Available online www.jsaer.com

Journal of Scientific and Engineering Research, 2020, 7(8):152-160

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Stability Analysis and Adaptability of 15 Genotypes of Shallot at Wetlands with Two Seasons in Central Kalimantan

Ronny Yuniar Galingging*, Andy Bhermana

Assessment Institute for Agricultural Technology (AIAT) of Central Kalimantan - Indonesia
Address: Jl. G. Obos KM 5 Palangka Raya, Kalimantan Tengah
*E-mail: ronnyyuniargalingging@yahoo.com

Abstract The stability of shallot yield is determined by genetic composition, genotype reaction individually and population according to area. The estimation of adaptability and phenothypic stability of yield can be obtained through repeated tests to the variety of growing environment in order to determine genotype responses (G) within its environment (G) and both interaction of GE and GGE. The objective of this study was to know the effect of genotype and genotype interaction to the environment and yield of 15 shallot genotypes. The experiment is conducted using a randomized completely block design with three replications at four environments. The result showed that there was interaction between each genotype and environment for productivity.

Regression deviation was used to know see the appearance of genotype across seasons and locations. There are 8 genotypes (Tajuk, Bima Brebes, Kramat 1, Katumi, Mentes, Pancasona, Manjungdan Bauji) that have specific adaptation to location and 7 genotypes (Pikatan, Super Philip, Maja, Biru Lancur, Ketamonca Rubarudan GH2) that have adaptation on sub-optimal land. The result of multivariate analysis showed that genotype G2 (Tajuk) has high productivity at location 1; genotype G10 (Pancasona) on location 2 and genotype G12 (Ketamonca) on location 4. The genotype G11 (BiruLancur) have low productivity at all location.

Keywords location, Alliumceva var. ascalonicum., stability, adaptability, multivariate, regression deviation., productivity

1. Introduction

The phenotypic performance of a plant is the result of interactions between genotypes and growing environment. The difference of plant performance is because of genetic composition that is expressed and not expressed. The effect of these interactions will result in diversity in crop appearance due to the composition that might occur even if the plants have the same type. Genotype interaction with the environment is needed to assist the process of identifying superior and location-specific genotypes. The method for genotype test is planting at several environments. The results of variance analysis will indicate that there is an interaction between genotype and environment (GxE).

Shallot productivity is mostly influenced by genotype, environment and its interaction factors. The maximum potential yield of a plant will be achieved if planted in an environment that is suitable with optimum needsof genetic. An understanding of the interaction of genotypes with environment is required in order to help the process of identifying superior genotypes. Based on the results of variants analysis, it will be identified whether there is a genotype interaction with the environment (GXE) where the stability of performave in a range of environments depends on interaction effects. If there is no GXE interaction, determination of ideal genotype can be carried out through selecting the expected genotypes with a higher average yield. However, if there is GxE interaction, the tested genotypes at various locations have different yield capability at each test location. There are three types of interactions for genotype x environment (GXE), namely: (a) no interaction, (b) no interaction between environments (no crossover interaction, or quantitative interaction), (c) there is interaction between environment (crossover interaction, or qualitative interaction [1]. Dehghani *et al* [2] added that the significance interaction of genotype x environment provide complex interpretations, so that static stability analysis is then required. The interaction of GxE within shallot plants can be recognised based on genotype that can live and produce well in a region but they may not produce well in other regions, this is likely caused by non-environmental and environmental factors. In specific environment such as tidal land (with Al and Fe stress), acid soils, and swampland, the interaction will occur.

Several methods that are often used to test the adaptability and stability of yields for a variety are repeated testing in various growing environments [3], Finlay and Wilkinson methods [4] and Eberhart and Russell methos [5]. The adaptability and yield stability parameters that are used include regression coefficient (βi), deviation regression ($\delta i2$) and average yield of a variety. Genotypes with a regression coefficient (βi) <1 means that genotypes have stability above average, genotypes with specific adaptation at environments with low productivity and less sensitivity to the environmental changes, mean there is environmental changes, and genotypes only provide slight changes to the yields. The value of $\beta i > 1$ means that genotypes have below average stability and specific adaptation to the high productivity environments, while $\beta i = 1$ means that genotypes have average yields above the general average, and it can adapt well to all environments.

