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# Mixed Cropping system with Biofertilizer under Dry land condition: I. Evaluation of Drought Tolerance Indices

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**ABSTRACT**
*Dry land farming fields share about 70% of the arable land of Lorestan province, west Iran. In order to study the drought tolerance indices to find the best agronomic treatment of mixed cropping system and fertilizer, two factors include chickpea - barley mixed cropping system of 100:0, 75:25, 50:50, 25:75, and 0:100, respectively, and fertilizer viz. chemical fertilizer, vermicompost, and compound fertilizer (vermicompost + %75 chemical fertilizer) were studied in two separated experiments include non stress (well watered) and stress (dry land) conditions. Result showed that mean productivity (MP), geometric mean productivity (GMP) and stress tolerance index (STI) increased by increasing barley ratio in mixed cropping system and compound fertilizer. These traits increased from 2235.5, 2197.0 and 0.42 in sole chickpea using chemical fertilizer to 3337.5, 3271.5 and 0.93 in sole barley using compound fertilizer, respectively. Positive and significant correlation was found between dry forage yield with MP, GMP, STI, TOL and SSI in normal condition, but with MP, GMP, TOL and STI in dry land condition, which was selected as best indices for drought tolerance investigation in mixed cropping system and fertilizer treatments and can be suggestion for dry land condition. M3F2, M4F2 and M5F2 were introduced as additive drought tolerant agronomic practices for dry land condition, and M2F3, M3F3, M4F3 and M5F3 were introduced for well watered condition.*
**Key words:** *Drought tolerance indices, Drought stress, Well watered, Vermicompost.*

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## INTRODUCTION

Dryland farming share about 70% of the arable land of Lorestan province, west Iran. The stress factors especially drought, negatively affect plant growth and development and causes a sharp decrease of plants productivity [1]. It can have a substantial impact on the agriculture of the affected region as its short intense can cause significant damage and harm the economy [2].

The agricultural performance level is very low in the dryland farming areas, and it is possible to raise this level through the adoption of dry farming technology, such as mixed cropping system and biofertilizer consumption.

Using monoculture of legumes or cereals with chemical fertilizer consumption is usual in irrigated or dryland condition of west Iran, contains usually less than 500 mm precipitation with abnormal distribution during mid fall to mid spring, which causes decreasing in quantity and quality of crop yield and damages soil and environment. Increasing biodiversity (ecological equilibrium), more resources exploitation, improving quantity and quality of yield and to relieve damages caused by pests, diseases and weeds, are the objects of intercropping as a type of sustainable systems in agriculture [3]. Nowadays, the management methods are improving in some agricultural systems in order to reduce agrochemical consumption, to compensate increasing production costs, to reduce impacts of chemicals on environments and to conserve soil fertility. Herein, expanding fodder crops cultivation has suggested as an alternative approach to synthetically fertilizers [4].

The different *Vicia* species are used as direct grazing and also for their green forage, hay and seed [5]. Molla and Sharaiha [6] stated that mixed cropping of Barley and Durum Wheat helps combine important characters in a cropping system so as to enhance productivity through complementary resource uses in drylands.

Drought indices provide a measure of drought based on loss of yield under drought conditions in comparison to normal conditions not only have been used for screening drought-tolerant genotypes [7], but also can help to find the best agronomic treatments to coping drought stress. These indices are either based on stress resistance or susceptibility of genotypes [8].
Khakwani et al [2] reported that the wheat variety Hashim-8 which indicated higher mean productivity (MP), geometric mean productivity (GMP) and stress tolerance index (STI) whereas stress susceptibility index (SSI) and tolerance (TOL) was observed at its lowest.
Mp, GMP and STI were recognized as beneficial drought tolerance indicators for selecting a stress tolerant in wheat variety [9].
The object of this study was to find the best combination of chickpea and barley in the mixed cropping system mixture with biofertilizer under normal and dryland condition to coping drought stress in respect to drought tolerance indices.

