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Analysis of Genetic Variability, Correlation and Path Coefficient in Pumpkin (*Cucurbita* spp.) Genotypes

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ABSTRACT: Genetic variability and its proper characterization are of vital importance in hybridisation programme of a crop for making a successful rapid improvement. In India, there is a wide range of genetic variability in pumpkin but, not much attention has been given to its improvement programme. Moreover, pumpkins (*Cucurbita* spp.) are grown as a summer crop in *Terai* region of West Bengal and no suitable genotypes are available for winter season cultivation. Hence, the present study focuses on identifying and conserving the superior genotypes for off-season to facilitate the future breeding programme. The present experiment was carried out at the experimental field of the department, Vegetable and Spice Crops, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India with thirty one genotypes of pumpkin (*Cucurbita* spp.) collected from the hills of West Bengal and North East region of India during the *Rabi* season of 2020-21. The genetic variability, correlation and path analysis of various attributes was analysed with the help of GENRES statistical software. The analysis of variances revealed significant difference among the genotypes which confirms the presence of good genetic variability. The highest PCV was observed in vitamin A content of the fruit (48.54%) while, the highest GCV was observed in average fruit weight (47.84%). However, for most of the traits the difference between PCV and GCV were minimum which indicates that the studied traits were least effected by environment. Heritability in broad sense and genetic advance was very high to high for most of the traits under study. The vine length, fruit length, fruit diameter, flesh thickness, seed cavity diameter, fruits per plant and average fruit weight was significantly and positively correlated with fruit yield per plant. The path coefficient analysis suggested that the fruit diameter (0.701) exerted the highest positive and direct effect on fruit yield followed by primary branches (0.452) and fruits per plant (0.447) which indicates a true relationship between these traits and yield per plant.

Keywords: Correlation, genotypes, genetic variability, path analysis, pumpkin.

INTRODUCTION

The "pumpkin" belongs to the genus *Cucurbita* which is one of the most diverse genera in plant kingdom (Pooja and Maurya 2022). It lies in the family group of cucurbitaceae which consist of the maximum numbers of edible vegetable crops (Tamilselvi and Jansirani 2017). The *Cucurbita* consists of five domesticated species and twenty two wild species (Dhatt *et al.,* 2020). And all of these species have a basic chromosomal number of 2n= 2x= 40. Certain fruits of this domesticated species are referred to as "pumpkin" (OECD, 2016). The genus *Cucurbita* is believed to have been originated from the Central- South America. It is a remarkable vegetable that has the potential to be consumed both as a nutritious diet and a medicine, as the fruits and seeds are a rich source of essential nutrients and phytochemicals such as β-carotene, total flavonoids, total phenolic etc. (Hosen *et al.,* 2021). It's uses for nutritional, ethnomedical, and technological purposes such as chemical extraction has increased in a recent past and therefore, the production of these plants should be increased. However, in most parts of the India *Cucurbitas* are grown as a summer crops and availability is limited within these periods. Hence, identification of the pumpkin genotypes with higher yield potential during the winter (off-season) would help to improve the production of this crop and may prolong the availability of pumpkin during off-season, consequently yielding better income to the farmers.

The ease in production techniques, higher productivity, longer period of storage, rich nutrient content and good transportability of pumpkin (Hazra *et al.,* 2007) contributed to its global ubiquity among farmers. Due to this, *Cucurbita* has developed a wide range of forms, local races, varieties, and commercial cultivars. Furthermore, the out crossing behaviour of this crop helped produced a significant amount of genetic diversity locally, regionally and globally. In India, there is a wide range of genetic variability therefore; genetic diversity assessment of the existing *Cucurbita* germplasm, its proper characterization and appropriate preservation is of utmost importance for future breeding programme to achieve specific objectives (Dhatt *et al.,* 2020). As, sometimes unheeded genotypes of a crop possess various traits that are of agronomic and horticultural importance. In addition to this estimation of heritability and genetic advance provides a helping hand in making an appropriate selection (Patil *et al.,* 2023). The, assessment of heritability provides the indication of the transmission of the characters from parents to offspring (Singh and Narayanan 1993). The yield is a complex characteristic which is influenced by intricate relationships between a numbers of agronomic characters therefore direct selection on the basis of *per se* performance may not be efficacious (Jogender *et al.,* 2023). Consequently, knowledge of the character associations of a crop is required. Thus, correlation aids in understanding of how yield and yield-contributing traits interact (Kumar *et al.,* 2022), which is crucial for selection. Fruit yield in pumpkin was significantly and positively correlated with the length of vine, number of primary branches, number of fruits, fruit weight and flesh thickness. But it does not provide an exact accounting of how each character affects fruit yield, so in order to separate the correlation coefficient into the direct and indirect effects of different traits on fruit yield, path analysis might be helpful (Aruah *et al.,* 2012). Report published by Ramjan and Ansari (2020) proclaimed that number of fruits per plant imposed a maximum direct positive effect on fruit yield per plant (0.664) while, maximum negative direct effect was imposed by vitamin A (-0.199), on fruit yield per plant. Therefore, the goal of this current experiment was to assess the genetic variability, correlation, and the direct and indirect contributions of some yield characteristics towards fruit yield in the pumpkin (*Cucurbita* spp.) genotypes.

