Greener Journal of Agronomy, Forestry and Horticulture
ISSN: 2354-2306

Bulb Yield Stability in Shallot: The Case of Eighteen Shallot Genotypes Evaluated under Southeastern Ethiopia Highlands

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Research Article

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ABSTRACT

Study was carried out to identify stable shallot genotypes with better yield performance over range of environments during 2008-2009 cropping season at south eastern highlands of Ethiopia. Eighteen shallot genotypes were evaluated including standard check (Huruta) and Local check over six environments (2 years x 3 locations) using randomized complete block design with three replications. Data was analyzed using MSTATC and IRRSTAT statistical softwares for combined analysis of variance and stability study respectively. Additive Main Effect and Multiplicative Interaction (AMMI) model was employed to handle the interaction effects. Combined analysis of variance indicated that there was highly significant difference (p<0.01) between genotypes, environments and genotype x environment (G X E) interactions. AMMI analysis confirmed that genotypes S2-68-89, DZ-SHT-57, DZSHT-82, DZSHT-119 and P-403-OP-S1 were the most stable genotypes. Their regression slopes were not significantly different from one (p<0.01) and scores near zero when observed across the first Interaction Principal Component Axis (IPCA1). However, genotypes Waliso, DZ-SHT-21, DZSHT-93 and Huruta were relatively unstable when observed on AMMI bi-plots and had regression slopes significantly different from one (p<0.01). Genotype DZ-SHT-21 was the best with 17300 kg/ha mean bulb yields. Environments Shallo 2008, Sinana 2009, Shallo 2009 and Lower Dinsh 2009 had large positive scores indicating that they interacted in positive direction with the genotypes whereas environments Sinana 2008 and Lower Dinsho 2008 had negative score indicating that they interacted in opposite direction with genotypes. These environments are described as unpredictable that makes cultivar recommendation difficult or complex. This study revealed that breeding shallot genotypes for local or specific adaptation is highly important.

Keywords: shallot, bulb yield, Genotype, stability.

INTRODUCTION

Shallot is widely produced in high- and mid- altitudes of Ethiopia and mainly used as condiment in Ethiopian traditional food (Getachew and Asfaw, 2000; Getachew et al., 2009). It is an important substitute for bulb onion in most highland parts of the country. According to BOARD (2002), shallot is among the major cash crops produced in different parts of the country. However, the number of varieties under production is very few with narrow genetic adaptation (MoARD APHRD, 2009). Maximizing crop productivity requires effective selection and targeting of cultivars for appropriate production area. Understanding the stability of genotype performance over different environments is important to effectively choose materials (James, 1992). Several methodologies and techniques have been developed to describe and interpret the response of genotypes to variation in environments. Each of these methods employs statistics to measure genotypic stability. Lin *et al.* (1986) classified stability into three types. Type 1 stability follows the biological concept and it is measured by the minimum variance across a range of environments. A genotype is considered type 2 stability if its environmental response is parallel to the mean response of all genotypes in the test. A genotype is considered to have type 3 stability if its mean square for deviation from regression is negligible. Though, so far there is a lot of work on stability analysis on cereals and other crops (Mosisa et al., 2001; Hristov et al., 2011 and Hintsa et al., 2011), there is virtually no information on stability of vegetable crops particularly on shallot. This experiment was, therefore, conducted to determine the bulb yield stability of shallot genotypes over different environments.

MATERIALS AND METHODS

Eighteen shallot *(Allium cepa L.* Aggregatum group*)* genotypes that were at pipe line in regional variety trial program were used and planted at Sinana, Shallo and Lower Dinsho in the south eastern parts of Ethiopia in randomized complete block design using three replication for tow years (2008-2009). The map of study area and description of the locations are given in Figure1 and Table 1 respectively. The plot size used was 3.2m^2 in four-rows, net harvested area was 0. 64m^2 from the two middle rows exclusive of border plant for the two respective rows and bulb yield (converted into qtha^{-1}) from this area was used for analysis. The genotypes were planted at the spacing of 40cm between rows and 10cm between plants. DAP fertilizer was applied at the rate of 200 kg/ha at planting in all the three locations, planting was made in early April during the onset of main rain season in the study areas. Combined analysis of data over years and location, was done using SAS GLM procedure (SAS Institute, 2002) and Stability analysis was under taken using IRRSTAT statistical software (IRRISTAT, 2003). Additive Main Effects and Multiplicative Interaction (AMMI) model analysis was carried out to identify stable genotypes.

