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Correlation coefficient studies in Knol-Khol (*Brassica oleracea* var. *gongylodes*) cv. White Vienna under Srinagar Garhwal Valley

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Abstract
An experiment was carried out at Horticultural Research Centre, H.N.B. Garhwal University, Chauras Campus (Uttarakhand), India during winter season, 2016-2017 with knol-khol cv. White Vienna to study the correlation coefficient between various traits. Association of yield with other characters revealed that, the knob yield per plot was highly positively significant correlation with fresh weight of knob, whole plant weight, fresh weight of leaves, plant height at harvest, knob length, Knob diameter, dry weight of leaves and days taken to complete harvest at both genotypic and phenotypic levels, where as significantly negative correlation at genotypic and phenotypic levels was observed in days taken to knob initiation. However, the association among yield components had found that the plant height at harvest showed significantly positive correlation with knob diameter, knob length, fresh weight of knob, fresh weight of leaves, whole plant weight, dry weight of leaves and dry weight of knob. The days taken to knob initiation showed highly significant positive correlation at genotypic and phenotypic levels with days taken to first harvest only, whereas knob diameter, knob length and dry weight of leaves showed negatively significant correlation with days taken to knob imitation at genotypic and phenotypic levels. The days taken to complete harvest showed positive correlation at genotypic and phenotypic levels with Knob diameter, knob length, fresh weight of knob, fresh weight of leaves and dry weight of knob. The Fresh weight of knob showed positive significant correlation at phenotypic and genotypic levels with fresh weight of leaves, whole plant weight and dry weight of leaves.

Keywords: Correlation, genotypic, Knol-khol, phenotypic and white Vienna

Introduction
Vegetables are important constituents of Indian agriculture and also provide nutritional security due to their short duration, high yielding capacity with nutritional richness. Our country is blessed with diverse agro-climates with distinct seasons, making it possible to grow wide variety of vegetables. Vegetable plays an important role in the balanced diet by providing not only energy but also supplying vital protective nutrients like, proteins, vitamins, minerals, dietary fibers, micronutrients and antioxidants. In vegetables, Brassicaceae are one of the most diversified families with wide range of variation in crops that supplied edible products.

Knol-khol (*Brassica oleracea* var. *gongylodes*) is a Rabi season crop originated from the costal countries of Mediterranean region. Among the Cole crops, it is comparatively hardy and short duration crop. It belongs to brassicaceae family and closely related to cabbage. It has been under cultivation by Romans since 600 B.C. (Bose, 2001) [3]. In India the cultivation of knol-khol is popular in Kashmir, West Bengal and Karnataka. In recent time it is becoming popular in most of the states like Punjab, Himachal Pradesh, Uttarakhand, Haryana, Delhi etc., and also in the vicinity of big cities of Rajasthan (Choudhary, 2015) [6]. The edible part of knol-khol is knob, which arise from a thickening of the stem tissue above the cotyledons. The fleshy turnip-like enlargement of the stem develops entirely above the ground. This knob is harvested for human consumption as raw and cooked vegetable, though in some parts, young leaves are also use (Chadda, 2009) [4].

Correlation coefficient measures the degree of association (genetic and non-genetic) between two or more traits. The concept of correlation was first given by Galton (1987) [8], the knowledge of the nature and magnitude of genetic association among components of economic

importance can help in improving the efficiency of selection by making possible use of suitable combination of characters. The phenotypic correlations among traits reflect true relationship between traits arising from the combined effects of genotype and environment, whereas genetic correlations estimate the association between traits, resulting either from linkage or pleiotropic effects between the traits. Correlations are more useful, especially for indirect selection and this type of selection can be advantageous over direct selection, only when the selected trait has very high heritability and breeding value of correlation between two traits is very high. Therefore, the present investigation was undertaken to study the correlation coefficient analysis between various traits in knol-khol.

