



CORRELATION AND PATH ANALYSIS IN CARROT AS INFLUENCED BY IRRIGATION INTERVAL, NITROGEN LEVELS AND INTRA-ROW SPACING IN DADIN-KOWA, GOMBE STATE. NORTHERN GUINEA SAVANNA

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ABSTRACT

In the study using the equivalent of a higher statistical analytical tool to determine the highest agronomic plant factors that gave the highest contribution to yield of carrot, the correlation and path analysis were used. The analysis of the association between root yield per hectare and some selected characters in carrot (*Daucus carota* L.) showed a positive and significant correlation. Partitioning the total yield contribution into individual and combined effects showed that fresh weight of root plant⁻¹ made the highest individual contribution (0.540 or 26.0%) in 2016, in 2017 it was root length plant⁻¹ (0.415 or 7.92%) while in 2018 root diameter (0.4248 or 20.95%) made the highest individual contribution. But when the contribution was converted into percentage, in 2016, the combination of root diameter and fresh weight of root plant⁻¹ made the highest combined contribution (24.78%) whereas in 2017 the duos of root length and root diameter (24.58%) made the highest combined or indirect percentage contribution, while the highest indirect contribution of (25.93%) in 2018 was made by the combination of root diameter and fresh weight of root plant⁻¹.

Keywords: Correlation, Yield, Growth, Characters, Contribution.

INTRODUCTION

Carrot (*Daucus carota* L.) is an important vegetable compared to many other perishable vegetables because of its high nutritive and medicinal values. Muhie and Yimer, (2023) reported carrot to be among the top ten most economically significant vegetable crop in the world. It is valued, as food because of its high carotene content and vitamin A, which is important in protecting blindness in children. Carrot is a cold season vegetable whose root yield can range from 30-100 ton ha⁻¹ (Muhie and Yimer, 2023). Data assemblage by FAOSTAT (2021) reported carrot output of about 42 million tons produced from 1,513,738 hectares of land in 2020. From this figure Africa generated about 2,213,000 tonnes from 126,239 hectares. However, Nigeria is said to produce about 225,000 tones yearly (FAOSTAT, 2021), Hamma *et al.*, (2012), reported a yield of about 4 ton / ha, which shows important yield difference with those of nearby countries. Thus to match food production efficiency these differences requires a site research activity of the region. It is reported that good agricultural practices is increasing, at the farmers level but it is possible for this effect to be masked if the physiological aspect that influences crop development and yield of the crop is ignored and not improved. Therefore it is necessary to find ways of improving the productivity of carrot. Several factors such as environmental conditions, crop factors (crop genetics) and cultural practices may influence the yield of carrot. When carrot was produced the final root yield may have depended on the activities of numerous characters such as fresh weight of shoot (g) plant⁻¹ root diameter (cm), fresh root weight plant⁻¹ (g) and crack roots plant⁻¹. The configuration of the component of the system can be optimized. In food transformation system the modification of driving variable or independent variable will change. Correlation coefficient is a scientific device originally developed by Sewall Wright (1921) (Agashe *et al.*, 2020) to predict how much of the variation in the growth and yield characters that contributed to the development and yield of the crop. Much more than the correlation coefficient the path coefficient analysis is a standardized partial regression coefficient to partition the correlation coefficient into direct/individual and indirect/combined effects, so that the real



contribution of each character to carrot yield can be measured (Ashad *et al.*, 2006; Priya *et al.*, 2015). Using the path coefficient analysis procedure the size and range of activities that further described this correlation more adequately than any other statistical analysis helps to verify the most effective characters from the levels of contribution they had to carrot yield.

Therefore the objective of this research is to study the correlation and path analysis of carrot character when the maximum yield was obtained from 100 kg N/ha of fertilizer, 7 days irrigation interval and 15 cm intra-row spacing.

MATERIALS AND METHODS

The Study Area

The experiment was conducted in 2016, 2017 and 2018 dry seasons at Dadin-Kowa ($11^{\circ} 30' N$, $10^{\circ} 20' E$ at 500 m above sea level), which has an average annual temperature of $30^{\circ}C$. The soil of the experimental site was loamy in texture. Before the start of the experiment soil samples were collected at random depth of 20 - 30 mm using a soil auger and the composite samples taken to the laboratory was analysed for its properties as described by Fagbenro (1988).

