

**Original Research Article**

**STUDIES ON INTER-TRAITS RELATIONSHIP AND PATH CO-EFFICIENT FOR  
FRUIT YIELD AND ITS RELATED TRAITS IN PUMPKIN (*CUCURBITA  
MOSCHATA* DUCH EX. POIR)**

**Abstract**

A field experiment on “Studies on inter-traits relationship and path co-efficient for fruit yield and its related traits in pumpkin (*Cucurbita moschata* Duch ex. Poir)” was carried out with aims to assess the inter-traits relationship and path co-efficient analysis at Main Experiment Station of Department of Vegetable Science of Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P), India, during summer 2019. The experimental material consisted of 28 pumpkin genotypes including three standard checks viz., Arka Chandan, Azad Kaddu, and Pusa Vikash were conducted in a Completely Randomized Block Design (RBD) with three replications. The germplasm of pumpkin was collected from different sources to study path co-efficient analysis of different characters on fruit yield per plant at the phenotypic and genotypic levels for different quantitative traits. The path co-efficient analysis revealed that the highly positive direct contribution towards fruit yield came from average fruit weight (0.781) followed by the number of fruit per plant (0.750) but also as well as fruit equatorial circumference (0.021) and flesh thickness (0.048) was exerted a positive direct effect on fruit yield per plant and these traits might be considered as a high yield symbols of pumpkin and might be used as selection criteria in the breeding program to improve the yield in pumpkin.

**Keywords:** *Pumpkin, Germplasm, Path co-efficient, and Fruit yield*

## Introduction

The *Cucurbita* genus is composed of five major species comprising the majority of pumpkin and squashes—*Cucurbita pepo*, *Cucurbita moschata*, *Cucurbita maxima*, *Cucurbita argyrosperma*, and *Cucurbita ficifolia*. The pumpkin species, *C. moschata*, ( $2n = 40$ ) is a significant vegetable widely cultivated and consumed in many countries around the world (Jun *et al.*, 2006). *Cucurbitaceae* is a wide family of plants with about 130 genera and as many as 800 species (Oyeleke *et al.*, 2019). Among them, there are several species of pumpkins (*Cucurbita*), the most popular of which are: *Cucurbita maxima*, *Cucurbita pepo*, and *Cucurbita moschata*. Pumpkins are widely used in the culinary arts. Many different parts of the plant are edible, e.g., leaves, flowers, fruits, peels, and seeds. Pumpkin is eaten raw and also in the form of preserves, such as soups, smoothies, and juices. Pumpkin flesh is also used as an additive to bread, cakes, cookies, chocolates, and candies (Kim *et al.*, 2012). The total area of pumpkins in India is 19,960 hectares whereas, the total production is 2093 ('000 MT) with a productivity of 21.71 t/ha (Anonymous, 2018). Pumpkin is monoecious and highly cross-pollinated in nature. Like other cucurbits, inbreeding depression is negligible in *Cucurbita* even after prolonged selfing (Whitaker, 1974). In Mexico, squash and pumpkin flowers are used in soups, quesadillas, tamales, and desserts (Asiain-Morales *et al.*, 2008), and fried squash blossoms are popular in Italy (Milc *et al.*, 2016). Pumpkin contains relatively high energy and nutrient. A hundred grams edible portion of fruit has 90 ml water, 8 g carbohydrates, 1 g protein, 0.5 g fibers, 20 mg calcium, 0.8 mg iron, 210 mg beta-carotene, 0.05 mg thiamine, 0.05 mg riboflavin, 0.5 mg niacin and 15 mg ascorbic acid (Tindall, 1987). Pumpkins are a good vegetable source for carotenoids (Bergantin *et al.*, 2018) as their flesh colors vary from yellow to orange which is associated with different carotenoid compositions (Marek *et al.*, 2008). As the precursors for vitamin A, (Marchetti *et al.*, 2019) carotenoids are essential components of the human diet and

play a significant role in reducing cancer risk and in stimulating the immune system. Carotenoids are efficient antioxidants to protect cells from damage by free radicals and singlet oxygen. (Krinsky *et al.*, 1989, Mortensen *et al.*, 1997, Beutner *et al.*, 2001). In addition, pumpkin is a source of antioxidants (such as polyphenols and carotenoids), which is particularly important for our health (Peiretti *et al.*, 2017; Saavedra *et al.*, 2015). Pumpkin seed is an excellent source of protein and also has pharmacological activities such as anti-diabetic (Li *et al.* 2003), anti-fungal (Wang and Ng 2003), anti-bacterial and anti-inflammation activities (Fu *et al.* 2006), and antioxidant effects (Nkosi *et al.* 2006). The present study was carried out to find out suitable selection criteria for higher fruit yield through the study of the direct and indirect effects of different characteristics the on the fruit yield of pumpkins. The study of path coefficient analysis gives the magnitude of contribution made by different plant characters towards yield thereby imparting confidence in the selection of important yield-contributing characters.