The objectives of this research was to know the adaptability and stability of 15 genotypes of shallots planted in two locations (tides and dry land) with two different growing seasons (dry season and rainy season)

Materials and Methods

The study was conducted in August 2017 to July 2018, on wetlands, in West Mambulau and East Mambulau, Anjir Serapat Timur District, Kapuas Regency, and up land in Palangka Raya, Banturung, Bukit Batu District, Central Kalimantan Province. Several materials used consisting of 10 shallots genotypes (Pikatan, Tajuk, Bima Brebes, Bauji, Kramat 1, Mentes, Biru Lancor, Keta Monca, Manjung and Rubaru), manure, urea fertilizer, TSP, KCl, herbicides, pesticides and other materials. The tools used involving hoes, machetes, tripe, scissors, plastic bags, digital scales, gauge, camera and label stationery.

For field research, it used a Complete Randomized Block Design (RCBD) with 15 shallots genotype treatments and 4 environments with 3 replications. The size of each plot is 10 x 2 m, with a spacing of 20 cm x 15 cm. Each experiment used beds as high as 75 cm to avoid flooding during high tide. The beds are made using simple soil tillage and applied with basic fertilizer for planting preparation. Basic fertilizer consists of cow manure 10 ton/ha, dolomite 5 ton/ha and SP-36 650 kg/ha. The basic fertilizer are then mixed evenly and covered with tarpaulin for 10 days. Basic fertilizer was applied 2 days before planting. Supplementary fertilization was carried out at the age of 15 and 30 days after planting (DAP). The NPK, 400 kg/ha was used at each stage. Watering and weeding was carried out according to conditions in the field. Pest control was carried out routinely using a systemic fungicide for every 3 days. The harvest of shallot was carried out 60 DAP which is marked by the leaves starting to turn yellow evenly, the base of the leaves begins to shrink and the bulbs have filled.

Data Analysis

The data was analyzed using SAS and PBSTAT software and further tested using Duncan and Dunn test. The Kruskal Wallis method use XLSTAT 2014 software. Variance analysis of each location and combined location [3] was then conducted for four growing environments (uplands with dry season, uplands with wet season and tidal lands with wet season, and tidal dry season). It was set in order to obtain homogeneous error variant for stability test of 10 genotypes. Analysis of productivity of tons per hectare was conducted using parametric and non-parametric approaches. The non-parametric approach used the Kruskal-Wallis method. While for parametric approach used Additive Main Effect Multiplicate Interation (AMMI) Method.

The Additive Main Effect Multiplicative Interaction (AMMI) Methods

The use of AMMI biplots [6] and GGE biplots [1] was aimed to visualize two-factor interaction data. The Additive Main Effect Multiplicative Interaction method can be used to analyze multilocation test results.

Assumptions that must be fulfilled in AMMI include errors that must be spread normally with homogeneous variations [7]. AMMI and AMMI biplot charts can provide more information about genetic interactions with location compared to the usual ANOVA method [8]. The stages of AMMI analysis involve (1) compiling matrix of the effects of strain and location interactions (2) decomposing bilinear against the matrix through SVD (singular value decomposition) (3) determines the number of real Main Components I through post dictive success (4) develop AMMI biplot [9].

Kruskall-Wallis Methods

This method is a non-parametric and rank-based test aimed to determine whether there is a statistically significant difference between two or more groups of independent variables, on the dependent variable at a numerical data scale (interval/ratio) and ordinal scale.

Result and Discussion

Genotype Screening

The combined analysis of variance (Table 1) showed that productivity is strongly influenced by environmental factors, but not influenced by genotype. This productivity character was also influenced by the interaction between genotypes and environment, so that it is important information because it can be used to improve the character in accordance with environmental conditions.

The interaction certainly affects the selection and new development program, namely the development of different shallot genotypes for different environments with different seasons or climates. The interaction pattern of genotypes with the environment can help developing a genotype that can exist at all environments or specific genotypes at specific environmental targets [10].