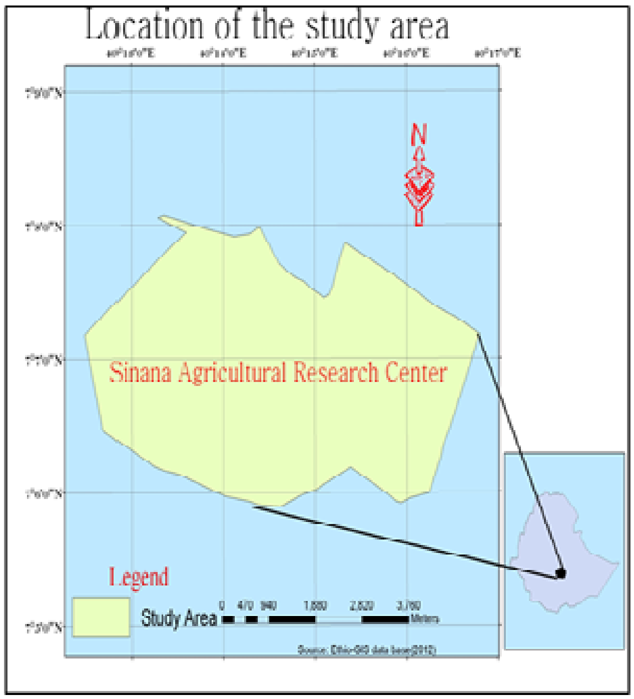

Fig.1: map of the study area

Table 1: Description of the Experimental sites

Experimental sites	Soil characteristics							
	Altitude (m)	Texture	PH	Total (N%)	(M (%)	Average P (ppm)	K (mg/kg)	CEC (meq/kg)
Sinan	2400	Clay	6.2	0.24	3.9	30.40	240	64.4
Shallo	2410	Clay	6.4	0.20	1.71	15.76	-	-
Lower DDinsho	2517	Clay	5.6	0.20	3.4	30.43	375	40.2

Source: Abayneh and Ashenafi (2006)

RESULT

The highest mean bulb yield 240.26 $qtha^{-1}$ was obtained from Sinana in 2008 cropping season whereas the least 44.73 $qtha^{-1}$ was obtained from Shallo during 2009 (Table 2). Genotypes S2-68-89, DZ-SHT-57, DZSHT-82, DZSHT-119 and P-403-OP-S1 were relatively stable, slopes of regression were not significantly different from one ($p < 0.01$) (Table 4,). In addition, the Additive Main Effect and Multiplicative Interaction (AMMI) and AMMI bi-plots conformed that these genotypes when seen across the first Interaction Principal Component Axis (IPCA1) are stable as they occupied the middle right side of AMMI bi-plots (interaction scores near zero) (Fig. 2,3,6 and 7).

On the other hand genotypes Waliso, DZ-SHT-21, DZSHT-93 and Huruta are relatively unstable, their regression slopes were significantly different from one ($p < 0.01$) (Table 4). In the same way, on first Interaction Principal Component Axis (IPCA1) these genotypes were located away from the middle right side of AMMI bi-plots (interaction scores were significantly different from zero) (Fig. 2, 3, 6 and 7), showing the instability of the genotypes except for Huruta, which was only with one year dat.

Table 2: Mean Yield (qtha^{-1}) of Eighteen Shallot Genotypes Tested in Six Environments over three Replication

