgh	0.01400	70.79 ab	76.13 b	5.100 cdef	7.167 l	2.847 c
SPS-11	55.33 bc	9.355 k	0.1350 h	0.01367	68.66 b	69.33 d	3.967 i	6.500 n	2.447 l
SPS-12	60.33 a	13.67 ab	0.2523 abc	0.01667	55.77 def	69.93 d	5.500 cd	7.300 k	2.797 e
SPS-13	52.00 efg	12.32 cde	0.2170 cdefg	0.01700	58.77 cd	72.43 cd	5.000 defg	8.300 g	2.557 j
SPS-14	51.00 fg	14.25 a	0.2913 a	0.01900	50.60 gh	73.97 bc	7.100 a	9.500 a	2.817 d
SPS-15	54.67 bcd	13.19 bc	0.2270 bcdef	0.01633	58.14 cd	75.20 bc	5.300 cdef	9.000 cd	2.667 h
SPS-16	55.33 bc	13.48 ab	0.2763 ab	0.01867	48.76 h	75.27 bc	6.300 b	7.900 i	2.387 m
SPS-17	54.00 bcde	13.14 bc	0.2130 cdefg	0.01600	61.70 c	74.23 bc	5.100 cdef	8.400 fg	2.507 k
SPS-18	56.33 b	12.06 defg	0.2157 cdefg	0.01733	55.91 def	81.23 a	5.700 c	7.100 l	2.617 i
Rawalakot Local	55.00 bc	11.21 ghi	0.2117 cdefg	0.01900	51.20 fgh	74.00 bc	4.800 efgh	8.800 e	2.567 j
Green Hot	56.00 bc	12.20 def	0.2387 abcd	0.01900	50.34 gh	74.53 b	5.200 cdef	9.067 c	2.857 c
LSD	**2.315**	**0.8081**	**0.05227**	NS	**4.659**	**2.920**	**0.5678**	**0.1045**	**0.01653**

Table-3 Shows mean values of no. of fruit plant^{-1}, number of seeds fruit^{-1}, fresh fruit yield, dry fruit yield, DPPH, pH, vitamin C, TSS and TPC:

Genotypes	Number of fruits plant^{-1}	Number of seeds fruit^{-1}	Fresh fruit yield (t/ha)	Average dry fruit yield (t/ha)	DPPH	pH	Vitamin C (mg/100g)	TSS (Brix)	TPC
SPS-1	9.267 defg	195.9 p	15.52 k	4.447 hij	24.03 b	3.993 efg	10.12	6.902 bcde	28.42 b
SPS-2	8.733 ghij	241.7 g	14.65 l	4.780 gh	21.17 fgh	3.897 g	10.05	10.34 a	27.14 c
SPS-3	8.800 fghij	239.0 i	16.29 j	5.403 def	19.48 i	3.947 fg	10.34	7.633 abcd	28.06 b
SPS-4	8.533 hij	213.4 n	18.07 fg	5.270 fg	21.43 fg	4.083 efg	08.16	6.250 cdef	26.69 c
SPS-5	7.133 l	219.0 m	12.90 m	4.733 ghi	20.56 gh	4.297 cdef	09.85	7.639 abcd	24.64 de
SPS-6	9.067 efgh	285.7 b	16.74 ij	4.417 ij	23.06 cd	4.150 defg	10.20	6.254 bcde	24.16 ef
SPS-7	7.533 l	241.7 g	17.88 fgh	4.170 j	21.59 ef	4.350 cde	08.86	8.331 ab	29.22 a
SPS-8	9.433 cdef	224.9 k	18.59 def	5.517 de	18.63 ij	4.220 cdefg	09.23	6.244 def	23.04 gh
SPS-9	8.333 ij	254.8 e	17.75 fgh	5.403 def	22.47 de	4.017 efg	08.86	6.943 bcde	22.80 h
SPS-10	9.233 defg	244.7 f	18.55 ef	5.040 fg	23.27 bcd	4.470 bcd	09.24	8.297 abc	29.87 a
SPS-11	5.867 m	179.6 r	11.56 n	3.810 k	23.60 bc	4.057 efg	10.13	6.253 bcde	24.95 d
SPS-12	7.700 kl	221.8 l	17.49 ghi	5.210 ef	16.46 i	4.510 bc	08.16	6.243 efg	25.00 d
SPS-13	9.133 efgh	271.3 c	18.42 ef	4.773 gh	18.20 jk	4.063 efg	09.65	4.167 i	23.59 fg
SPS-14	11.60 a	238.9 i	21.55 a	7.507 a	18.13 jk	4.807 ab	10.20	4.168 i	25.35 d
SPS-15	9.800 cd	188.3 q	19.37 cd	5.870 c	17.52 k	4.530 bc	08.16	4.860 g	22.97 gh
SPS-16	10.57 b	234.6 j	20.20 b	6.490 b	26.53 a	5.117 a	09.55	5.553 fg	25.39 d
SPS-17	9.600 cde	218.8 m	18.94 cde	5.663 cd	19.27 i	4.473 bcd	09.34	4.489 hi	24.91 d
SPS-18	10.03 bc	299.3 a	19.48 bc	5.893 c	20.39 h	4.103 efg	09.19	5.550 fg	22.97 gh
Rawalakot Local	8.167 jk	197.6 o	15.12 kl	4.257 j	18.30 jk	5.017 a	10.09	4.860 h	27.12 c
Green Hot	8.867 fghi	265.9 d	17.13 hi	5.363 def	21.05 fgh	4.367 cde	08.48	4.168 i	21.81 i
LSD	**0.5773**	**0.2957**	**0.7502**	**0.3264**	**0.8901**	**0.3179**	**NS**	**0.2024**	**0.6974**

CONCLUSION

Taking in conjunction the results of the present study, it is clearly recognized that pepper (*Capsicum annum* L.) genotype SPS-14 and SPS-16 showed good performance in account of fresh fruit yield, average dry fruit yield, and seed production. Its is conclude that Rawalakot area is fine place for vegetative growth parameters, seed production, fruit quality, total fruit yield and chemical composition of pepper and these genotypes recommended for future improvement, to obtain optimum results and also recommended for growing under agro-climatic conditions of Rawalakot, Kashmir-Pakistan.

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