## **Materials and Methods**

This study, comprised of 28 germplasm including three standard checks viz., Arka Chandan, Azad Kaddu, and Pusa Vikash from *Cucurbita moschata* were considered for analysis. The experiment was laid out in a Randomized Block Design with three replications at the Main Experiment Station of the Department of Vegetable Science at Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P) during the summer season (March-1<sup>st</sup> week of July). The seeds were sown in the summer season, having a plot size of 3×3 m accommodating 6 plants per plot with a row-to-row spacing of 3 m and plant-to-plant spacing of 0.50 m. All the recommended agronomic packages of practices and plant protection measures were followed to raise a good crop. Observations were recorded for node number to first staminate flower anthesis, node number to first pistillate flower anthesis, days to first staminate flower anthesis, days to first pistillate flower anthesis, days to first fruit

harvest, number of primary branches, fruit polar circumference (cm), fruit equatorial circumference (cm), vine length (m), flesh thickness (cm), number of fruits per plant, average fruit weight (kg) and fruit yield per plant (kg.)

The data on thirteen quantitative characters are recorded on five competitive and randomly selected plants of each genotype and in each replication. All the statistical analyses were carried out using OPSTAT statistical software. The path coefficient among genotypes was estimated by using statistics analysis (Dewey and Lu, 1959).

## **RESULTS AND DISCUSSION**

### **Path coefficient analysis**

Path coefficient analysis was estimated to resolve the direct and indirect effects of different characters on fruit yield. The Path coefficient analysis was presented in the table-1 and 2, respectively.

The direct and indirect effects of different characters on fruit yield per plant at the phenotypic level are presented in table-1. The highly positive direct effect on yield per plant was exerted by average fruit weight (0.781) followed by the number of fruit per plant (0.750) but also as well as days to first staminate flower anthesis (0.120), and the number of primary branches (0.105), exerted a positive direct effect on fruit yield per plant. The direct effects on fruit yield per plant showed by the rest of the traits were substantially too low such as namely flesh thickness (0.048) and days to first harvest (0.032), fruit equatorial circumference (0.021), and vine length (0.009). Although, average fruit weight showed the highest positive direct effects on fruit yield per plant. Most of the characters namely node number to first staminate flower appearance (-0.092), fruit polar circumference (-0.029), node number to

pistillate flower appearance (-0.021), and days to first pistillate flower anthesis (-0.012) exerted negative direct effects on fruit yield per plant *via*. this trait.

Fruit equatorial circumference (0.147) and flesh thickness (0.033) showed indirect positive effects *via*. average fruit weight on fruit yield per plant. However, fruit polar circumference (-0.278) exhibited a high negative and considerable indirect effect *via*. average fruit weight on the fruit yield per plant. Indirect effects the number of fruit per plant (-0.269), vine length (-0.188), days to first pistillate flower anthesis (-0.142), days to first staminate flower anthesis (-0.135), number of primary branches (-0.129) and node number at first flower anthesis (-0.128) were showed indirect negative effects *via*. average fruit weight on fruit yield per plant.

Flesh thickness (0.112) and vine length (0.120) showed indirect positive effects *via*. number of fruit yield per plant on the fruit yield per plant while average fruit weight (-0.258) indirect negative effect *via*. number of fruit per plant on fruit yield per plant. The rest of the traits on fruit yield were very low.

