ISSN: 0976-3104

SUPPLEMENT ISSUE

ARTICLE OPEN ACCESS

ECONOMIC AND BIOLOGICAL YIELD ASSESSMENT OF WHEAT GENOTYPES UNDER TERMINAL DROUGHT IN PRESENCE OF HUMIC ACID USING STRESS TOLERANCE INDICES

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ABSTRACT

This research was carried out to study the effect of application of a peat based liquid humic fertilizer on economic and biological yield of six bread wheat genotypes under terminal drought stress. Irrigation and humic levels (well irrigated; well irrigated + humic fertilizer; terminal drought and terminal drought + humic fertilizer) had significantly different effects on economic and biological yield, but it was not significant for harvest index. Humic fertilizer decreased drought stress intensity by 20%. There were significant differences among genotypes in terms of economic yield and harvest index. Tolerance indices including SSI, TOL and STI were estimated. Some correlations were observed between indices when humic fertilizer was applied compared to without humic fertilizer condition. Gascogne, Sabalan and 4057 genotypes had the highest harvest index and economic yield. Correlation between economic and biological yield was positively significant for all four irrigation and humic levels. Humic fertilizer led to significantly negative correlation between harvest index and biological yield. This did not create similar effect in drought condition. Genotype 4057 had the highest economic yield in both stressed and non-stressed condition irrespective of whether humic fertilizer was applied or not. Gascogne was placed after 4057 as a tolerant genotype when humic fertilizer was applied.

Published on: 25th– Sept-2016

KEY WORDS

Humic substances, Organic matters, Triticumaestivum, Harvest index, STI, SSI

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INTRODUCTION

World demand for wheat, as a stable food crop, is increasing. So, it is an immediate need to develop new genotypes which could tolerate serious terminal drought stress in semi-arid regions, without considerable reduction in kernel yield. Selecting wheat genotypes based on their yield performance under drought conditions is a common approach to achieve this aim. For identifying tolerant genotypes to water deficit condition, some drought stress indices or selection criteria have been suggested by different researchers [1]. As the most important abiotic stress, drought is a major restriction to wheat and other agricultural crops production in arid and semi-arid regions[2]. Drought stress induces several physiological, biochemical and molecular responses in crop plants which help them to adapt to such limiting environmental conditions [3]. The susceptibility of plants to drought stress varies depending on the stress degree, different accompanying stress factors, plant species and their developmental stages [4].

Most genetic gains in wheat yield potential were mainly achieved by means of improvements in harvest index with marginal or no modification of biomass, though recently some researchers reported slight increases in biomass in spring and winter wheat [5].Although trends in harvest index with the year of release of cultivars were slightly positive before the introgression of semi-dwarf genes, the incorporation of genes derived from Norin 10 (Rht1 and Rht2) into wheat-breeding programs has been decisive to increase harvest indices [5].

Rosielle and Hamblin [6] defined stress tolerance (TOL) as the differences in yield between the stressed (Ys) and non-stressed (Yp) environments and mean productivity (MP) as the average yield of Ys and Yp. Fischer and Maurer [7] proposed a stress susceptibility index (SSI) of the cultivar. Fernandez [8]defined a new advanced index (STI= stress tolerance index) which can be used to identify genotypes that produce high yield under both stressed and non-stressed conditions and claimed that selection based on STI and GMP would result in genotypes

THE IIOAB JOURNAL
ISSN: 0976-3104

with higher stress tolerance and good yield potential. The geometric mean (GM) is often used by breeders interested in relative performance since drought stress can vary in severity in field environment over years [9].

In addition to food security, environmental protection has become an important concern worldwide in recent years. With growing population, it becomes more important to manage the use of chemical fertilizers and nutrient elements [10]. Organic matters have been recognized as one of the basis in nutritional plant and soil fertility due to constructive effects on soil physical and biological properties. Organic fertilizers are a major contributor to availability of organic matter in rhizosphere[11]. Humic acid makes up a stable form of carbon that improves certain soil properties such as water holding capacity, pH, buffer and insoluble thermal conductivity [12,13]. Researchers believe that humic substances can be helpful for living organisms at developing stages (as background material or nutrient source, or with an enzyme-like activity); as carriers of nutrients and catalyzes in biochemical reactions and antioxidant activities [14]. In research conducted by Bakri *et al*[15]humic acid as foliar application significantly increased morphological traits such as biological yield in wheat. Seyedbagheri[16]has shown that the application effect of humic substances on plant could be different depending on source and amount used, soil type and cropping system.

The present study was carried out in order to introduce the drought tolerant bread wheat and also to assess the performance of different genotypes under application of a liquid humic fertilizer against terminal drought in Ardabil region, Iran.