Cultural Practices

In every year the field was cleared using cutlasses and harrowed using a tractor drawn harrow, and ridged at 75 cm apart. Using a split plot design the field was marked out in different sizes and replicated 3 times.

Treatments and Experimental Design

Irrigation intervals was assigned to the main plot. The intervals were 3, 7 and 9 days directed through water channels from the college dam. Fertilizer treatments were imposed in sub-plots at the levels of 0.50, 100 and 150 kg N ha⁻¹ in the form of urea (45% N) mixed in the soil. A blanket rate of 60 kg ha⁻¹ each of single super phosphate (18% P₂O₅) and muriate of potash (60% K₂O) were applied as basal. With the sub-plots, the sub-sub plots were planted at 5, 10 and 15 cm using a common intra-row spacing of 30 cm. In the first week of November of each year, three carrot seeds were planted and later reduced to 1 seed per hole at 3 weeks after planting. The carrot variety of Nantes planted was sourced from the agricultural development project of Bauchi State. The seeds have a maturity period of 100-120 days. Weeds were controlled by spraying Metolachlor pre-emergent and manual weeding was followed at 6 WAS.

Data Collection

The plant height

Plant height of carrot was measured using five randomly selected plants with the help of a ruler in a centimeter unit. It was measured from the base of the stem to the tip of the highest leaf. Measurement at 3 week interval from the seed germination.

Number of leaves

At three weeks interval number of leave / plant was counted by manual counting from 5 randomly selected plants and the average was recorded.

Root diameter

Root diameter was measured from about 1 cm from the root, from five randomly selected plants at harvest using a digital vernier caliper adjusted at 0.001 mm precision and the average was recorded.

Fresh roots weight

Was obtained at harvest by measuring the average of five randomly tagged plants crop samples were uprooted and washed with water and there after using sensitive electronic meter balance (model MT – 201) their weights were weighed and the average value was calculated and used for analysis.

Root length

Was measured at harvest from the shoulder of the root to the tip of the same root, from five randomly selected plants using a caliper adjusted at 0.001 mm precision at harvest and the average was recorded.



Root yield

Was calculated per unit plot from the central and the yield per unit area was converted to yield per hectare.

Fresh weight of shoot

Fresh weight of shoot per plant were recorded from another set of five tagged plants excluding boarder rows randomly selected for destructive sampling in each plot.

Harvesting was carefully done at 100 days after planting from a 1m length of the beds in the inner rows and weighed using a portable weighing scale.

Data Analysis

Data collected were subjected to statistical analysis done using SAS (Statistical Analysis System, 1997). The difference between treatments means were compared using Duncan Multiple Range Test (DMRT) at 5% probability level (Duncan, 1955). All statistical procedures were done as described by Gomez and Gomez (1984). The average values for the various parameters reported from the field trials were analyzed for the correlation and coefficient after the normal conventional analysis.

RESULTS AND DISCUSSION

Table 1 present the correlation and coefficient between root yield and yield attributes of carrot. The results showed that in 2016 carrot yield plant⁻¹ is highly significantly correlated with crack root plant-1 (0.6551), root length plant (0.68248), root diameter (0.77357), fresh weight of root plant-1 (0.79234) and crack root plant-1 (0.655). Among the highly positive significant correlations of root had the strongest relationship (0.84217) with carrot yield plant⁻¹ while weakest was between crack root plant-1 (0.65502) and yield.

Table 1: Correlation coefficient among some growth and yield attributes of carrot in 2016 - 2018 at Dadin-Kowa