MATERIAL AND METHODS

Thirty one genotypes of pumpkin (*Cucurbita* spp.) collected from the various parts of West Bengal and North East India were evaluated under the natural field conditions at the experimental field of the department, Vegetable and Spice Crops, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India during the *Rabi* season of 2020-21. The exact location were 26°40'N and 89°38'E latitude and longitude, respectively and elevation of 43 meter above sea level. In terms of agro climatic zone it falls under Terai zone of West Bengal with sandy loam type of soil. The experiment was carried out adopting Randomized Block Design (RBD) with three replications. To grow the healthy crop, the recommended package of practises as per was followed. Data on a few agronomic traits were gathered from randomly tagged 5 plants using the common descriptor lists suggested by Srivastava *et al.* (2001). Sixteen characters were considered for the investigation of various genetic parameters and their interactions; Vine length (m), Inter-nodal length (cm), Petiole length (cm), Primary branches per plant, Number of leaves per plant (90 DAS), Days to first female flowers emergence, Node for first female flowers, Fruit length (cm), Fruit diameter (cm), Flesh thickness (cm), Seed cavity diameter (cm), Fruits per plant, Average fruit weight (kg), Vitamin A (IU), Vitamin C (mg/100g) and Fruit yield (kg/plant). All the statistical analysis was carried out using GENRES statistical software. The mean values of the data collected for the various attributes were subjected to analysis of variance as per the procedure given by Panse and Sukhatme (1967). The Genotypic Coefficients of variability (GCV %) and Phenotypic Coefficients of variability (PCV %) were calculated as per the formula of Burton and De-Vane (1953). Broad sense heritability (h^2) was estimated using the formula given by Hanson *et al.* (1956) and classified as per Robinson (1966). Genetic advance (GA) and genetic advance as percent mean for each trait was determined and categorised using formula of Johnson *et al.* (1955). By using the technique provided by Al-Jibouri *et al.* (1958), the genotypic (r_g) and phenotypic (r_p) correlation coefficient was calculated. Finally, following the procedure described by Dewey and Lu (1959) path co-efficient analysis was carried out.

RESULTS AND DISCUSSION

The results of the analysis of variance showed that the traits in genotypes exhibit a large amount of variation. For all traits, the mean sum of squares was highly significant indicating that there was significant variation in genotypes (Table 1). The findings are in consonance with Srikanth *et al.* (2017) in pumpkin.

Genetic variability: The presence of genetic variability in the base population of any plant is one of the essential criteria for the crop improvement program. Proper knowledge regarding genetic variability is required to obtain desired results in some important characters. Table 2 presents the range of variation in some important traits of the pumpkin. The range of vine length was 2.77-5.02 m, inter-nodal length and petiole length ranged between 12.23-23.56 cm and 11.82-22.97 cm, respectively. The number of primary branches per plant was between 3.33-5.11 while, the number of leaves per plant at 90 DAS was between 84.83-170.67. Days to first female flowers emergence ranged from 46.00-78.00 and node for first female flowers ranged from 9.20-16.67. The fruit characteristics like, fruit length, fruit diameter, flesh thickness and seed cavity diameter had a range from 13.58-33.19 cm, 10.25-23.25 cm, 2.20-5.00 cm and 6.15-12.77 cm, respectively. Srikanth *et al.* (2017) reported the similar results in the fruit length (19.48-32.21 cm), fruit diameter (13.72-24.58cm) and flesh thickness (2.97-5.25 cm) of pumpkin. Further, there was a wide variation in yield attributes such as, fruits per plant ranged from 1.80-6.73, average fruit weight ranged from 0.53-4.05 kg and fruit yield/ plant ranged from 2.12-12.14 kg. The variation in yield attributes is also reported by Thirumdasu and Chatterjee (2018); Krishnamoorthy and Sampath (2020). Variability in quality of fruits *viz.*, vitamin A and vitamin C was recorded between 677.67-3471.47 IU and 3.03-10.01 mg/100g, respectively.

Genotypic and phenotypic coefficient of variation: In Table 2, the estimates of the genotypic and phenotypic coefficients of variation (GCV and PCV, respectively) for 16 characters are depicted. In all of the studied characters the phenotypic co-efficients of variation (PCV) were higher than the genotypic co-efficients of variation (GCV). It indicates that the variation is not only due to genotype but the environment had a significant moderate influence (Gaikwad *et al.,* 2011). Therefore, when selection is made for these traits on the basis of phenotype alone it is crucial to be conscientious as environmental variation is unpredictable in nature (Dabalo *et al.,* 2020). The prior findings of Singh *et al.* (2019); Srikanth, *et al.* (2017), and Sultana *et al.* (2015) also mentioned the higher PCV than the GCV. The highest PCV was observed in vitamin A content of the fruit (48.54%) which is in harmony with the findings of Ramjan (2021); Akter *et al.* (2013). Similarly, higher PCV was recorded in characters like average fruit weight (48.15%), fruit yield per plant (45.59%), flesh thickness (21.23%), Vitamin C (34.24%), and in fruits per plant (33.99%). As for GCV the highest was observed in average fruit weight (47.84%) which suggests that, in comparison to other characteristics, the performance of this trait was less influenced by the environment Nagar *et al.* (2017); Sampath and Krishnamoorthy (2017) also reported highest estimates of GCV for fruit weight. Similarly, higher GCV was also recorded in fruits per plant (33.00%), vitamin A (46.33%), vitamin C (29.79%) and in Fruit yield/plant (44.79%). A high GCV is a sign of high variability overall in the population and indicates that there is room for these qualities to be improved through direct selection. Rest of the attributes except for the Flesh thickness (high PCV and moderate GCV) displayed moderate PCV and GCV. For most of the traits the difference between PCV and GCV were minimum which indicates that these traits are least effected by environment. This also suggested that the genes responsible for these traits were successful in expression of the phenotype (Begum *et al.,* 2022). Although, GCV provides a good indication of genetic variability present but GCV along with heritability would be more efficient for selection of particular trait as GCV alone cannot estimate the amount of variation (Singh and Kumar 2005).

