Sjournals
Scientific Journals
Scientific Journal of Biological Sciences (2014) 3(45) 37-46
ISSN 2322-1968
doi: 10.14196/sjbs.v3i4.1336

Contents lists available at Sjournals
Scientific Journal of
BiologicalSciences
Journal homepage: www.Sjournals.com

Original article

Yield analysis of bread wheat under saline conditions using some statistical procedures

A. Gholizadeh[a], H. Dehghani[a,*], Y. Dvorak[b]
[a]*Plant Breeding, Tarbiat Modares University, Iran.*
[b]*Plant Science, University of California, Davis, United States.*

*Corresponding author; Plant Breeding, Tarbiat Modares University, Iran, Email: dehghanr@modares.ac.ir.

ARTICLE INFO

Article history,
Received 01 April 2014
Accepted 19 April 2014
Available online 29 April 2014

Keywords,
Salt stress
Bread wheat
Factor analysis
Principal components
Cluster analysis

ABSTRACT

Study on the interrelationships between yield and related yield traits will improve the efficiency of breeding programs through the use of appropriate selection indices. In this research, the relationship among wheat seed yield and its contributing components under salt stress condition were investigated by using three statistical procedures including; principal components, factor analysis and cluster analysis. The experiment was conducted under saline field conditions based on randomized complete block design with three replications. Electrical conductivity of irrigation water was 10ds.m-1. Results indicated that biological yield, plant height and chlorophyll content were the most effective variables influencing seed yield. Based on the results, it seems that high yield of wheat plants under saline field conditions can be obtained by selecting breeding materials with high biological yield, harvest index and chlorophyll content.

1. Introduction

Salinity is one of the major environmental stresses that limit crop production in irrigated and rain-fed environments around the word, especially in arid and semi-arid regions (Ghassemi et al. 1995; Flowers, 1999; Zhu, 2001). Harmful effects on plant growth and yield due to osmotic stress from decreased soil water potential or specific ion effects on plant cellular metabolism (Hasegawa et al. 2000; Munns et al. 1995; Munns and Tester, 2008). Since, salinity management through reclamation or improve irrigation techniques is often usually expensive and provides only short-term solutions to overcome salinity, seems that selection for genotypes with increased productivity under salt stress conditions is as the most efficient way to increasing of wheat yield and improvement of salt tolerance of wheat genotypes (Ashraf, 1994; Shannon, 1997). Improving the salt tolerance of species and crop requires availability to new genetic variation and effective techniques for identifying salt-tolerance (Munns and James, 2003). There is remarkable natural genetic diversity in processes controlling the salt tolerance in bread wheat and other crop species. This genetic diversity could be identified using the key traits related to salt tolerance and exploited through introduction of salt tolerant germplasm into cultivars by breeding methods (Dehghani et al. 2012a; Dehghani et al. 201b).

Salinity tolerance indicates the ability of genotype to grow and yield well in saline conditions. Some investigators prefer to use biomass and especially seed yield as the final propose for identifying of salt tolerant genotypes under salt stress conditions. On the other hand, seed yield is a quantitative trait, which is largely influenced by the environment and usually has a low heritability. Therefore, selection of genotypes based on yield is not effective (Sabaghnia et al., 2010). Morphological traits and related characters with seed yield due to ease of measurement and usually have a high heritability can be used as criteria for distinguish salinity tolerant plants and for improvement of seed yield in wheat genotypes especially under salt stress conditions. It suggested that yield component and related yield characters could be used as a selection criterion in selecting for increased seed yield (Annicchiarico and Pecetti, 1998; Leilah and Al-Khateeb, 2005; Arduini et al., 2006). Knowledge of the interrelationships between yield and its components will improve the efficiency of breeding programs especially under salt stress conditions through appropriate selection criteria. Different statistical techniques have been used to evaluate yield and yield components including correlation, regression, path analysis, factor analysis, principal component and cluster analysis (Mohamed, 1999; Naser and Leilah, 1993; Leilah and Al-Khateeb, 2005; Mohammadi et al, 2011). Factor analysis is often used in data reduction to identify a small number of factors that explain most of the variance observed in much larger number manifest variables. Factor analysis attempts to identify underlying variables, or factors, that explain the pattern of correlations within a set of observed variables (Walton, 1972). This technique for the evaluation of different trait relationships was used by (Moghaddam et al., 1998; Mohamed, 1999; Leilah and Al-Khateeb, 2005) in wheat. It has been also used in soybeans (Leilah et al., 1988) and sesame (El-Deeb and Mohamed, 1999). Principal component analysis (PCA) is a multivariate statistical technique that uses to transform a number of possibly correlated variables into a smaller number of linearly uncorrelated variables named principal components (Everitt and Dunn, 1992). The number of principal components is less than or equal to the number of original variables. This technique can be used for exploration and simplifying complex data sets. Cluster analysis is statistical techniques which can be applied to identify variables that can be could be classified into main groups and subgroups based on similarity and dissimilarity (El-Deeb and Mohamed, 1999). This technique is useful tool for crop modeling and parental selection in breeding programs (Jaynes et al., 2003).

