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MOISTURE STRESS RESPONSE IN MUSKMELON (*CUCUMIS MELO* L.) UNDER ARID ECOSYSTEM

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ABSTRACT

A set of 40 genotypes of muskmelon were evaluated during summer season, 2012 at the "Agricultural Research Station", Beechwal, Bikaner, Rajasthan, India for correlation studies among ten characters to help breeders to determine selection criteria for breeding programmes for fruit yield improvement. The correlation study revealed that fruit yield was positively and significantly correlated with traits namely fruits per plant (0.588 and 0.573); (0.345 and 0.356) ; (0.361 and 0.372) , fruit weight (0.939 and 0.936); (0.978 and 0.975); (0.991 and 0.983) , vine length (0.566 and 0.561); (0.893 and 0.866); (0.872 and 0.766) and proline content (0.435 and 0.429); (0.343 and 0.337); (0.386 and 0.363) under optimum moisture, 50% water stress and 25% water stress situations at genotypic and phenotypic levels respectively. Thus, suggesting that number of fruits per plant, fruit weight, vine length and proline content traits may be considered as prime traits during selection for yield enhancement in muskmelon under arid ecosystem.

INTRODUCTION

Muskmelon (*Cucumis melo* L.) is a one of the most economically important vining fruit vegetable especially during summer in hot and dry regions of India. Its fruits are very sweet in taste and have high nutritive and medicinal value too. It is economically remunerative during summer due to high prices in markets but low yielding open pollinated varieties are hindering its commercial cultivation in arid regions. Drought is another constraint to muskmelon productivity. Among stress, it is alone a factor affecting world food security bitterly and the catalyst of the great famines of the past (CGIAR, 2003). Climate changes will results more severe drought in future (Lobell *et al.,* 2007, IPCC 2007, Pathak and Wassmannn 2009). Thus, is a need to improve tolerance to drought and select genotypes that have little effect of drought. Many researchers have been already tried to determine impact of water stress on muskmelon (Patil *et al.,* 2014, Mirabad *et al.,* 2013, Ibrahim 2012, Kusvuran, 2011). Drought tolerance is therefore an important breeding objective in improving muskmelon productivity potential. Further, selection of muskmelon genotypes with good performance in water stress condition will increase its production in rain fed areas (Rashidi M and Seyfi K., 2007).

Knowledge about the stress tolerance mechanism and their association with yield can significantly improve breeding efficiency. However, researchers have only studied association between yield and its component traits and that too only under optimum environment (Tomar *et al.,* 2008, Rad *et al.,* 2010, Choudhary *et al.,* 2010, Reddy *et al.,* 2013, Singh *et al.,* 2014). The present study was therefore, undertaken to find out affect of water regimes on various characters of economic importance and how the water regime changes the association between different traits.

MATERIALS AND METHODS

Source of material and experimental site

40 genotypes of muskmelon (Table 1) obtained from NAIP project, Biotechnology Centre, SKRAU, Bikaner, were used for the study. The experiment was carried out at the experimental site of Agricultural Research Station, Beechwal, Bikaner, Rajasthan, India.

Seed sowing and experimental design

The experiments were laid in randomized block design with three replications. Ridges for seed sowing were prepared at a spacing of 2.5 meter. Three to five seeds were grown per hole in furrow of 50 cm. Extra plants were rouged out at seedling stage except one to two healthy seedlings. Plants were grown in a plot size of 4 m length and 3 m width. A row to row spacing of 3 m and plant to plant spacing of 80 cm was adopted. All the recommended package of practices was followed to raise a healthy crop.

Drought Imposition

Two water stress levels (50% and 25%) were imposed to determine potential drought resistance of accessions. All plots in the beginning were irrigated with enough irrigation water for healthy seed germination. The plants received enough irrigation until the period of true leaves. Drought was imposed at 40 days after sowing. In stress S_1 condition (50% water), the half irrigation was applied than irrigated condition by alternate irrigation, while in stress condition S_2 (25% water), the drought wad imposed by applying one fourth water to crop than irrigated *i.e* an interval of 14 to 15 days than irrigated (5-6 days). Drought imposition through 50% and 25% water regimes were scheduled till fruit harvest.

