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Variability assessment for different quantitative and qualitative traits in pumpkin (*Cucurbita moschata* L.) genotypes

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Abstract
Present investigation was planned to assess the variation in 40 genotypes including two checks of pumpkin, collected from different regions of Uttarakhand. The experiment was conducted at Vegetable Research Center of G.B.P.U.A. & T., Pantnagar during spring-summer season of 2018 and 2019. The experiment was laid out in Randomized Block Design with three replications. All genotypes were evaluated for GCV, PCV, heritability and genetic advance. Results of analysis of variance (ANOVA) showed presence of sufficient variability for different traits and provides opportunity for further genetic improvement of pumpkin crop. High heritability was reported for almost all the quantitative and qualitative characters under study. High heritability coupled with high genetic advance was reported by traits such as days to first female flower, days to first harvest, fruits set percent, number of seeds per fruit and non-reducing sugars during both the experimental years. Information about genetic variability, their heritability and genetic advance is crucial and helpful in planning future breeding program.

Keywords: Genetic variation, GCV, PCV, heritability, genetic advance

Introduction
Pumpkin (*Cucurbita moschata* L.) is a nutritious vegetable as it is rich in Vitamin A content and a good source of carbohydrates. It is also known as butter nut squash, crookneck squash, musky gourd in western countries and sitaphal, kashiphal, kaddu etc. in India. The plant is an annual creeping vine which bears branched tendrils. Plant put down secondary roots in the ground for support and their tendrils twine around other weed plants and creeps forward with the help of them. Genetic variability in breeding materials is essential for execution of a successful plant breeding program. Pumpkin exhibit high variability in fruit shape, fruit size, fruit flesh colour, plant vegetative growth etc. Knowledge about the magnitude of variability in a crop species is extremely important, since it provides the basis for selection. Economic characters are polygenic in nature and they are highly affected by environment effects. However, the qualitative characters are oligogeneic in nature and mostly not affected by environmental conditions. The knowledge of genetic variability, their nature of governance, their heritability and genetic advance is of utmost importance and very much essential for planning future breeding. According to Patil *et al.*, (2012) [5] assessment of variability present in any crop species is an essential pre requisite for formulating an effective breeding program, as the existing variability can be used to enhance the yield level of cultivars following appropriate breeding strategies. The yield potential of any crop needs to be improved through utilization of present variability. With this regard the present study was conducted with the objective to study the variability for fruit yield and its contributing characters in pumpkin genotypes.

Material and Methods
Present experiment was carried out during spring-summer season of 2018 and 2019 at Vegetable Research Centre of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar which is situated at an elevation of 243.48 meters above sea level in the foot hills of sub-mountainous region of Shivalik hills, known as *tarai* region. The research material was consists of 40 diverse genotype of pumpkin including two checks (Pusa Vishwas and Pusa Vikas), collected from different parts of Uttarakhand. Experiment was laid out in Randomized

Block Design with three replications. Each genotype had five plants to evaluate and spaced at 3 m distance between the channels and 1 m spacing between plants. Observations were recorded on twenty three yield and yield contributing characters *viz.* days to first female flower, nodes to first female flower, male female flower ratio, days to first harvest, pedicle length, average fruit weight, fruit diameter, flesh thickness, central cavity, number of harvest, fruit set percent, diameter of main vine, main vine length, fruits per vine, yield per plant, number of seeds per fruit, test weight, total soluble solids, reducing sugars, non-reducing sugars, ascorbic acid content, carotenoid content and carbohydrate content. The crop was raised by adopting all standard agronomical practices.

Results and Discussion

Analysis of variance (ANOVA) for all twenty three quantitative as well as qualitative traits is presented in table 1. During first season of experiment almost all the characters showed highly significant values in treatments except for the three characters i.e. diameter of main vine, average fruit weight and carotenoid content. However, in second year along with these traits, fruits per vine also showed non-significant value. The significant differences indicate presence of sufficient variability for different traits which provides opportunity for further genetic improvement of pumpkin crop.

Coefficient of Variation

Coefficient of variation is a statistical tool to measure the degree of variation for one or different traits. It is judged by measuring genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV). The estimates of GCV and PCV for different quantitative and qualitative parameters during first season and second season are presented in table 1. It was observed that in general the PCV was found higher than the GCV for all the characters in both the seasons which indicate that the variations were not only due to genotype but also due to the influence of environment. Selection for such traits sometimes may be misleading. The results were in accordance with Kumari *et al*., (2017) [3] in cucumber and Anantham and Krishnamoorthy (2017) [2] in ridge gourd. A narrow range of difference between GCV and PCV was recorded for almost all the characters which reveal that these traits are mostly governed by genetic factors with minimum effect of environmental conditions on phenotypic expression. Therefore, selection of these traits on the basis of phenotypic expression can be effective. Narrow range of difference between GCV and PCV was also reported by Akter *et al.,* (2013) [1] for days to first female flower, number of seeds per fruit and beta-carotene in pumpkin genotypes.