The direct and indirect effects of different traits on fruit yield at the genotypic level are presented in Table 2. Substantial positive and direct effects on fruit yield per plant were exerted by days to first fruit harvest (2.245) followed by days to first pistillate flower anthesis (2.203), vine length (1.369), flesh thickness (0.908), number of fruit per plant (0.459), number of primary branches (0.135) and fruit equatorial circumference (0.046) While high order negative direct effect on fruit yield per plant was exerted by days to first staminate flower anthesis (-3.497) followed by fruit polar circumference (-2.026), node number at first staminate flower anthesis (-0.858), average fruit weight (-0.518) and node number at first pistillate flower anthesis (-0.157). Days to first pistillate flower anthesis (-0.646), days to first staminate flower anthesis (-0.568), days to first fruit harvest (-0.521), number of primary branches (-0.131), and node number at first pistillate flower appearance (-0.117) exhibited

considerable negative indirect effects on fruit yield *via.*, days to first staminate flower anthesis through which average fruit weight (0.156), flesh thickness (0.138) and fruit equatorial circumference (0.105) showed considerable positive indirect effect respectively. Days to first fruit harvest (-3.031), days to first pistillate flower anthesis (-2.315), number of primary branches (-1.267), vine length (-1.234), and node number at first pistillate flower anthesis (-1.214) exhibited considerable negative indirect effects on fruit yield while average fruit weight (0.195), flesh thickness (0.650) and fruit equatorial circumference (0.191) showed the highest positive indirect effect on fruit yield *via.* days to first staminate flower anthesis, respectively.

An indirect positive effect of days to first fruit harvest (1.912), days to first staminate flower anthesis (1.846), node number at first staminate flower anthesis (1.660), fruit polar circumference (0.566), node number at first pistillate flower anthesis, (0.512) number of primary branches (0.508), number of fruit per plant (0.186) and fruit equatorial circumference (0.130) showed a positive indirect effect on fruit yield *via.* days to first pistillate flower anthesis, through which flesh thickness (-0.691) and average fruit weight (-0.474) showed a negative indirect effect on fruit yield *via.* these traits.

**Table-1: Direct and indirect effect of different characters on fruit yield at a phenotypic level in pumpkin germplasm**

Characters	Node number at first staminate flower anthesis	Node number at first pistillate flower anthesis	Days to first staminate flower anthesis	Days to first pistillate flower anthesis	Days to first fruit harvest	Number of primary branches	Fruit polar circumference (cm)	Fruit equatorial circumference (cm)	Vine length (m)	Flesh thickness (cm)	Number of fruit per plant	Average fruit weight (kg)	Fruit yield per plant (kg)
Node number at first staminate flower anthesis	<b>-0.092</b>	-0.003	0.062	-0.006	0.011	0.016	0.000	-0.003	0.000	-0.006	0.061	-0.128	-0.088
Node number at first pistillate flower anthesis	-0.012	<b>-0.021</b>	0.032	-0.002	0.006	0.031	-0.006	-0.001	0.004	0.005	0.089	-0.037	0.089
Days to first staminate flower anthesis	-0.047	-0.006	<b>0.120</b>	-0.005	0.013	0.030	0.001	-0.001	0.002	-0.005	0.003	-0.135	-0.028
Days to first pistillate flower anthesis	-0.046	-0.004	0.054	<b>-0.012</b>	0.017	0.017	-0.005	0.001	0.000	-0.010	0.082	-0.142	-0.046
Days to first fruit harvest	-0.031	-0.004	0.048	-0.006	<b>0.032</b>	0.014	-0.004	0.001	0.001	-0.006	-0.027	-0.033	-0.018
Number of primary branches	-0.014	-0.006	0.035	-0.002	0.004	<b>0.105</b>	-0.003	0.003	0.001	0.012	-0.073	-0.129	-0.068
Fruit polar circumference (cm)	0.001	-0.004	-0.003	-0.002	0.005	0.009	<b>-0.029</b>	0.002	0.002	0.003	0.031	-0.276	-0.262*
Fruit equatorial circumference (cm)	0.015	0.001	-0.007	-0.001	0.002	0.013	-0.003	<b>0.021</b>	-0.002	0.015	0.066	0.147	0.267*
Vine length (m)	0.002	-0.009	0.031	0.000	0.002	0.007	-0.006	-0.004	<b>0.009</b>	-0.005	0.120	-0.188	-0.041
Flesh thickness (cm)	0.011	-0.002	-0.012	0.002	-0.004	0.027	-0.002	0.006	-0.001	<b>0.048</b>	0.112	0.033	0.219*
Number of fruit per plant	-0.007	-0.003	0.001	-0.001	-0.001	-0.010	-0.001	0.002	0.001	0.007	<b>0.750</b>	-0.269	0.469**
Average fruit weight (kg)	0.015	0.001	-0.021	0.002	-0.001	-0.017	0.010	0.004	-0.002	0.002	-0.258	<b>0.781</b>	0.515**