NO.	Genotypes	Sinana 2008	Shallo 2008	Lower Disho2008	Sinana 2009	Shallo 2009	Lowr Dinsh 2009	Mmean
1	S1-29-89	283.3	218.1	276.6	83.5	43.9	116.0	170.2
2	S1-63-89	219.3	147.0	168.2	46.1	32.5	100.0	118.9
3	S2-68-89	151.9	189.1	307.1	48.4	49.4	89.0	139.1
4	Walso	273.4	11.8	305.8	58.2	44.5	109.7	133.9
5	K-62	264.4	119.9	282.2	61.9	23.9	114.8	144.5
6	DTKT-3	247.2	92.6	245.3	49.7	28.8	109.6	128.9
7	DZ-SHT-OP-S9	205.8	172.1	230.6	80.0	58.5	116.6	143.9
8	DZ-SHT-3	311.9	187.7	109.2	84.9	57.2	122.3	145.5
9	DZ-SHT-21	333.6	129.6	294.1	72.6	47.0	161.2	173.0
10	DZ-SHT-57	212.2	198.0	243.6	83.2	49.5	135.2	153.6
11	DZ-SHT-71	281.6	75.9	269.5	75.8	49.2	135.3	147.9
12	DZSHT-82	251.5	117.6	242.5	83.7	46.3	140.4	147.0
13	DZSHT-93	325.1	122.7	282.1	74.5	43.3	110.0	159.6
14	DZSHT-119	235.7	135.0	262.1	79.8	42.9	163.1	153.1
15	P-403-OP-S1	242.7	127.8	270.5	89.8	56.3	136.2	153.9
16	R-621-OP-S1	242.8	182.2	307.6	77.7	49.0	127.3	164.4
17	LOCAL	242.5	176.9	178.8	75.3	52.1	122.2	141.3
18	HURUTA	-	-	-	72.6	31.1	94.0	65.9
Mean		240.3	133.6	237.5	72.1	44.7	122.4	141.8

Table 3: Combined Analysis of Variance of Eighteen Shallot Genotypes Tested in Six Environments

Source	Degrees of Freedom	Sum of Squares	Mean Square
Year (y)	1	1246432.565	1246432.565**
Location (L)	2	479125.286	239562.643**
YL	2	88233.453	44116.726**
R (LY)	12	34260.364	2855.030
Genotypes (G)	17	283061.887	16650.699**
YG	17	205737.060	12102.180**
LG	34	177399.115	5217.621**
YLG	34	158369.942	4657.939**
Error	195	41051.763	1748.983**
Total	314	3013671.435	

CV=29.50%
**=Significant (0.01)

Table 4: Analysis of variance and stability regression of eighteen genotypes of shallot tested in six environments

No.	Genotypes	MEAN	SLOPE	SE	MS-TXL	MS-REG	MS-DEV	R**2 (%)
1	S1-29-89	170.22	1.199	0.183	1165.25	1332	1123.57	23
2	S1-63-89	118.87	0.84	0.143	720.72	862.08	685.38	24
3	S2-68-89	139.15	0.981	0.36	3477.33	12.61	4343.51	0
4	Waliso	133.9	1.358	0.348	4112.59	4312.77	4062.54	21
5	K-62	144.52	1.287*	0.063	662.84	2772.59	135.4	84
6	DTKT-3	128.86	1.152	0.083	341.11	778.47	231.77	46
7	DZ-SHT-OP-S9	143.95	0.817	0.118	595.76	1123.21	463.9	38
8	DZ-SHT-3	145.51	0.768	0.413	4955.06	1804.14	5742.79	7

9	DZ-SHT-21	173.01	1.406*	0.123	1514.39	5532.67	509.82	73
10	DZ-SHT-57	153.6	0.875	0.171	888.55	524.17	979.65	12
11	DZ-SHT-71	147.87	1.198	0.187	1204.31	1320.61	1175.24	22
12	DZSHT-82	146.99	1.012	0.072	140.47	4.81	174.39	1
13	DZSHT-93	159.62	1.385	0.138	1509.17	4971.67	643.55	66
14	DZSHT-119	153.1	1.022	0.108	315.18	16.31	389.9	1
15	P-403-OP-S1	153.87	1.025	0.08	176.73	20.32	215.84	2
16	R-621-OP-S1	164.43	1.169	0.157	853.89	955	828.61	22
17	LOCAL	141.29	0.801	0.174	1079.88	1335.88	1015.88	25
18	Huruta	32.95	0.295*	0.205	2387.08	6288.87	1411.63	91