2015/2016 Yield Attributes	1	2	3	4	5	6	7	8
RYield	1.000							
PH	0.078210 ^{NS}	1.000						
NLP	0.79234**	0.92097**	1.000					
FWSP	0.65502**	0.90706**	0.83045**	1.000				
RLP	0.68248**	0.90828**	0.95583**	0.83122**	1.000			
RDP	0.77357**	0.96716**	0.94167**	0.89459**	0.90302**	1.000		
FWRP	0.77109**	0.08379 ^{NS}	0.80732**	0.79778*	0.80595**	0.66605**	1.000	
CRP	0.84217**	0.96675**	0.94243**	0.91345**	0.89568**	0.86642**	0.89364**	1.000
2016/2017 Yield Attributes								
RYield	1.000							
PH	0.65121**	1.000						
NLP	0.64311**	0.79264**	1.000					
FWSP	0.41363**	0.61934**	0.67321**	1.000				
RLP	0.59864**	0.76723**	0.76563**	0.79642**	1.000			
RDP	0.66871**	0.84324**	0.79231**	0.70321**	0.87763**	1.000		
FWRP	0.69561**	0.74322**	0.73613**	0.62415**	0.79342**	0.56732**	1.000	
CRP	0.74962**	0.81633**	0.87362**	0.74962**	0.64923**	0.76234**	0.76348**	1.000
2017/2018 Yield Attributes								
RYield	1.000							
PH	0.59632**	1.000						
NLP	0.61324**	0.60793**	1.000					
FWSP	0.32476**	0.51934**	0.58688**	1.000				
RLP	0.51495**	0.86413**	0.69776**	0.72106*	1.000			
				*				
RDP	0.69862**	0.81564**	0.71144**	0.68993*	0.78909**	1.000		
				*				
FWRP	0.58432**	0.69442**	0.71314**	0.61788*	0.68817**	0.53004**	1.000	
				*				
CRP	0.69241**	0.79326*	0.82562**	0.65666*	0.61996**	0.65993**	0.68974**	1.000
				*				

1=PH = Plant height, 2 = NLP = Number of leaves plant⁻¹, 3 = FWSP = Fresh weight of shoot plant⁻¹, 4 = RLP = Root length plant⁻¹, 5 = RDP = Root diameter, 6 = FWRP = Fresh weight of root plant⁻¹, 7 = CRP = Crack root plant⁻¹ R = Yield kg/ha⁻¹

However, in 2017 carrot yield ha⁻¹ was highly significantly correlated with plant height (r=0.41363), number of leaves plant⁻¹ (r=0.64311), root length plant⁻¹ (r=0.74962), root diameter (r=0.66871), fresh weight of root plant⁻¹. Among the highly positively significant correlations, root length plant⁻¹ had the strongest relations (r=0.74962) with carrot yield, while that between plant height and carrot yield plant⁻¹ (r=0.41363) was the weakest.

The result shows in 2018 yield plant⁻¹ significantly and positively correlated with plant height (r=0.57932), number of leaves plant⁻¹ (r=0.32476), root weight plant⁻¹ (r=0.585432), and (r=0.61324) and root length (r=0.51495). Among the highly positively significant correlations, root diameter had the (r=0.69862) strongest relationship (r=0.69862) while that of number of leaves (r=0.32476) was the weakest.

Table 2 present the direct and indirect effects of some growth and yield attributes to carrot yield in 2016, 2017 and 2018 at Dadin-Kowa.

In 2016 the fresh weight of root plant⁻¹ had the strongest and positive effect on carrot yield (0.540). It was followed by root diameter plant⁻¹ (0.438) and root length plant⁻¹ (0.435) while that from plant height was the least (0.287). The strongest indirect effect of one character via another was that noted

from fresh weight of root plant⁻¹ (0.5382) after wards number of leaves plant⁻¹ (0.500) and that from root diameter plant⁻¹ (0.492) via root diameter. Only the direct effect of number of leaves plant⁻¹ (-0.620) and crack root plant⁻¹ (-0.414) that were negative and weak.

Table 2: The direct and indirect contributions of the different growth and yield components to yield at Dadin-Kowa