Most of the experiments are carried out under controlled condition and this is in spite of the fact that genotypic differences observed controlled conditions may not correspond to those observed at the adult stages in the field conditions (Houshmand et al., 2005) because in controlled conditions the plants are not exposed with the conditions such as spatial and temporal heterogeneity of soil chemical and physical properties that prevail in salt affected field conditions (Munns and James, 2003). Therefore, this study was carried out to determine the interrelationships among seed yield and related traits in bread wheat by three statistical procedures and identifying traits which may be useful in breeding higher-yielding genotypes under salt stress condition in field.

2. Materials and methods

2.1. Experimental site and soil properties

The experiment was carried out during 2011-2012 growing seasons in the saline conditions at the research field of the National Salinity Research Center (NSRC) at Yazd, Iran (31°86′N, 53°95′E and 1609 mail). Before starting the experiment was conducted sampling in the different layers of soli (0-30, 30-60, 60-90 cm depth) in the experiment location. Relevant soil characteristics of the experimental site are given in Table 1.

Table 1
Soil properties of the experimental site.

Location	**Depth (cm)**	**pH**	**EC (dS.m-1)**	**meq/L**				**P (mg.kg-1)**	**K (mg.kg-1)**
				K+	Na+	Mg+	Ca+		
Stress	0-30	7.6	9.80	1.7	175.8	52.6	52.3	25.9	209
	30-60	7.6	7.89	0.9	149.8	41.2	38.2	5.0	177
	60-90	7.3	9.58	0.9	219.7	61.7	48.3	3.7	201

2.2. Plant material and growth conditions

The forty one genotypes of bread wheat (triticum aestivum L.) which were used in this experiment were almost all the commercial wheat genotypes cultivated in different parts of Iran. All wheat genotypes were selected from the germplasm collection at the Iranian Institute of Seed and Plant Improvement Institute (SPII), Karaj, Iran. The genotypes cultivated in saline condition with 3 replications in from of randomized complete block design. The salinity of water used in irrigation was 10dS.m-1. Each plot consisted two rows 20 cm apart and 2 m in length. Nitrogen, P and K fertilizers were applied based on the soil test and the Iranian Soil and Water Institute (ISWI) recommendation model (Milani et al., 1998). A total of 150 kg N ha-1 each time at sowing, top-dressed at tillering stage and at the start of podding. Other fertilizers were applied before plowing at the recommended rates of 115 kg P2O5 ha-1 and 80 kg K2SO4 ha-1, for the purpose of determining the salinity of soil during growth season, sampling have been done from the depth of 0-30, 30-60, 60-90. The average of salinity rate during growth season was 9.5dS.m-1. Weeds were controlled by hand as needed.