## MATERIALS AND METHODS

A factorial experiment was used based on RCBD of three replications in research field of Islamic Azad University, branch Khorramabad, west Iran (48°21'E, 33°29'N, 1190 m), during early 2013.
Two separated experiments include normal (well irrigated) and dry land conditions were studied. In each experiment two factors include fertilizer (vermicompost biological fertilizer, ammonium phosphate chemical fertilizer, and compound fertilizer of vermicompost + %75 ammonium phosphate) and chickpea - barley mixed cropping of 100:0, 75:25, 50:50, 25:75, and 0:100, respectively, were used in a silty clay loam soil. 10 ton $ha^{-1}$ vermicompost and 60 Kg $ha^{-1}$ ammonium phosphate added to soil.
The chickpea (cv. Grit) and barley (cv. Izeh) in plant density of 40 and 400 plant $m^{-2}$, respectively, were mixed sown when frosty season was terminated on 2th of March, 2013 in a replacement series experiment. Each plot consisted of 5 rows with 25 cm spacing (1.5 m width) and 6 m long. There was 50 cm distance as a border line between the plots. All agronomic practices like irrigation in well watered experiment and weed control were kept normal and uniform in treatments. Crops soilage was harvested at 50% flowering of chickpea, when barley kernels were at early doughy stage (early June) and wet and dry forage yield were measured.
To determine fresh and dry forage yields, all plants in four middle rows of first half area of each plot were harvested from ground surface, two crops were separated and weighted immediately for fresh yield. A 500 g sample was separated from both crops of each plot and putted in 70°C oven for 48 h and then again weighted to calculate moisture content of samples, which was used to determine dry yield. For estimating the tolerance and susceptibility of treatments the following indices were used:
Stress Susceptibility Index [10]: $SSI = (1 - (Ys \div Yp)) \div SI$
Stress Index: $SI = 1 - (\bar{Y}s \div \bar{Y}p)$
Tolerance [11]: $TOL = Yp - Ys$
Mean Productivity [11]: $MP = (Yp + Ys) \div 2$
Geometric Mean Productivity [11]: $GMP = \sqrt{(Ys \times Yp)}$
Stress Tolerance Index [8]: $STI = (Yp \times Ys) \div (\bar{Y}p)2$
Where Yp is mean dry forage yield under non-stress (well watered) condition, Ys is mean dry forage yield under stress (dry land) condition and $\bar{Y}p$ and $\bar{Y}s$ are the mean dry forage yield of all treatments under non-stress and stress condition.
Simple correlation coefficient between different traits was estimated. To display the treatment by trait two-way data in biplot, a principal component analysis is necessary. The principal components the original data set, consisting of *n* measurements on *p* variables, are reduced to one consisting of *n* measurements on *k* principal components. The biplot display of principal component analysis was used to indentify suitable stress tolerant indices, stress tolerant and high-yielding treatments. Analysis of principal components often reveals relationships that were not previously suspected and thereby allows interpretations that would not ordinarily result [12]. Treatments can be categorized into four groups based on their performance in stress and non-stress environments: treatments express uniform superiority in both stress and non-stress environments (Group A), treatments perform favorably only in non- stress environments (Group B), treatments yield relatively higher only in stress environments (Group C), and genotypes perform poorly in both stress and non-stress environments (Group D). The optimal selection criterion should distinguish Group A from the other three groups [8].
Analysis of variance, correlation among traits, correlation among indices and grain yield, principal component analysis and biplot drawing were performed using SAS, and MINITAB software.

## RESULTS AND DISCUSSION

### Analysis of variance:

There was significant difference among forage yield and all drought indices except SSI (Table 1). Mean dry forage yield of treatments (chickpea – barley mixed cropping and fertilizer) in two well watered and dry land conditions is shown in table 1. It showed that different characteristics are among treatments. The highest dry forage yield of 4235 kg ha$^{-1}$ was found in M5F3 (sole barley and fertilizer) and the lowest one of 2655 kg ha$^{-1}$ was found in M1F1 (sole chickpea and sole chemical fertilizer) under well watered condition. In dryland condition, the highest dry forage yield of 2675 and 2558 kg ha$^{-1}$ achieved from M5F2 and M5F3 (sole barley and sole vermicompost or compound fertilizer), respectively, and the lowest one of 1818 kg ha$^{-1}$ achieved from M1F1 (sole chickpea and sole chemical fertilizer).