During first season (2018) of experiment, high GCV and PCV (>20 %) were observed for carotenoid content (59.21, 59.76), followed by ascorbic acid content (46.20, 46.34), main vine length (42.64, 43.19), number of fruits per plant (37.83, 37.93), test weight (35.99, 36.42), average fruit weight (25.12, 25.59), number of harvest (24.86, 25.50) and flesh thickness (23.68, 25.46). However, traits showing values between 10-20 % showed moderate value for GCV and PCV. Similarly, during second year of experiment high PCV and GCV (>20%) were observed for carotenoid content (59.18, 59.76), ascorbic acid (48.07, 48.26), main vine length (37.91, 37.97), flesh thickness (34.34, 35.43), number of seeds per fruit (31.65, 31.99), nodes to first female flower (19.21, 19.60), total soluble solids (23.91, 24.59), diameter of main vine (21.50, 21.67), central cavity (21.59, 21.70), and number of harvest (20.45, 22.15) and traits showing values between 10-20 % showed moderate GCV and PCV, whereas low values of GCV and PCV (<10 %) were observed for yield per plant (9.85, 10.05) and days to first harvest (8.80, 8.85). High values of GCV and PCV indicating wide variability in the traits among the genotypes and such traits could be improved by further selection method. Characters showing low GCV and PCV in both the seasons are lacking in sufficient genetic variability among genotypes. Therefore, variation has to be generated through introduction and hybridization with diverse genotypes to create variability. Similar results were also recorded by Shet *et al*., (2018) [8] for characters like node at first female flower appears and flesh thickness in cucumber.

Heritability

Measures of variance alone do not provide the clear idea of heritable variances and non-heritable variances which is very important in planning any genetic improvement program. Heritability in broad sense is the better tool to know the extent to which any trait transmit from parent to offspring. The heritability for different quantitative and qualitative parameters during 2018 and 2019 is presented in Table 1.

It was reported during first season that all the characters under study were highly heritable (>75 %) except the fruit yield per plant (74.20). The heritability varied from 74.20-99.59 % during experiment. Maximum heritability was observed for reducing sugars (99.59). During second season estimates of heritability ranged from 85.25-99.65 % and trait main vine length was the most heritable character (99.65) followed by fruit diameter (99.42). High heritability (>75 %) reported in various characters indicates these characters are mainly govern with genetic factors and environmental conditions play least role on expression of these characters. These characters can directly be improved through selection and would exhibit high response to selection. Present findings were in accordance with Mishra *et al.,* (2017) [4] in musk melon and Tyagi *et al.,* (2018) [9] in bitter gourd, who has found high heritability for various traits under study.

Genetic advance

Though heritability is a good measure but it is highly influenced by various genotype and environmental interactions, hence it does not provide the clear idea about genetic gain in the next generation. Heritability along with genetic advance is more helpful for predicting genetic gain of offspring in next generation. The results for genetic advance and genetic advance as a percent of mean in present investigation during 2018 and 2019 are presented in Table 1.

During first year of experiment, maximum genetic advance was recorded for the traits like number of seeds per fruit (200.5), followed by fruit set percent (21.04). However, minimum genetic advance was reported for the traits ascorbic acid (9.17), male female flower ratio (7.0), nodes to first female flower (3.9), total number of harvest (2.0), total soluble solids (2.1), carbohydrate content (1.90), yield per plant (1.84), pedicle length (1.79), flesh thickness (1.73), diameter of man vine (1.3), average fruit weight (1.04), and carotenoid content (0.74). Similarly, during second year of experiment maximum genetic advance was recorded for the trait number of seeds per fruit (160.9). whereas minimum genetic advance was reported for the traits like ascorbic acid (9.22), main vine length (4.44), number of harvest (2.03), fruit per plant (1.62), diameter of main vine (1.32), and carbohydrate content (1.90), yield per plant (1.84), carotenoid content (0.72), and average fruit weight (0.66).The high value

of genetic advance as percent of mean (>20 %) was obtained for almost all the traits. However, moderate values (10-20 %) were recorded for yield per plant (19.0) during first year and during second year for yield per plant (19.9) and days to first harvest (18.0). The high value of genetic advance indicates additive genetic component have predominant role in expression of these traits and environment play insignificant role in phenotypic expression. Hence, phenotypic selection is an effective tool to improve these characters.