Data were collected on the following 18 characters in all replications on five randomly selected plants from each plot. The traits were own length (X1), number of seed per spike (X2), number of fertile tiller (X3), number of spikelet per spike (X4), flag leaf length (X5), 100-seed weight (X6) (The 100-seed weight was measured on a sub-sample of seed harvested from each plot), seed weight per spike (X7), peduncle weight (X8), spike weight (X9), chlorophyll content (X10) (The chlorophyll content (X10) of base, middle and tip (Munns and James, 2003) of the third leaves was measured using a SPAD-502 chlorophyll meter (Minolta, Japan) which provides rapid and non-destructive measurements of leaf chlorophyll content), plant height (X11), days to heading (X12), days to maturity (X13), spike length (X14), peduncle length (X15), harvest index (X16) (The harvest index was calculated as the ratio between grain yield and biological yield), biological yield (X17) and seed yield (SY) were recorded.

2.3. The statistical technique

The datasets were first tested for normality by the Anderson and Darling normality test using Minitab version 14 statistical software. Factor analysis was used to obtain more information on the relationship between various characteristics and profound understanding of data structures. Also Principal components analysis used to transform a number of correlated variables into a (smaller) number of uncorrelated variables named principal components. The first principal component accounts for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability as possible (Everitt and Dunn, 1992). In order to classify variables, cluster analysis based on ward's method on the measured traits was carried out using squared Euclidean distance based on mean standardized data. To determine the appropriate location for cutting the dendrogram was used discriminant function analysis. Data analysis was performed using SAS version 9.1 and SPSS version 19 statistical software.

3. Results

3.1. Factor analysis

Factor analysis is technique that determines certain factors, explain correlations in variable data. Factor analysis is often used in data reduction to determine small number of factors explaining most of the variance. The aim of factor analysis is summarizing of the data of covariance structure in a few dimensions of the data. Factor analysis indicated that five main factors (groups) were accounted for 75.5% of the total variation in the dependent structure (Table 2). The first factor represents 26.3% of the total variation of the data and this factor includes seed yield, biological yield, peduncle length, plant height and chlorophyll content. The suggested name for this factor is seed yield. The second factor included days to heading, days to maturity, number of spikelet per spike and own length which accounted for 20.0% of the total variation of the data and it was named the maturity characteristics. The third factor represents 13.3% of the total variation of the data and this factor includes spike weight, seed weight per spike, and number of seed per spike. The suggested name for this factor is yield components. The fourth factor included the 100-seed weight, flag leaf length and number of fertile tiller which accounted for 9.6% of the total variation of the data and it was named the economical yield. The fifth factor represents 6.2% of the total variation of the data and this factor includes harvest index, spike length and peduncle weight. The suggested name for this factor is harvest index. According to the results, it seems that the selection based on the first factor will has the most effectiveness in the seed yield and biological yield, peduncle length, plant height and chlorophyll content efficiency have the highest community and high relative contribution in wheat seed yield (Table 3).

Table 2
Rotated (Varimax rotation) factor loadings and communalities for the estimated variables of bread wheat.

Variables	Factor1	Factor2	Factor3	Factor4	Factor5	Communality
Own length (X1)	0.21	0.62	-0.24	-0.25	-0.41	0.73
Number of seed per spike (X2)	-0.13	0.16	0.70	-0.49	0.13	0.81
Number of fertile tiller (X3)	0.24	0.32	-0.03	0.61	0.31	0.65
Number of spikelet per spike (X4)	-0.07	0.53	0.47	-0.31	-0.16	0.64
Flag leaf length (X5)	0.25	0.26	0.24	0.72	0.03	0.72
The 100-seed weight (X6)	0.16	-0.22	-0.08	0.82	-0.19	0.80
Seed weight per spike (X7)	0.19	-0.00	0.80	0.27	-0.14	0.78
Peduncle weight (X8)	0.47	0.34	0.02	0.01	0.53	0.63
Spike weight (X9)	0.00	-0.05	0.93	0.05	-0.06	0.88
Chlorophyll content (X10)	0.79	0.21	0.15	-0.10	0.19	0.74
Plant height (X11)	0.91	0.10	0.02	0.23	-0.04	0.89
Days to heading (X12)	-0.01	0.86	-0.00	-0.25	-0.19	0.84
Days to maturity (X13)	0.28	0.86	0.02	0.02	0.02	0.82
Spike length (X14)	0.14	0.22	-0.05	-0.00	0.65	0.50
Peduncle length (X15)	0.81	-0.22	0.02	0.26	0.05	0.79
Harvest index (X16)	-0.50	-0.22	-0.13	-0.10	0.67	0.79
Biological yield (X17)	0.68	0.36	0.23	0.22	0.00	0.70
Seed yield	0.83	0.26	0.03	0.15	0.17	0.82
Latent roots	4.74	3.60	2.40	1.73	1.11	13.51
Factor variance (%)	26.34	20.05	13.33	9.62	6.21	75.55