Where: SLOPE - slops of regression of genotype means on site
** Indicates slopes significantly different from the slop for the over all regression which is 1.0.*
MS-TXL –contribution of each genotypes to interaction MS
MS-REG - contribution of each genotype to the regression component of the treatment by location interaction.MS-DEV–deviation from regression component of interaction.
*R**2 -squared correlation between residuals from the mean effects model and the site index*

DISCUSSION

Combined analysis of variance showed that there is highly significant difference ($p < 0.01$) between the genotypes, environment and G x E interaction (Table 3) indicating the inconsistent performance of genotypes across the environments. This result was in line with the findings of Mosisa *et al*. (2001) in maize and Hintsa *et al*. (2011) in Wheat. However, the genotypes DZ-SHT-21 recorded the highest mean bulb yield (173 qtha^{-1}) over environments compared to the stable genotypes, which is difficult for regional or national variety recommendation.

Usually those genotypes with slopes of regression grater than one highly perform in favorable environments while those with regression slopes less than one perform under stress environments (Khan *et al*., 2007). Genotypes with regression slopes equal to one indicate no or little response to change in growing environments.

CONCLUSION

Stability of genotypes over different environments is highly essential to exploit the potential of genotypes over wide range of environments. To this effect the current study revealed that environments Shallo 2008, Sinana 2009, Shallo 2009 and Lower Dibsho 2009 had large scores on the first Interaction Principal Component Axis (IPCA1) indicating that these environments interacted in positive direction with the genotypes, whereas environments Sinana 2008 and Lower Dinsho 2008 had opposite direction indicating that these environments interacted in a negative with the genotypes (Fig. 4, 5 and 7). These environments are described as unpredictable making cultivars recommendation difficult or complex. From the current investigation, it was observed that breeding shallot genotypes for local or specific adaptation is highly important.

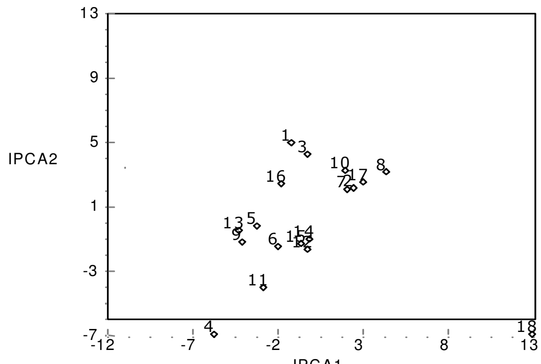

Fig.2: AMMI3 Interaction Score for Marketable Data File: Stable Model Fit: 98.1% of GXE SS

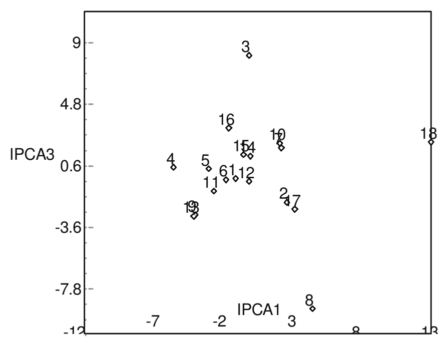

Fig.3: AMMI3 Interaction Score for Genotypes, Stable Model Fit: 98.1% of GXE SS
Where: 1=S-29-89, 2= S263-89, 3= S1-68-89,4= Waliso,5= K- 62, 6= DTKT-3,7= DZ-SHT-OP-S9,8 =DZ-SHT-3, 9= DZ- SHT-21, 10= DZ-SHT-57,11=DZ- SHT-71,12= DZSHT-82, 13= DZSHT-93, 14= DZSHT-119,15= P-403-OP-S1,16= R-621-OP-S1, 17= LOCAL,18=Huruta

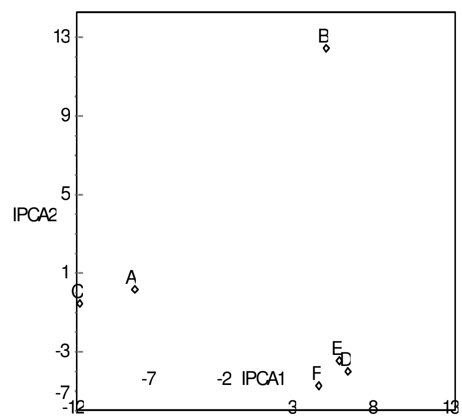

Fig.4: AMMI3 Interaction Score For Environments : Stable Model Fit: 98.1% of GXE SS
Where: A= Sinana 2003,B= Shallo = 2003, C= Lower Dinsho =2003, D = Sinana =2004, E= Shallo =2004, F =lower Dinsho2004

