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Nonparametric stability analysis of forage yield for *Agropyron elongatum* accessions under different environments

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Abstract

The most important role in the breeding for creation of the new varieties has their stability in different environments. To stability analysis the forage yield and yield components of 18 accessions of *Agropyron elongatum* an field experiment seasons was conducted based on randomized complete block design (RCBD) with three replications during three cropping seasons at the Research Field Station of Islamabad Gharb and Researches Center and Natural Resources of Kermanshah, Iran. The moisture level in one of the experiments was irrigated condition (100% field capacity) while the second experiment was conducted under drought stress (Rainfed). The results of present study showed that accessions G15, G10, G5 and G14 had the most forage yield and yield components under different conditions. Nonparametric stability analysis revealed that the accessions G2, G6, G17 and G15 had the most yield stability. The visualizing graphics of principal component analysis (PCA) indicated that two fires components together explained 81.57% (PC1 = 66.75 and PC2 = 14.82%) of the total variation. Our findings suggested the accessions of G10, G14 and G15 which had a reliable stability along with high yield, can be introduced for breeding programs in Kermanshah climate condition.

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Introduction

Agropyron is one of the major genuses of the Poaceae family which all of the 21 species grow in Iran and is of the most important grasses in semi-arid and temperate areas. This drought tolerant perennial species are valuable for providing pasture forage (Broomandan and Motamedi, 2007). The main purpose of International Plant Breeding Centers is to obtain cultivars with wide adaptability, high stability and resistance to environmental stresses (Rossa *et al.*, 1990). Huehn (1979) ranked genotypes separately by using nonparametric measures in all environments in terms of performance and presented several non-parametric statistics to analysis of the stability. Thennarasu (1995) stated that the rank of a genotype in a specific environment should not be based on the phenotype because sustainability must be achieved independent of environmental effects. Therefore, we suggest that at first, the performance of each cultivar to be corrected in order to remove the effects of environment, and then the size of the desired trait for each genotype to be corrected based on its phenotypic trait, and them to be ranked. In this case, the obtained ranks will be just based on the interaction of genotype and environment and experimental error. Due to genotype x environment interaction, their performance could be altered so much that their ranking order in different environments would be different, which makes the selection of the best varieties difficult (Zrinka and Jerko, 2002). Therefore, it is important to identify the stable genotypes. Kang (1988) proposed the method of rank set to select stable genotypes with high performance. Three nonparametric statistics were suggested by Fox *et al.* (1990) by using the ranking of genotypes in each environment. Ketata *et al.* (1989) also introduced three nonparametric statistics according to the ranking of genotypes. The main objective of this study was to evaluate the stability of forage yield and yield components of 18 accessions of *Agropyron elongatum* using nonparametric analysis in Agropyron accessions.

Materials and method

Plant material and experimental conditions

Forage yield for 18 accession of *Agropyron elongatum* (Table1) were investigated in a field experiment based on randomized complete block design with three replications during three years at two environments conditions irrigated (E1, E3 and E5) and rainfed (E2, E4 and E6) environments in the Research Field Station of Islam Abad Gharb Research and Center Natural Resource of Kermanshah, Iran (47° 20′ N latitude, 34° 20′ E longitude and 1351m altitude). The research site is located in the moderately cold region in western Iran that experiences minimum and maximum temperatures of – 20 °C and 45 °C, respectively, and 60-100 days of freezing temperatures annually. The average long-term annual precipitation is estimated to be 455 mm, consisting of 90% rain and 10% snow. Each plot has two lines with spacing of 50 cm from each other and each plot was 2m.

Statistical analysis of data

Five series of nonparametric statistics were used. The first series included four methods ($S_i^{(1)}$, $S_i^{(2)}$, $S_i^{(3)}$ and $S_i^{(6)}$) proposed by Huehn (1979). The second series included four method proposed by Thennarasu (1995) ($NP_i^{(1)}$, $NP_i^{(2)}$, $NP_i^{(3)}$ and $NP_i^{(4)}$). Total Rating Kong (RS) where genotypes with high performance are located in the first rank and genotypes with low stability variance have also obtained rank one and the total rank of these two statuses named Total Rating Kang was the third used series (Kang, 1988). Method proposed by Fox *et al.* (1990) was the fourth used series and TOP statistics were only used. The fifth series consisted of *gy,* kr and σr proposed by Ketata *et al.* (1989). Calculating nonparametric statistics, analysis to principal components, cluster analysis and related graphs were produced using SPSS and EXCEL.