Heritability and Genetic advance: Heritability in broad sense was estimated for 16 characters (Table 2). Most of the traits under study expressed very high broad sense heritability. The heritability values were 88.59% in vine length, 91.55% in inter-nodal length, 94.21% in petiole length, 99.73% in number of leaves per plant (90 DAS), 97.62% in days to first female flowers emergence, 92.63% in node for first female flowers, 93.97% in fruit length, 98.05% in fruit diameter, 84.41% in flesh thickness, 92.63% in seed cavity diameter, 94.27% in fruits per plant, 98.73% in average fruit weight, 91.07% in vitamin A and 96.53% in fruit yield. All of these characters are highly heritable and during selection, these traits in genotypes must be considered as expression of these traits will be higher in succeeding generation. This result is in accordance with the previous findings of Singh *et al.,* (2019) and Chaudhari *et al.* (2017). When the heritability for certain character is very high, transmission of such character to its progeny is easy due to the closer association between the genotype and phenotype which occurs from the minimal contribution of environment to the phenotype (Dabalo *et al.,* 2022). Meanwhile, the vitamin C exhibited moderate high heritability (75.67%) and primary branches per plant exhibited moderate heritability (46.96%). For easy selection, heritability of a trait should be more than 70% according to Singh (2001), but high heritability alone cannot make effective selection in an advanced generation unless it is coupled with a significant amount of genetic advance (Owusu *et al.,* 2021).

The genetic advance of mean (GAM) for the traits studied (Table 2) was in the range of 14.40% to 97.92%. For most of the characters GAM was in the higher range except for the primary branches per plant (14.40%). Table 2 confirmed that the heritability coupled with GAM was higher in almost all of the attributes. Ratnakar *et al.* (2018) also reported high heritability along with GAM for most of the characters under study. It suggests that the heritability of these traits are due to the additive gene effect and their selection maybe effective (Singh and Narayanan. 1993). On the other hand, primary branches per plant exhibited moderate heritability with moderate GAM.

Correlation: The pattern of inheritance of character is complicated and is affected by the number of associated traits, better understanding of character association helps in the better selection criteria for breeding programme. Referring Table 3, it is evident that genotypic correlation was greater than the phenotypic correlation for most of the studied attributes. Similar result was found by Sultana *et al*. (2015).

In present experiment, the vine length ($r_g = 0.371^{**}$, $r_p = 0.354^{**}$), fruit length ($r_g = 0.555^{**}$, $r_p = 0.529^{**}$), fruit diameter ($r_g = 0.771^{**}$, $r_p = 0.749^{**}$), flesh thickness ($r_g = 0.588^{**}$, $r_p = 0.517^{**}$), seed cavity diameter ($r_g = 0.658^{**}$, $r_p = 0.619^{**}$), fruits per plant ($r_g = 0.354^{**}$, $r_p = 0.362^{**}$) and average fruit weight ($r_g = 0.753^{**}$, $r_p = 0.744^{**}$) was significantly and positively correlated with fruit yield per plant. Mohsin *et al.* (2017); also reported these characters have positive and significant correlation with yield per plant. Conversely, the traits like; petiole length, primary branches per plant, days to first female flowers emergence and vitamin A exerted negative and non significant correlation with fruit yield per plant. This means that these characters are not influencing yield and increase in any of these character would decrease the yield per plant and vice-versa.

Correlation studies among the other attributes revealed positively significant high genotypic and phenotypic correlation of average fruit weight with fruit length (r_g = 0.890** ,r_p = 0.864**), fruit diameter (r_g = 0.911** ,r_p = 0.896**), flesh thickness (r_g = 0.8 20** ,r_p = 0.759**), and seed cavity diameter (r_g = 0.873** ,r_p = 0.835**). It implies that the average fruit weight increases with the increase in fruit length, fruit diameter, flesh thickness and seed cavity diameter. But it had significantly negative correlation with days to first female flowers emergence (r_g = -0.396**, r_p = -0.391**) and fruits per plant (r_g = -0.311**, r_p = -0.303**). Likewise, days to first female flowers emergence showed negatively significant correlation with node for first female flowers (r_g = -0.291**, r_p = -0.282**), fruit length (r_g = -0.575**, r_p = -0.548**), fruit diameter (r_g = -0.243**, r_p = -0.240**), flesh thickness (r_g = -0.466**, r_p = -0.425**), seed cavity diameter (r_g = -0.365**, r_p = -0.352**) and average fruit weight (r_g = -0.396**, r_p = -0.391**). Following the quality attributes of pumpkin genotypes *viz.*, vitamin A and vitamin C most of it revealed non significant correlation with other attributes.

