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GENOTYPES BY YEARS DATA ANALYSIS OF IRAQI DATE PALM USING GGE BIPLOT

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Abstract

Plant breeders select and recommend high yielding and stable genotypes over multi environments as multiple environment trials (MET) are commonly applied by. Genotype-by-environment interactions are often resulted from the analysis of MET data which often results in difficulties in the interpretation of results and lower efficiency for choosing the best genotypes. These difficulties could be solved via recent technique as GGE biplot analysis in MET data analysis. The objective of this study was to determine, evaluate and describe genotype performance across environments. Seven (7) date palm genotypes such as zahdi, khistawi, khadrawi, sayer, hillawi, deary and oeth were evaluated across four (4) successive years in Iraq.GGE Biplot analysis showed that zahdi (stable) followed by khistawi were the best cultivars over years using scaling 1 and centering 2 when subjected the yield per tree to these techniques of GGE Biplot which sum of PC1 and PC2 interpreted 99.4% of variation. But when used yield per hectare, the best cultivar was zahdi followed by oeth. It could be concluded that GGE Biplot effectively extracted the variation among cultivars across years. Thus, it could be recommended that zahdi could be economically used to rely yield on because its yield was stable and high over years.

Key words : BIPLOT, GGE, Genotypes, Date palm.

Introduction

Date palm is extremely responsive to environmental conditions and therefore yields show great variation. These variations are the main cause of the differential performance of genotypes in different environments, thus giving rise to the concept of genotype by environment (G xE) interaction (Ataga, 1993). This interaction results from the relative ranking of the genotypes or changes in the magnitudes of differences between genotypes from one environment to another (Baker, 1988). Changes in ranking make it difficult for the plant breeder to decide which genotype should be selected. Busey (1983) suggested that heterogeneity in genotype performance across locations or years certainly necessitates for widely testing in different environments. The degree of inconsistency could help to predict the variability expected among different plantations. A significant G × E interaction may be either (i) a non-crossover type as account of genotype performance changed made the rank order of genotypes across environments unchanged, or (ii) a crossover type when genotype ranks change across environments. According to Baker (1990), crossover interaction is more important than non-crossover interaction. The identification of winning genotypes and test environments could be facilitated via the "which-won-where" view that test such genotype; a necessary condition for specific adaptation (Baker, 1988; Yan and Rajcan, 2002). When selecting genotypes across a number of environments, plant breeders look for a non-crossover type of G × E interaction for general adaptation (Matus-Cadiz *et al*., 2003) and a crossover type of G X E interaction for specific adaptation. Okoye *et al*. (2008) stated that GGE biplot analysis was effective in oil palm hybrids yield trials for selecting cultivars that are stable, high yielding and responsive. Usually, several locations and years are used to test a large number of genotypes in MET. It is often not easy to assess the responses' pattern of genotypes across environments. So this problem could be solved using the biplot technique. Biplots are beneficial tool for abstracting response patterns that are found in the raw data. Gabriel (1971) had been developed the biplot concept to visualize graphically two-way data. Both G and GE are very interesting for cultivar evaluation simultaneously (Yan *et al*., 2000; Yan and Kang, 2003). The GE interaction pattern of the data are effectively identified using a G + GE (GGE) biplot and to display clearly, which genotype won in which environments. Moreover, the GGE biplot is effective in extracting superior genotypes and test environments for a given mega environment, thus is, a category of locations that consistently had the same best genotype or genotypes (Yan and Kang, 2003). As a result from Northwestern Ethiopia on pea cultivars, Yihunie and Gesesse (2018) recommended to use genotype EH99005-7 for wider cultivation in Northwestern Ethiopia and similar areas. The identification of stable genotypes and representative environments should assist the breeding of new cultivars (Shahriari *et al*., 2018) and precise prediction on yield over years. Todd *et al*. (2018) extracted that the resulting graphical patterns and statistical analysis suggest yield variability is strongly dependent on crop, year, and variety. El-Merghany and El-Daen (2013) assessed seven date palm cultivars grown under toshky environments during two successive seasons. So, they found that sakkoty and bartamoda were the best dry date palm cultivars. Wherever, sokkary was the best soft cultivars. Some conditions of Aswan in Egypt were investigated to evaluate two cultivars of date palm, which found that El-bardashen and Giza were suitable for Samany cv. (Osman, 2008). Al-Rawi and Al-Mohemdy (2010) stated that date palm cultivars by some stressed environments affected differently over these environments. In Sudan, Ezebilo *et al*. (2013) revealed that the diversity date palm cultivars were impacted by some growth inputs like field locations and farming years. In Iraq, there is no study used to evaluate the performance of date palm yield and stability across years. Thus, this investigation was applied to assess the efficiency of GGE biplot to extract the performance of seven cultivars of Iraqi date palm over four years and to derive the economical cultivar with high stable and maximal date yield.

