ASSESSMENT OF MULTI-CULTIVARS OF CARAWAY USING TERNARY PLOT UNDER ARID ZONE CIRCUMSTANCES

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ABSTRACT

The certain crop cultivars could be adapted that characterized their performance via given trait over given environments. Thus this adaptation could be investigate by many methods. Therefore, ternary plot method advocated to assess the adaptation of ten caraway cultivars using seed yield (Mg ha^{-1}) over two environments viz. Fallujah and Ramadi for two successive seasons (2011/2012 and 2012/2013). This method was fortified with AMMI Biplot technique. PAST software was adopted to construct triangle graph. Cropstat7.2 software was also applied to extract cultivars own biplots. Results from ternary plot showed that G7 was the both most adaptable cultivars over most circumstances, G3 irresponded because it located on point of cross of triangle diameters. G4 was semi adaptable. While, G3 was the average genotype due to be laid on cross point of triangle. Thus, it could be concluded that ternary plot and AMMI biplot were effectively explained the stable and adaptable genotypes of caraway multienvironment trial and supplemented each other. Therefore, it could be recommended to apply suitable biplot as AMMI technique supplemented with simple statistics parameters as quantiles fortified by ternary plot.

Keywords: Adaptability, environment, locations, genotypes.

تقييم عدة أصناف من الكراوية باستعمال Ternary plot تحت ظروف المنطقة الجافة

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المستخلص

يمكن تقييم اداء وتطبع اصناف محاصيل معينة في بيئات معينة باستعمال صفات معينة، فقد يختبر هذا التطبع بعدة طرائق منها Ternary plot . لذا استعملت هذه الطريقة لتقييم تطبع 10 اصناف من الكراوية باعتماد حاصل البذور (ميكاغرام هـ$^{-1}$) في بيئتين هما الفلوجة والرمادي لموسمين متتاليين (2011/-2012 و2012-2013). استخلصت رسوم هذه الطريقة بتطبيق برنامج PAST بشكل مثلث. اما رسوم AMMI Biplot بنيت باستعمال برنامج Cropstat 7.2 لأنشاء رسوم خاصة الأصناف لدعم طريقة Ternary plot . أظهرت النتائج من طريقة Ternary plot ان الصنف G7 كان اكثر الاصناف تطبعاً في اغلب البيئات، اما الصنف G3 فهو لم يستجب لأنه وقع على نقطة تقاطع اقطار المتوسط كان الصنف G4 شبه متطبع. يمكن الاستنتاج ان طريقة Ternary plot وتقانة AMMI Biplot كانتا فعاليتين في تفسير التراكيب الوراثية الثابتة والمتطبعة في تجربة الكراوية متعددة البيئات وان الطريقتين تكمل احداهما الأخرى. لذا الأيصاء بتطبيق تقانة biplot مناسبة كتقانة AMMI مدعومة بمعالم بسيطة مثل الربيع الاحصائي مدعم برسم Temary plot.

الكلمات المفتاحية: القابلية للتطبع، بيئة، مواقع، التركيب الوراثية.