3.2. Principal components

Principal component analysis was shown to be a major tool to extract information from a complex dataset. Data presented in Table 4 and graphically shown in Fig. 1 revealed that the principal component analysis had grouped the measured variables into five main components which generally accounted for 75.4% of the total variation of seed yield. The number of significant principal components was selected on the basis of the Kaiser criterion with eigenvalue higher than 1 (Kaiser, 1960). According to this criterion, the first five principal components were selected because subsequent eigenvalues were all less than one. The first, the second, the third, the fourth and the fifth factors are accounted for 26.3%, 20.0%, 13.3%, 9.6% and 6.2%, respectively of the variation in seed yield. Results indicated that PC1 correlated moderately well with own length, peduncle weight, and harvest index. Meanwhile, the PC2 correlated moderately with number of seed per spike, number of spikelet per spike, flag leaf length, days to heading and peduncle length. The third component (PC3) contained seed weight per spike and spike weight. The PC4 correlated moderately with plant height, chlorophyll content, days to maturity, biological yield and seed yield and the fifth component (PC5) contained number of fertile tiller and the 100-seed weight. Variables which significantly correlated with the first five eigenvectors were the variables with the greatest variation. According to the results, it seems that the selection based on the fourth component (PC4) will has the most effectiveness in the seed yield. Therefore, plant height, chlorophyll content, biological yield and days to maturity shown to be the important variables affecting greatly seed yield

Table 3
Summary of factors loading for the estimated variables of bread wheat.

variables	Loading	Total communality (%)	Suggested factor name
Factor 1	4.74	26.3%	Seed yield
Seed yield	0.83		
Chlorophyll content (X10)	0.79		
Plant height (X11)	0.91		
Peduncle length (X15)	0.81		
Biological yield (X17)	0.68		
Factor 2	3.60	20.0%	Maturity characteristics
Own length (X1)	0.62		
Number of spikelet per spike (X4)	0.53		
Days to heading (X12)	0.86		
Days to maturity (X13)	0.86		
Factor 3	2.40	13.3%	Yield components
Number of seed per spike (X2)	0.70		
Seed weight per spike (X7)	0.80		
Spike weight (X9)	0.93		
Factor 4	1.73	9.6%	Economical yield
Number of fertile tiller (X3)	0.61		
Flag leaf length (X5)	0.72		
The 100-seed weight (X6)	0.82		
Factor 5	1.11	6.2%	Harvest index
Peduncle weight (X8)	0.53		
Spike length (X14)	0.65		
Harvest index (X16)	0.67		
Cumulative variance	13.51	75.55%	

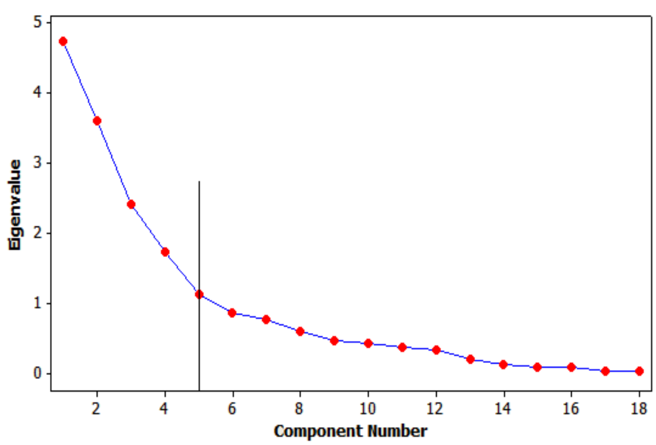

Fig. 1. Scree plot showing eigenvalues in response to number of components for the estimated variables of bread wheat.