Data collection and character studied

Data were recorded on three randomly chosen plants from each replication. The plants were labeled and tagged and used for recording different characters viz. days to first female flowering, number of fruits per plant, fruit weight, vine length, number of branches per plant, relative water content, leaf chlorophyll content, proline content, total sugar content and fruit yield per plant. The mean value was used for statistical analysis.

Correlation analysis

The character associations between different pairs of characters at the phenotypic and genotypic levels were calculated from the phenotypic and genotypic components of variances and co-variances for each environment separately. The components of variances and co-variances were calculated from the expectations of mean sum of squares as described by Singh and Choudhary (1979). The expectations of mean of cross products given in Table 2 are similar to those for mean sum of squares.

Correlation coefficient

Correlation is the relationship between two variable are such that change in one variable result change in another variable. Correlation coefficient is the measure of degree of relationship between two variables. Correlation coefficient was worked out by employing the following formulae as suggested by Al-Jibourie *et al.* (1958) for calculation the phenotypic (r_p) and genotypic (r_g) correlation coefficient using the appropriate variance and co-variance components.

(i) Genotypic correlation coefficients between character X and Y

$$R_{xy(g)} = \frac{Cov_{xy(g)}}{\sqrt{Vx(g).Vy(g)}}$$

(ii) Phenotypic correlation coefficients between character X and Y

$$RXY(p) = \frac{COV_{xy(p)}}{\sqrt{V_{x(p)} - V_{y(y)}}}$$

Where,

$r_{xy(g)}$, $r_{xy(p)}$ and $r_{xy\ (e)}$ denote genotypic, phenotypic and environmental correlation coefficients between X and Y characters, respectively.

$Cov_{xy(g)}$, $Cov_{xy(p)}$ and $Cov_{xy(e)}$ denote genotypic, phenotypic and environmental co-variances between X and Y characters, respectively.

$V_{x(g)}$, $V_{x(p)}$ and $V_{x\ (e)}$ denote genotypic, phenotypic and environmental variances for characters X, respectively.

The significance of correlation coefficient was tested at 5% and 1% level of significance against the expected value from Fisher "r" table at (n-2) degree of freedom (Fisher and Yates 1938).

Test of significance

The significance of correlation coefficient was tested using the following formula

$$T_{(n-2)} = R\sqrt{\frac{N-2}{1-R^2}}$$

Where,

r	=	Correlation coefficient
t	=	Students 't' value, and
n	=	Total no. of observations.

RESULTS AND DISCUSSION

Genotypic and phenotypic correlation coefficients were worked out among different characters including fruit yield. A character by character examination of simple correlation coefficients revealed that different characters were differentially associated with each other (Table 3, 4 and 5). The correlation coefficient provides symmetrical measurement of degree of association between characters (Sharma *et al.*, 2014). The genotypic correlation coefficients were generally stronger than the respective phenotypic correlation coefficients which indicate higher degree of association, reliable and free from environmental factors at genotypic level under optimum and moisture stress conditions (Tomar *et al.*, 2008; Feyzian *et al.*, 2009; Rad *et al.*, 2010; Reddy *et al.*, 2013). It help in designing the selection strategies based on the traits least influenced by the environment.

Correlation coefficient under non-stress (normal water) condition

Fruit yield per plant showed significant positive association with number of fruits per plant (0.588 and 0.573), fruit weight (0.939 and 0.936), vine length (0.566 and 0.561), proline content (0.435 and 0.429), total sugar (0.567** and 0.560**), relative water content (0.746** and 0.682**) and total chlorophyll content (0.685** and 0.673**). Therefore, rapid improvement in fruit yield of muskmelon is expected to result if selection is practiced for these component traits. Selection on the basis of yield itself is highly unreliable. Because, yield is an end product of the multiplicative interaction between the yield components. Yield *per se* may not have genes and separate gene system but there could be genes which govern the inheritance of component characters (Harland, 1939; Grafius, 1959) and contribution of them is through the component compensation mechanism (Adams 1967). Correlation of fruit yield with above components traits is corroborated with the earlier findings of Taha *et al.* (2003), Bronson *et al.* (2003), Boggs *et al.* (2003) Bayoumi *et al.* (2008), Rad *et al.* (2010), Choudhary *et al.* (2010), Reddy *et al.* (2013), Ghaffari and Sedighe (2013), Singh *et al.* (2014) and Nisha and Veeraragavathatham (2015).