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INTRODUCTION

Performance of certain genotype was known that produced from the effects of its genetic components, environmental factors and their interactions. Thus, the interaction of that genotype by environment is considered as primary cause to assess the variations of stability and adaptability of given traits in various genotypes. From prior particularity, certain adaptation of cultivars could characterize the performance of these cultivars in relative to given trait over certain environment (4, 9, 10). Where adaptation represents as interested purpose for the breeding the crops plants and investigate genotype by environment interaction. Consequently, many statistical methods were applied to analyze this important aspect in plant breeding (27, 28, 33). Many applied methods enhanced the assessment and analysis of genotype by environment interaction using multivariate analyses embedded with graphs visualization such as AMMI (15, 32), GGE Biplot (38) and ternary plot (24). Elsahookie and Almehemdi (12) also reviewed GGE biplot technique using examples and concluded that technique was most effective to estimate average performance of cultivars across environments. Abbas et al. (1) used GGE-Biplot to analyze yield data of eight cultivars of soybean that sown at four environments (2 locations X 2 years) which GGE-Biplot interpreted 88.7% of total variance, whereas the first two principal components were investigate explained 59.5% and 29.2 % of total variance, respectively. Another technique of GGE-biplot which is GT-Biplot was used to investigate effect of different levels of boron, the chemicals factor, on six peanut cultivars. Thus, GT-Biplot illustrated 86.1% and 85.3% of overall variance, for each season, respectively. Furthermore, AMMI models possessed effective potentiality to identify the best and ideal cultivar (11). Moreover, AMMI analysis of variance showed that the environment effect was a predominant source of variation (67.6% of the treatment SS) followed by GE interaction (21.1 %) and genotype effect (8.6%). First two interaction principal component axes (IPCA) cumulatively explained 92.75% of total interaction effects (23). Fox et al. (13) from discussed adaptation measurement sorted genotypes those possessed performance across each environment. Consequently genotypes had been categorized into three classes viz. top, middle and bottom. To extract the information precisely from Fox et al. method, Kozak (24) developed this method using quantiles of given trait. Thus, quantiles divide traits values into three ranks then would be graphed trilinear plot to derive the adaptation of genotypes. More recently, Almehemdi et al. (3) revealed that ternary plot method sorted ten cultivars of caraway Carum carvi L. into three categories relied on carvone% viz non-adaptable cultivars included G4. While the other two categories involved cultivars those had two behaviors once adaptable again non-adaptable that located on straight line between Ibottom and Itop the last one included cultivars that once behad near to Itop again to Imiddle that located on mid of triangle. Trait quantiles could be replaced by dominant and non dominant genes to characterize Hardy-Weinberg law (17) which three traits used to determine the adaptation of genotypes. Where Golba et al. (15) found that the pattern of yield measurement in terms of three components by ternary plot precisely classified cultivars of bread wheat over two environment, one had the best inputs and another had the worst components of management. Furthermore, Gozdowski et al. (16) stated that ternary plot was clear to visualize data with trilinear graph and extract four components in yield and facilitatively indentified cultivars. Moreover, this method was conducted out to display genetic divergence among given genotypes in certain crop (36) and study chemical composition in crops (20). Ternary plot is common in soil researches as texture triangle and hydrological studies with three components (25 and 31). On caraway, Solberg et al. (34) established interaction effect of genetic material and location, where they extracted that location possessed the highest impact on chemical compounds. While the genotype had the most interested effect on morphological traits. Therefore, this method is conducted out to characterize performance multi genotypes of caraway grown in multi environments in arid zone of Iraq and interpret adaptation of these genotypes.

MATERIALS AND METHODS

The concept of Fox et al. (13) could sort the genotypes over each environment into three classes viz. top, middle and bottom relied on ranks. So, simple statistic could be applied to generalize this concept via conduction out of quantiles. Thus, ql and qu could be undertaken. Consequently, singular scores of each genotype over each environment should be subjected to the formula below:

Top→if $Y_{ge} > q_u$,

Middle → if $q_l > Y_{ge} \leq q_u$,

Bottom→ if $Y_{ge} \leq q_u$.

Thus, Y_{ge} represents the g^{th} (g=1…..G) value of genotype trait over eth environment (e=1….E). Consequently, the g^{th} genotype could be derived by transformation in the following paths:

Ig, top represents environments number where the g^{th} genotype possesses the top score, Ig, middle is environments number where the g^{th} genotype possesses the middle score and Ig, bottom represents an environment number where the gth genotype possesses the bottom score. Thus, total number of environments could be extracted from summation of each environment in each class as formula below:

E= Ig, top+ Ig, middle+ Ig, bottom represents scores for each gth genotype (g=1….G).

Ternary plot graphing

Software of past version 2.17c was applied to transformed classes scores into trilinear graph (20) which was known ternary plot by Kozak (24). This graph could also be constructed with ternary plot purpose embedded into vcd package (26) jointed in R software (8). So to visualize plot by this software R code could be get from the author.