Materials and Methods

Data collection

Date yield per tree and date yield per hectare of seven date palm cultivars were collected over four years from six orchards grown separately. These orchards were considers as replicates. Five trees were chosen from each cultivar to record the data according on complete randomized block design with six replicates. Table 1 represents means yield of seven cultivars of date palm across four years grown in Iraq.

Statistical analysis

Environment-centered matrix, containing the GGE data was subjected to singular value decomposition (SVD); each element in the matrix was estimated using the following :

equation: $E(Yij) = \mu + \beta j + \Sigma\ \lambda k \gamma ik \delta jk$

where, $E(Yij)$ is the expectation of genotype i in environment j; μ is the general mean; βj represents the environment main effect; K is the number of principal components (PC) needed to provide an adequate description of G + GE; λk is a proportionality constant or singular value for the kth PC (PCk) and γik and δjk are the ith genotype score and the jth environmental score, respectively, for PCk. SVD was achieved by providing a scaling factor f to obtain alternative genotype ($nik = \lambda f\ k\lambda ik$) and environment ($mjk = \lambda f{-}1k\delta jk$) scores.

The SVD allowed G × E table of means to be displayed in a plot having n points for the genotypes plus m points for the environments. We chose the most straightforward scaling, that is, symmetric scaling (f = 0.5) (Yan, 2002). The statistical theory of this method has been described in detail by Yan and Kang (2003). All presented biplots were constructed using the software GGE biplot package that set up in a Windows event (Yan, 2001).

Results and Discussion

Date yield per tree

Fig. 1 represents biplot for yield across the four environments. A GGE biplot is constructed by plotting the first principal component (PC1) scores of the genotypes and the environments against their respective scores for the second principal component (PC2) that result from SVD of environment-centered or environment-standardized. Upon examination of date palm cultivars means using GGE biplot analyses, the first two principal components (PC1 and PC2) explained 96.9 and 2.5% (totally, 99.4%), respectively, of the variations for date yield (Fig. 1). Where, Genotypes zahdi and khastawi had the highest date yield per tree in environments y12 (2012) and y11 (2011), respectively. Genotypes khadrawi and oeth showed the high yield in environments y12 and y11, respectively. However their yields were unstable. Whilst, sayer had exhibited the lowest yield in all environments.

The GGE biplot had an effective visual tool that is called the "which-won-where" pattern (Yan *et al*., 2000) which is important in mega-environment analysis by

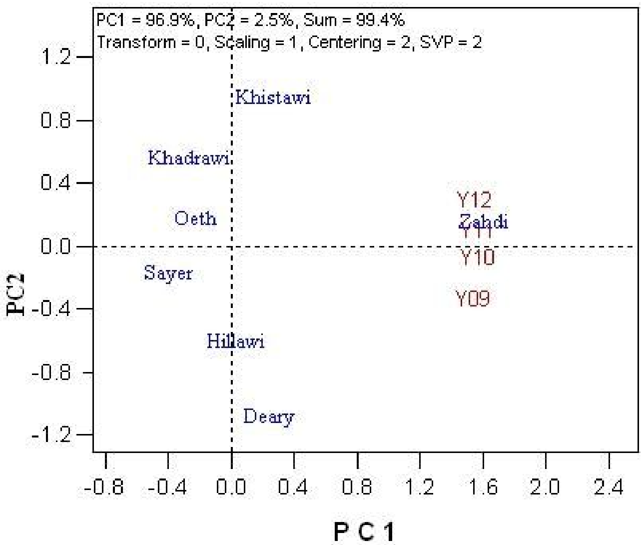

Fig. 1 : GGE biplot based on set of yield per tree of seven date palm cultivars over four successive years.