Basically, higher mean productivity (MP), geometric mean productivity (GMP) and stress tolerance index (STI), whereas lower stress susceptibility index (SSI) and tolerance (TOL) indicate high relative tolerance to drought stress. Result showed that MP, GMP and STI increased by increasing barley share in mixed cropping system and compound fertilizer. These traits increased from 2236.5, 2197.0 and 0.42 in sole chickpea and chemical fertilizer (M1F1) to 3396.5, 3291.4 and 0.94 in sole barley and compound fertilizer (M5F3), respectively (Table 1).

It is noticeable that difference between tolerance indices in terms of lack of (F1 and F2 treatments) and consumption of vermicompst (F3 treatment) increased by increasing the proportion of barley in mixed cropping system. For example, STI of sole chickpea increased from 0.42 in chemical fertilizer treatment to 0.56 and 0.63 with consumption of vermicompst and compound fertilizer, respectively, while in sole barley it increased from 0.59 to 0.93 and 0.86, respectively. It seems that barley with consumption of vermicompst caused higher system tolerance to water stress.

**Table 1.** Mean values of tolerance and susceptibility indices in well watered (P) and dry land (drought stress) (S) conditions.

| Treatment | Yp(kg/ha) | Ys(kg/ha) | MP | GMP | TOL | SSI | STI |
|---|---|---|---|---|---|---|---|
| M1F1 | 2655 | 1818 | 2236.5 | 2197.0 | 837.0 | 0.84 | 0.42 |
| M1F2 | 3268 | 1974 | 2621.0 | 2539.9 | 1294.0 | 1.06 | 0.56 |
| M1F3 | 3319 | 2182 | 2750.5 | 2691.1 | 1137.0 | 0.92 | 0.63 |
| M2F1 | 2734 | 1890 | 2312.0 | 2273.2 | 844.0 | 0.83 | 0.45 |
| M2F2 | 3261 | 2048 | 2654.4 | 2584.2 | 1213.1 | 1.00 | 0.58 |
| M2F3 | 3478 | 2091 | 2784.5 | 2696.8 | 1387.0 | 1.07 | 0.63 |
| M3F1 | 2951 | 1929 | 2440.0 | 2385.9 | 1022.0 | 0.93 | 0.49 |
| M3F2 | 3434 | 2266 | 2850.0 | 2789.5 | 1168.0 | 0.91 | 0.67 |
| M3F3 | 3651 | 2084 | 2867.5 | 2758.4 | 1567.0 | 1.15 | 0.66 |
| M4F1 | 3088 | 1877 | 2482.5 | 2407.5 | 1211.0 | 1.05 | 0.50 |
| M4F2 | 3700 | 2349 | 3024.5 | 2948.1 | 1351.0 | 0.98 | 0.75 |
| M4F3 | 3975 | 2338 | 3156.5 | 3048.5 | 1637.0 | 1.10 | 0.80 |
| M5F1 | 3261 | 2088 | 2674.3 | 2609.1 | 1173.5 | 0.96 | 0.59 |
| M5F2 | 4000 | 2675 | 3337.5 | 3271.1 | 1325.0 | 0.89 | 0.93 |
| M5F3 | 4235 | 2358 | 3296.5 | 3160.1 | 1877.0 | 1.19 | 0.86 |
| **Probability level** | ** | * | * | * | * | **ns** | * |
| **LSD(5%)** | **650.2** | **425.6** | **398.7** | **545.1** | **374.3** | **-** | **0.26** |
| **Mean** | **3400.7** | **2131.1** | **3116.2** | **3022.2** | **1503.1** | **1.0** | **0.8** |
| **SI** | **0.3733** | | | | | | |

M1 to M5: chickpea - barley mixed cropping of 100:0, 75:25, 50:50, 25:75, and 0:100, respectively. F1 to F3: chemical fertilizer, vermicompost, and compound fertilizer, respectively. For SSI and TOL, lower values are desirable whereas for MP, GMP and STI, higher values are desirable.

ns, * and ** : Non significant and significant at 0.05 and 0.01 probability level, respectively.