AMMI model

AMMI analysis technique was adopted to graphically visualize the genotypes and environments values produced from additive main and multiplicative interaction effects for AMMI model. This model could be mathematically expressed by equation:

$Y_{ij}= \mu+g_i+e_j+\Sigma\lambda_k\gamma_{ik}\xi_{jk}+\rho_{ij}+\varepsilon_{ij}$

Where, Y_{ij} represents yield of genotype (i) over environment (j). μ is grand mean, g_i is the main effect of genotype (i^{th}), e_j is the main effect of environment j^{th}, λ_k is singular value of principle component interaction k^{th}, γ_{ik} is vector value i^{th} of column of k ordinate, ξ_{jk} is vector value j^{th} of row of k ordinate, ρ_{ij} is the residual from AMMI model (outliers produced from interaction) and ε_{ij} is pooled error. CROPSTAT7.2 software was applied to extract AMMI biplot related to the genotypes and environments (22).

Table1. Historical information of ten genotypes

symbol	Genotype	origin	Notes
G1	Balady	Egyptian	Common cultivar
G2	Mosul	Iraqi	Originated from wild, from Mosul desert
G3	Konczewiski	Polish	Produced from Netherlands line by selection
G4	Berry	Iraqi	Wild, collected from desert of Mosul
G5	Plewiska	Netherlands	/
G6	Holland	Netherlands	/
G7	Iraqi	Iraqi	Cultivated in 2009
G8	Hungary	Hungary	Produced from commercial seeds
G9	F1selected	Iraqi	Produced from wild population by two cycles selection
G10	Karzo	Canadian	/

RESULTS AND DISCUSSION

Ternary plot technique

Data of caraway fruit yield ($Mg.ha^{-1}$) were advocated to be visualized using this method. Table 2 reveal fruit yield means of ten caraway genotypes grown across four Iraqi environments and scores of environments classes. Results showed that g7 was superior which achieved the highest scores for three environments, followed by g4 had two scores for two environments. Whereas, stayed on center of triangle (the point of intercrossed of triangle diameters) which could be stable genotype. So, these three genotypes could be considered as the best adaptable genotypes. Whilst the other genotypes possessed worst performance where possessed the highest scores in bottom category fluctuated from 2 upto 3 i.e. it could be meant those g7, g4, g3 genotypes were the best adaptable genotypes via fruit yield over three environments. Thus they were possessed wide adaptation.

Furthermore, half of genotypes were located on bottom category where they had special adaptation. The extracted three categories (classes) depended on quantiles, Kozak (24) referred that the choice of upper quantile could produce the genotypes that had best performance.

Table2. Transformed fruit yield to be graphed using ternary plot of ten caraway genotypes

genotypes	Average yield ($Mg.ha^{-1}$)	Ig,bottom	Ig,middle	Ig,top	Rank	Yield ranking
G1	2.10	3	0	1	G1	2.10
G2	2.29	2	1	1	G5	2.05
G3	2.50	1	1	2	G2	2.29
G4	2.68	2	0	2	G9	2.35
G5	2.05	3	0	1	G8	2.44
G6	2.50	2	1	1	G10	2.47
G7	2.78	0	1	3	G3	2.50
G8	2.44	3	0	1	G6	2.50
G9	2.35	3	0	1	G4	2.68
G10	2.47	3	0	1	G7	2.78

Ternary plot could be sort genotypes data into three categories depended on Fox et al. (13) approach. So it is observed from Fig. 1 that this technique categorized the ten genotypes of caraway into five groups, first group represents g7 which is the most adaptable genotypes from these over most investigated environments. Thus, that genotype was located on the upper top of triangle. The second group that involved g3, third that included g4 which had adaptability over semi investigated environments i.e. is located in mid of triangle. Fourth group represents the genotypes viz. g2, g5, g6 and g8. Finally, fifth group contained g1, g9 and g10. The genotypes in these two groups had special adaptation because they were located on lower category of bottom the down tip of triangle (Fig.1)