Table 4
Eigenvalue of the correlation matrix for the estimated variables of bread wheat using the principal component procedure.

Variables	PC1	PC2	PC3	PC4	PC5
Own length (X1)	0.44	0.15	0.22	-0.12	-0.30
Number of seed per spike (X2)	0.08	-0.35	-0.21	0.33	-0.12
Number of fertile tiller (X3)	0.21	0.18	0.17	0.06	0.45
Number of spikelet per spike (X4)	0.16	-0.35	-0.14	0.00	-0.00
Flag leaf length (X5)	0.13	0.33	-0.22	0.06	0.27
The 100-seed weight (X6)	0.07	0.33	-0.14	-0.20	0.38
Seed weight per spike (X7)	0.25	-0.00	-0.42	0.13	0.09
Peduncle weight (X8)	0.34	-0.07	-0.09	0.13	-0.08
Spike weight (X9)	0.17	-0.11	-0.48	0.25	0.06
Chlorophyll content (X10)	0.27	-0.23	0.04	0.44	0.13
Plant height (X11)	-0.03	0.24	0.08	0.34	-0.30
Days to heading (X12)	0.18	-0.34	0.21	-0.26	0.09
Days to maturity (X13)	-0.15	-0.18	0.27	0.31	0.17
Spike length (X14)	0.24	0.09	0.21	0.05	-0.25
Peduncle length (X15)	0.23	0.33	0.00	0.08	-0.32
Harvest index (X16)	0.43	-0.02	0.14	-0.26	0.26
Biological yield (X17)	0.37	0.08	0.04	0.37	-0.07
Seed yield	0.13	0.04	0.30	0.49	0.28
Eigenvalue	4.74	3.60	2.40	1.73	1.11
Proportion	26.30	20.00	13.30	9.60	6.20
Cumulative (%)	26.30	46.30	59.30	68.90	75.40

3.3. Cluster analysis

Cluster analysis based on ward's method was performed on the measured traits in bread wheat genotypes. Based on the results of the discriminant function analysis on various sections of the cut, the maximum difference between the groups was observed in four clusters (Table 5 and Figure 2). Cluster 1 includes own length (X1) and number of fertile tiller (X3) while cluster 2 includes Flag leaf length (X5), chlorophyll content (X10), plant height (X11), spike length (X14), peduncle length (X15), harvest index (X16), biological yield (X17) and grain yield. Cluster 3 includes number of seed per spike (X2), number of spikelet per spike (X4), seed weight per spike (X7), peduncle weight (X8) and spike weight (X9) and cluster 4 includes the 100-seed weight (X6), Days to heading (X12) and Days to maturity (X13). Our data reflected the tendency of each grouped variables in one cluster to relate closely to each other. Therefore, the results of cluster analysis indicated that flag leaf length, chlorophyll content, plant height, spike length, peduncle length, harvest index, Biological yield were the variables that had the most relationship with seed yield. This strategy for classify variables was used by Leilah and Al-Khateeb (2005) in wheat.

4. Discussion

The multiple statistical procedures which have been used in this study indicated that biological yield, plant height and chlorophyll content were the important variables influencing seed yield and can be used as selection criteria for improving seed yield of bread wheat under saline conditions. Based on the results, it seems that biological yield and harvest index traits are appropriate indices for salinity breeding programs and selection salt stress tolerant genotypes. This suggests that evaluation for salt tolerance among genotypes can be based on the genetic diversity in biological yield and plant height. These characters are a yield component and are easier to determine than yield and generally have a high heritability. Donald et al. (1976), Mohammed. (1999) and Leiah and Al-Khateeb (2005) reported a high, positive, significant, correlation between biological yield with seed yield.