Direct and Indirect contributions					Effects			Total Correlation
2015/2016	1	2	3	4	5	6	7	
1. PH	0.287	-0.608	0.351	0.354	0.408	0.350	-0.396	0.746
2. NLP	0.194	-0.620	0.378	0.328	0.376	0.500	-0.334	0.822
3. FSWP	0.068	-0.413	0.392	0.313	0.317	0.538	-0.370	0.845
4. RLP	0.153	-0.560	0.369	0.435	0.316	0.450	-0.339	0.824
5. RD	0.036	-0.526	0.358	0.349	0.438	0.492	-0.376	0.771
6. FWRP	0.026	-0.420	0.330	0.332	0.353	0.540	-0.328	0.833
7. CRP	0.209	-0.515	0.339	0.322	0.383	0.469	-0.414	0.703
2016/2017								
1. PH	-0.149	0.041	-0.173	0.385	0.131	0.220	-0.099	0.702
2. NLP	-0.093	0.158	-0.133	0.400	0.051	0.262	-0.103	0.808
3. FSWP	-0.118	0.046	-0.255	0.388	0.075	0.290	-0.084	0.852
4. RLP	-0.096	0.086	-0.152	0.415	0.094	0.314	-0.080	0.885
5. RD	-0.110	0.009	-0.150	0.368	0.251	0.262	-0.084	0.846
6. FWRP	-0.097	-0.045	-0.105	0.388	0.115	0.366	-0.095	0.782
7. CRP	-0.062	0.034	-0.155	0.376	0.148	0.267	-0.130	0.788
2017/2018								
1. PH	0.1581	-0.0431	0.1327	0.2026	0.1999	0.1479	-0.0887	0.7094
2. NLP	0.1297	-0.0697	0.1321	0.1742	0.1988	0.1337	-0.0805	0.7249
3. FSWP	0.1433	-0.04962	0.2011	0.1273	0.1350	0.1185	-0.0807	0.6738
4. RLP	0.1329	-0.0602	0.1660	0.2647	0.2169	0.2053	-0.0817	0.6990
5. RD	0.1435	-0.03656	0.1595	0.0431	0.4248	0.1280	-0.0608	0.8015
6. FWRP	0.1187	-0.0432	0.1394	0.2602	0.3053	0.3422	-0.0718	0.9443
7. CRP	0.1432	-0.0427	0.1568	0.2627	0.2026	0.1120	-0.1170	0.7176

1=PH = Plant height, 2 = NLP = Number of leaves plant⁻¹, 3 = FSWP = Fresh weight of shoot plant⁻¹, 4 = RLP = Root length plant⁻¹, 5 = RDP = Root diameter, 6 = FWRP = Fresh weight of root plant⁻¹, 7 = CRP = Crack root plant⁻¹ R = Yield kg/ha⁻¹

In 2017 the root length plant⁻¹ (0.415) had the strongest direct effect on carrot yield. It was followed by fresh weight of root plant⁻¹ (0.366) and that from fresh weight of shot plant⁻¹ (0.255) while the least direct effect on yield was from the number of leaves plant⁻¹ (0.518). Crack root plant⁻¹ and plant height this time had the weak and negative effect on carrot yield. Likewise most of the strong and indirect effect to yield via another character was via root length plant⁻¹.

In 2018 it was observed that the root diameter plant⁻¹ had the strongest effect (0.4248) in carrot yield while number of leaves had the weakest effect (-0.0697) on carrot yield and crack root (-0.1170) that was negative as well. Likewise the strongest and weakest indirect effect of other parameters to root yield were via root diameter and via number of leaves and crack root plant⁻¹.

Percent individual and combined contribution to carrot yield at Dakin-Kowa during the 2016, 2017 and 2018 is presented on Table 3. The highest percent contribution to carrot yield was from fresh weight of root plant⁻¹ in 20216 (26.00%) and root length plant⁻¹ in 2017 (22.79%) and root diameter (20.95%) in 2018. While the least percent contribution to carrot root was from crack root plant⁻¹ in 2016 and 2018, while in 2017 it was number of leaves plant⁻¹ (0.34%).

Table 3: Percentage contribution of some growth and yield parameters to carrot root yield 2016, 2017 and 2018 combined at Dadin-Kowa.