Table 1: The results of the combined analysis used a combination of ANOVA and AMMI to productivity parameters of 10 shallot genotypes at 4 environments

Variation source	Db	JK	KT	Fhit	Ftabel
Environment	3	1013,45	337.83	10.6032	0.003676**
Replication (environment)	8	254.88	31.86	1.3199	0.247630
Genotype	9	267.17	29.69	0.8477	0.580432
Environment*genotipe	27	945.46	35.02	1.4507	0.107799
PC1	11	564.73	51.34	2. 1300	0.028500*
PC2	9	221.44	24.60	1.0200	0.432600
PC3	7	159.29	22.76	0.9400	0.481500
Error	72	1737.97	24.14		

Note : ** significant at 1%, *significant at 5%

Interaction between genotypes and environment provide opportunities to assemble varieties of plants that are widely adapted to certain environments. Unpredictable environmental changes cause unpredictable production results so that it is necessary to assemble varieties that are broadly adapted and able to respond to changes in the environment optimally. Genotype interactions with the environment that affect productivityis shown at Figure 1.

Differences in productivity between different environments and seasons indicate there is the interactions between genotypes, seasons and the environment [11]. The highest productivity is in the dry land areas and rainy season and for the tidal land is in rainy season. This information showed that planting of shallots in both tidal and uplandscan produce better at rainy season. Selection of new genotypes is not enough in one environment, interaction patterns of genotype x environment are very useful in plant breeding to develop a genotype that is suitable for all environments or specific genotypes in certain environmental targets.

Many characters, such as production, iscontrolled by many genes which may have small effect called quantitative characters. Quantitative characters are strongly influenced by the environment on expression of genes present in plants. Interactions that affect shallots productivity have low interactions so that they can be developed into broadly adapted varieties, conversely if interaction of genotypes with the environment lead these varieties can be developed into site-specific varieties.

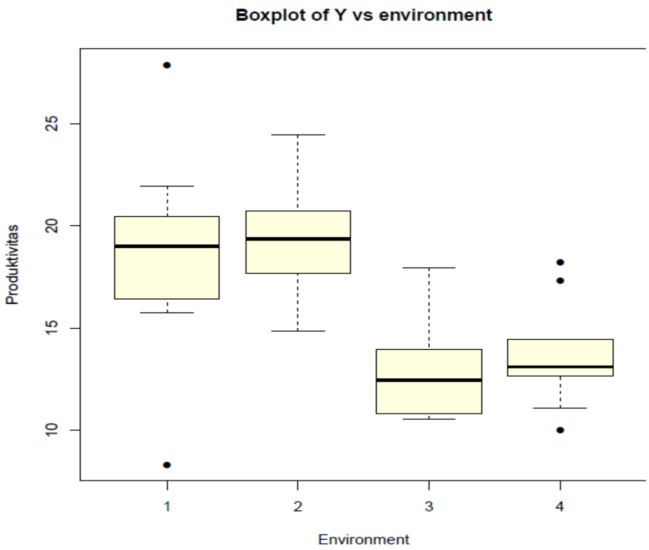


Figure 1: Effect of oxygen interaction with the environment influencing the productivity of red onions

The results of research in various locations with various seasons are mixed data of GE interaction for type of qualitative interaction (crossover) and quantitative type of interaction (noncrossover). Interaction that occurs certainly affects productivity for 15 genotypes tested. This is also supported by Suwarto et al [12] which states that differences in genotype ranking between environments indicate the presence of GE qualitative (crossover) interactions.

Stability Analysis

Differences in productivity between genotypes indicate the existence of interactions between genotypes and growing environment that requires stability analysis to obtain information on whether the genotypes tested have dynamic and agronomic or static and biological stability. Stability is diversity of the results of a genotype in several environments. Genotypes that have small diversity of environments are called stable genotypes.

Parametric analysis to evaluate stability of a genotype and environment has been carried out by Atabe [13], Kadhem *et al* [14] and Shreedar *et al* [15]. Regression results according to Idris *et al* [16] have not been able to reveal the overall impact of location and seasonal variability on results, but a screening approach in selecting genotypes has specific or broad adaptations.