Also, the results of different statistical techniques this study showed that chlorophyll content was one of the most effective traits on seed yield under saline conditions. Salinity stress significantly reduces the total chlorophyll content and the rate of reduction in total chlorophyll depending on salt tolerance of plant species and salt concentrations. In salt-tolerant species, chlorophyll content increased, while in salt-sensitive species it was decreased (Ashraf and McNeilly, 1988). Plant physiologists have found chlorophyll content to be a valuable tool to monitor plant stress response.

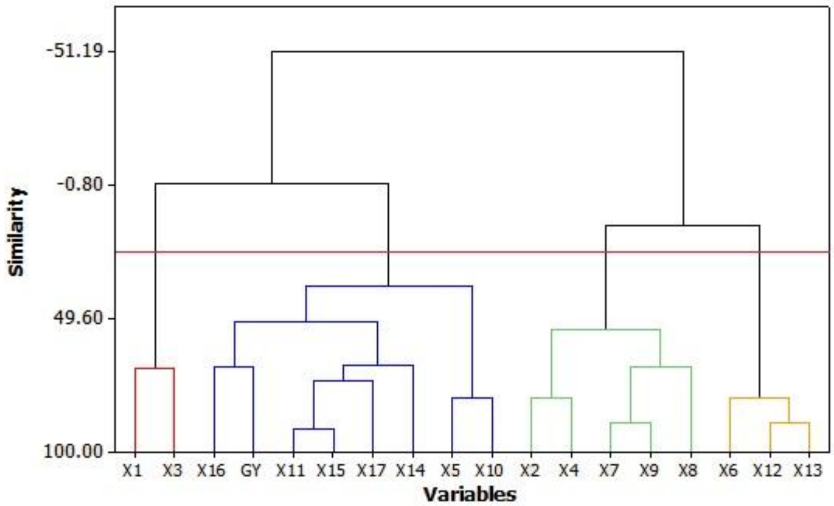

Fig. 2. Dendrogram of cluster analysis based on ward's method on the measured traits in bread wheat genotypes.

Table 5
Discriminant function analysis to determine the cut-off point of dendrogram resulting from cluster analysis based on all measured traits.

Number of clusters	Eigenvalues	Percent of variance	Canonical Correlation	Wilkes Lambda	Probability
2	1.236	11.22	0.743	0.447	0.070
3	1.478	13.45	0.772	0.180	0.050
4	8.308	85.48	0.945	0.019	0.000

The chlorophyll content meter is useful for improving nitrogen and fertilizer management and is ideal for crop stress, leaf senescence, plant breeding, health determination and other studies (Peñuelas and Filella 1998; Gitelson et al., 2003). Determination of the relationships of the chlorophyll content, yield and yield components facilitates selection of high yielding varieties from breeding programs (Singh, 2001). The results of different statistical techniques revealed that leaf chlorophyll content was one of the effective traits on seed yield under saline conditions. Similar to these results, Araus et al. (1998), Kabanova and Chaika, (2001), Ramesh et al. (2002), Boggs et al. (2003) and Bronson et al. (2003) were found a positive correlation between leaf chlorophyll content and yield for wheat and other crops. In the present study, the results revealed that leaf chlorophyll content due to rapid and non-destructive measurement can be advised one of the indicators in the improvement of seed yield in bread wheat under saline conditions.

5. Conclusion

Generally, analysis of three statistical procedures which have been used this study revealed that biological yield, and chlorophyll content were the most important traits influencing seed yield under saline conditions. This was clear with all used statistical procedures (Table 6). Therefore, high yield of wheat plants under saline conditions can be obtained by selecting breeding materials with high biological yield, plant height and chlorophyll content.

Table 6
The characteristics effective on seed yield of bread wheat under salt stress conditions with each one of the used statistical techniques.