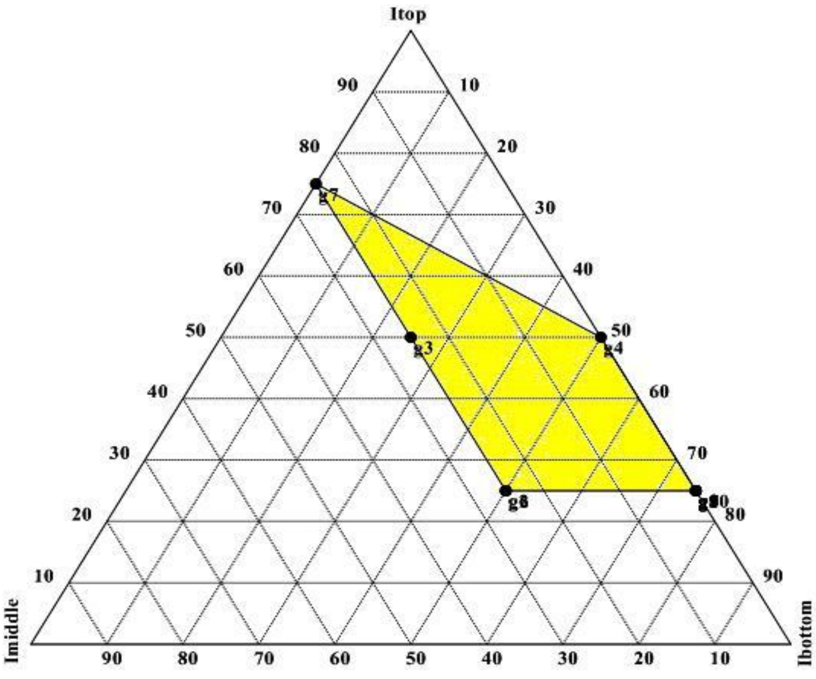

Fig 1. behaviour of ten genotypes of caraway fruit yield data over four environments (ql=2.75 and qu=8.25) using ternary plot constructed with past software

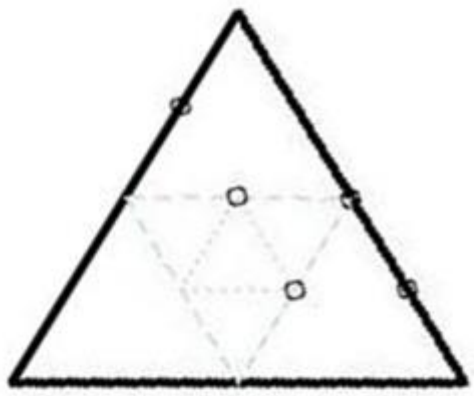

Fig 2. Kozak ternary plot constructed using R software, it was rotated to be symmetrical with Fig.1

AMMI biplot technique

AMMI models could be interpreted powerfully using biplot analysis. Thus, latent components of genotypes and environments are depicted thereby graphs that called biplot on the own ordinate and coordinate. Therefore, the interactive relationships could be displayed. Thus, two essential AMMI biplot are derived, AMMI 1 on which it could be graphed the main effects represented by genotype and environment effects togather and AMMI 2 biplot where interactive principal component analysis first and second scores (IPCA1 and IPCA2) are depicted. So from AMMI 1, abscissa displacements pointed to variation in additivity (main effects), whereas ordinate displacements represented the variation of the interaction that explained the common interpretation of biplot. Meanwhile, genotypes those sorted together possessed the same adaptibility. While environments located on the same group similarly impacted the genotypes. The location of any genotype close to certain environment that is not meant necessarily had a highly adaptation. Hence, the most adaptabled genotype could be detected far from the certain environment. Consequently, genotype would consider as stable and possessed a smal interaction, if that genotype or certain environment possessed PCA scores approximately close to origin point of zero. Furthermore, when given genotype and certain environment located in the similar signed quarter of biplot on the IPCA axis, they had positive interaction and vers versa they would be negative, if they located on different signed quarter. From these informative points, the second season of ramadi (B) displacemented far from the origin point. While the first season of ramadi (A) and the first and the second season of Fallujah enivironments (C and D) revealed the highest interaction effect i.e. these environments gave small variation value in main effect amongst them. The genotypes g3, g8, g9, g10, g6 and g2 possessed IPCA1 scores close to zero line had high additivity (main effects). Thus, the mentioned genotypes could be stable and possessed general adaptibilty across all environments. The genotype g3 was high yielding genotype but it located on poor environment and represented an average yielding genotypes as in Fig.3. Other genotypes in this group had low yielding.even though some of them located on faverable environment. Therefore, the best adapted genotype was g7 followed by g4 due to be located on faverable environment with yield (Fig.3) due to be had above-average yield with high stability.