Kruskall-Wallis Methods

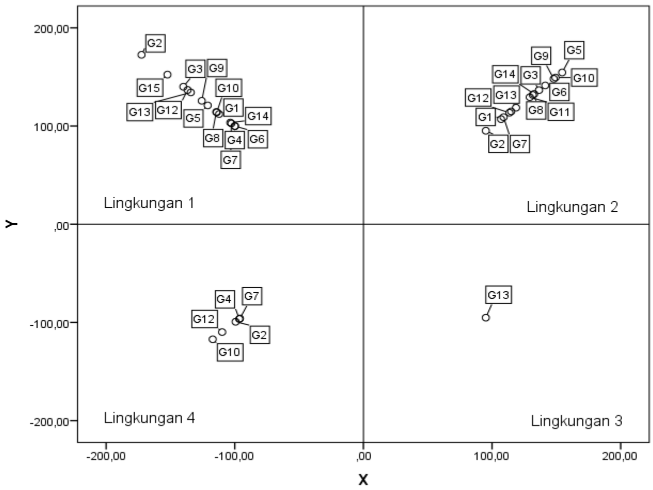
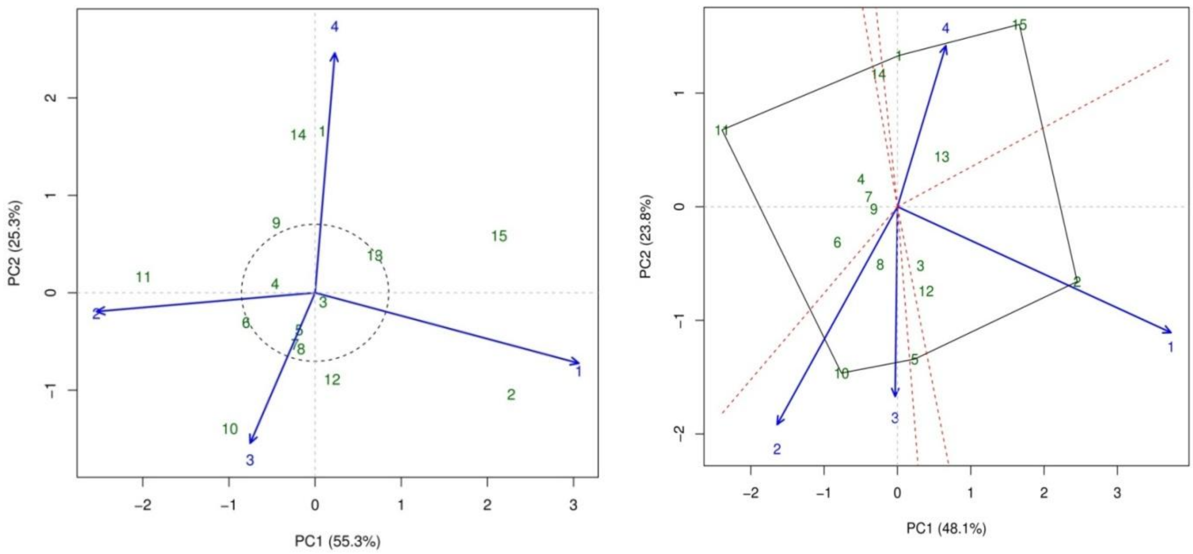


Figure 2: Genotype plot with the highest productivity in each environment

Table 2: Variance analysis of AMMI for 15 genotype of shallots in 2 location and 2 seasons

Sumberkeragaman	Db	JK	KT	F hit	Pr(>)	Kontri-busithd pGxl (%)	Kontri-busi (%)3
Lingkungan	3	1460.66	486.89	21.63	0.6	55.3	
Ulangan	8	180.1	22.51	0.95	0.48	80.7	
(Lingkungan) Genotipe	14	347.99	24.56	0.71	0.75	100	
Lingxgenotipe	42	146.5	34.89	1.47	0.06		
PC1	16	810.89	50.68	2.14	0.01		55.3
PC2	14	371.31	26.52	1.12	0.35		25.3
PC3	12	283.29	23.61	0.99	0.46		19.3
Galat	112	2657.4	23.73				
Total	221	6.258,14					

The widely adapted genotypes according to AMMI include genotypes 4 (Super Philip), 3 (BimaBrebes), 5 (Bauji)), 7 (Maja), 8 (Katumi), 6 (Kramat 1), 13 (Manjung) and 9 (Mentes) with each productivity respectively, 15.64 tons/hectare, 17.8 tons/hectare, 17.98 tons/hectare, 14.74 tons/hectare, 14.86 tons/hectare, 15.22 tons/hectare, 15.64 tons/hectare and 16.42 tons/hectare.