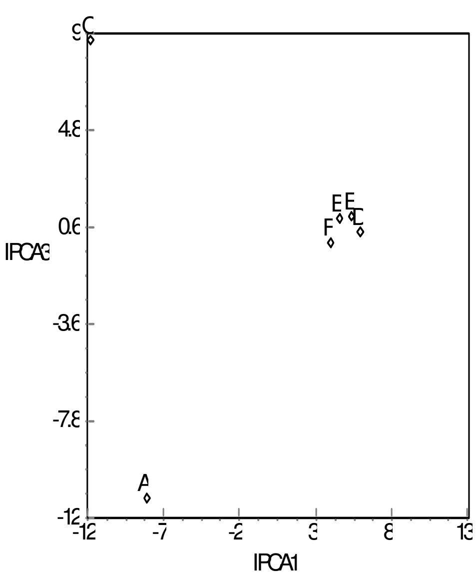

Fig.5: AMMI3 Interactions Score for Environments, Stable Mode Fit: 98.1% of GXE SS

Where: A= Sinana 2003,B= Shallo = 2003, C= Lower Dinsho =2003, D = Sinana =2004,E= Shallo =2004, F =lower Dinsho2004

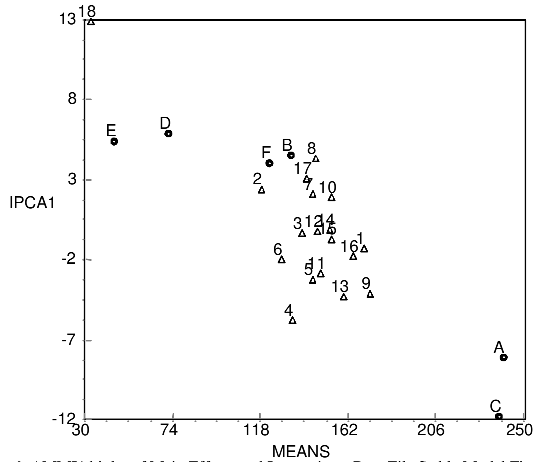

Fig.6: AMMI1 biplot of Main Effects and Interactions, Data File Stable Model Fit: 90.1% of Table

Where: A= Sinana 2003,B= Shallo = 2003, C= Lower Dinsho =2003, D = Sinana =2004,E= Shallo =2004, F =lower Dinsho2004 and 1=S-29-89,2= S263-89, 3= S1-68-89,4= Waliso,5= K- 62, 6= DTKT-3,7= DZ-SHT-OP-S9,8=DZ-SHT-3,9=DZ-SHT-21,10=DZ-SHT-57, 11=DZ- SHT-71,12= DZSHT-82, 13= DZSHT-93, 14= DZSHT-119,15= P-403-OP-S1,16= R-621-OP-S1, 17= LOCAL,18=Huruta

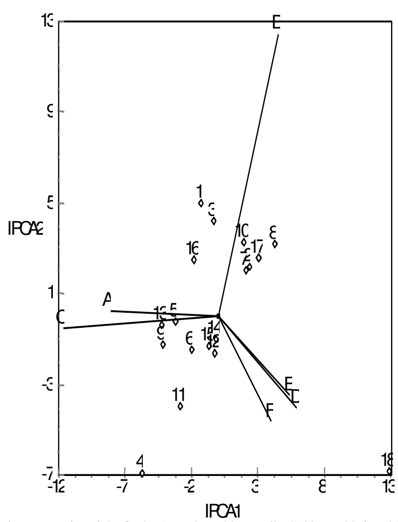

Fig7: Interaction Biplot for the AMMI2 Model Data File: Stable Model Fit: 75.4% of GXE

ACKNOWLEDGMENT

The author acknowledges the horticulture research division of sinana Agricultural Research Center (SARC) for experiment management and data collection. He is also grateful to Oromia Agricultural Research Institute for financial support.

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