Table 1: List of muskmelon genotypes used for present investigation

S. N.	Genotype	S. N.	Genotype
1	Arka Jeeth	21	IIHR-RM-652
2	Durgapura Madhu	22	IIHR-RM-653
3	EC-564755	23	IIHR-RM-655
4	IIHR-GPW-12	24	IIHR-RM-659
5	IIHR-GPW-15	25	IIHR-RM-660
6	GYNO	26	IIHR-RM-662
7	Hara Madhu	27	IIHR-RM-663
8	MM-06-662	28	IIHR-RM-671
9	MG-5	29	IIHR-RM-673
10	MS-1	30	IIHR-RM-675
11	Punjab-Sunehri	31	IIHR-RM-680
12	Pusa Madhuras	32	IIHR-RM-681
13	IIHR-RM-43	33	IIHR-RM-699
14	IIHR-RM-190	34	IIHR-RM-708
15	IIHR-RM-352	35	IIHR-RM-712
16	IIHR-RM-387	36	IIHR-RM-716
17	IIHR-RM-604	37	IIHR-RM-718
18	IIHR-RM-616-1	38	IIHR-RM-719
19	IIHR-RM-619	39	IIHR-RM-720
20	IIHR-RM-624	40	EC-564754

Table 2: Analysis of co – variance between characters X and Y.

Source ofVariation	D.F	M.S.P.	Expectation of mean sum cross products
Replications	r-1	MsPr	
Genotypes	g-1	MsPg	Cov. e_1 e_2 + r $cov_{g1, g2}$
Error	(r–1) (g-1)	MsPe	Cov. e_1 e_2
Total	(rg-1)		

In a hybridization program, knowledge of the interrelationships among yield and yield contributing characters are necessary. Thus, determination of correlation among the characters is a matter of considerable importance in selection of correlated response. In interrelationship study among yield attributing characters, it was observed that significant and positive association of fruit weight was found with vine length (0.675** and 0.671**), proline content (0.373* and 0.371*), total sugar (0.568** and 0.559**), relative water content (0.740** and 0.681**) and total chlorophyll content (0.628** and 0.622**). A similar association of fruit weight with vine length was also reported by Taha *et al*. (2003), Pandey *et al*. (2005) and Reddy *et al*. (2013), Ibrahim and Ramadan (2014), Rani *et al*. (2015).

Vine length showed significant and positive correlation with relative leaf water content (0.416** and 0.367*) at both genotypic and phenotypic levels.

Proline content showed significant and positive correlation with relative leaf water content (0.416** and 0.367*) at genotypic level only.

Total sugar showed significant and positive correlation with relative leaf water content (0.521** and 0.471**) and total chlorophyll content (0.553** and 0.543**) at both genotypic and phenotypic levels.

Relative leaf water content showed significant and positive correlation with total chlorophyll content (0.716** and 0.640**) at both genotypic and phenotypic levels.

Correlation coefficient under 50% water stress conditions

Fruit yield per plant showed significant positive association with number of fruits per plant, fruit weight, vine length, proline content and relative water content in both stress condition respectively (Table 4). Most of these results corroborated with the earlier findings of Bayoumi *et al*. (2008), Rad *et al*. 2010), Choudhary *et al*. (2010), Reddy *et al*. (2013), Ghaffari and Sedighe (2013), Ibrahim and Ramadan (2014) and Nisha and Veeraragavathatham (2015).

In interrelationship study among yield attributing traits, it was found that number of fruits per plant showed significant and positive correlation with proline content (0.326*) at genotypic level but strong positive correlation (0.305) at phenotypic level.

Fruit weight showed significant and positive correlation with vine length (0.915** and 0.893**) and relative leaf water content (0.370* and 0.330*) and total chlorophyll content (0.553** and 0.543**) at both genotypic and phenotypic levels. Similar association of fruit weight with vine length was also observed by Taha *et al*. (2003), Reddy *et al*. (2007) and Ibrahim and Ramadan (2014).

Vine length showed significant and positive correlation with relative leaf water content (0.376* and 0.327*) at both genotypic and phenotypic levels.

Number of branches per plants showed significant and negative correlation with total sugar (-0.415 and -0.333) at both genotypic and phenotypic levels.