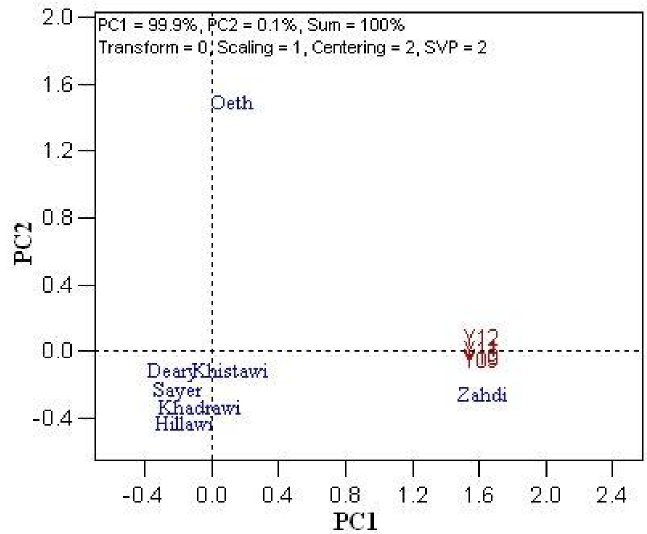

Fig. 3 : GGE biplot based on set of yield per hectare of seven date palm cultivars over four successive years.

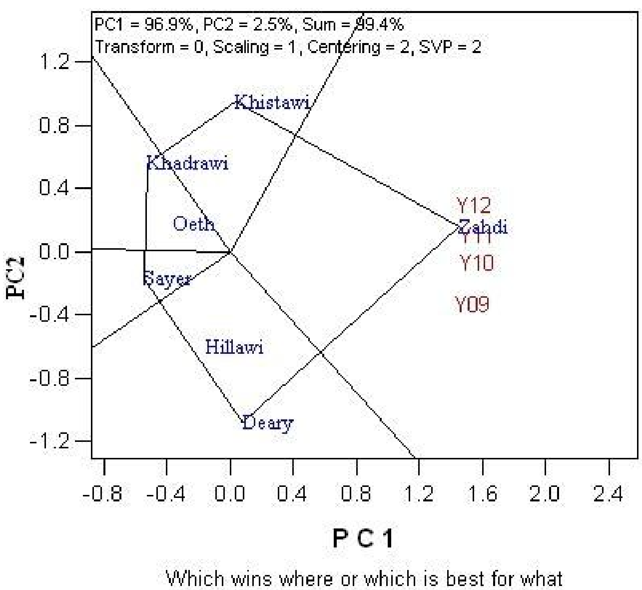

Fig. 2 : GGE biplot based on averaged yield per tree of Iraqi date palm cultivars over four successive years using the which won where for what technique.

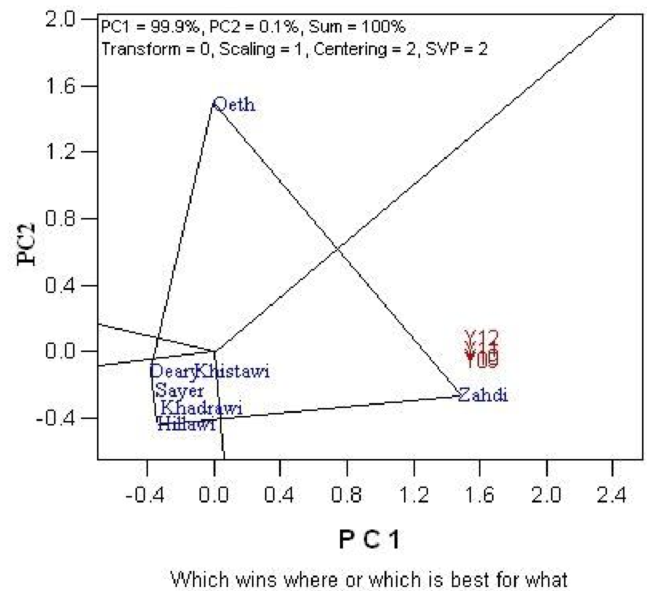

Fig. 4 : GGE biplot based on averaged yield per hectare of Iraqi date palm cultivars over four successive years using the which won where for what technique.

