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Genetic evaluation of fruit quantitative traits in sweet pepper at outdoor condition for dry and humid regions

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Abstract
Present experimental study was carried out with the goal to study presence of genetic variability of genetic variability for fruit quantitative characters in sweet pepper at outdoor condition of hot and humid climate of Telangana State. Significant differences were observed for all the traits and it was resulted all the traits had reported high GCV and PCV except fruit yield per plant and fruit yield per hectare had given moderate GCV value which indicates presence of genetic variation for precise characters. Broad sense heritability tied with genetic advance over mean was high for the trait which resembles trait importance over selection adverse stable and better performing elite genotypes for sweet pepper improvement through breeding programs.

Keywords: GCV, PCV, broad sense heritability, GAM

1. Introduction
Sweet pepper commonly known as bell pepper is one of the conservative and sensitive solanaceous crop grown for its bell shape, low pungent, pleasant flavored and bright colored variant fruits (Blanco-Rios *et al*., 2013) [2]. Sweet peppers are one of the best sources of carbs, proteins, good fat and vitamins like Ascorbic acid (97%), vitamin B6 (17%), vitamin K (7%), Vitamin A in colored peppers and Thiamine (5%), and minerals like Manganese (6%) and Potassium (4%).
Sweet pepper is involved in Indian culinary dishes, commonly used as free diet salad and topping in pizza and burgers. In India Sweet pepper are becoming most popular now a days due to its low scoville scale non-pungent (Nadeem *et al*., 2011) [3], bright appearance and highly blending with fried veggies. But, due low productivity and weak supply chain and heavy demand had made high market price of bell pepper.
In order to overcome present lacuna exhibiting in popular market hybrid by production of desired and prominent hybrids. Creation of hybrid is specially originated and depart from more stable and high performing parental lines based on its heterosis nature. Usefulness of plant breeding program is depending on selection of parental lines.
Presently many scientists had reported occurrence of variability for fruit trait or character present in limited gene pool due to limited usage of parental line in hybrid production. Thus, there is a need to survey and study vast diversity present for fruit trait in order to create basic material for sweet pepper improvement.

2. Material and Methods
2.1 Plant material and Experimental design
Around 109 genotypes sown in portray by treating with 20 ppm GA3 for overnight. After 30 days after sowing sapling were transplanted into outdoor condition with two replications in randomized blocks which consists of 25 plants per each block with the spacing of 65 X 45 cm apart.

2.2 Crop management
Saplings were fertigated through drip lines with recommended dosage of fertilizer into proper interval. And, proper care was taken against insect and disease damage. Crop was pruned and trained into two-stem training system.

2.3 Evaluation of line for fruit traits
Upon harvesting stage subsequently fruit trait observations were recorded after 65-70 DAT for

a period of four weeks. Traits like (a) Fruit length, measured in centimeters from pedicel attachment to its apex; (b) Fruit circumference, expressed in centimeter and measured using thread; (c) Fruit diameter, measured using vernier caliper in terms of centimeter; (d) Pedicel length, measured in centimeters from distance between the points of attachment to the stem and to the fruit; (e) Fruit yield per plant, expressed in terms of kilograms; (f) Fruit yield per hectare, measured in terms of tones

2.4 Biometrical analysis
Statistical analysis like Analysis of Variance, descriptive statistics and genetic parameter estimations were done using online statistical tool *i.e.*, OPSTAT.

3. Results and Discussion
Analysis of variance have shown significant difference (p<0.01) for all traits like, fruit length, fruit circumference, fruit diameter, pedicel length, fruit yield per plant and fruit yield per hectare. The mean sums of squares of for all the traits were presented in table 1. The perse mean performance for all the traits was pictured in figure 1.

Fruit length for 109 genotypes recorded a mean value of 8.74 cm with the range of 3.20 to 21.00 cm accounting highest genotypic coefficient of variation (40.97%) and phenotypic coefficient of variation (41.38%) as well as highest heritability coupled with high genetic advance over mean (83.55%). Fruit circumferences accounted overall mean value of 5.62 cm and range of 1.80 to 8.00 cm and it has credited high GCV (25.39%), PCV (25.89%) value and high heritability tied with high GAM (51.30%).

Fruit diameter has recorded average of 18.17 cm and pedicel length of about 3.67 cm with range of 6.34 cm to 25.33 cm and 1.61 cm to 6.35 cm respectively. Both the traits had shown high genotypic coefficient of variation (25.36% & 26.40%) as well phenotypic coefficient of variation (25.73% & 26.47%). Similarly, fruit diameter and pedicel length has represented high heritability coupled with high genetic advance over mean (51.50% & 54.24%).

Fruit yield per plant documented mean of 1.42 kg/plant and whereas, fruit yield per hectare recorded 35.46 tn/ha of mean value. In both the traits it has been recorded moderate genotypic coefficient variation (19.75% & 19.75%) with high phenotypic coefficient variation (20.62% & 20.64%). However, both the characters had documented highest heritability coupled with high genetic advance over mean (38.99% & 38.93%).