R SQUARE = 0.7729 RESIDUAL EFFECT = 0.4766

Bold values show direct and normal values show indirect effects

The indirect positive effect of days to first pistillate flower anthesis (1.949), days to first staminate flower anthesis (1.946), node number at first staminate flower anthesis (1.362), node number at first pistillate flower anthesis, (0.760), fruit polar circumference (0.615), number of primary branches (0.547), vine length (0.262) and fruit equatorial circumference (0.183) showed the positive indirect effect on fruit yield *via.* days to first fruit harvest, through which flesh thickness (-0.407) and number of fruit per plant (-0.324) showed the negative indirect effect on fruit yield *via.* these traits (days to first fruit harvest).

Node number at first pistillate flower appearance (-0.568), days to first fruit harvest (-0.555), Days to first pistillate flower anthesis (-0.520), vine length (0.501), flesh thickness (-0.212) days to first staminate flower anthesis (-0.152), and number of fruit per plant (-0.139) exhibited considerable negative indirect effects on fruit yield *via.* fruit equatorial circumference, through which average fruit weight (1.046) showed a considerable positive indirect effect on fruit yield respectively. Node number at first pistillate flower appearance (0.645), days to first staminate flower anthesis (0.483), fruit equatorial circumference (0.339), number of fruit per plant (0.250), and days to first fruit harvest (0.159) exhibited considerable positive indirect effects on fruit yield *via.* vine length, through which average fruit weight (-0.364) and flesh thickness (-0.172) showed a considerable negative indirect effect on fruit yield.

An indirect positive effect of fruit equatorial circumference (0.355), number of primary branches (0.273), node number at first pistillate flower anthesis, (0.125), number of fruit per plant (0.109), and average fruit weight (0.105) showed the positive indirect effect on fruit yield *via.* flesh thickness, through which days to first pistillate flower anthesis (-0.285), days to first staminate flower anthesis (-0.169), days to first fruit harvest (-0.165), node number at first

**Table-2: Direct and indirect effect of different characters on fruit yield on the genotypic level in pumpkin germplasm**

Characters	Node number at first staminate flower anthesis	Node number at first pistillate flower anthesis	Days to first staminate flower anthesis	Days to first pistillate flower anthesis	Days to first fruit harvest	Number of primary branches	Fruit polar circumference(cm)	Fruit equatorial circumference(cm)	Vine length(m)	Flesh thickness(cm)	Number of fruit per plant	Average fruit weight(kg)	Fruit yield per plant(kg)
Node number at first staminate flower anthesis	<b>-0.858</b>	-0.021	-2.315	1.660	1.362	0.021	0.098	-0.006	-0.016	-0.146	0.042	0.094	-0.086
Node number at first pistillate flower anthesis	-0.117	<b>-0.157</b>	-1.214	0.512	0.760	0.044	-0.568	-0.006	0.645	0.125	0.039	0.038	0.101
Days to first staminate flower anthesis	-0.568	-0.054	<b>-3.497</b>	1.846	1.946	0.049	-0.152	-0.003	0.483	-0.169	0.009	0.118	0.007
Days to first pistillate flower anthesis	-0.646	-0.037	-2.929	<b>2.203</b>	1.949	0.031	-0.520	0.003	0.013	-0.285	0.039	0.111	-0.068
Days to first fruit harvest	-0.521	-0.053	-3.031	1.912	<b>2.245</b>	0.033	-0.555	0.004	0.159	-0.165	-0.066	0.010	-0.027
Number of primary branches	-0.131	-0.051	-1.267	0.508	0.547	<b>0.135</b>	-0.272	0.012	0.097	0.273	-0.032	0.106	-0.075
Fruit polar circumference (cm)	0.041	-0.044	-0.263	0.566	0.615	0.018	<b>-2.026</b>	-0.002	0.339	0.095	0.031	0.268	-0.362**
Fruit equatorial circumference (cm)	0.105	0.021	0.191	0.130	0.183	0.036	0.088	<b>0.046</b>	-0.448	0.355	-0.050	-0.219	0.440**
Vine length (m)	0.010	-0.074	-1.234	0.021	0.262	0.010	-0.501	-0.015	<b>1.369</b>	-0.114	0.084	0.138	-0.046
Flesh thickness (cm)	0.138	-0.022	0.650	-0.691	-0.407	0.041	-0.212	0.018	-0.172	<b>0.908</b>	0.055	-0.060	0.247*
Number of fruit per plant	-0.078	-0.013	-0.069	0.186	-0.324	-0.010	-0.139	-0.005	0.250	0.109	<b>0.459</b>	0.172	0.540**
Average fruit weight (kg)	0.156	0.012	0.795	-0.474	-0.042	-0.028	1.046	0.020	-0.364	0.105	-0.153	<b>-0.518</b>	0.556**