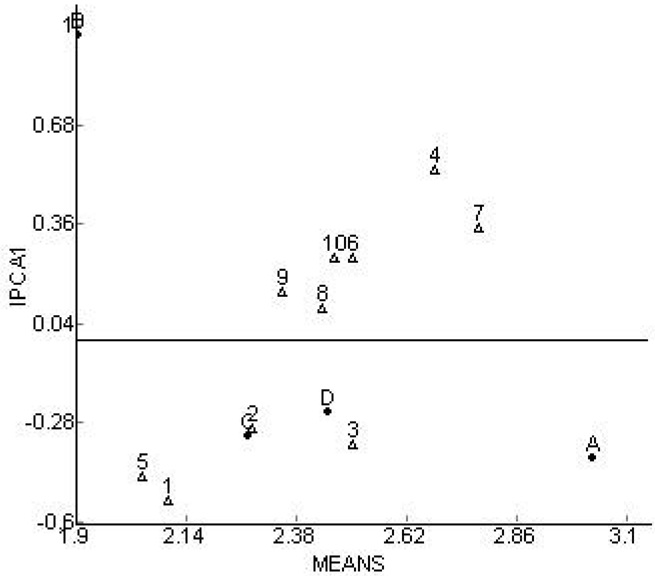

Fig 3. AMMI1 biplot of ten genotypes yield of caraway grown in Iraq

The genotypes g8, g9, g10 had the highest stable behavior, since it is displaced close to origin point, but possessed below-average yield. However g7 was the best genotype due to be had the highest stability with above-average yield followed by g4. The genotypes g6, g5, g2 and g1 were the most unstable genotypes (Fig.4) due to their distances far from the origin point.

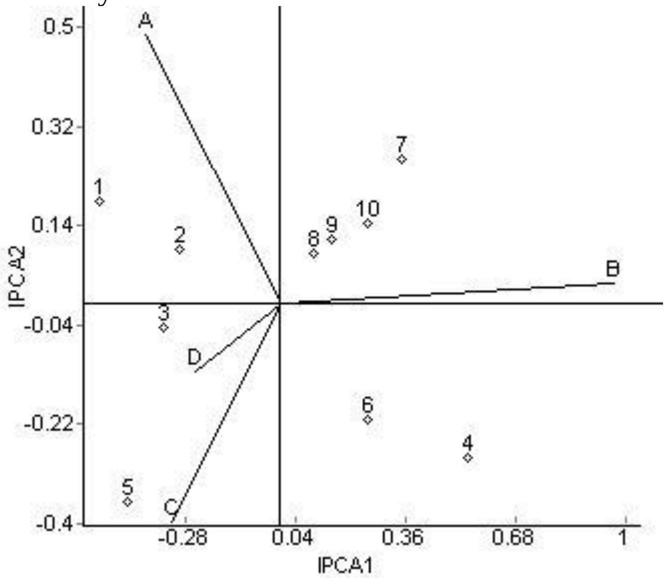

Fig 4. AMMI2 biplot visualizing IPCA1 vs main effects showing ten genotypes yield of caraway grown in Iraq

From Fig.4, it could derived that the environments A (location of Fallujah during first season) were highly involved to genotype by environment interaction that meant the instability possessed the highest value due to the scores were the biggest laid on the interaction axes. From other hand, the environments B and D were the most stable which possessed lower IPCA1 scores. Thus, the higher stability from sites Fallujah (B) and Ramadi (D) could be suggested that the genotype sorting in the previous category would possess lesser standard deviation of the genotype performances than another sorting in other sites of production. The same particularity was suggested by de Mattos et al. (7). So genotypes and sites that had similar sign score on the graph of AMMI2 biplot (Fig.4) should perform positively and verse versa if the signs were dissimilar, they would behave negatively. As in de Mattos et al. (7) extracted the genotypes and locations those had similar sign of PC1 scores achieved positive specific performances on sugarcane.