Variables	1+	2	3
Own length (X1)			
Number of seed per spike (X2)			
Number of fertile tiller (X3)			
Number of spikelet per spike (X4)			
Flag leaf length (X5)			√
The 100-seed weight (X6)			
Seed weight per spike (X7)			
Peduncle weight (X8)			
Spike weight (X9)			
Chlorophyll content (X10)	√	√	√
Plant height (X11)	√	√	√
Days to heading (X12)			
Days to maturity (X13)		√	
Spike length (X14)			√
Peduncle length (X15)	√		√
Harvest index (X16)			√
Biological yield (X17)	√	√	√

1+ = Factor analysis, 2 = Principal component analysis and 3= Cluster analysis.

References

Annicchiarico, P., Pecetti, L., 1998. Yield vs. morphophysiological trait-based criteria for selection of durum wheat in a semi-arid Mediterranean region (northern Syria). Field. Crop. Res., 59, 163-173.

Araus, J., Amaro, T., Voltas, J., Nakkoul, H., Nachit, M., 1998. Chlorophyll fluorescence as a selection criterion for grain yield in durum wheat under Mediterranean conditions. Field. Crop. Res., 55, 209-223.

Arduini, I., Masoni, A., Ercoli, L., Mariotti, M., 2006. Grain yield, and dry matter and nitrogen accumulation and remobilization in durum wheat as affected by variety and seeding rate. Euro. J. Agron., 25, 309-318.

Ashraf, M., McNeilly, T., 1988. Variability in salt tolerance of nine spring wheat cultivars. J. Agron. Crop. Sci., 160, 14-21.

Ashraf, M., Wu, L., 1994. Breeding for salinity tolerance in plants. Crit. Rev. plant Sci., 13, 17-42.

Boggs, J.L., Tsegaye, T., Coleman, T.L., Reddy, K., Fahsi, A., 2003. Relationship between hyperspectral reflectance, soil nitrate-nitrogen, cotton leaf chlorophyll, and cotton yield: a step toward precision agriculture. J. Sustain. Agri., 22, 5-16.

Bronson, K.F., Chua, T.T., Booker, J., Keeling, J.W., Lascano, R.J., 2003. In-season nitrogen status sensing in irrigated cotton. Soil Sci. Soc. Am. J., 67, 1439-1448.

Dehghani, H., Dvorak, J., Sabaghnia, N., 2012a. Biplot Analysis of Salinity Related Traits in Beard Wheat (Triticum aestivum L.). Ann. Biol. Res., 3 (7), 3723-3731.

Dehghani, H., Dvorak, J., Sabaghnia, N., 2012b. Graphic analysis of biomass and seed yield of beard wheat in salt stress condition. Ann. Biol. Res., 3 (9), 4246-4253.

Donald, C., Hamblin, J., 1976. The biological yield and harvest index of cereals as agronomic and plant breeding criteria. Advan. Agron., 28, 361-405.

El-Deeb, A., Mohamed, N., 1999. Factor and cluster analysis for some quantitative characters in sesame (Sesamum indicum L). Annu. Confer. ISSR., Cairo University.

Everitt, B.S., Dunn, G., 1992. Applied Multivariate Data Analysis. Oxford University Press, New York, NY.

Flowers, T.J., 1999. Salinisation and horticultural production. Sci. Horti., 78, 1–4.