(A) (B)

Figure 2: (A) Biplotof interaction effect for AMMI2 model for productivity of 15 genotype at 4 location, (B) Graphyc of GGE biplot PC1 vs PC2

Note : 1=Pikatan, 2=Tajuk, 3=BimaBrebes, 4=Super Philip, 5=Bauji, 6=Kramat 1, 7=Maja, 8=Katumi, 9=Mentes, 10=Pancasona, 11=BiruLancur, 12=Ketamonca, 13=Manjung, 14=Rubaru, 15=GH2,L1=Uplands, dry season, 2= Uplands, wet seasons, 3= Wetlands, wet seasons, 4=wetlands, dry seasons

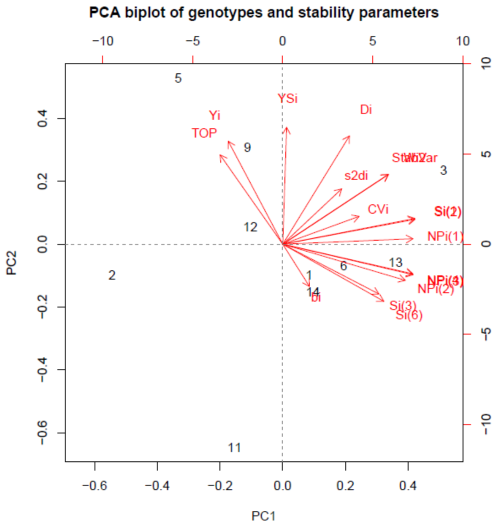
The results of analysis using AMMI Method can show the presence of stable genotypes with extensive adaptation and specific adaptability (Figure 2A). The position of genotypes in the biplot showed the interaction of genotypes with growing environment. Mattjik and Sumertajaya [17] stated that the closer the position of a genotype to the center point, the higher the level of stability and stability in all test environments. Site-specific genotypes are genotypes that are far from the center but close to environmental lines [18].

The genotype that has high yield specific environmental adaptation 4 (wetlands, dry season) is genotype 1 (Pikatan); environment 3 (wetlands land, rainy season) is genotype 10 (Pancasona), environment 2 (uplands, rainy season) is 11 (Blue Lancur) and environment 1 (uplands, dry season) is 2 (Tajuk).

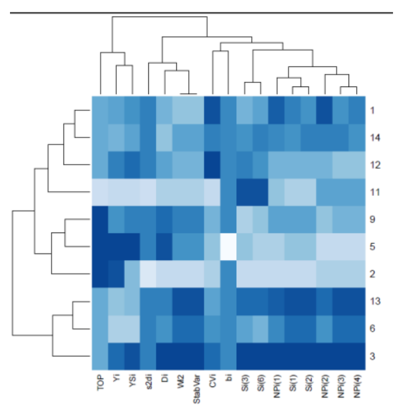
The results of multilocation study on 15 genotypes that became polygon corner of biplot graph include genotypes 10 (Pancasona), 15 (GH2), 2 (Tajuk) and 11 (Biru Lancur). Genotypes that become polygon vertex for each sector are genotypes that have productivity in environment with the same sector i.e genotype 2 (Tajuk) in environment 1, genotype 10 (Pancasona) in environment 2 and genotype 15 (GH2) in environment 4, while G11 (BiruLancur) produces the lowest productivity in all environments (Figure 7B).

The existence of genotypes and environment in two opposite sectors with the farthest distance showed that the genotype has greatest negative interaction with the environment. Genotype 10 (Pancasona) has lowest productivity in environment 4 and genotype 11 (Biru Lancur) has lowest productivity in environment 1.

Measurement using parametric and non-parametric methods (Figure 8 (A) and (B)). The stability of genotypes was divided into 2 major groups namely group 1 with 4 genotypes (G3, G6, G7 and G13) and group 2 with 11 genotypes (G1, G2, G4, G5, G8, G9, G10, G11, G12 and G14).



(A)



(B)

Figure 3: (A) PCA biplot genotype using stability parameters (B) Dendogramof 15 genotype menggunakan parameter stabilitas

The results of stability analysis and results of the dendogram and PCA genotype biplot using stability parameters determine that genotype 3 (BimaBrebes) is a stable genotype in various environments even almost at all stability measurements based on parametric and non-parametric and the combination showed that this genotype is stable in various environmental conditions.