Path coefficient analysis: Analysis of path coefficient (Table 4) provides estimates of the direct effects of certain attributes on yield as well as estimates of the indirect effects via other components, which aids in identifying yield components. The experiment revealed that the fruit diameter (0.701) exerted the highest positive and direct effect on fruit yield followed by primary branches (0.452) and fruits per plant (0.447). Similarly, Srikanth *et al.* (2015) reported positive and direct effect of these traits on pumpkin yield. It can be interpreted that direct selection of these traits would be fruitful for yield enhancement. Vine length (0.098), seed cavity diameter (0.037) and vitamin C (0.069) contributed a direct and positive effect to yield but are negligible. The other traits *viz.*, petiole length (-0.267), number of leaves (-0.247), days to first female flowers emergence (-0.251), node for first female flowers (-0.205), fruit length (-0.298), and vit A (-0.349) content exerted a negative and direct effect on fruit yield per plant. Shivananda *et al.* (2013) also recorded negative direct effect of carotene content and nodes upto first female flower on fruit yield; while Chaudhari *et al.* (2017) reported negative and direct effect of days to opening first female flower, polar circumferences of fruit and ß-carotene on fruit yield. The fruit diameter presented positive indirect effect on fruit yield via traits like vine length, petiole length, number of leaves per plant, node for first female flowers, fruit length, flesh thickness, seed cavity diameter and average fruit weight. Similarly, average fruit weight exhibited indirect positive effect on fruit yield through traits like vine length, petiole length, fruit length, fruit diameter, flesh thickness and seed cavity diameter.

Table 1: Analysis of variance for yield and yield attributing characters in pumpkin.

DF	Mean sum of square		
	Replication	Treatment	Error
	2	30	60
Characters			
Vine length (m)	0.03	1.19	0.05
Inter-nodal length (cm)	1.58	14.26	0.43
Petiole length (cm)	2.78	26.56	0.53
Primary branches per plant	0.63	0.72	0.20
Number of leaves per plant (90 DAS)	2.50	986.88	0.89
Days to first female flowers emergence	4.51	282.16	2.28
Node for first female flowers	0.63	14.46	0.37
Fruit length (cm)	3.22	54.08	1.13
Fruit diameter (cm)	0.01	21.79	0.14
Flesh thickness (cm)	0.18	1.22	0.07
Seed cavity diameter (cm)	0.14	8.09	0.21
Fruits per plant	0.42	4.22	0.08
Average fruit weight (kg)	0.00	1.70	0.01
Vitamin A (IU)	140216.27	2106514.82	66673.17
Vitamin C (mg/100g)	4.03	6.89	0.67
Fruit yield (kg/plant)	0.03	17.25	0.20

DF= Degree of freedom

Table 2: Estimates of variability, heritability, genetic advances per cent of mean.

Sr. No.	Characters	Range	GCV (%)	PCV (%)	Heritability in bs (%)	GA (% of Mean)
1.	Vine length (m)	2.77-5.02	16.56	17.60	88.59	32.11
2.	Inter-nodal length (cm)	12.23-23.56	12.82	13.40	91.55	25.28
3.	Petiole length (cm)	11.82-22.97	18.38	18.93	94.21	36.74
4.	Primary branches per plant	3.33-5.11	10.20	14.88	46.96	14.40
5.	Number of leaves per plant (90 DAS)	84.83-170.67	15.66	15.68	99.73	32.22
6.	Days to first female flowers emergence	46.00-78.00	15.00	15.19	97.62	30.54
7.	Node for first female flowers	9.20-16.67	15.13	15.72	92.63	30.00
8.	Fruit length (cm)	13.58-33.19	18.95	19.55	93.97	37.84
9.	Fruit diameter (cm)	10.25-23.25	18.38	18.56	98.05	37.48
10.	Flesh thickness (cm)	2.20-5.00	19.50	21.23	84.41	36.91
11.	Seed cavity diameter (cm)	6.15-12.77	17.78	18.47	92.63	35.24
12.	Fruits per plant	1.80-6.73	33.00	33.99	94.27	66.00
13.	Average fruit weight (kg)	0.53-4.05	47.84	48.15	98.73	97.92
14.	Vitamin A (IU)	677.67-3471.47	46.33	48.54	91.07	91.07
15.	Vitamin C (mg/100g)	3.03-10.01	29.79	34.24	75.67	53.38
16.	Fruit yield (kg/plant)	2.12-12.14	44.79	45.59	96.53	90.65

GCV= Genotypic coefficient of variation; PCV: Phenotypic coefficient of variation; GA: Genetic advance

Table 3: Genotypic (r_g) and Phenotypic (r_p) correlation of pumpkin for quantitative and qualitative characters.