## Correlation analysis:

Result showed positive and significant correlation between dry forage yield and all measured drought indices in well watered condition, but only with MP, GMP and STI in dry land condition, which have selected as best indices for drought tolerance in different fertilizer and mixed cropping systems (Table 2). No significant correlation was found between TOL and SSI with dry forage yield. Correlation result showed drought tolerance increasing by log in barley in mixed cropping system, which intensified by using biological fertilizer.

Mean productivity (MP), geometric mean productivity (GMP) and stress tolerance index (STI) were recognized as beneficial drought tolerance indicators for selecting a stress tolerant variety in wheat [13]. Positive and significant correlation is reported between Yp and MP and STI and Ys and MP and STI in mungbean [8] and in maize [14]. Thus, a better approach than a correlation analysis such as principal component analysis and biplot are needed to identify the superior treatments for stress condition.

**Table 2.** Correlation coefficient among various tolerance drought indices of mean dry forage yield of chickpea – barley mixed cropping and fertilizer.

| | Yp | Ys | MP | GMP | TOL | SSI |
|---|---|---|---|---|---|---|
| Ys | 0.868** | | | | | |
| MP | 0.985** | 0.941** | | | | |
| GMP | 0.973** | 0.959** | 0.998** | | | |
| TOL | 0.906** | 0.584* | 0.825** | 0.789** | | |
| SSI | 0.627* | 0.164ns | 0.485ns | 0.433ns | 0.888** | |
| STI | 0.964** | 0.965** | 0.995** | 0.998** | 0.771** | 0.403ns |

ns, * and ** : Non significant and significant at 0.05 and 0.01 probability level, respectively.

**Principal component analysis (PCA):**

PCA was performed in order to further investigate the relations between treatments and drought indices (Table 3). PCA reduced five indices to two components. PCA revealed that the first PC explained 82.9% of the variation with Yp, Ys, MP, GMP and STI, respectively. Thus, the first dimension can be named as the yield potential and drought tolerance. Considering the high and negative value of this PCA on biplot, selected treatments will be high yielding under stress conditions.

The second PC explained 17.0% of the total variability and had negative correlation with SSI and TOL, respectively. Therefore, the second component can be named as a non stress tolerance dimension and it separates the stress-tolerant treatments from non-stress tolerant ones. Thus, selection of treatments that have high PC1 and low PC2 are suitable for stress and non-stress conditions.

**Table 3.** The principal component analysis for drought tolerance indices

| Component | Yp | Ys | MP | GMP | TOL | SSI | STI | Eigenvalue | Cumulative percentage |
|---|---|---|---|---|---|---|---|---|---|
| 1 | -0.414 | -0.369 | -0.411 | -0.407 | -0.368 | -0.245 | -0.404 | 5.8324 | 0.833 |
| 2 | -0.042 | 0.422 | 0.118 | 0.173 | -0.421 | -0.747 | 0.201 | 1.157 | 0.165 |

The biplot of agronomic treatments based on 1 and 2 components introduced M3F2, M4F2 and M5F2 (treatments No. 8, 11 and 14, respectively) for dry land condition, showed that consumption of vermicompost and increasing the proportion of barley in mixed cropping system causes high drought tolerance in agronomic system. M2F3, M3F3, M4F3 and M5F3 (treatments No. 6, 9, 12 and 15, respectively) were introduced for well watered condition, represented that consumption of compound fertilizer should be together with sufficient water to produce the highest dry forage yield. Fernandez [8], Farshadfar [14] and Golabadi *et al.* [15] were able to reveal that genotypes with larger PCA1 and lower PCA2 scores gave high yields (stable genotypes), and genotypes with lower PCA1 and larger PCA2 scores had low yields (unstable genotypes), due to different variation in genotypes.

 