Table 3: Effect of two seasons (dry and wet season) and two land typologies (wetlands and uplands) to productivity of 15 shallots genotypes

Genotipe	Produktivitaston hektar^{-1}				
	LahanKering MK	LahanKering MH	Pasut MH	Pasut MK	Rata-rata
Pikatan	16.9	17.4	11.72	18.22	16.07
Tajuk	27.87	14.84	15.55	12.67	17.73
BimaBrebes	20.41	20.56	13.97	13.78	17.18
Super Philip	15.53	17.87	15.37	13.78	15.64
Bauji	21.94	24.44	12.87	12.67	17.98
Kramat 1	15.77	20.74	13.24	11.11	15.22
Maja	15.98	16.76	15.1	11.11	14.74
Katumi	18.93	21.11	10.28	9.11	14.86
Mentes	18.2	22.5	10.55	14.44	16.42
Pancasona	16.9	22.04	17.13	9.55	16.41
BiruLancur	8.32	19.72	12.04	10.00	12.52
KetaMonca	19.8	17.87	17.96	12.67	17.07
Manjung	20.48	17.69	10.83	13.55	15.64

Rubaru	16.43	18.98	10.55	17.33	15.82
GH$_a$	22.57	11.39	8.98	13.33	14.07
Means	18.40	18.93	13.076	12.89	15.82

Note:1= Uplands, dry season; 2= Uplands, wet season, 3= Wetlands, wet seasons; 4= wetlands, dry season

The analysis showed that there are 7 genotypes that can be planted in sub-optimal land with lowest productivity of 12.52 tons/ha (BiruLancur) and thehighest of 17.07 tons ha (Ketamonca). Genotypes that have specific adaptation are genotypes whichcan produce high productivity at optimum lands. In this study, there are 8 genotypes with the lowest 14.86 tons/hectare (Katumi) and the highest of 17.98 tons/hectare (Bauji). Genotypes with high productivity includeTajuk, BimaBrebes, Bauji, Kramat 1 Katumi, Mentes, Pancasona and Manjung. Stability analysis through a statistical (regression) approach in this study showed that stability type of the 15 shallot genotypes tested was dynamic or agronomic.

Dendogram of GenotypeInteraction with TheEnvironment

Results of dendogram analysis of interactions between genotypes and environment in two seasons and two typologies of land showed fluctuations in yield between genotypes. Fluctuations in environmental factors (abiotic and biotic) and their interactions are closely related to the stability mechanism of plant appearance. Dendogram results of interactions between genotypes and the environment (Figure 4) showed that the results are divided into 2 groups, where group 1 consist of 2 genotypes (GH2, Tajuk) and group 2 involve 13 genotypes (BimaBrebes, Manjung, Katumi, Bauji, Mentes, Super Philip , Maja, Kramat 1, Ketamonca, Pancasona, Pikatan, Rubaru and BiruLancur)

