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Research Note

Genetic variability and correlation studies in sunflower (*Helianthus annuus* L.)

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Abstract
The present study was conducted in order to investigate genetic variability and to understand the relationship and contribution of characters towards total dry matter and root length. The investigation was carried out at Main Agricultural Research Station, UAS, Raichur during *Rabi* 2012-13, 32 genotypes were evaluated in RBD fashion under root structures. At flowering stage all morphological and root characters were scored. The total dry matter content was assessed after drying the root, stem, leaf, petiole and flower of the plant at 70 ^{0}C in an oven.. High GCV coupled with high PCV recorded for most of the characters except stem girth, SPAD reading and number of leaves, indicating more variability for these traits and are less influenced by the environment. High heritability coupled with high GAM reported for all the traits under study suggested for the greater effectiveness for selection and improvement expected for these traits in future generations. The total dry matter and root length had very highly significant positive association with plant height, root volume, fresh root weight, dry root weight, fresh stem weight, dry stem weight, fresh leaf weight and dry leaf weight indicating the importance of root characters in determining the moisture stress tolerance and putforthing the total dry matter content of the plant.

Keywords
Sunflower, correlation, genetic variability, root length, total dry matter

In India importing of vegetable oil is still undergoing process from other countries to meet the domestic requirements (Anonymous, 2014). Among vegetable oil sources, sunflower oil is preferred one and it is recommend to the heart patients due to its high PUFA (poly unsaturated fatty acid) content. Sunflower is cultivated as rainfed oil seed crop in India.Under rainfed situation crop was subjected to many biotic and abiotic stresses, which leads to low productivity. Among abiotic stresses moisture stress is most important factor which reduces productivity. Under dryland or moisture stress conditions, sustainability of crop is mainly attributed to its ability to extract a significant proportion of water from the deeper soil layers (Bremner *et al.*, 1986; Cox and Jolliff, 1986; Hattendorf *et al.*, 1988). Geetha *et al.* (2012) suggested that, root characters are also important while breeding varieties for drought tolerance apart from yield. An increase in root length in response to moisture stress is an adoptive measure for drought stress reported by Rauf and Sadaqat (2008). These studies influencing that, higher root growth associated with better drought tolerance.

Angadi and Entz (2002) reported that greater soil water depletion shown by standard height sunflower hybrids through deeper rooting depth. The genotypes with better root system drag moisture from deeper layers of soil. Hence, identification of better root characteristics such as root length, root biomass, and root volume would determine the efficiency of water extraction from soil and will have a distinctive advantage to combat moisture stress and inturn add to the total dry matter content of the plant. Therefore, presence of genetic variability is a pre-requisite in the breeding material for any breeding programme for crop improvement. Estimation of correlated response of different characters is of utmost importance for the selection of desirable genotypes (Ali *et al*., 2009). Hence, the present investigation was mainly focused to exploit the variability and also estimation of correlation coefficients in order to determine mutual relationship of various traits on root length and total dry matter content of plant both at genotypic and phenotypic level.

A total of 32 sunflower genotypes which includes, five CMS lines, two restorer lines, 23 germplasm lines and two check hybrids were used in the study. The experiment was conducted at Main Agricultural Research Station, UAS, Raichur during *Rabi* 2012-13. All the genotypes were planted with two replications in RBD under specially designed root structures for proper root growth and development. The root structure is a cement block measuring of 18 m L x 1.2 m H and 1.5 m W constructed with cement blocks and were filled with red soil to represent normal field conditions. The row and plant spacing followed was 60 x 30 cm^2 and prescribed package of practices were followed to raise the crop. At flowering stage, observations were recorded on plant height, stem diameter, leaf area, number of leaves per plant and SPAD reading. The tanks were dismantled during peak flowering stage of the crop and all the plants removed from the soil without damaging the roots by using water with jet pump. From each harvested plant, observations recorded on root length and root volume. The fresh weights of root, stem, leaf, petiole and flower and respective dry weights were also recorded after oven drying at 70 ^{0}C.

The estimation of mean, range and genetic variability parameters were assessed for 18 different characters are presented in Table 1. The root length, root volume and total dry matter content of plants had recorded in the range of 20.75 to 71.00 cm, 21.25 to 247.13 cc and 51.02 to 262.86 g respectively.