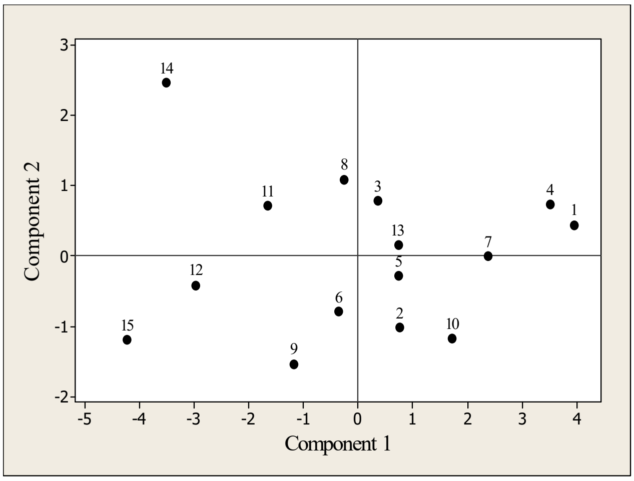


**Figure 1.** The biplot of 15 treatments based on 1 and 2 components.

## CONCLUSIONS

Drought tolerance indices calculated based on the dry forage yield under well watered and dry land conditions, when the researcher is looking for the agronomic practices adapted for dry land environment. The MP, GMP and STI are suggested as useful indicators for selecting the best treatment of chickpea – barley mixed cropping and fertilizer, where the stress is severe (dry land condition). These indices were able to identify additive drought tolerant agronomic practices such as M3F2, M4F2 and M5F2 for dry land condition. But the SSI and TOL are suggested as useful indicators and identified M2F3, M3F3, M4F3 and M5F3 for well watered condition. These agronomic practices were recommended for cultivation in dry land area in temperate region of west Iran.

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## REFERENCES

1. Pan X.Y., Wang, Y.F., Wang, G.X., Cao, Q.D. & Wang, J. (2002). Relationship between growth redundancy and size inequality in spring wheat populations mulched with clear plastic film, Acta Phytoecology Sinica 26: 177-184.
2. Khakwani, A.A., Dennett M.D. & Munir, M. (2011). Drought tolerance screening of wheat varieties by inducing water stress conditions, Songklanakarin J. Sci. Technol 33 (2), 135-142.
3. Beets, W.C. (1982). Multiple Cropping and Tropical Farming Systems, Westview Press, Boulder, Colorado, ISBN: 0-566-00567-0, pp: 156.
4. Franzluebbers, A.J. (2007). Integrated crop-livestock systems in the southeastern USA, Agron. J., 99: 349-355. DOI: 10.2134/agronj2006.0076.
5. Lanyasunya, Z.T.P., Wang, H.R., Ayako W.O. & Kuria, D.M. (2007). Effect of age at harvest and manure or fertilizer application on quality of Vicia villosa Roth, Agric. J. 2: 641-645. http://www.medwellonline.net /fulltext/aj /2007/641-645.pdf.
6. Molla A. & Sharaiha, R.K. (2010). Competition and Resource Utilization in Mixed Cropping of Barley and Durum Wheat under Different Moisture Stress Levels, World Journal of Agricultural Sciences 6 (6): 713-719.
7. Mitra, J. (2001). Genetics and genetic improvement of drought resistance in crop plants. Curr. Sci. 0:758-762.
8. Fernandez, G.C.J. (1992). Effective Selection Criteria for Assessing Plant Stress Tolerance, In Proceedings of the International Symposium on Adaptation of Vegetative and other Food Crops in Temperature and Water Stress, Taiwan 13. pp. 257-270.
9. Drikvand, R., Hossinpur, T., Ismaili, A. & Salahvarzi, E. (2012). Assessment of drought tolerance indices for screening of rainfed wheat genotypes Journal of Food, Agriculture & Environment Vol.10 (1): 768-772.
10. Fischer R.A. and R. Maurer, 1978. Drought resistance in spring wheat cultivars, Australian Journal of Agricultural Research 29, 897-912.
11. Rosielle, A.A. & Hamblin, J. (1981). Theoretical aspects of selection for yield in stress and non stress environments, Crop Science 21: 943- 946.
12. Johanson, R.A. & Wichern, D.W. (1996). Applied Multivariate Statistical Analysis. Prentice Hall of India, New Delhi 642 p.
13. Sio-Se Mardeh, A., Ahmadi, A., Postini, K. & Mohammadi, V. (2006). Evaluation of drought resistance indices under various environmental conditions, Field Crops Research 98:222-229.
14. Farshadfar, E. & Sutka, J. (2003). Screening drought tolerance criteria in maize, Acta Agronomica Hungarica 50:411-416.
15. Golabadi, M., Arzani, A. & Mirmohammadi Maibody, S.A.M. (2006). Assessment of drought tolerance in

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