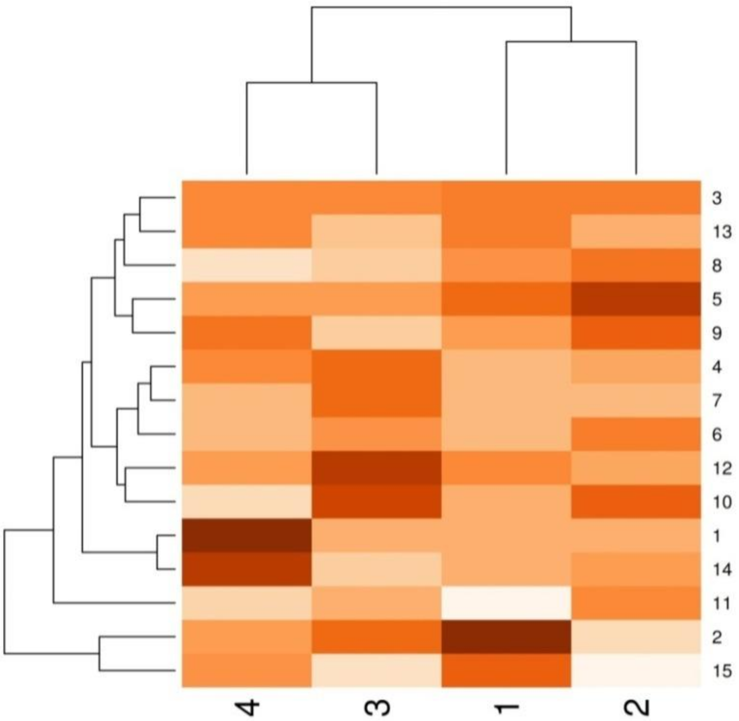


Figure 4: Dendogramas areslt of interaction between genotype and environment

The color on dendogram informed that the darker color (dark brown) indicates that the character has a high correlation of 15 shallots genotypes, while the opposite occurs when the character has lighter color (light brown). The closer accession to another accession, the greater similarity among these accessions. Based on this conditon, genotype 2 (Tajuk) with dark brown color indicated that it has highest productivity in sector 1 (uplands and dry season), while the lowest is genotype 11 (Biru Lancur). Sector 2 (uplands and rainy season) has the highest production i.e genotype 5 (Bauji) with a productivity of 24.44 ton/hectare. Tidal lands in sector 3 (tidal land and rainy season) provide genotype 12 (Ketamonca) that has highest productivity of 17.96 tons/hectare, while the lowest is 14 (Rubaru) and 9 (Mentes) with productivity of 10.55 tons/hectares. The genotype that has highest productivity in sector 4 is genotype 1 (Pikatan) (18.22 tons/hectare) while the lowest is genotype 8 (Katumi).

Path Analysis

The results of the path analysis (Figure 5) show that direct effect is on the parameters of weights per tuber (0.438) and root length (-0.034). Ppositively, it can be used to select number of tuber and tuber diameter, while negative selection can be carried out on root length and hardness to obtain suitable shallot character to be planted atwetlands or tidal lands in Central Kalimantan (Table 16).

Table 4: The results of the path analysis tothe characters affected productivity

Characters	Direct effects	In-direct effects			
		Tuber weight	**Root length**	**Hardness**	**Diameter**
Tuber weight	0.438		-0.009	0.015	0.022
Root length	-0.034	0.109		0.007	0.114
Hardness	-0.070	-0.093	0.003		0.191
Diameter	0.462	0.021	-0.008	-0.029	
Error	0.774				

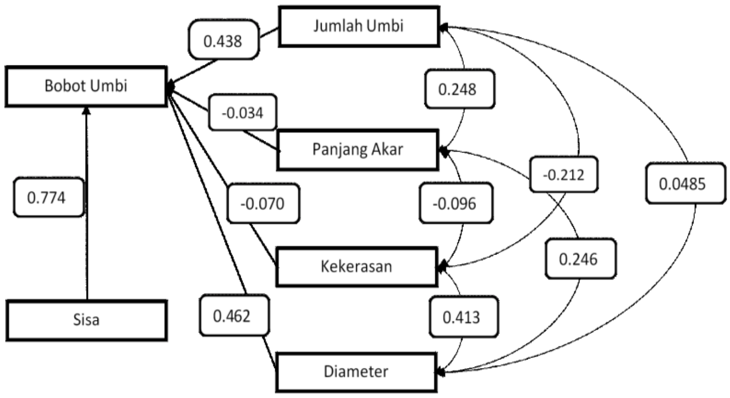


Figure 5: Direct and indirect effects of four characters on the productivity of shallots

Conclusion

Shallots productivity is influenced by interaction of genotypes with environment, whereas for character of weight per tuber is only influenced by genotypes. The most stable and high-yielding genotypes using parametric and non-parametric methods include G3 (Bima Brebes), then G5 (Bauji) which is tested on wetlands and upland with two seasons, dry and rainy seasons.

The analysis of regression showed that there are 8 genotypes (Tajuk, Bima Brebes, Kramat 1, Katumi, Mentes, Pancasona, Manjung and Bauji) that have wide area adaptation and 7 genotypes (Pikatan, Super Philip, Maja, Biru Lancur, Ketamonca Rubaru and GH2), which has adaptation in sub-optimum land.