Materials and Methods

The experiment was carried out at Horticultural Research Centre, H.N.B. Garhwal University, Chauras Campus (Uttarakhand), India during winter season, 2016-2017 with knol-khol cv. White Vienna in Randomized Block Design with three replications. Geographically, the Horticultural Research Centre of H.N.B. Garhwal University, Srinagar (Garhwal) is situated in Alaknanda valley which lies between $78^0$47'30" E longitude and $30^0$13'0"N latitude, right in the heart of Garhwal region at an elevation 540 m above MSL, in the lesser Himalayan region. The climate of Horticultural Research Centre is humid sub-tropical which exhibits dry summer and rigorous winter with occasional dense fog in the morning up to 10 am from December to mid February. Except during rainy season, rest to the months is usually dry, with exception of occasional showers during winter or early spring. The study comprised of 21 treatments *viz.*, RDF (100%), RDF (50%), *Azosprillum*, *Azotobacter*, Neem cake, Chicken manure, RDF (100%) + *Azosprillum*, RDF (100%) + *Azotobacter*, RDF (100%) + Neem cake, RDF (100%) + Chicken manure, RDF (50%) + *Azosprillum*, RDF (50%) + *Azotobacter*, RDF (50%) + Neem cake, RDF (50%) + Chicken manure, *Azosprillum* + *Azotobacter*, *Azosprillum* +Neem cake, *Azosprillum* + Chicken manure, *Azotobacter* + Neem cake, *Azotobacter* + Chicken manure, Neem cake +Chicken manure and Control. The seeds of knol-khol cv. White Veinna were sown in well prepared nursery beds. All necessary practices and precautions in raising healthy nursery were followed, till seedlings attained the age and height of transplanting. For transplanting the experimental field was deep ploughed & harrowed followed by planking and leveling 15 days prior to the date of transplanting. The field was divided into 63 beds of equal size *i.e.*, 1.5 m x 1.35 m. Five weeks old seedlings of knol-khol were transplanted at a distance between 30 x 45 cm. Five plants from each plot were randomly selected and tagged for recording the data. The data were recorded for 12 growth and yield parameters *viz.*, plant height at harvest (cm), days taken to knob imitation, days taken to first harvest, days taken to complete harvest, whole plant weight (g), fresh weight of knob (g), fresh weight of leaves (g), knob length (cm), knob diameter (cm), dry weight of leaves (g), dry weight of knob (g) and knob yield/plot (kg). The data recorded for each character on the basis of observational plants were averaged and the mean values obtained were used for statistical analysis. Correlation coefficients were worked out to determine the degree of association among the characters as well as yield. Correlations of various biometrical characters were undertaken as per the procedure suggested by Al-Jibouri *et. al.* (1958) [1].

Results and Discussion

According to Dey *et. al.* (2005) [7] the knowledge of correlation among yield and its contributing traits may be helpful to a plant breeder to determine the degree of association between them and help to improve the efficiency of selection by the use of favourable combination of characters and to minimize the retarding effect of those characters which are negatively correlated. The phenotypic correlation indicates the extent of observed relationship between the two characters while the genotypic correlation provides information about linkage for the genes controlling the pairs of characters. Therefore, it is necessary to study the relationship between both genotypic and phenotypic levels.

In the present study the correlation coefficients were estimated for 12 characters with knob yield and among the characters themselves both at genotypic and phenotypic levels which is presented in Table 1. The magnitude of genotypic correlation coefficients was higher than phenotypic correlation coefficients in the present investigation. Similar results were also reported by Dey *et al.* (2005) [7], Bharathi *et al.* (2005) [2], Chittora & Singh (2017) [5] and Kumar *et al.* (2017) [11]. This could be explained on the basis that there was strong inherent genotypic relation between the characters under studied. The environmental factor has not played much role in expression of phenotypic correlation.

Association of yield with other characters

The results (Table 1) indicated that the knob yield per plot was highly positively significant correlation with fresh weight of knob (0.927, 0.922), whole plant weight (0.661, 0.658), fresh weight of leaves (0.621, 0.618), plant height at harvest (0.527, 0.523), knob length (0.492, 0.467), Knob diameter (0.473, 0.458), dry weight of leaves (0.401, 0.397) and days taken to complete harvest (0.356, 0.354) at both genotypic and phenotypic levels, whereas significantly negative correlation at genotypic and phenotypic levels was observed in days taken to knob imitation (-0.455, -0.451). Similar findings were also reported by Soni *et al.* (2013) [18], Kannan *et al.* (2015) [9], Santhosha *et al.* (2015) [15] and Kumar *et al.* (2017) [11].

Association among yield components

The plant height at harvest showed significantly negative correlation with days taken to knob imitation -0.538, -0.537) and days taken to first harvest (-0.435, -0.434) at genotypic and phenotypic levels. However positive significant correlation for plant height at harvest with other traits were observed in knob diameter (0.557, 0.541), knob length (0.617, 0.592), fresh weight of knob (0.641, 0.639), fresh weight of leaves (0.383, 0.382), whole plant weight (0.452, 0.451), dry weight of leaves (0.808, 0.801) and dry weight of knob (0.386, 0.375). These results corroborate the work of Kibar *et al.* (2014) [10] and Singh *et al.* (2014) [17] in cauliflower.

The days taken to knob imitation showed highly significant positive correlation at genotypic and phenotypic levels with days taken to first harvest (0.771, 0.770) only, whereas knob diameter (-0.564, -0.549), knob length (-0.501, -0.482) and dry weight of leaves (-0.441, -0.438) showed negatively significant correlation with days taken to knob imitation at genotypic and phenotypic levels. However, fresh weight of knob (0.677) and whole plant weight (0.463) showed significantly positive correlation at genotypic level and significantly negative *i.e.*, (-0.676) and (-0.462) at phenotypic level.