R SQUARE = 0.6888 RESIDUAL EFFECT = 0.5578

Bold values show direct and normal values show indirect effects

staminate flower anthesis (-0.146) and vine length (-0.114) showed a negative indirect effect on fruit yield via. this trait (flesh thickness).

Average fruit weight showed an indirect negative effect on fruit yield via. number of fruit per plant. Fruit polar circumference (0.268), number of fruit per plant (0.172), vine length (0.138), days to first staminate flower anthesis (0.118), days to first pistillate flower anthesis (0.111), number of primary branches (0.106) showed a positive indirect effect on fruit yield via. average fruit weight while fruit equatorial circumference showed a negative indirect effect on fruit yield via. these traits (average fruit weight).

The positive direct effect of various traits on fruit yield has also been reported by earlier workers viz., for average fruit weight (Mohsin *et al.* 2017; Shivananda *et al.* 2013; Yadegari *et al.* 2012; Murlidharan *et al.* 2015; Naik *et al.* 2015) for number of fruits per plant (Mohsin *et al.* 2017; Shivananda *et al.* 2013; Murlidharan *et al.* 2015; Naik *et al.* 2015; Sulatana *et al.* 2015) for several branches (Murlidharan *et al.* 2015) for days to first pistillate flower anthesis (Sultana *et al.* 2015) for vine length (Mohanty 2001; Murlidharan *et al.* 2015; Arunkumar *et al.* 2011) for flesh thickness (Yadav *et al.* 2006) for the equatorial and polar circumference of fruit (Pandey *et al.* 2002; Yadav *et al.* 2006) for several primary branches (Murlidharan *et al.* 2015).

## **Conclusion**

The direct effects of different characters on fruit yield per plant at the phenotypic level revealed that the highly positive direct effect on yield per plant was exerted by average fruit weight (0.781) followed by the number of fruit per plant (0.750) and node number to first staminate flower appearance (-0.092), fruit polar circumference (-0.029), node number to pistillate flower appearance (-0.021), and days to first pistillate flower anthesis (-0.012) exerted negative direct effects on fruit yield per plant via. these traits. The direct effects of different characters on fruit yield per plant at the genotypic level revealed that positive and direct effects on fruit yield per plant were exerted by days to first fruit harvest (2.245) followed by days to first pistillate flower anthesis (2.203), vine length (1.369), flesh thickness, while high order negative direct

effect on fruit yield per plant was exerted by days to first staminate flower anthesis (-3.497) followed by fruit polar circumference (-2.026), node number at first staminate flower anthesis (-0.858), average fruit weight (-0.518) and node number at first pistillate flower anthesis (-0.157). Finally, the path coefficient analysis revealed that focusing node number to first staminate flower appearance, node number to pistillate flower appearance, days to first pistillate flower anthesis, vine length, flesh thickness on several fruits per plant, and fruit equatorial circumference on average fruit weight could improve total yield per plant in pumpkin. Hence, due emphasis should be given to these characters during selection for developing high-yielding genotypes in pumpkins.