Proline content showed significant and positive correlation with total sugar (0.392* and 0.387*) and relative leaf water content (0.378* and 0.347*) at both genotypic and

Table 3: Genotypic and phenotypic correlation coefficients among ten characters in muskmelons genotypes under non-stress (normal water) condition.

S. No.	Characters	Levels	Days to First Female Flowering	Number of Fruits /Plant	Fruit Weight (gm)	Vine Length (cm)	Number of branches /plant	Proline (μg/gm fresh weight)	Total Sugar	Relative leaf water content (%)	Total Chlorophyll (mg/gm) (gm)	Fruit yield/ plant
1	Days to first female flowering	G	1.000	0.186	0.067	-0.026	-0.015	-0.034	-0.076	0.026	0.029	0.123
		P	1.000	0.147	0.065	-0.025	-0.004	-0.031	-0.064	0.036	0.029	0.113
2	Number of fruits/plant	G		1.000	0.316	0.071	-0.195	0.284	0.302	0.486**	0.503**	0.588**
		P		1.000	0.295	0.067	-0.113	0.261	0.293	0.415**	0.460**	0.573**
3	Fruit weight (gm)	G			1.000	0.675**	-0.258	0.373*	0.568**	0.740**	0.628**	0.939**
		P			1.000	0.671**	-0.224	0.371*	0.559**	0.681**	0.622**	0.936**
4	Vine length (cm)	G				1.000	-0.129	0.136	0.201	0.416**	0.163	0.566**
		P				1.000	-0.117	0.137	0.195	0.367*	0.161	0.561**
5	Number of branches/plant	G					1.000	0.015	-0.307	-0.297	-0.316	-0.258
		P					1.000	-0.0006	-0.243	-0.268	-0.284	-0.214
6	Proline (μg/ gm fresh weight)	G						1.000	0.152	0.340*	0.300	0.435**
		P						1.000	0.148	0.320	0.296	0.429**
7	Total sugar	G							1.000	0.521**	0.553**	0.567**
		P							1.000	0.471**	0.543**	0.560**
8	Relative leaf water content (%)	G								1.000	0.716**	0.746**
		P								1.000	0.640**	0.682**
9	Total chlorophyll (mg/gm)	G									1.000	0.685**
		P									1.000	0.673**
10	Fruit yield/plant (gm)	G										1.000
		P										1.000

** Significant at 1% (P= 0.01) level of significance;* Significant at 5% (P=0.05) level of significance

Table 4: Genotypic and phenotypic correlation coefficients among ten characters in muskmelon genotypes under S1 (50%) water stress condition

S. No.	Characters	Levels	Days to First Female Flowering	Number of Fruits/Plant	Fruit Weight (gm)	Vine Length (cm)	Number of branches /plant	Proline (μg/gm fresh weight)	Total Sugar	Relative leaf water content (%)	Total Chlorophyll (mg/gm)	Fruit yield /plant (gm)
1	Days to first female flowering	G	1.000	0.153	0.028	-0.068	0.185	-0.142	0.006	0.207	-0.051	0.075
		P	1.000	0.130	0.024	-0.070	0.177	-0.140	-0.007	0.180	-0.047	0.068
2	Number of fruits/plant	G		1.000	0.151	0.119	0.084	0.326*	0.222	0.306	-0.056	0.345*
		P		1.000	0.156	0.105	0.077	0.305	0.213	0.267	-0.052	0.356*
3	Fruit weight (gm)	G			1.000	0.915**	-0.292	0.295	0.280	0.370*	0.142	0.978**
		P			1.000	0.893**	-0.206	0.292	0.279	0.330*	0.143	0.975**
4	Vine length (cm)	G				1.000	-0.228	0.285	0.125	0.376*	0.173	0.893**
		P				1.000	-0.186	0.283	0.123	0.327*	0.173	0.866**
5	Number of branches/plant	G					1.000	-0.186	-0.415*	-0.306	-0.111	-0.268
		P					1.000	-0.145	-0.333*	-0.232	-0.083	-0.185
6	Proline (μg/ gm fresh weight)	G						1.000	0.392*	0.378*	0.190	0.343*
		P						1.000	0.387*	0.347*	0.188	0.337*
7	Total sugar	G							1.000	0.446**	0.134	0.293
		P							1.000	0.413**	0.132	0.292
8	Relative leaf water content (%)	G								1.000	0.222	0.428**
		P								1.000	0.197	0.378*
9	Total chlorophyll (mg/gm)	G									1.000	0.123
		P									1.000	0.124
10	Fruit yield/plant (gm)	G										1.000
		P										1.000