Growth and Yield Characters	Percentage contributions		
	2016	2017	2018
Individual Contribution			
Plant height	0.43	4.97	0.71
Number of leaves plant ⁻¹	1.17	0.37	0.77
Fresh shoot weight plant ⁻¹	2.73	1.96	1.19
Root length plant ⁻¹	3.43	22.79	2.09
Root diameter	8.82	7.92	20.95
Fresh weight of root plant ⁻¹	26.00	9.64	13.37
Crack root plant ⁻¹	0.05	1.13	0.01
Combined Contribution			
Plant height and Number of leaf plant ⁻¹	-7.21	5.84	8.89
Plant height and fresh shoot weight plant ⁻¹	-1.22	-9.00	0.11
Plant height and root length plant ⁻¹	2.37	12.97	0.01
Plant height and root diameter	-0.35	2.26	-0.02
Plant height and fresh weight of root plant ⁻¹	9.35	15.86	0.02
Plant height and crack root plant ⁻¹	-0.26	-4.78	-0.55
Number of leaves plant ⁻¹ and fresh shoot weight plant ⁻¹	5.46	7.17	5.58
Number of leaf plant ⁻¹ and root length plant ⁻¹	-0.73	0.89	-4.45
Number of leaf plant ⁻¹ and root diameter	-2.37	9.92	-5.58
Number of leaf plant ⁻¹ and fresh weight of root plant ⁻¹	-1.02	-12.46	-0.13
Number of leaf plant ⁻¹ and crack root plant ⁻¹	14.57	-1.62	-0.00
Fresh shoot weight plant ⁻¹ and root length plant ⁻¹	-5.50	-15.78	-0.77
Fresh shoot weight plant ⁻¹ and root diameter	-2.60	1.98	-1.06
Fresh shoot weight plant ⁻¹ and fresh weight of root plant ⁻¹	9.75	1.13	6.07
Fresh shoot weight plant ⁻¹ and crack root plant ⁻¹	-1.34	3.09	-5.27
Root length plant ⁻¹ and root diameter	2.73	25.58	6.07
Root length plant ⁻¹ and fresh weight of root plant ⁻¹	-5.46	-2.26	-6.07
Root length plant ⁻¹ and crack root plant ⁻¹	2.37	1.98	2.79
Root diameter and fresh weight of root plant ⁻¹	24.78	-1.98	-25.93
Root diameter and crack root plant ⁻¹	9.75	3.09	0.11
Fresh weight of root and crack root plant ⁻¹	-9.75	-3.09	-0.11
Residual	14.02	11.43	29.34
Total	100	100	100

The combined contribution of two characters to carrot yields showed that root diameter and fresh weight of root made the highest percentage contribution of (24.78%) in 2016 and (25.93%) in 2018, and root diameter and root length in 2017 (24.58%). The least combined contributions of two characters to carrot root yield was from plant height and crack root plant⁻¹ (-0.26%) in 2016, crack root and number of leaves plant⁻¹ (-1.62%) in 2017 and number of leaves plant⁻¹ and crack root plant⁻¹ (-0.00%) in 2018.

Root yield of carrot correlated positively and significantly with plant height, number of leaves plant⁻¹ and fresh weight of shoot plant⁻¹ in all the three years indicating that these parameter contributed to carrot growth. Except in 2016 where the relationship between carrot root yield and plant height was positive but not significant (Table 1). This might be due to the availability of essential resources for growth and development obtained from the 100kgN/ha of fertilizer as well as the intra-row spacing of 15cm that provided free space between plants and reduced competition (Muhie and Yimer, 2023).



DISCUSSION

Priya *et al.*, (2010) Carrot yield correlated positively and highly significantly with root length of plants, root diameter of plant and fresh weight of root plant⁻¹ in all the three years indicating that these parameters contributed to carrot root yield in these periods. Thakur *et al* (2015) reported that the root weight of carrot per plant was highly and positively associated with root diameter per plant and root length per plant. Positive correlation was observed between fresh weight of shoot plant⁻¹ and root diameter plant⁻¹, in previous study Thakur and Jamwal (2015) found root diameter to be related to root yield. Thus, the vigorous growth of carrot crop might have contributed to the overall vegetative growth and improved performance. This growth of carrot might be as a result of more photosynthate produced that promote crop growth and root expansion which could be as a result of meristematic tissue activities and nutrient accumulation of the root due to structural and physiological functions resulting in heavier carrot root expressed in carrot yield. The increased widening potential could have increased the potential for root formation and sink size filling (Muhie, and Yimer (2023).

In 2017, the highest percentage individual contribution to carrot yield per hectare came through root length plant⁻¹ (22.79%) to carrot yield. The combined contribution of two characters to carrot yields showed that root diameter and root length in 2017 (12.85%) made the highest combined contribution. This suggest that root length and its association with root diameter are good determinant of carrot yield. Tegen *et al.*, (2021) reported increase in root length as an important trait for carrot production and is thereby an important aspect of carrot growth improvement. The results indicated that root length, root diameter, fresh weight of root are highly and positively correlated with the yield of carrot and are therefore, important characters for growth and increase crop production and ensure sustainability. The negative direct effect of plant height and cracks root of plant and their association with all other parameters to carrot yield per hectare may be due to competition for photosynthate between carrot yield and these parameters.