Results and discussion

Stability analysis of the studied traits

Stability analysis of yield and yield components of the 18 *Agropyron elongatum* accessions based on different nonparametric methods are shown in Table 1. The important role in the creation of the new varieties has their stability in different environments.

Due to genotype x environment interaction, their performance could be altered so much that their ranking order in different environments would be different, which makes the selection of the best varieties difficult. Therefore, it is important to identify the stable genotypes. Nonparametric measures of stability are used less often then parametric measures. However, they have certain advantages. Their use does not depend on any assumption, because they are based on ranks (Zrinka and Jerko, 2002; Farshadfar *et al.*, 2000). The results of this study indicated that accessions G15, G10, G5 and G14 had the highest forage performance with 4.5, 4.49, 4.25 and 4.24 tons per hectare, respectively.

Table 1. List of studied *Agropyron elongatum* accessions by mentioning the location.

Sector	Province	Accession	Sector	Province	Accession	Sector	Province	Accession
Central	Kermanshah	G13	Central	Javanrood	G7	Central	Islamabad Gharb	G1
Firozabad	Kermanshah	G14	Central	Ravansar	G8	Shiyan	Islamabad Gharb	G2
Mahidasht	Kermanshah	G15	Shaho	Ravansar	G9	Hasanabad	Islamabad Gharb	G3
Kozaran	Kermanshah	G16	Central	Songhor	G10	Homehjonobi	Islamabad Gharb	G4
Homeh	Harsin	G17	Central	Sahneh	G11	Homil	Islamabad Gharb	G5
Bisetoon	Harsin	G18	Dinavar	Sahneh	G12	Milesar	Islamabad Gharb	G6

The results of principal components analysis revealed that the first component explained 66.75%, the second component 14.28% and the third one 10.10% of the variation. Also 91.68% of the total variation in data structure was expressed by three first components which had specific value higher than one. According to all statistics analysis, the first component and average performance had a share in expressed variance with this component and three statistics of TOP, kr and RS and average performance had the highest negative share and other statistics had the highest positive share. In the second component, RS statistics had the highest positive share and statistics $S_i^{(1)}$ and $NP_i^{(4)}$ had the highest negative share. In the third component, two statistics of $S_i^{(1)}$ and $NP_i^{(4)}$ had the highest positive share. Therefore, given that stable accessions had lower ratings than unstable accessions, accessions with the highest value based on the first component in interpreting stability based on the components had the highest stability based on statistics of TOP, RS and kr and also showed a high performance. On the other hand, accessions with the highest value based on the second component had the lowest stability based on statistics of RS and the highest stability based on statistics $S_i^{(1)}$ and $NP_i^{(4)}$. Accordingly, biplot analysis of the first and second components was prepared for the values of the first and the second components of accessions and statistics (Fig. 1). As we can see, the results of cluster analysis by WARD method for accessions based on statistics were compatible with the distribution of accessions based on the values of the first component. The first group included accessions of G12, G7, G4, G9, G5 and G15 that they had high values based on the first component, therefore, they were stable based on the statistics of TOP, RS and kr and had also more average performance, but were unstable for forage production according to other statistics. But given the consideration of these two factors among accessions on this group, only accessions 15G had both stability (based on the statistics TOP, RS and kr) and top forage production. Accessions of G1, G3, G10, G11, G14 and G18 which were in the second group, as they had moderate values based on the first component, so they showed a moderate stability based on all statistical analysis. But among the accessions of this group, accessions of G10 and G16 (third group) were the most stable group forage production according to most analysis, given that they had a low values based on the first component, while none of the accessions of this group had desirable forage performance. In a general result, accessions of G10 and G14 from the second group and accessions of G15 from the first group can be introduced as accessions with desirable performance and proper stability and also accessions of G2, G6, G17 and G16 can be identified as stable accessions with weak performance. Phenotypes are a mixture of genotype (G) and environment (E) components and interactions (GEI) between them. The GE interaction is a major problem in the study of quantitative traits because it reduces the association between genotypic and phenotypic values and complicates the process of selecting of genotypes with superior performance (Delacy *et al.*, 1996; Yan, 2002). Therefore, the first goal of plant breeders in a crop breeding program is the development of genotypes which are stable or adapted to a wide range of diversified environments (Farshadfar *et al.,* 2011).