MATERIALS AND METHODS

In order to determine the effect of a liquid humic fertilizer (HF) on economic and biological yield as well as harvest index of wheat genotypes under terminal drought conditions, an experiment was conducted at Agricultural Research Farm of Islamic Azad University, Ardabil branch, Iran. Applied liquid humic fertilizer was extracted from peat. Applied liquid peat-based humic fertilizer had 3.3 % humic acid and 0.9 % fulvic acid. Totally, its humic extracts were 4.2 %.

In this study six winter bread wheat genotypes (Gascogne, Sabalan, 4057, Ruzi- 84, Gobustan and Saratovskaya-29) were planted under four different conditions including well irrigated, terminal drought, well irrigated with HF and terminal drought with HF in a split plot design based on randomized completely block design (with three replications). Amount of planted seed was on the basis of 450 seeds per m² and 1000 seed weight of genotypes. The main plot size was 3 × 7m and the sub plot size was 0.6 × 3m. Wheat genotypes were distributed randomly in sub plots.

Applications of HF were done at four stages: 1) preplanting on seeds 2) tillering 3) stem elongation 4) after anthesis. Preplanting treatment of seeds was on the basis of 220 ml HF plus 10 litres of water for 1 ton seeds. For this, 1000 grain weight of wheat genotypes was measured and the amount of HF was calculated and used for pretreatment of seeds per plot. Spraying treatments on foliage was on the basis of 400 ml of HF plus 50 liters of water per hectare. Five times irrigation were given to the well irrigated treatments, and two times no irrigation were given to the drought treatments after anthesis. All the cultural practices were uniformly applied to all the experimental units.

After physiological ripening, all the wheat plants were harvested and weighed as a biological yield for each plot. Before harvesting, plot margins were removed. Economic and biological yield in a unit area (1.44 m²) basis were estimated. Harvest index was calculated as seed weight divided by un-thrashed plant weight × 100. Drought tolerance indices were calculated according the following equations:

$STI = (Ypi \times Ysi)/Yp^2$

$TOL = (Ypi - Ysi)$

$SSI = (1- (Ysi/Ypi)) / SI \; ; \; SI = 1- (Ys/Yp)$

Where Ysi and Ypi are stress and optimal (potential) yield of a given genotype, respectively.Ys and Yp are average yield of all genotypes under stress and optimal conditions, respectively.

RESULTS

Mean Comparisons of economic yield and biological yield for different experimental levels of this research is presented in the Figures 1-4.

There are correlation coefficients between economic yield, biological yield and harvest index in Table 1.

Average yields of wheat genotypes under different conditions of this study with humic fertilizer or control (without humic fertilizer), and tolerance indices is presented on the Table 2.

Table3 show correlation between different selection indices and average yield of wheat genotypes under water stress treatments with humiclevels.

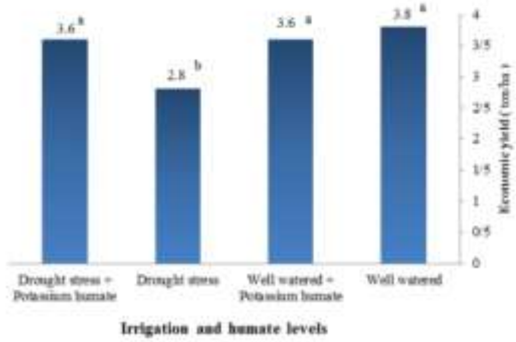

Fig: 1. Mean comparisons of economic yield for different irrigation and humic levels

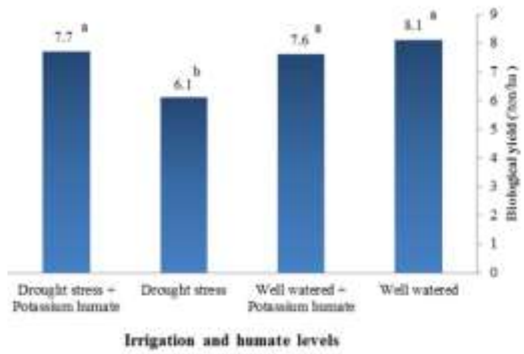

Fig: 2. Mean comparisons of biological yield for different irrigation and humic levels