When the combined contribution of any two parameters was examined, it was found that the combination of root diameter plant⁻¹ and root weight plant⁻¹ (24.78%) in 2016, root length plant⁻¹ and root diameter plant⁻¹ (24.58%) in 2017; and the contribution of root diameter plant⁻¹ and root weight plant⁻¹ (25.93%) in 2018 gave the highest.

From the data 2018 root diameter exhibited the highest positive effects of (0.4248) on carrots yield and the association of root weight per plant and root diameter per plant gave the highest indirect contribution (0.3053) to carrot root yield. This result suggest that increase in root diameter increased carrots yield indirectly by increasing carrot root weight per plant. Singh *et al* (2007) and Tegen *et al.*, (2021) reported increasing root diameter and root length per plant increase carrots yield indirectly by increasing the root weight per plant and fresh shoot per plant.

The residual in 2016, 2017 and 2018 were 14.02, 11.42 and 29.34 respectively. The residual indicate the presence of other components that influence yield and which were not consider. It was assumed that all associations were linear such that the agronomist are faced with variation in the total contribution to yield. This is because in separating the correlation coefficient, it was assumed that all associations were linear and unknown residual effects of other factors exist.

CONCLUSION AND RECOMMENDATION

It is concluded through indirect and indirect partition among the characters of high correlation with the basic variable that the responses of the duos of root diameter and fresh weight of root plant⁻¹, root diameter and root length plant⁻¹, fresh weight of root plant⁻¹ and root diameter can be considered for selection.



REFERENCES

- Ashad, M. Ali, N. and Ghafoor, A. (2006). Character correlation and path coefficient in soyabean glycerine max(L). Merrill. Pak. *Journal of Botany* 38(1): 121-130 2006.
- Duncan, D.B. (1955). Multiple Range and Multiple F-test Biometrics 11: 1-42.
- Fagbenro, J.A. (1988). Studies on the extraction of soil organic matter and the effect of humic acid on the growth of teak (*Tectona grandis* Linn F) seedlings. *Ph.D. Thesis, Department of Agronomy, University of Ibadan, Nigeria*.
- FAOSTAT (2021). Food and Agriculture. Data (DAOSTAT) 2024 *Food and Agriculture database*.
- Gomez, K. A. and A. A. Gomez, (1984). Statistical Procedures for Agricultural Research. 2nd Edition *John Wiley and Sons Inc. New York U.S.A* ISBN: 13-9780471879312, Pages 600-680.
- Hamma, I.L., Ibrahim, U. and Haruna, M. (2012). Effect of Irrigation Intervals and NPK Application on the Growth and Yield of Carrot (*Daucus carota* L.) in Samaru, Kaduna State, Nigeria.
- Muhie, S.H. and Yimer, S.H. (2023). Growth and Yield Performance of Carrot (*Daucus carota* L.) as influenced by plant population density under irrigation condition. *Advances in Horticultural Science* 37 (3): 307-315.
- Nigerian Journal of Agriculture, Food and Environment*, 8(1): 59-62.
- Priya, P.A. and Santhi, V.P. (2015). Variability character association and path analysis for yield and yield attributes in carrot (*Daucus Carota*) *Electronic Journal of Plant Breeding*. 6(3), 861-865.
- Singh, B., Singh, A., Singh, T. and Singh, N. (2007). Integrated Nutrient Management in Carrot (*Daucus carota*, L.) *Progressive Agriculture*. 7(1&2): 84-86.
- Tegen, H. and Mnuyelet, J. (2021) Influence of spacing on yield and root size of carrot (*Daucus carota* L.) under ridge furrow production. *Open Agriculture*. 6(1): 826-835.
- Thakur, N. and Jamwal, R.S. (2015). Correlation Coefficient and path Analysis Studies in European Carrot (*Daucus carota* L). *Annals of Biology* 31 (1) 97-100.
- Wright, S. (1921). Correlation and Causation. *Journal of Central European Agriculture*, 20(1), 194-207. The Methods of Path Analysis, *Analysis of Mathematic Statistics* 5: 161-215.
- Yadav, M., Tirkey, S., Singh, D.B., Chaudhary, Roshan, R.K. and Pebam, N. (2009). Genetic variability, Correlation Coefficient and Path Analysis in Carrot. *India Journal of Horticulture*, 66: 315-318.