Table 1: Genotypic and phenotypic correlation coefficients for 12 characters of knol-khol

	Plant height at harvest	Days taken to knob imitation	Days taken to first harvest	Days taken to complete harvest	Knob diameter (cm)	Knob length (cm)	Fresh weight of knob (g)	Fresh weight of leaves (g)	Whole plant weight(g)	Dry wt. of leaves (g)	Dry wt. of knob (g)	Knob Yield/plot (kg)
Plant height at harvest	*	-0.538** -0.537**	-0.435** -0.434**	-0.025 -0.024	0.557** 0.541**	0.617** 0.592**	0.641** 0.639**	0.383** 0.382**	0.452** 0.451**	0.808** 0.801**	0.386** 0.375**	0.527** 0.523**
Days taken to knob imitation		*	0.771** 0.770**	0.148 0.148	-0.564** -0.549**	-0.501** -0.482**	0.677** -0.676**	-0.183 -0.183	0.463** -0.462**	-0.441** -0.438**	-0.126 -0.124	-0.455** -0.451**
Days taken to first harvest			*	0.384** 0.383**	-0.485** -0.472**	-0.505** -0.488**	-0.526** -0.526**	0.001 0.001	-0.370** -0.370**	-0.386** -0.384**	0.035 0.034	-0.250 -0.249
Days taken to complete harvest				*	0.077 0.073	0.040 0.039	0.210 0.210	0.110 0.110	-0.051 -0.051	-0.114 -0.112	0.090 0.089	0.356** 0.354**
Knob diameter (cm)					*	0.925** 0.850**	0.641** 0.622**	0.435** 0.422**	0.302* 0.293*	0.580** 0.564**	0.198 0.188	0.473** 0.458**
Knob length (cm)						*	0.653** 0.630**	0.361** 0.348**	0.229 0.221	0.671** 0.638**	0.214 0.207	0.492** 0.467**
Fresh weight of knob (g)							*	0.583** 0.583**	0.730** 0.730**	0.513** 0.510**	0.093 0.092	0.927** 0.922**
Fresh weight of leaves (g)								*	0.680** 0.680**	0.371** 0.369**	0.201 0.197	0.621** 0.618**
Whole plant weight(g)									*	0.279* 0.277*	-0.061 -0.059	0.661** 0.658**
Dry wt. of leaves (g)										*	0.743** 0.731**	0.401** 0.397**
Dry wt. of knob (g)											*	0.133 0.130
Knob Yield/plot (kg)												*

The days taken to first harvest showed negative significant correlation at both genotypic and phenotypic level with knob diameter (-0.485, -0.472), knob length (-0.505, -0.488), fresh weight of knob (-0.526, -0.526), whole plant weight (-0.370, -0.370) and dry weight of leaves (-0.386, -0.384). While days taken to complete harvest (0.384, 0.383) showed significant positive correlation at genotypic and phenotypic level.

The days taken to complete harvest showed positive correlation at genotypic and phenotypic levels with Knob diameter (0.077, 0.073), knob length (0.040, 0.039), fresh weight of knob (0.210, 0.210), fresh weight of leaves (0.110, 0.110) and dry weight of knob (0.090, 0.089), whereas Whole plant weight (-0.051, -0.051) and dry weight of leaves (-0.114, -0.112) showed negatively correlation with days taken to complete harvest at genotypic and phenotypic levels. These results are in agreement with the findings of Kumar *et al.* (2011) [13].

The knob diameter showed significant positive correlation with Knob length (0.925, 0.850), fresh weight of knob (0.641, 0.622), fresh weight of leaves (0.435, 0.422), whole plant weight (0.302, 0.293) and dry weight of leaves (0.580, 0.564) at both genotypic and phenotypic levels, whereas dry weight of knob (0.198, 0.188) reported positive correlation with knob diameter at both genotypic and phenotypic level.

A positively significant correlation at genotypic and phenotypic levels was observed with fresh weight of knob (0.653, 0.630), fresh weight of leaves (0.361, 0.348) and dry weight of leaves (0.671, 0.638), whereas whole plant weight (0.229, 0.221) and dry weight of knob (0.214, 0.207) showed positive correlation at genotypic and phenotypic level.

The Fresh weight of knob showed positive significant correlation at phenotypic and genotypic levels with fresh weight of leaves (0.583, 0.583), whole plant weight (0.730, 0.730) and dry weight of leaves (0.513, 0.510), while dry weight of knob (0.093, 0.092) showed positive correlation at genotypic and phenotypic levels. Meena *et al.* (2010) [14], Sheemar *et al.* (2012) [16] and Kumar *et al.* (2017) [11] in cauliflower and Kumar *et al.* (2010) [12] in cabbage who reported similar findings.

The fresh weight of leaves showed significant positive association at genotypic and phenotypic levels with whole plant weight (0.680, 0.680) and dry weight of leaves (0.371, 0.369), whereas dry weight of knob (0.201, 0.197) showed positive association at genotypic and phenotypic levels.

The whole plant weight had significant positive correlation at genotypic and phenotypic level with dry weight of leaves (0.279, 0.277), whereas negative correlation was noticed with dry weight of knob (-0.061, -0.059) at genotypic and phenotypic levels.

This trait had positive significant association at genotypic and phenotypic level with dry weight of knob (0.743, 0.731).

Conclusion

From the above findings the correlation coefficient indicated that maximum emphasis should be given to the traits like, fresh weight of knob, whole plant weight, fresh weight of leaves, plant height at harvest, knob length, Knob diameter, dry weight of leaves and days taken to complete harvest. These characters are major yield contributing characters, which had positive association with knob yield per plot.

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