The analysis reflected the magnitude of phenotypic coefficient of variation is slightly more than genotypic coefficient of variation for all the traits except for fruit yield per plant and fruit yield per hectare has shown moderate GCV over high PCV due to influence of environmental factor as depicted in figure 2b. The presence of high GCV and PCV value indicates presence vast genetic diversity more over slight variation in

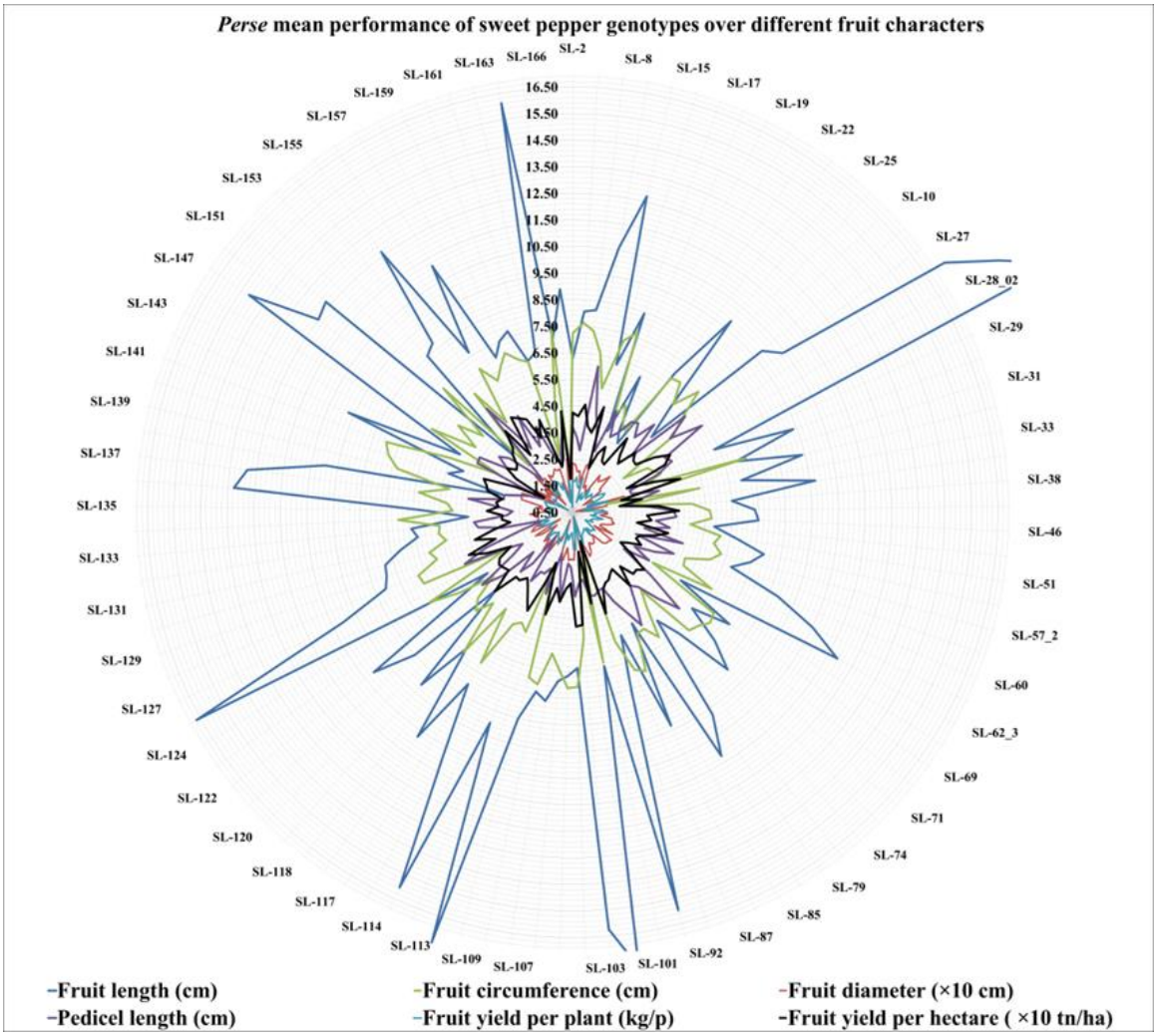
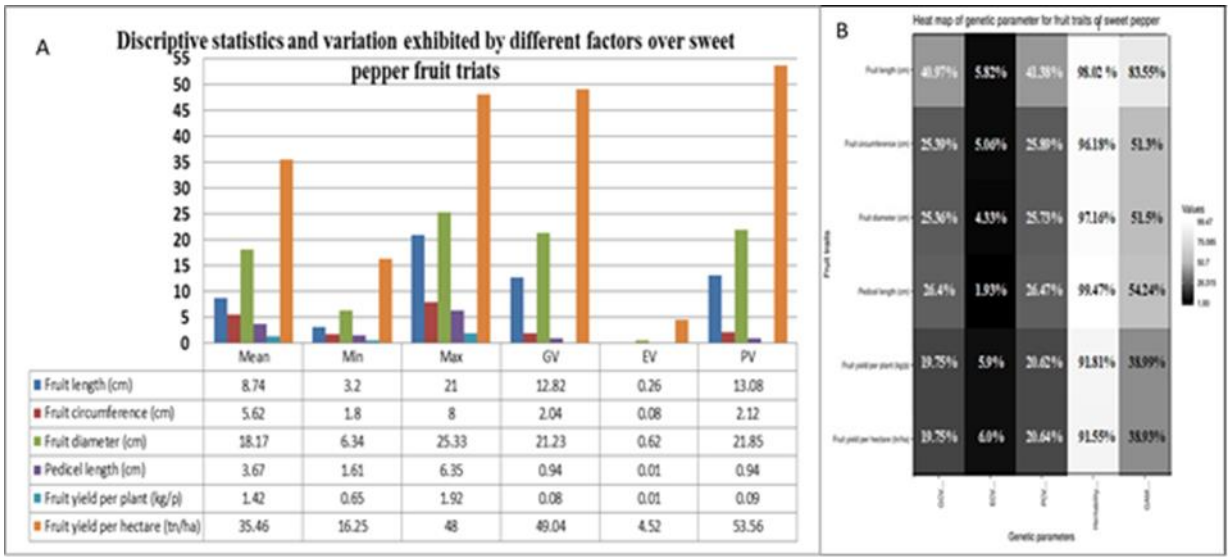