Ghassemi, F., Jakeman, A.J., Nix, H.A., 1995. Salinisation of land and water resources: human causes, extent, management and case studies. Ed.Eds, Cab Int.
Gitelson, A.A., Merzlyak, M.N., 2003. Relationships between leaf chlorophyll content and spectral reflectance and algorithms for non-destructive chlorophyll assessment in higher plant leaves. J. plant physiol., 160, 271-282.
Hasegawa, P.M., Bressan, R.A., Zhu, J.K., Bohnert, H. J., 2000. Plant cellular and molecular responses to high salinity. Ann. Rev. Plant. Biolo., 51, 463-499.
Houshmand, S., Arzani, A., Maibody, S.A.M., Feizi, M., 2005. Evaluation of salt-tolerant genotypes of durum wheat derived from in vitro and field experiments. Field Crop. Res., 91, 345-354.
Jaynes, D., Kaspar, T., Colvin, T., James, D., 2003. Cluster analysis of spatiotemporal corn yield patterns in an Iowa field. Agr. J., 95, 574-586.
Kabanova, S., Chaika, M., 2001. Correlation analysis of triticale morphology, chlorophyll content and productivity. J. Agr.Crop. Sci., 186, 281-285.
Kaiser, H.F., 1960. The application of electronic computers to factor analysis. Educat. Psychol. measurement, 20, 141–151.
Leilah, A., Al-Khateeb, S., 2005. Statistical analysis of wheat yield under drought conditions. J. Arid Env., 61, 483-496.
Leilah, A., Badawi, M., El-Moursi, S., 1988. Yield analysis of soybean. J. Agr. Sci., 13, 2344-2351.
Maas, E.V., Lesch, S.M., Francois, L.E., Grieve, C.M., 1994. Tiller development in salt-stressed wheat. Crop. Sci., 34, 1594-1603.
Milani, P., Malakouti, M., Khademi, Z., Balali, M., Mashayekhi, M., 1998. A fertilizer recommendation model for the wheat field of Iran. Soil Water Res. Inst., Tehran, Iran.
Moghaddam, M., Ehdaie, B., Waines, J., 1998. Genetic variation for and interrelationships among agronomic traits in landraces of bread wheat from southwestern Iran. J. Genet. Breed., 52, 73-82.
Mohamed, N., 1999. Some statistical procedures for evaluation of the relative contribution for yield components in wheat. Zagazig J. Agri. Res., 26, 281-290.
Mohammadi, M., Karimizadeh, R., Shefazadeh, M.K., Sadeghzadeh, B., 2011. Statistical analysis of durum wheat yield under semi-warm dry land condition. Aust. J. Crop. Sci., 5, 1292-1297.
Munns, R., James, R.A., 2003. Screening methods for salinity tolerance: a case study with tetraploid wheat. Plant Soil., 253, 201-218.
Munns, R., Schachtman, D., Condon, A., 1995. The significance of two-Phase growth response to salinity in wheat and barley. Aus. J. Plant Physiol., 22, 561-569.
Munns, R., Tester, M., 2008. Mechanisms of salinity tolerance. Annu. Rev. Plant Biol., 59, 651-681.
Naser, S., Leilah, A., 1993. Integrated analysis of the relative contribution for some variables in sugar beet using some statstical techniques. Bulletin of the Faculty of Agriculture, University of Cairo., 44, 253-266.
Peñuelas, J., Filella, I., 1998. Visible and near-infrared reflectance techniques for diagnosing plant physiological status. Trend. plant sci., 3, 151-156.
Ramesh, K., Chandrasekaran, B., Balasubramanian, T., Bangarusamy, U., Sivasamy, R., Sankaran, N., 2002. Chlorophyll dynamics in rice (Oryza sativa) before and after flowering based on SPAD (chlorophyll) meter monitoring and its relation with grain yield. J. Agr. Crop. Sci., 188, 102-105.
Richards, R., Dennett, C., Qualset, C., Epstein, E., Norlyn, J., Winslow, M., 1987. Variation in yield of grain and biomass in wheat, barley, and triticale in a salt-affected field. Field Crop. Res., 15, 277-287.
Sabaghnia, N., Dehghani, H., Alizadeh, B., Mohghaddam, M., 2010. Interrelationships between seed yield and 20 related traits of 49 canola (Brassica napus L.) genotypes in non-stressed and water-stressed environments. Span. J. Agr. Res., 8, 356-370.
SAS Institute Inc., 2011. SAS/STAT user's guide, second edition. SAS institute Inc., cary, Nc.
Shannon, M.C., 1997. Adaptation of plants to salinity. Advan. Agron., 60, 75-120.
Singh, S.P., 2001. Broadening the genetic base of common bean cultivars. Crop. Sci., 41, 1659-1675.
SPSS, I., 2010. SPSS 19. Users Guied. Chicago, IL., USA.
Wright, S., 1921. Correlation and causation. J. Agr. Res., 20, 557-585.
Zhu, J.K., 200. Plant salt tolerance. Trend. plant sci., 6, 66-71.