Characters		VL (m)	INL (cm)	PL (cm)	PB	NL (90 DAS)	DFFFE	NFFF	FL (cm)	FD (cm)	FT (cm)	SCD (cm)	FPP	AFW (kg)	Vit.-A (IU)	Vit.-C (mg/100g)	FY (kg/p)
VL (m)	r_g	1.000	0.497**	0.365**	-0.144^{NS}	0.063^{NS}	-0.331**	0.707**	0.416**	0.395**	0.408**	0.267**	-0.164^{NS}	0.419**	0.003^{NS}	0.092^{NS}	0.371**
	r_p	1.000	0.454**	0.323**	-0.086^{NS}	0.059^{NS}	-0.297**	0.659**	0.392**	0.367**	0.343**	0.250*	-0.134^{NS}	0.392**	-0.008^{NS}	0.052^{NS}	0.354**
INL (cm)	r_g		1.000	0.571**	-0.323**	0.076^{NS}	-0.253	0.512**	0.140^{NS}	0.100^{NS}	0.252*	0.051^{NS}	-0.175^{NS}	0.158^{NS}	0.281**	0.486**	0.043^{NS}
	r_p		1.000	0.542**	-0.176^{NS}	0.070^{NS}	-0.247*	0.471**	0.133^{NS}	0.101^{NS}	0.236*	0.050^{NS}	-0.170^{NS}	0.157^{NS}	0.257*	0.399**	0.040^{NS}
PL (cm)	r_g			1.000	-0.268**	-0.324**	-0.523**	0.363**	0.546**	0.227*	0.607**	0.311**	-0.597**	0.362**	0.168^{NS}	0.058^{NS}	-0.049^{NS}
	r_p			1.000	-0.184^{NS}	-0.317**	-0.505**	0.337**	0.509**	0.217*	0.560**	0.305**	-0.572**	0.343**	0.169^{NS}	0.050^{NS}	-0.063^{NS}
PB	r_g				1.000	0.133^{NS}	0.483**	-0.090^{NS}	-0.235*	-0.175^{NS}	-0.382**	-0.253*	0.101^{NS}	-0.211*	0,303**	-0.199^{NS}	-0.047
	r_p				1.000	0.083^{NS}	0.320**	-0.061^{NS}	-0.152^{NS}	-0.105^{NS}	-0.206*	-0.155^{NS}	0.085^{NS}	-0.144^{NS}	0.190^{NS}	-0.163^{NS}	-0.011^{NS}
NL (90 DAS)	r_g					1.000	0.162^{NS}	0.040^{NS}	-0.063^{NS}	0.147^{NS}	-0.206*	0.107^{NS}	0.005^{NS}	0.013^{NS}	-0.290**	0.118^{NS}	0.069^{NS}
	r_p					1.000	0.162^{NS}	0.038^{NS}	-0.060^{NS}	0.145^{NS}	-0.190^{NS}	0.101^{NS}	0.005^{NS}	0.014^{NS}	-0.276**	0.101^{NS}	0.066^{NS}
DFFFE	r_g						1.000	-0.291**	-0.575**	-0.243*	-0.466**	-0.365**	0.432**	-0.396**	0.116^{NS}	-0.024^{NS}	-0.110^{NS}
	r_p						1.000	-0.282**	-0.548**	-0.240*	-0.425**	-0.352**	0.419**	-0.391**	0.104^{NS}	-0.029^{NS}	-0.105^{NS}
NFFF	r_g							1.000	0.192^{NS}	0.235*	0.210*	0.138^{NS}	-0.174^{NS}	0.257*	-0.074^{NS}	-0.009^{NS}	0.167^{NS}
	r_p							1.000	0.175^{NS}	0.218*	0.168^{NS}	0.122^{NS}	-0.149^{NS}	0.249*	-0.083^{NS}	-0.023^{NS}	0.163^{NS}
FL (cm)	r_g								1.000	0.757**	0.835**	0.751**	-0.480**	0.890**	-0.106^{NS}	-0.022^{NS}	0.555**
	r_p								1.000	0.737**	0.764**	0.702**	-0.440**	0.864**	-0.108^{NS}	-0.015^{NS}	0.529**
FD (cm)	r_g									1.000	0.711**	0.894**	-0.243*	0.911**	0.088^{NS}	0.048^{NS}	0.771**
	r_p									1.000	0.669**	0.859**	-0.229*	0.896**	0.093^{NS}	0.043^{NS}	0.749**
FT (cm)	r_g										1.000	0.731**	-0.325**	0.820**	0.013^{NS}	0.085^{NS}	0.588**
	r_p										1.000	0.682**	-0.302**	0.759**	0.032^{NS}	0.072^{NS}	0.517**
SCD (cm)	r_g											1.000	-0.314**	0.873**	-0.013^{NS}	-0.174^{NS}	0.658**
	r_p											1.000	-0.296**	0.835**	-0.003^{NS}	-0.171^{NS}	0.619**
FPP	r_g												1.000	-0.311**	-0.166^{NS}	0.317**	0.354**
	r_p												1.000	-0.303**	-0.162^{NS}	0.282**	0.362**
AFW (kg)	r_g													1.000	0.018^{NS}	-0.027^{NS}	0.753**
	r_p													1.000	0.015^{NS}	-0.030^{NS}	0.744**
Vit.-A (IU)	r_g														1.000	0.245*	-0.057^{NS}
	r_p														1.000	0.211*	-0.059^{NS}
Vit.-C (mg/100g)	r_g															1.000	0.224*
	r_p															1.000	0.197^{NS}
FY (kg/p)	r_g																1.000
	r_p																1.000

VL: Vine length, INL: Inter-nodal length, PL: Petiole length, PB: Primary branches per plant, NL: Number of leaves per plant, DFFFE: Days to first female flowers emergence, NFFF: Node for first female flowers, FL: Fruit length, FD: Fruit diameter, FT: Flesh thickness, SCD: Seed cavity diameter, FPP: Fruits per plant, AFW: Average fruit weight, Vit.-A (IU), Vit.-C (mg/100g), FY: Fruit yield.