Fig 1: Perse mean performance of sweet pepper genotypes for different fruit traits



	Mean	Min	Max	GV	EV	PV
Fruit length (cm)	8.74	3.2	21	12.82	0.26	13.08
Fruit circumference (cm)	5.62	1.8	8	2.04	0.08	2.12
Fruit diameter (cm)	18.17	6.34	25.33	21.23	0.62	21.85
Pedicel length (cm)	3.67	1.61	6.35	0.94	0.01	0.94
Fruit yield per plant (kg/p)	1.42	0.65	1.92	0.08	0.01	0.09
Fruit yield per hectare (tn/ha)	35.46	16.25	48	49.04	4.52	53.56

Where, Min- Minimum; Max- Maximum; GV- Genotypic Variance; EV- Environmental Variance; PV- Phenotypic Variance; GCV-Genotypic Coefficient of Variation; PCV- Phenotypic Coefficient Of Variation; ECV- Environmental Coefficient Of Variation; hbs- Broad sense Heritability; GA- Genetic Advance;

Fig 2: Descriptive statistics and genetic parameter for fruit traits of sweet pepper (a). Descriptive statistics and source variability for fruit traits of sweet pepper. (b) Heatmap representing genetic parameter for fruit traits in sweet pepper

Table 1: Analysis of variance for different fruit characters of sweet pepper germplasm.

Source of Variation	Degrees of Freedom	Fruit length (cm)	Fruit circumference (cm)	Fruit diameter (cm)	Pedicel length (cm)	Fruit yield per plant (kg/p)	Fruit yield per hectare (tn/ha)
Genotype	108	25.904*	4.16*	43.085*	1.882*	0.164*	102.599*
Error	108	0.259*	0.081*	0.62*	0.005*	0.007*	4.524*
Total	217	2992.259	593.189	5756.144	211.094	36.005	23657.433
C.D.	-	1.011	0.566	1.563	0.136	0.161	4.222
S. Em. ±	-	0.36	0.202	0.557	0.048	0.057	1.504
C. V. (%)	-	5.826	5.074	4.335	1.864	5.724	5.998

Where,
*Significance at p>0.05; C.D. – Critical Difference; S. Em. – Standard Error over Mean;
C. V. –coefficient of variation.

Plate 1: Morphological variation for multiple fruit character present experimental material.

GCV to PCV indicates influence of high genetic constitution factor and less environmental factor and it ensure ample scope for selection and crop improvement in sweet pepper. The results of high GCV and PCV for specified traits are in concurrent with the findings of Naik *et al.* (2014) [4] and whereas, Tariq *et al.* (2014) [9], Sharma *et al.* (2019) [7] and Sharma *et al.* (2010) [8] for fruit yield per plant. Pandit and Adhikary (2014) [5] reported on fruit length and fruit diameter. The high heritability value yields the productive concept of inheritance of trait and Genetic advance over mean value provide selection efficiency. The high heritability tied with high genetic advance over mean indicates the selection of elite genotype over the particular trait and specifies the trait efficiency. Hence, these two parameters are important for breeder for selection. In present study all the traits had shown high heritability coupled with high GAM. The results are correspondingly similar to verdicts of Sharma *et al.* (2010) [8], Ahmed *et al.* (2012) [1], Pandit and Adhikary (2014) [5], Naik *et al.* (2014) [4], Riduan *et al.* (2018) and Sharma *et al.* (2019) [7].

4. Conclusion

From this present study it may be concluded that all the traits *i.e.*, fruit length, fruit circumference, fruit diameter, pedicel length, fruit yield per plant and fruit yield per hectare had shown high PCV and GCV value except fruit yield per plant and fruit yield per hectare had given moderate GCV value which indicates presence of ample amount of variation for particular traits. Whereas, all the traits has resulted high heritability coupled with high genetic advance over mean which point out the selection over this traits might be helpful for selection of elite genotypes for sweet or bell pepper improvement.

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