## References

- Anonymous (2018). Indian Horticulture Database. National Horticulture Board, Ministry of Agriculture and Farmers Welfare, Government of India, Gurgaon.
- Arunkumar, K. H.; Patil, M. G.; Hanchinamani, C. N.; Shanker, G. I. and Hiremath S. V. (2011). Genetic relationship of growth and development traits with fruit yield in F<sub>2</sub> population of BGD L x Hot season of cucumber (*Cucumis sativus* L.). *Karnataka Journal of Agriculture Science*, **24**(4): 497-500.
- Asiain-Morales, J. A.; Guemes-Vera, N.; Santamaría, M. I. R.; Aquino-Bolaños, E. N.; Corona-Velazquez, R. & Meza-Rangel, J. (2008). Uso de atmósferas controladas en la conservación de flor de Calabaza. [https://uaeh.edu.mx/investigacion/icap/LI\\_GranSem/Norma\\_Vera/8.pdf](https://uaeh.edu.mx/investigacion/icap/LI_GranSem/Norma_Vera/8.pdf)
- Beutner, S.; Bloedorn, B. & Frixel, S. (2001). Quantitative assessment of antioxidant properties of natural colorants and phytochemicals: carotenoids, flavonoids, phenols, and indigoids. The role of  $\beta$ -carotene in antioxidant functions. *J Sci Food Agric*, **81**(6): 559-568. DOI:10.1002/jsfa.849
- Bergantin, C.; Maietti, A.; Tedeschi, P.; Font, G.; Manyes, L.; & Marchetti, N. (2018). Determination of major carotenoids and their bioaccessibility from “Delica”

(*Cucurbita maxima*) and “Violina” (*Cucurbita moschata*) pumpkins as food traceability markers. *Molecules*,**23**(11): 2791. DOI: 10.3390/molecules23112791

Dewey, D.I. and Lu, K.H. (1959). A Correlation and Path-Coefficient Analysis of Components of Crested Wheatgrass Seed Production. *Agronomy Journal*, 51: 515-518.

<http://dx.doi.org/10.2134/agronj1959.00021962005100090002x>

Fu, C-L.; Huan, S. H.; Li, Q-H. (2006). A review of pharmacological activities and utilization technologies of pumpkin. *Plant Foods for Human Nutrition Journal*, **61**: 70.

Jun, H.-I.; Lee, C. H.; Song, G. S. & Kim, Y. S.(2006). Characterization of the pectic polysaccharides from pumpkin peel. *LWT-Food Sci. Technol*, **39**: 554–561.

Kim, M. Y.; Kim, E. J.; Kim, Y.-N.; Choi, C. & Lee, B. H. (2012). Comparison of the chemical compositions and nutritive values of various pumpkin (Cucurbitaceae) species and parts. *Nutrition Research and Practice*, **6**(1), 21-27.  
<https://doi.org/10.4162/nrp.2012.6.1.21>

Krinsky, N. I. (1989). Antioxidant functions of carotenoids. *Free Radic Biol Med.*, **7**(6): 617-635.DOI 10.1016/0891-5849(89)90143-3.  
<http://www.ncbi.nlm.nih.gov/pubmed/2695406>

Li, Q-H.; Tian, Z.; & Cai, T-Y. (2003) Study on the hypoglycemic action of pumpkin extract in diabetic rats. *Acta Nutrimenta Sinica*,**25**: 34-36.

Marchetti, N.; Giovannini, P. P.; Catani, M. Pasti, L.; & Cavazzini, A. (2019). Thermodynamic insights into the separation of carotenoids in reversed-phase liquid chromatography. *Int. J. Anal Chem.*, 1-7. DOI:10.1155/2019/7535813

Marek, G.; Radzanowska, J.; Danilcenko, H.; & Jariene, E. (2008). Quality of pumpkin cultivars about sensory characteristics. *Not Bot Horti Agrobot Cluj-Napoca*,**36**(1): 73-79.

Milc, J., Caffagni, A., Ronga, D., Francia, E., Pasquariello, M., Laviano, L., Mazzamurro, V. & Pecchioni, N. (2016). Evaluation of *Cucurbita pepo* germplasm for staminate flower

production and adaptation to the frozen food industry *Scientia Hort.* 213 321 330  
<https://doi.org/10.1016/j.scienta.2016.10.045>

Mohanty BK. Studies on correlation and path analysis in pumpkin (*Cucurbita moschata*). (2001)  
*Haryana J. Hort. Sci.*, **30**: 86-89.