The high GCV coupled with high PCV reported for plant height, leaf area, root length, root volume, fresh and dry weights of root, stem, leaf, petiole and flower and total dry matter content of plant indicates presence of variability, suggesting that these traits are under genetic control. The similar results of high GCV and high PCV reported for plant height by Suma and Virupaksha (1994), Sujatha *et al.* (2002), Khan *et al.* (2007), Makane *et al.* (2011) and Hassan *et al.* (2012); for leaf area by Tyagi and Tyagi (2011) and Iqbal *et al.* (2013). However moderate GCV and PCV was recorded for stem girth and number of leaves this is accordance with the reports of Saravanan *et al.* (1996), Sujatha *et al.* (2002) and Hassan *et al.* (2012) for stem girth; Sujatha *et al.* (2002), Patil *et al.* (1996) and Thirumala Rao (2012) for number of leaves. Low GCV coupled with moderate PCV was reported for SPAD reading.

The genotypes studied for plant height, stem girth, leaf area, number of leaves per plant, root characters (length and volume), fresh and dry weights of root, stem, leaf, petiole and flower reported high proportion of heritability which ranged from 71-97 coupled with high genetic advance as percent of mean (GAM) ranged from 44 to 146%. This suggested the greater effectiveness for selection and improvements expected for these traits in future breeding programme as estimated from GAM. The genetic variance is probably due to the less influence of environment in expression of characters. The high heritability coupled with high GAM also reported for plant height by Saravanan *et al.* (1996), Sujatha *et al.* (2002), Sridhar *et al.* (2006), Makane *et al.* (2011) and Mahmoud (2012); for stem girth by Saravanan *et al.* (1996); for number of leaves by Saravanan *et al.* (1996) reported high heritability with moderate GAM and Rauf *et al.* (2009) recorded high heritability for root length and root volume.

For plant growth, survival and fitness under moisture stress conditions roots are essential. Therefore, root system is important because crop productivity is always influenced by the availability and accessibility of water and nutrients for plants in the soil (Herrera *et al.* 2012). Therefore, it is important to know about the contribution of various traits to the root length, since plants having longer root system drags moisture from the deeper layers of soil under moisture scarcity conditions in the soil. The degree of such association among variables can be determined through correlation studies. Knowledge of such correlation is required to obtain the expected response of other characters when selection is applied to the character of interest in a breeding programme and the genetic correlation between two or more characteristics may result from pleiotropic effects of genes or linkage of genes governing inheritance of two or more characteristics and (Falconer 1989). The genotypic and phenotypic correlations for root length and total dry matter content of plant with other different characters were shown in Table 2 and 3 respectively. It was observed that, all the characters recorded higher genotypic correlation coefficients values than the phenotypic correlation coefficients and it is the indication of the reliability of the results. Similar results reported by Iqbal *et al.* (2013). The results indicated that root length had positive and high significant correlations with the plant height, stem girth, leaf area, number of leaves per plant, root volume, fresh and dry weights of root, stem, leaf, petiole and flower at both genotypic and phenotypic level. Angadi and Entz (2002) reported reducing plant height results in reduced rooting depth. El Midaoui (2003) reported close relationship exist between root volume and root dry weight.

The plant height was significantly correlated with the stem girth/diameter, number of leaves per plant, leaf area, root length, root volume, fresh and dry weights of root, stem, leaves, petiole and flower both at genotypic and phenotypic levels. Similarly significant genotypic correlation of plant height with number of leaves per plant also reported by IIlai *et al.* (2009); with total leaf area by Iqbal *et al.* (2013) and Yasin and Singh (2010). However non significant correlation of plant height with the stem diameter reported by IIlai *et al*. (2009), Iqbal *et al.* (2009) and Iqbal *et al.* (2013); with the leaf number per plant by Yasin and Singh (2010) at both genotypic and phenotypic levels.

High production of biomass in plants is strongly associated with water use and water use efficiency (Passioura, 1986). In all screened entries, it was also examined that, how TDM and its components are related to each other by correlating many growth parameters with TDM. The results revealed that TDM had a positive and significant strong relationship with plant height, root volume, fresh root weight, dry root weight, fresh and dry stem weight, fresh and dry leaf weight, indicating that the biomass production in sunflower genotypes depends on the plant height, stem girth, number of leaves per plant, leaf area, fresh and dry weights of root, stem, leaves, petiole and flower. Similarly Nagarathna *et al.* (2012) reported that TDM had positive significant correlation with total leaf area and root dry weight.