**Significant at 1% (P=0.01) level of significance * Significant at 5% (P=0.05) level of significance

phenotypic levels. Similar association of proline content with relative water content was also obtained by Kumar *et al.* (2014)

Total sugar showed significant and positive correlation with relative leaf water content (0.446** and 0.413**) at both genotypic and phenotypic levels.

Correlation coefficient under 25% water stress conditions

Fruit yield per plant showed significant positive association with number of fruits per plant (0.361** and 0.372**), fruit weight (0.991** and 0.983**), vine length (0.872** and 0.766**) and proline content (0.386* and 0.363*) in 25% water stress condition (Table 5). Most of these results corroborated with the earlier findings of Taha *et al.* (2003), Bayoumi *et al.* (2008), Rad *et al.* 2010), Choudhary *et al.* (2010), Reddy *et al.* (2013), Ghaffari and Sedighe (2013), Ibrahim *et al.* (2014) and Nisha and Veeraragavathatham (2015).

In interrelationship study among yield attributing traits, days to first female flowering showed significant and positive correlation with number of branches per plant (0.380* and 0.320*) at both genotypic and phenotypic levels. Similar association of days to first female flowering with number of branches per plant at genetic level was also observed by Gupta *et al.* (2015).

Number of fruits per plant showed significant and positive correlation with Proline content (0.470** and 0.392*) and total sugar (0.367* and 0.324*) at both genotypic and

Table 5: Genotypic and phenotypic correlation coefficients among ten characters in muskmelon genotypes under S_2 (25%) water stress condition.

S. No.	Characters	Levels	Days to First Female Flowering	Number of Fruits/ Plant	Fruit Weight (gm)	Vine Length (cm)	Number of branches /plant	Proline (µg/ gm fresh weight)	Total Sugar	Relative leaf water content (%)	Total Chlorophyll (mg/gm)	Fruit yield/ plant (gm)
1	Days to first female flowering	G	1	0.187	0.055	-0.045	0.380*	-0.069	0.025	0.291	-0.036	0.109
		P	1	0.158	0.043	-0.008	0.320*	-0.055	0.024	0.206	-0.027	0.085
2	Number of fruits/plant	G		1	0.246	0.124	0.095	0.470**	0.367*	0.269	0.05	0.361*
		P		1	0.233	0.134	0.086	0.392*	0.324*	0.205	0.04	0.372*
3	Fruit weight(gm)	G			1	0.897**	-0.129	0.343*	0.224	0.252	0.153	0.991**
		P			1	0.804**	-0.103	0.331*	0.215	0.223	0.144	0.983**
5	Vine length (cm)	G				1	0.024	0.306	0.135	0.257	0.232	0.872**
		P				1	-0.009	0.282	0.129	0.229	0.218	0.766**
6	Number of branches/plant	G					1	-0.168	-0.169	0.006	0.048	-0.111
		P					1	-0.134	-0.138	-0.021	0.039	-0.085
7	Proline (µg/ gm fresh weight)	G						1	0.628**	0.221	0.208	0.386*
		P						1	0.624**	0.213	0.208	0.363*
8	Total sugar	G							1	0.052	-0.001	0.256
		P							1	0.059	-0.0004	0.243
9	Relative leaf water content (%)	G								1	0.01	0.304
		P								1	0.005	0.262
10	Total chlorophyll (mg/gm)	G									1	0.155
		P									1	0.141
4	Fruit yield/plant (gm)	G										1
		P										1

** Significant at 1% (P = 0.01) level of significance * Significant at 5% (P = 0.05) level of significance

phenotypic levels.

Fruit weight showed significant and positive correlation with vine length (0.897** and 0.804**) and proline content (0.343* and 0.331*) at both genotypic and phenotypic levels.

Proline content showed significant and positive correlation with total sugar (0.628** and 0.624**) at both genotypic and phenotypic levels.

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