providing elegant polygon. The polygon does not only display the best genotype for each test environment. The test environment however, is also sorted into many groups by that polygon (Yan and Kang, 2003). To suppose exhibition of different mega-environments, two criteria are necessitated. First, it suggests that are found various genotypes are winning in different test environments. Second, the variation among groups had been significantly higher than the variation within individual group (Gauch and Zobel, 1997). Graphically, test environments should be involved in different mega-environments. The polygon is plotted joining the genotype that are fallen farthest from the biplot origin (0,0) that constructed as corners of polygon. Therefore, all genotypes are delineated in the polygon. Then, perpendicular line to each side of the polygon is drawn passing through the biplot origin, so the environment are divided into several sectors, each sector with different corner genotype. Within a sector, genotype which is located at the top of polygon is the best genotypes in all environments that located in the sector (Yan *et al*., 2000). Thus, fig. 2 represents the which-won-where for what pattern of date yield per tree that are generated five sectors with the corner genotypes are zahdi, khistawi, khadrawi, sayer and deary. Only two sectors included environment, thus constructed three mega-environments (fig. 2). Mega-environment is the group of environments

Table 1 : Yield of seven cultivars of date palm across four years.

Cultivars	Yield (Kg.tree^{-1})				Yield (Mg.ha^{-1})			
	2009	2010	2011	2012	2009	2010	2011	2012
Zahdi	67.0	74.8	78.2	77.2	31.54	35.39	37.21	37.62
Sayer	54.4	56.3	60.1	60.8	1.73	1.90	2.15	2.47
Hillawi	57.8	59.5	63.7	63.2	2.02	2.14	2.36	2.42
Khadrawi	53.4	56.3	60.6	62.2	2.28	2.49	2.73	2.91
Khistawi	57.1	59.6	66.1	67.7	5.65	6.01	6.82	7.15
Deary	60.4	61.6	64.7	64.9	1.13	1.29	1.57	1.98
Oeth	55.4	58.0	60.7	63.7	6.34	7.47	9.08	11.00

that had the same best genotype determined as being plotted at the corner of polygon (Samonte *et al*., 2005). Based on mega-environment that generated it could be observed that zahdi and khistawi are high yielding genotype at y11 and y12, respectively (small mega-environment). And vice versa, genotype and environment at two sectors that are opposite to the farthest distance showed that genotype had the largest negative interactions in the environment. For example, oeth, sayer and hillawi had lowest date yield per tree in all environments.

Dates yield per hectare

The GGE biplot of first two principal components for the studied donor genotypes (fig. 3) explain about 100% from the variability of the four studied years. Thus, it observed that the donor cultivar zahdi has the most superior values for majority dare yield per hectare that was stable across four years. Also, donor genotype oeth registered the most superior values of date yield per hectare. But this high yield was unstable. In the case of genotypes as khistawi, deary, sayer, khadrawi and hillawi, these cultivars had lowest unstable values of date yield per hectare.

The polygon views of the date yield per hectare are shown in fig. 4. Where, the biplot is divided by the perpendicular line into multiple sectors. The environments locate into the sectors. However, there are three sectors in fig. 4. Consequently, the genotypes zahdi, oeth and other genotypes are constructed as the corner or vertex genotypes of the polygon. Whereas, all years fell near to the sector that zahdi was the vertex genotype, suggesting that zahdi is the best in all 4 environments. No year located into the sector other cultivars as the vertices, extracting that none of these cultivars are fitted for the test years.

As the rank of genotypes differs in multiple environments. The G X E interactions would be interesting (Baker, 1988). Thus, the polygon view of the GGE biplot investigated the presence of crossover interactions including the genotypes that had highly response. While Environments located in the same sector had the same superior genotype and other fell in different sectors had different superior genotypes (Yan, 1999; Yan *et al*., 2000, 2001; Yan and Rajcan, 2002). The identification of winning genotypes and test environments could be facilitated via the "which-won-where" view that test such genotype; a necessary condition for specific adaptation (Baker, 1988; Yan and Rajcan, 2002). Therefore, the potential use of both G and G × E interaction are ensured by selection of winning genotypes for each environment. A sustainable solution is provided using Breeding for specific adaptation on how agricultural production is improved in marginal areas. The differential change of mean yield but not ranking of genotypes zahdi, khistawi, khadrawi, oeth and deary for date yield per tree and date yield per hectare, respectively pointed that G × E interaction had a non-crossover nature. Herewith, the results revealed the effectiveness of GGE biplot tool for selecting cultivars that are stable, high yielding and responsive. The GGE biplot analysis isolated genotypes zahdi, khistawi, and khadrawi as superior for date yield per tree, and zahdi and oeth as wining cultivars for date yield per hectare, respectively. The highest stable cultivars were zahdi, oeth and sayer for date yield per tree and zahdi and khistawi for date yield per hectare. When farmers used these cultivars, it would result in stable performance over the years.

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