Majority of the studied characters under investigation recorded high heritability coupled with high GAM suggested the greater effectiveness for selection and improvement expected for these traits in future breeding programme. It is also suggested that, the choice of plant height, root length, number of leaves per plant, leaf area, stem girth, root volume, fresh and dry weights of root, stem, leaves, petioles and flower and total dry matter content of plants could be promising selection criteria for screening moisture stress tolerant genotypes .

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Table 1. Estimation of mean, range and different genetic parameters in sunflower

Sl. No	Character	Mean	Range		GCV (%)	PCV (%)	h² (Broad Sense)	GAM (%)
			Min.	Max.				
1	Plant height (cm)	118.68	49.17	166.67	24.99	26.34	90.00	62.61
2	Stem girth (cm)	2.34	1.17	3.41	18.11	19.60	85.00	44.18
3	Leaf area (cm^2)	511.61	137.70	1038.83	34.69	36.75	89.00	86.46
4	SPAD values	24.83	21.18	31.83	8.97	11.50	61.00	18.49
5	No. of leaves $plant^{-1}$	25.00	18.25	30.50	11.93	14.18	71.00	26.50
6	Root length (cm)	50.79	20.75	71.00	25.70	27.94	85.00	62.41
7	Root volume (cc)	118.66	21.25	247.13	47.43	49.86	91.00	119.08
8	Fresh root weight (g)	121.53	30.58	269.07	48.48	49.85	95.00	124.47
9	Fresh stem weight (g)	388.95	109.58	742.62	38.18	41.13	86.00	93.55
10	Fresh leaf weight (g)	241.90	61.23	552.55	40.41	42.56	90.00	101.27
11	Fresh petiole weight (g)	110.14	31.85	290.01	44.13	46.40	91.00	110.81
12	Fresh flower weight (g)	117.84	13.01	247.14	55.49	58.60	90.00	138.74
13	Dry root weight (g)	28.91	8.90	78.76	56.28	57.26	97.00	146.01
14	Dry stem weight (g)	41.68	16.47	79.53	40.23	42.95	88.00	99.45
15	Dry leaf weight (g)	40.77	14.50	85.70	41.15	43.39	90.00	103.04
16	Dry petiole weight (g)	12.27	3.40	26.13	36.09	39.45	84.00	87.14
17	Dry flower weight (g)	14.97	3.90	30.25	45.99	49.28	87.00	113.33
18	Total dry matter (g)	138.60	51.02	262.86	38.88	40.03	94.00	99.71

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Table 2. Estimation of genotypic correlation coefficients in sunflower

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}
X_1	1	0.723**	0.752**	0.158	0.678**	0.820**	0.789**	0.867**	0.695**	0.580**	0.654**	0.715**	0.859**	0.692**	0.657**	0.725**	0.930**	0.845**
X_2		1	0.874**	-0.031	0.633**	0.723**	0.692**	0.802**	0.791**	0.769**	0.292*	0.596**	0.778**	0.675**	0.753**	0.403**	0.661**	0.745**
X_3			1	-0.154	0.626**	0.818**	0.744**	0.776**	0.791**	0.728**	0.310*	0.646**	0.760**	0.660**	0.724**	0.426**	0.691**	0.751**
X_4				1	-0.170	-0.076	0.123	0.178	-0.081	0.056	0.458**	0.168	0.214	0.063	0.154	0.484**	0.128	0.211
X_5					1	0.741**	0.694**	0.785**	0.834**	0.580**	0.209	0.748**	0.811**	0.734**	0.491**	0.405**	0.555**	0.799**
X_6						1	0.992**	0.916**	0.853**	0.786**	0.487**	0.910**	0.910**	0.792**	0.791**	0.603**	0.824**	0.946**
X_7							1	0.949**	0.822**	0.742**	0.493**	0.923**	0.903**	0.776**	0.761**	0.543**	0.808**	0.933**
X_8								1	0.943**	0.836**	0.550**	0.881**	0.935**	0.866**	0.806**	0.615**	0.827**	0.971**
X_9									1	0.900**	0.230	0.753**	0.858**	0.920**	0.823**	0.353**	0.716**	0.893**
X_{10}										1	0.187	0.608**	0.725**	0.835**	0.957**	0.285*	0.613**	0.784**
X_{11}											1	0.501**	0.547**	0.268*	0.328**	0.935**	0.618**	0.551**
X_{12}												1	0.872**	0.736**	0.607**	0.581**	0.697**	0.926**
X_{13}													1	0.755**	0.703**	0.656**	0.822**	0.951**
X_{14}														1	0.792**	0.396**	0.719**	0.884**
X_{15}															1	0.409**	0.734**	0.783**
X_{16}																1	0.670**	0.664**
X_{17}																	1	0.836**
X_{18}																		1