Mohsin, G. M.; Islam, M.S.; Rahman, M.S.; Ali, L. and Hasanuzzaman, M. (2017). Genetic variability, correlation and path coefficients of yield and the analysis of its components in pumpkin (*Cucurbita moschata* Duch Ex Poir). *Int. J. Agril. Res. Innov. & Tech.* **7**(1): 8-13. <http://www.ijarit.webs.com>

Mortensen, A.; Skibsted, L. H. (1997). The relative stability of carotenoid radical cations and homologtocopherol radicals. A real-time kinetic study of antioxidant hierarchy. *FEBS Lett.***417**(3): 261-266. DOI: 10.1016/S0014-5793(97)01297-0  
<http://www.ncbi.nlm.nih.gov/pubmed/9409729>

Muralidhara, M. S.; Gowda, N. C.; Narase, N. P. (2015). Correlation and path analysis for different quantitative characters in pumpkin (*Cucurbita moschata* Duch ex. Poir). *Indian Horticulture Journal*, **4**(2): 112-115.

Naik, M. L.; Prasad, V. M.; Laxmi, R. P. (2015). A study on character association and path analysis in pumpkin (*Cucurbita moschata* Duch. ex Poir.). *International Journal of Advanced Research*, **3**(1): 1030-1034.

Nkosi C. Z.; Opoku, A. R.; Terblanche, S. E. (2006). Antioxidant effects of pumpkin seeds (*Cucurbita pepo*) protein isolate in CCl<sub>4</sub>-induced liver injury in 4 low-protein fed rats. *Phytotherapy Research*, **20**: 935- 940.

Oyeleke, A. W.; Oluwajuyitan, D. T.; Oluwamukomi, O. M. and Enujiugha, N. V. (2019). Amino acid profile, functional properties, and in-vitro antioxidant capacity of *Cucurbita maxima* and *Cucurbita mixta* fruit pulps and seeds. *European Journal of Nutrition & Food Safety*, **10**(4): 224-241. DOI:10.9734/EJNFS/2019/v10i430117

- Pandey, S.; Singh, J.; Upadhyay, A. K. and Ram, D. (2002). Genetic variability for antioxidants and yield components in pumpkin (*Cucurbita moschata* Duch. ex poir.) *Veg. Sci.* **29**: 123-126.
- Peretti, P. G.; Meineri, G.; Gai, F.; Longato, E.; & Amarowicz, R. (2017). Antioxidative activities and phenolic compounds of pumpkin (*Cucurbita pepo*) seeds and amaranth (*Amaranthus caudatus*) grain extracts. *Natural Product Research*, **31**(18): 2178-2182. <https://doi.org/10.1080/14786419.2017.1278597>
- Saavedra, M. J., Aires, A., Dias, C., Almeida, J. A., De Vasconcelos, M. C., Santos, P., & Rosa, E. A. (2015). Evaluation of the potential of squash pumpkin by-products (seeds and shell) as sources of antioxidant and bioactive compounds. *Journal of Food Science and Technology*, **52**(2): 1008-1015. <https://doi.org/10.1007/s13197-013-1089-5>
- Shivananda, M. M.; Madalageri, M. B.; Srinivas, S. C.; Kumar, A. B. M.; Yathiraj, K. (2013). Correlation and path co-efficient studies in pumpkin (*Cucurbita moschata* Duch. Ex. Poir). *International Journal of Agricultural Sciences*, **9**(1):76.79.
- Sultana S, Kawochar MAS, Naznina S, Mahmud F. (2015). Variability, correlation, and path analysis in pumpkin (*Cucurbita moschata* L.). *Bangladesh J. Agril. Res.*, **40**(3): 479-489.
- Tindall HD (1987). *Vegetables in the tropics*. Macmillan Education, London, 166.
- Whitaker, T. W. (1974). *Cucurbita*. In *Handbook of Genetics*, R. C. King (eds), pp. 135-144.
- Wang, H. X.; Ng, T. B. (2003). Isolation of cucurmoschin: A novel antifungal pep-tide abundant in arginine, glutamate, and glycine residues from black pumpkin seeds. *Peptides* **24**, 969-972.
- Yadav, R. K.; Sanwal. S. K.; Yadav, D. S.; Sarma, P. (2006). Correlation and path analysis in pumpkin. *Haryana Journal of Horticultural Sciences*. **35**(3/4): 338-339.

Yadegari, M.; Ahmad, R.G.; Rahim, B. (2012). Multivariate analysis of quantitative traits in Iranian pumpkin lines Cucurbita spp. *African Journal of Agricultural Research*. 7(5): 764-774.

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