The best planting of shallots is in the rainy season for both uplands and wetlands. The results of multivariate analysis showed that genotype 2 (Tajuk) has the highest productivity at location 1, G5 (Bauji) at location 2 and G12 (Ketamonca) at location 3 and G1 (Pikatan) at location 4.

References

[1]. Yan W and Kang MS. 2003.GGE biplot analysis of the test sites and trait relations of soybean in Ontario. Crop science 42:(11-20).

[2]. Deghani H., Sabaghpour SH., and Ebadi A. 2010.Study of Genotype x Environment Interaction for Chickpea Yield in Iran. Agronomy Journal Vol. 102 Issue 1.

[3]. Sing RK, Chaudhary BD. 1979. Biometrical methods in quantitative genetic analysis. New Delhi (IN): Kalyani.

[4]. Finlay KW, Wilkinson GN. 1963. The analysis of adaptation in a plant-breeding Programme. Aust. J. Agric. Res. 14:742-754.
[5]. Eberhart, S.A. and W.A. Russell, 1966. Stability parameters for comparing varieties. Crop Sci., 6: 36-40.
[6]. Zobel, R. W., S. A. El-Shaarawy, A. M. R. Abd El-bary, H. M. Hamoud and W. M.B. Yehia. 1998. 1704 Use of High Efficient AMMI Method to Evaluate New Egyptian Cotton Genotypes for Performance Stability. Cotton Research Institute, Giza, Egypt.1-11 p.
[7]. Syukur M, Sujiprihati S, Yunianti R. 2015. Teknik Pemuliaan Tanaman. Jakarta (ID): Penebar Swadaya. Ed. Revisi.
[8]. Hadi, A. F., & Sa'diyah, H. (2004). Model AMMI untuk analisis interaksi genotipe x lokasi. Jurnal Ilmu Dasar, 5(1), 33-41.
[9]. Sujiprihati S., Syukur M and Yunianti R. 2010.The Analysis of Stability of Seven Sweet Corn Population Using Additivi Main Effect Multiplicative Interaction (AMMI). Bulletin Agronomy (34) (2): 93-97.
[10]. Bridges Jr, W. C. (1989). Analysis of a plant breeding experiment with heterogeneous variances using mixed model equations. Applications of mixed models in agriculture and related disciplines, 145-154.
[11]. Galingging R., Y and Bhermana A. 2019. Tolerance test of Shallots (Allium cepa L.) at Tidal Swampland (a case study of Central Kalimantan). Journal of Scientific and Engineering Research, 2019, 6(4): 126-134.
[12]. Suwarto. 2010. Analisisstabilitashasildanadaptabilitasmenggunakananalisis AMMI (Additive Main Effect and Multiplicative Interaction). Agronomika 10(1):88-96.
[13]. Atabe, S.D. 2008. Phenotypic Stability for Several Rice Varieties (Oryza sativa L.). Ph.D. Thesis. College of Agriculture, Univ. of Baghdad, Iraq.
[14]. Kadhem, F., I. S. Al-Nedawi, S. D. Al-Atabe, and F. Y. Baktash. 2010. Association between Parametric and Nonparametric Measures of Phenotypic Stability in Rice Genotypes (Oryza sativa L.). Diyala Agric. Sciences Journal 2(2): 20-33.
[15]. Sreedhar, S., T.D. Reddy, and M.S. Ramesha. 2011. Genotipe x Environment Interaction and Stability for Yield and Its Components in Hybrid Rice Cultivars (Oryza sativa L.). Int. J. Plant Breeding and Genetics 5(3):194-208.
[16]. Idris, A.E., K.A. Mohamed, and H.I. Mohamed. 2012. Using Regression Indices and Multiple Criteria Analysis for Study of Some Rice Genotypes under Interaction of Variable Environmental Conditions. American Journal of Experimental Agriculture. 2(3): 407-425.
[17]. Mattjik, A. A. dan I. M. Sumertajaya. 2006. RancanganPercobaandenganAplikasi SAS dan Minitab jilid I, Edisi 2. IPB Press, Bogor.
[18]. Galingging R., Y. Sobir, Syarifah Iis Aisyah and Awang Maharijaya GC-MS Profiling of Volatile Compounds from Fifteen Different Varieties of Indonesian Shallot Grown in Tidal Swampland. 2018. RASĀYAN Journal of Chemistry.