Table 4: Path coefficient analysis for pumpkin considering yield as a dependent variables.

C	VL (m)	INL (cm)	PL (cm)	PB	NL (90 DAS)	DFFFE	NFFF	FL (cm)	FD (cm)	FT (cm)	SCD (cm)	FPP	AFW (kg)	Vit.-A (IU)	Vit.-C (mg/100g)	Correlation with FY (kg/p)
VL (m)	**0.098**	0.049	0.036	-0.014	0.006	-0.032	0.069	0.041	0.039	0.040	0.026	-0.016	0.041	0.000	0.009	0.371**
INL (cm)	0.172	**0.346**	0.197	-0.112	0.026	-0.087	0.177	0.049	0.035	0.087	0.018	-0.061	0.055	0.097	0.168	0.043 NS
PL (cm)	-0.098	-0.152	**-0.267**	0.072	0.087	0.140	-0.097	-0.146	-0.061	-0.162	-0.083	0.160	-0.097	-0.045	-0.015	-0.049NS
PB	-0.065	-0.146	-0.121	**0.452**	0.060	0.218	-0.041	-0.106	-0.079	-0.173	-0.114	0.046	-0.095	0.137	-0.090	-0.047NS
NL (90 DAS)	-0.015	-0.019	0.080	-0.033	**-0.247**	-0.040	-0.010	0.016	-0.036	0.051	-0.026	-0.001	-0.003	0.071	-0.029	0.069NS
DFFFE	0.083	0.063	0.131	-0.121	-0.041	**-0.251**	0.073	0.144	0.061	0.117	0.092	-0.108	0.099	-0.029	0.006	-0.110NS
NFFF	-0.145	-0.105	-0.074	0.018	-0.008	0.060	**-0.205**	-0.039	-0.048	-0.043	-0.028	0.036	-0.053	0.015	0.002	0.167NS
FL (cm)	-0.124	-0.042	-0.163	0.070	0.019	0.171	-0.057	**-0.298**	-0.226	-0.249	-0.224	0.143	-0.266	0.032	0.007	0.555**
FD (cm)	0.277	0.070	0.159	-0.123	0.103	-0.170	0.165	0.531	**0.701**	0.499	0.627	-0.170	0.639	0.062	0.034	0.771**
FT (cm)	0.112	0.069	0.167	-0.105	-0.057	-0.128	0.058	0.230	0.196	**0.275**	0.201	-0.089	0.226	0.004	0.023	0.588**
SCD (cm)	0.010	0.002	0.011	-0.009	0.004	-0.013	0.005	0.028	0.033	0.027	**0.037**	-0.012	0.032	0.000	-0.006	0.658**
FPP	-0.073	-0.078	-0.267	0.045	0.002	0.193	-0.078	-0.215	-0.109	-0.145	-0.140	**0.447**	-0.139	-0.074	0.142	0.354**
AFW (kg)	0.135	0.051	0.116	-0.068	0.004	-0.128	0.083	0.287	0.293	0.264	0.281	-0.100	**0.322**	0.006	-0.009	0.753**
Vit.-A (IU)	-0.001	-0.098	-0.059	-0.106	0.101	-0.041	0.026	0.037	-0.031	-0.005	0.004	0.058	-0.006	**-0.349**	-0.085	-0.057NS
Vit.-C (mg/100g)	0.006	0.033	0.004	-0.014	0.008	-0.002	-0.001	-0.002	0.003	0.006	-0.012	0.022	-0.002	0.017	**0.069**	0.224*

VL: Vine length, INL: Inter-nodal length, PL: Petiole length, PB: Primary branches per plant, NL: Number of leaves per plant, DFFFE: Days to first female flowers emergence, NFFF: Node for first female flowers, FL: Fruit length, FD: Fruit diameter, FT: Flesh thickness, SCD: Seed cavity diameter, FPP: Fruits per plant, AFW: Average fruit weight, Vit.-A (IU), Vit.-C (mg/100g), FY: Fruit yield.

CONCLUSIONS

According to the findings of this study, for each of the thirty one pumpkin genotypes, significant differences were found, showing a wide range of variability that can be used to select a potential genotype. Characters such as average fruit weight, fruits per plant, and fruit yield per plant exhibit substantial genetic and phenotypic variance, as well as high heritability and genetic advance in the percent of mean, and can be utilised for pumpkin genotype selection. The character fruit diameter could be regarded as the principal trait as it had the greatest positive direct influence on fruit yield as well as a highly significant positive correlation. While, other traits like average fruit weight, seed cavity diameter, and flesh thickness should also be prioritised because they have been shown to have a strong correlation with fruit yield in plants. Therefore, selection made based on these traits would help to increase the fruit yield of pumpkins.