Table 2. Rank of 13 non-parametric statistics of stability and the forage yield of 18 *Agropyron elongatum* accessions.

Accession	Yield	Huehn (1979)				Thennarasu (1995)				Ketata *et al.* (1989)			Kang (1988)	Fox *et al.* (1990)
		$S_i^{(1)}$	$S_i^{(2)}$	$S_i^{(3)}$	$S_i^{(6)}$	$NP_i^{(1)}$	$NP_i^{(2)}$	$NP_i^{(3)}$	$NP_i^{(4)}$	kr	δr	δgy	RS	TOP
G1	17	13	14	8	6	11	6	6	10	17	14	12	15	3
G2	16	7	1	2	2	1	2	2	1	16	1	2	17	3
G3	12	10	5	5	5	4	5	5	8	11	5	5	5	4
G4	8	6	16	16	15	16	12	16	6	6	16	13	7	3
G5	3	5	17	17	18	17	16	18	4	3	17	18	8	2
G6	14	2	4	4	4	5	4	4	2	14	4	4	11	4
G7	10	15	11	12	12	14	17	10	16	10	11	14	10	4
G8	11	3	13	11	13	18	15	12	7	13	13	16	14	4
G9	9	8	9	14	14	15	11	13	14	9	18	15	13	3
G10	2	8	9	14	16	9	10	17	9	1	9	8	2	1
G11	7	11	10	10	10	12	13	11	13	7	10	10	6	4
G12	6	16	12	13	11	13	14	15	17	5	12	17	12	2
G13	13	17	8	7	7	7	7	7	15	12	8	9	9	4
G14	4	14	7	9	9	6	8	9	11	4	7	7	3	3
G15	1	18	15	18	17	8	18	14	18	2	15	11	1	2
G16	18	1	2	1	1	2	1	1	1	18	2	1	18	5
G17	15	4	3	3	3	3	3	13	5	15	3	3	16	5
G18	5	9	6	6	8	10	9	8	12	8	6	6	4	3

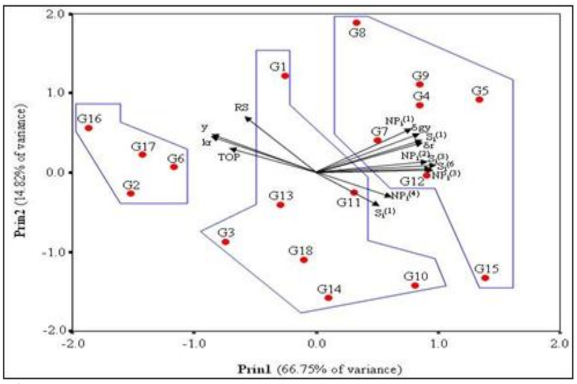

Fig. 1. Biplot analysis of the first and second component values for *Agropyron elongatum* accessions along with non-parametric statistics using WARD method.

Conclusion

The results showed that accessions G15, G10, G5 and G14 had the most forage yield and yield components under different conditions. Nonparametric stability analysis revealed that the accessions G2, G6, G17 and G15 had the most yield stability. The visualizing graphics of principal component analysis (PCA) indicated that two fires components together explained 81.57% (PC1 = 66.75 and PC2 = 14.82%) of the total variation. Our findings suggested the accessions of G10, G14 and G15 which had a reliable stability along with high yield, can be introduced for breeding programs in Kermanshah climate condition.

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