Fig.5 shows AMMI3 biplot with IPCA1 vs IPCA2 for ten genotypes of caraway grown in Iraq. This graph revealed scores of genotypes without their environments to discuss performance of these genotypes only. Thus, genotypes viz. g3, g2, g8 and g9 are considered as the most stable genotypes due to be laid on close to origin point as well as possessing the lowest interaction. Moreover, genotypes viz. g1, g4 g5 and g6 possessed distinct interaction due to be laid on farther from the center point. The ideal genotypes could be decided that was g7.

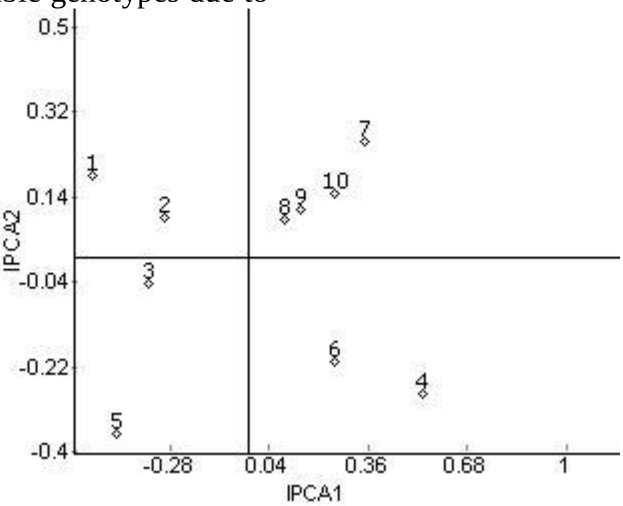

Fig 5. AMMI3 biplot with IPCA1 vs IPCA2 for ten genotypes of caraway grown in Iraq

AMMI models were very effective technique to extract the stability and adaptability of given genotypes over certain environments as mentioned in several references. where, first two interaction principal component axes (IPCA) cumulatively explained 92.75% of total interaction effects (23). Hamlabad (18) recommended exploiting AMMI model to estimate the stability in wheat genotypes. Likewise, on faba bean in Ethiopia Tadesse et al. (35) summarized the pattern and the interaction among genotypes and test environments using AMMI2 model. Furthermore, noise could be reduced using AMMI model as in Aljumaily (2) who found that PCA data were adjusted using that technique with 98% of interaction effect on soybean genotypes as similar as in Asfaw et al. (5) from Ethiopia on soybean, they demonstrated that AMMI and GGE models possessed the potentiality to investigate the pattern of genotype by environment interaction enabling to interpret grain yield data of soybean produced from multienvironment. In responded to Nachit et al. (29), using of the AMMI model makes YEI sum of squares effectively partitioning in relative with the joint regression model. This is why the linear regression is less used than the AMMI analysis for calculation of GEI for wheat quality parameters. The highly significant heterogeneity of E regression indicates the necessity of amending the linear model. Although Hill et al. (21) claimed that the linear model may be quite useful for acquiring complete and balanced data sets which cover a range of environments without much discontinuity; this study did not accord with their view. Moreover, the diversity among locations was the principal source of variation of all the analyzed traits, most of which being unforeseeable and thus causing problems even when the multiplicative approach was used (6). The usefulness of AMMI and ternary plot was demonstrated here. The two techniques supplemented each other, which interpreted effectively fruit yield of caraway genotypes in multienvironment trial. Thus, the extracted adaptability and stability from AMMI and ternary plot revealed the same genotypes viz. g7, g4 and g3. Ternary plot was very simple to derive information. However, some data were overlapped so they had to jitter these data to be more informative. While, AMMI biplot was more informative technique. But it had rather complexity.

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