FUTURE SCOPE

The basic aim of this experiment was to examine the performance of pumpkin (*Cucurbita* spp.) genotypes for off-season cultivation which were non-native to this area with respect to yield and quality. This study confirmed the presence of variation and elucidated characters exhibiting high GCV and PCV, high heritability and genetic advance, characters that are positively correlated with the fruit yield and characters that are positively and directly influencing the fruit yield. These biometrical results are necessary for selection of elite genotypes which can be used to plan future crop improvement programmes. As yield improvement is the major goal, therefore accordingly the interpretation of this experiment can be utilised to enhance the yield of pumpkin during *Rabi* (winter) season for this area.

REFERENCES

Akter, S., Rasul, M. G., Islam, A. A. and Rahman, M. M. (2013). Genetic variability, correlation and path coefficient analysis of yield and quality traits in pumpkin (*Cucurbita moschata* Duch ex Poir.). *Bangladesh Journal of Plant Breeding and Genetics*, *26*(1), 25-33.

Al-Jibouri, H. A., Miller, P. A. and Robinson, H. F. (1958). Genotypic and environmental variance and covariance in an upland cotton cross of inter specific origin. *Agronomy Journal, 50*, 633-636.

Aruah, B. C., Uguru, M. I. and Oyiga, B. C. (2012). Genetic variability and inter-relationship among some Nigerian pumpkin accessions (*Cucurbita* spp.). *International Journal of Plant Breeding, 6*(1), 34-41.

Begum, T., Munda, S., Pandey, S. K. and Lal, M. (2022). Estimation of selection criteria through multi-year assessment of variability parameters, association studies and genetic diversity of *Solanum khasianum* CB Clarke. *Scientia Horticulturae, 297,* 110923.

Burton, G. W. and Devane, E. W. (1953). Estimating heritability in tall fescue (*Festuca arundinaceae*) from replicated clonal material. *Agronomy Journal, 45*, 478-481.

Chaudhari, D. J., Acharya, R. R., Patel, J. N., Gohil, S. B. and Bhalala, K. C. (2017). Variability, correlation and path analysis in Pumpkin (*Cucurbita moschata* Duch. ex. Poir.). *Journal of Pharmacognosy and Phytochemistry, 6*(6), 142-145.

Dabalo, D. Y., Singh, B. C. S. and Weyessa, B. (2020). Genetic variability and association of characters in linseed (*Linum usitatissimum* L.) plant grown in central Ethiopia region. *Saudi Journal of Biological Sciences, 27*(8), 2192-2206.

Dewey, D. R. and Lu, R. H. (1959). A correlation and path coefficient analysis components of crested wheat grass seed production. *Agronomy Journal, 5*, 515-518.

Dhatt, A. S., Sharma, M., and Kaur, B. (2020). Advances in Improvement of Pumpkin and Squashes. In: Gosal S S and Wani S H (ed) *Accelerated Plant Breeding, Volume 2* (pp. 301-335). Springer Nature Switzerland AG.

Gaikwad, A. G, Musmade, A. M., Dhumal, S. S. and Sonawane, H. G. (2011). Variability studies in cucumber (*Cucumis sativus* L.). *Ecology Environment and Conservation, 17*(4), 799-802.

Hanson, C. H., Robinson, H. F. and Comstock R. E. (1956). Biometrical studies of yield in segregating population of Korean Lespedeza. *Agronomy journal, 48,* 268-272.

Hazra, P., Mandal, A. K., Datta, A. K. and Ram, H. H. (2007). Breeding pumpkin (*Cucurbita moschata* Duch. Ex Poir.) for fruit yield and other characters. *Int. J. Pl. Breed*, *1*(1), 51-64.

Hosen, M., Rafii, M. Y., Mazlan, N., Jusoh, M., Oladosu, Y., Chowdhury, M.F.N., Muhammad, I., Khan, M. M. H. (2021). Pumpkin (*Cucurbita* spp.): A Crop to Mitigate Food and Nutritional Challenges. *Horticulturae, 7,* 352.

Jogender, Sangwan, O., Kumar, S., Jattan, M., Kumar, D., Shreya and Kanika (2023). Study of Correlation and Path Analysis of Seed Cotton Yield andits Attributing Traits in Desi Cotton (*Gossypium arboreum* L.) under Rainfed condition. *Biological Forum – An International Journal*, *15*(2), 24-28.

Johnson, H. W., Robinson, H. F. and Comstock, R. E. (1955). Genotypic and phenotypic correlations in Soybeans and their implications in selection. *Agronomy Journal, 47,* 477– 483.

Khan, A. S. M. M. R., Kabir, M. Y. and Alam, M. M. (2009). Variability, correlation, path analysis of yield and yield components of pointed gourd. *Journal of Agriculture and Rural Development, 7,* 93-98.

Kirkpatrick, K. J., Decker, D. S., Wilson, H. W. (1985). Allozyme differentiation in the *C. pepo* complex: *C. pepo* var. *medullosa* vs. *C. texana*. *Economic Botany, 39*, 289-299.

Krishnamoorthy, V. and Sampath, S. (2020). Evaluation of pumpkin genotypes (*Cucurbita moschata*) suitable for summer season. *Annals of Plant Sciences, 9*(1), 3693-3698.

Kumar, R., Prakash, S., Luthra, S. K., Singh, B., Chand, P., Kumar, V., Singh, R. and Alam, K. (2022). Analysis of Correlation and Path coefficient Among the Yield and Yield Attributes Characters in Potato (*Solanum tuberosum* L.). *Biological Forum – An International Journal, 14*(3), 916-922.