*- significant at 5%

**- significant at 1%

X_1- Plant height (cm), X_2- Stem girth (cm), X_3- Leaf area (cm^2), X_4- SPAD values, X_5- No. of leaves $plant^{-1}$, X_6- Root volume (cc), X_7- Fresh root weight (g), X_8- Fresh stem weight (g), X_9 - Fresh leaf weight (g), X_{10}- Fresh petiole weight (g), X_{11}- Fresh flower weight (g), X_{12}- Dry root weight (g), X_{13}- Dry stem weight (g), X_{14}- Dry leaf weight (g), X_{15}- Dry petiole weight (g), X_{16}- Dry flower weight (g), X_{17}- Root length (cm) and X_{18}- Total dry matter (g).

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Table 3. Estimation of phenotypic correlation coefficients in sunflower

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}
X_1	1	0.688**	0.700**	0.086	0.609**	0.756**	0.736**	0.757**	0.644**	0.539**	0.628**	0.667**	0.765**	0.637**	0.592**	0.682**	0.867**	0.791**
X_2		1	0.807**	-0.072	0.526**	0.638**	0.645**	0.693**	0.703**	0.674**	0.259*	0.566**	0.667**	0.575**	0.639**	0.370**	0.618**	0.672**
X_3			1	-0.162	0.555**	0.737**	0.679**	0.666**	0.688**	0.650**	0.263*	0.602**	0.651**	0.586**	0.641**	0.357**	0.673**	0.680**
X_4				1	-0.186	-0.013	0.085	0.076	-0.051	-0.030	0.267*	0.108	0.118	0.021	0.022	0.258*	0.067	0.113
X_5					1	0.646**	0.585**	0.648**	0.670**	0.487**	0.168	0.617**	0.688**	0.640**	0.445**	0.309*	0.496**	0.690**
X_6						1	0.903**	0.830**	0.777**	0.701**	0.437**	0.835**	0.828**	0.735**	0.700**	0.530**	0.731**	0.882**
X_7							1	0.875**	0.777**	0.701**	0.454**	0.913**	0.844**	0.716**	0.676**	0.494**	0.733**	0.898**
X_8								1	0.883**	0.774**	0.488**	0.818**	0.929**	0.825**	0.744**	0.558**	0.692**	0.946**
X_9									1	0.861**	0.224	0.703**	0.813**	0.896**	0.776**	0.343**	0.619**	0.871**
X_{10}										1	0.216	0.580**	0.678**	0.787**	0.935**	0.314*	0.529**	0.766**
X_{11}											1	0.478**	0.501**	0.251*	0.334**	0.932**	0.547**	0.538**
X_{12}												1	0.822**	0.680**	0.550**	0.544**	0.636**	0.900**
X_{13}													1	0.729**	0.665**	0.599**	0.688**	0.938**
X_{14}														1	0.747**	0.361**	0.616**	0.870**
X_{15}															1	0.414**	0.628**	0.759**
X_{16}																1	0.573**	0.640**
X_{17}																	1	0.739**
X_{18}																		1

*- significant at 5%

**- significant at 1%

X_1- Plant height (cm), X_2- Stem girth (cm), X_3- Leaf area (cm^2), X_4- SPAD values, X_5- No. of leaves plant^{-1}, X_6- Root volume (cc), X_7- Fresh root weight (g), X_8- Fresh stem weight (g), X_9 - Fresh leaf weight (g), X_{10}- Fresh petiole weight (g), X_{11}- Fresh flower weight (g), X_{12}- Dry root weight (g), X_{13}- Dry stem weight (g), X_{14}- Dry leaf weight (g), X_{15}- Dry petiole weight (g), X_{16}- Dry flower weight (g), X_{17}- Root length (cm) and X_{18}- Total dry matter (g).