High heritability accompanied with high genetic advance was observed for to first female flower, days to first harvest, percent fruit set per plant, number of seeds per fruit and non-reducing sugars which indicates the predominant role of additive genetic effects in expression of these traits. Direct phenotypic selection would be effective in improvement for such characters. However, high heritability coupled with low genetic advance was exhibited by main vine length, diameter of main vine, male female flower ratio, total number of harvest, pedicle length, total soluble solids, and carotenoid content and carbohydrate content. It reveals that the high heritability is primarily due to favorable effect of environmental conditions. Genetic component does not play any significant role; hence selection of such traits would not be beneficial. Low heritability coupled with low genetic advance was observed during first season for only one trait; fruit yield per plant, indicating the trait is governed with non-additive gene action and highly influenced by environmental effects. Selection would not be a good method for improvement of such trait.

Present study was similar to the earlier study of Rambabu *et al.,* (2017) [7] for vine length, days to first female flower appearance, days to first harvest, number of fruits per plant, average fruit weight, fruit yield per plant, sex ratio, seed number per fruit, 100 seed weight, total soluble solids of the pulp, total sugar content and ascorbic acid content in bottle gourd. However, Rajawat and Collis (2017) [6] reported high heritability accompanied by lower genetic advance for vitamin C, total soluble solids, fruit yield per vine and days to first fruit harvest in cucumber.

Table 1: Estimates of GCV and PCV, heritability, genetic advance and genetic advance as per cent of mean in pumpkin genotypes. (2018-2019).

SI. No.	Characters	Genotypic Coefficient of Variance		Phenotypic Coefficient of Variance		Heritability (%)		Genetic Advance		Genetic Advance as per cent of mean (%)	
		2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
1.	Days to first female flower	16.42	13.88	16.48	13.92	99.3	99.4	18.0	15.9	33.7	28.5
2.	Nodes to first female flower	19.49	19.21	19.66	19.60	98.3	96.1	3.9	3.6	39.8	38.8
3.	Male : female flower ratio	18.30	17.07	18.37	17.39	99.3	96.3	7.0	6.4	37.6	34.5
4.	Days to first harvest	12.14	8.80	12.25	8.86	98.1	98.7	18.3	14.0	24.8	18.0
5.	Pedicle length (cm)	19.15	17.82	19.46	18.52	96.8	92.6	1.8	1.6	38.8	35.3
6.	Average fruit weight (kg)	25.13	17.63	25.59	17.71	96.4	99.1	1.0	0.7	50.8	36.1
7.	Fruit diameter (cm)	19.46	20.03	19.53	20.09	99.2	99.4	7.6	7.0	39.9	41.2
8.	Flesh thickness (cm)	23.68	34.35	25.47	35.43	86.5	94.0	1.7	2.7	45.4	68.6
9.	Central cavity (cm)	23.82	21.60	23.92	21.71	99.2	99.0	7.4	5.8	48.9	44.3
10.	Number of harvest	24.86	20.46	25.50	22.15	95.0	85.3	2.0	1.6	49.9	38.9
11.	Fruit set percent	13.65	11.56	13.70	11.91	99.3	94.1	21.0	16.7	28.0	23.1
12.	Diameter of main vine (cm)	20.65	21.51	21.73	21.67	90.3	98.5	1.3	1.4	40.4	44.0
13.	Main vine length (cm)	42.65	37.91	43.19	37.98	97.5	99.7	4.4	3.7	86.7	78.0
14.	Fruits per vine	16.61	12.41	16.96	12.55	95.9	97.7	1.6	1.3	33.5	25.3
15.	Yield per plant (kg)	10.69	9.85	12.41	10.05	74.2	96.0	1.8	1.9	19.0	19.9
16.	Number of seeds per fruit	37.84	31.66	37.94	31.99	95.9	97.7	1.6	1.3	33.5	25.3
17.	Test weight (g)	35.99	29.72	36.43	29.96	97.6	98.4	7.6	6.1	73.3	60.8
18.	Total soluble solids (^{0}brix)	19.70	23.92	22.48	24.59	76.8	94.6	2.1	2.9	35.6	47.9
19.	Reducing sugars (g/100g)	18.98	20.44	19.02	20.82	99.6	96.4	16.4	17.0	39.0	41.3
20.	Non-reducing sugars (g/100g)	20.93	23.33	21.26	23.78	96.9	96.2	15.5	18.0	42.4	47.1
21.	Ascorbic acid (mg/100g)	46.21	48.07	46.35	48.27	99.4	99.2	9.2	9.2	94.9	98.6
22.	Carotenoid content (mg/100g)	59.22	59.18	59.76	59.77	98.2	98.1	0.7	0.7	120.9	120.7
23.	Carbohydrate content (g/100g)	16.65	16.26	17.49	16.87	90.7	92.8	1.9	1.9	32.7	32.3

Conclusion

Variability is the mother of selection and crop improvement is based on it. During present study pumpkin genotypes collected from different regions of Uttarakhand showed sufficient variability for various qualitative as well as quantitative characteristics. Presence of this variation provides scope to further harness potentiality of the crop.

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