Mohsin, G.M., Islam, M.S., Billah, M., Hossain, S., Hossain, K. and Doullah, A. (2017). Determination of genetic divergence in pumpkin (*Cucurbita moschata* Duch Ex Poir) through multivariate analysis. *Journal of Noakhali Science and Technology University, 1*(1), 1-7.

OECD (2016). Squashes, pumkins, zucchinis and gourds (*Cucurbita* species). in Safety Assessment of Transgenic Organisms in the Environment, Volume 5: OECD Consensus Documents, OECD Publishing, Paris.

Owusu, E.Y., Karikari, B., Kusi, F., Haruna, M., Amoah, R.A., Attamah, P. and Issahaku, M. (2021). Genetic variability, heritability and correlation analysis among maturity and yield traits in Cowpea (*Vigna unguiculata* (L) Walp) in Northern Ghana. *Heliyon, 7*(9), e07890.

Panse, V. G. and Sukhatme, P. V. (1967). Statistical methods for agricultural workers. 2nd Ed. ICAR, New Delhi. Pp.381.

Patil, H. E., Pali, V., Elangovan, M., Vadodariya, G. D., Ramani, M. P., Pandey S. and Pandey C. D. (2023). Genetic Analysis for Yield and Morphological Traits in Finger Millet [*Eleusine coracana* (L.) Gaertn.]. *Biological Forum – An International Journal, 15*(2), 130-136.

Pooja. and Maurya, S.K. (2022). Assessment of genetic divergence in pumpkin (*Cucurbita moschata*). *Indian Journal of Agricultural Sciences, 92*(6), 726–731.

Ratnakar, M. S., Shantappa, T. A. and Gurumurthy, S. B. (2018). Genetic variability and correlation studies for productivity traits in cucumber (*Cucumis sativus*, L.). *International Journal of Chemical Studies, 6*(5), 236 – 238.

Ramjan, M. D. (2021). Characterization of pumpkin (*Cucurbita moschata* Duch. Ex. Poir.) germplasm through genetic variability, heritability and genetic advance. *Electronic Journal of Plant Breeding, 12*(1), 91-96.

Ramjan, M. D. and Ansari, M. T. (2020). Assessment of Yield and Quality Characters in Pumpkin from North East India. *Indian Journal of Agricultural Research, 54*(4), 452-458.

Robinson, H. F. (1966). Quantitative genetics in relative to breeding and impact of mendalism in agriculture, biology and medicine. *Indian Journal of Genetics, 26,* 171-178.

Shivananda, M. M., Madalageri, M. B., Chikkur, S.S., Mohankumar, A. B. and Yathiraj, K. (2013). Correlation and path co-efficient studies in pumpkin (*Cucucrbita moschata* Dutch. Ex. Poir.). *International Journal of Agricultural Sciences*, *9*(1), 76-79.

Singh, P. and Narayanan, S. S. (1993). Biometrical techniques in plant breeding. Kalyani Publishers.

Singh, O. and Kumar, J. (2005). Variability, heritability and genetic advance in brinjal. *Indian Journal of Horticulture, 62*, 265–267.

Singh, M. K., Singh, V. B., Yadav, G. C. and Kumar, P. (2019). Studies on variability, heritability (narrow sense) and genetic advance analysis for growth, yield and quality traits in pumpkin (*Cucurbita moschata* Duch. ex. Poir). *Journal of Pharmacognosy and Phytochemistry, 8*, 3621-3624.

Srivastava, U., Mahajan, R. K., Gangopadhyay, K. K., Singh, M. and Dhillon, B. S. (2001). Minimal Descriptors of Agri Horticultural Crops. Part II: Vegetable Crops. National Bureau of Plant Genetic Resources, Pus a Campus, New Delhi, ix + 262 p.

Srikanth, M., Bharad, S. G., Potdukhe, N. R. and Ravinayak, B. (2015). Character Association and Path Analysis in Pumpkin (*Cucurbita moschata* Duch ex. Poir). *Research Journal of Agricultural Sciences*, *6*(3), 495-498.

Srikanth, M., Bharad, S. G., Thulasiram, L. B. and Potdukhe, N. R. (2017). Studies on Genetic Variability, Heritability and Genetic Advance in Pumpkin (*Cucurbita moschata* Duch ex Poir.). *International Journal of Current Microbiology and Applied Sciences, 6*(6), 1416-1422.

Sultana, S., Kawochar, M. A., Naznin, S., Siddika, A. and Mahmud, F. (2015). Variability, correlation and path analysis in pumpkin (*Cucurbita moschata* L.). *Bangladesh Journal of Agricultural Research, 40*(3), 479-489.

Tamilselvi, N. A. and Jansirani, P. (2017). Evaluation of Pumpkin (*Cucurbita moschata* L.) Genotypes for Earliness, Yield and Quality. *International Journal of Current Microbiology and Applied Sciences, 6*(3), 1554-1559.

Thirumdasu, R. K. and Chatterjee, R. (2018). Search for Superior Fruit Characters of Pumpkin Genotypes from Various Parts of India and Evaluation under Eastern Himalayan Region. *International Journal of Current Microbiology and Applied Sciences, 7*(5), 1643-1650.

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