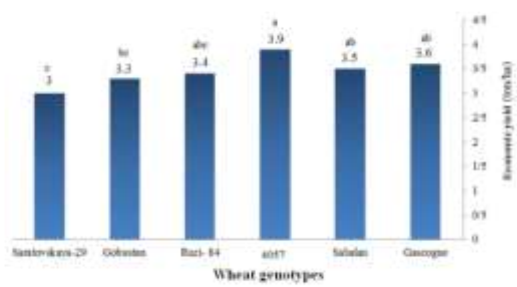

Fig:3. Mean comparisons of economic yield for wheat genotypes

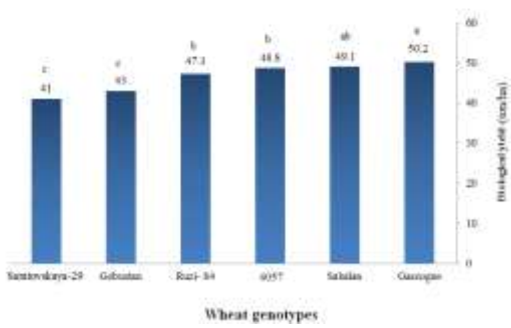

Fig: 4. Mean comparisons of biological yield for wheat genotypes

Table 1.Correlation coefficient between economic yield, biological yield and harvest index

Levels	Well irrigated		Well irrigated +humic fertilizer		Drought stress		Drought stress +humic fertilizer	
Characters	Biological yield	Harvest index	Biological yield	Harvest index	Biological yield	Harvest index	Biological yield	Harvest index
Economic yield	0.850**	0.601**	0.760**	0.155	0.931**	0.422	0.875**	0.647**
Biological yield		0.119		-0.515*		0.073		0.205

Table 2.Average yields of wheat genotypes under optimal (Yp) and stressed (Ys) conditions with and without humic fertilizer, and tolerance indices

Genotypes	Ypi		Ysi		STI		TOL		SSI	
	HF	-	HF	-	HF	-	HF	-	HF	-
Gascogne	3.9	3.7	2.5	4.3	0.66	1.20	1.41	0.00	1.4	0.00
Sabalan	3.8	3.3	3.2	3.8	0.83	0.96	0.64	0.00	0.65	0.00
4057	4.4	4.0	3.4	4.0	1.02	1.19	0.98	0.00	0.87	0.00
Ruzi- 84	4.0	3.8	2.9	3.1	0.79	0.90	1.13	0.71	1.09	7.45
Gobustan	3.7	3.4	2.8	3.3	0.71	0.84	0.97	0.10	1.00	1.25
Saratovskaya-29	3.1	3.7	2.3	2.9	0.48	0.78	0.82	0.80	1.02	8.88

HF: humic fertilizer

Table 3.Correlation between selection indices and average yield of wheat genotypes under well- irrigated and stressed condition, with and without humic fertilizer

	Ypi		Ysi		STI		TOL		SSI	
	HF	-	HF	-	HF	-	HF	-	HF	-
Ysi	0.81	0.14								
STI	0.94**	0.51	0.97**	0.93**						
TOL	0.31	0.29	-0.31	-0.90*	-0.07	-0.67				
SSI	-0.80	0.30	-0.66	-0.90*	-0.45	-0.67	0.92**	0.99**		

HF: humic fertilizer

DISCUSSION

The lowest amounts of economic and biological yield belonged to the drought stress condition (Figure 1 and 2). Terminal drought stress decreased economic and biological yield by 32% and 28% respectively, relative to mean of irrigation and humic levels. Demirevska*et al*[4]reported that stress degree, plant species and their developmental stages had effect on susceptibility of plants to drought. By application of humic fertilizer in drought stress condition, the economic and biological yield became like well irrigated plants. These results are in conformity with Kulikuva*et al*[14]that expressed the mitigating effect of humic substances on living organisms. In a research conducted by Bakry*et al*[15]foliar application of humic acid significantly increased morphological traits such as biological yield in wheat. Humic fertilizer increased economic and biological yield by 0.8 ton/ha (28.6%) and 1.6 ton/ha (26.2%) respectively. Seyedbagheri[16] evaluated commercial humic acid products derived from lignite and leonardite in different cropping systems from 1990 to 2008. The results of their

THE IIOAB JOURNAL
ISSN: 0976-3104

evaluations differed as a result of the source, concentration, processing and quality of humic substances as well as type of soil and cropping systems. In their research, crop yield increased from a minimum 9.4 to a maximum 35.8%.

Mean comparisons (Figure 1) showed that HF increased biological yield from 6.1 to 7.7 ton/ha, also economic yield from 2.8 to 3.6 ton/ha in drought condition. This increase was not significant for well irrigated condition. This finding corroborates the finding of Shahryari and Shamsi[17]. They studied effect of humic fertilizer derived from sapropel and reported that it increased the rate of biomass production but had no effect on harvest index. Humic acid makes up a stable form of carbon that improves certain soil properties such as water holding capacity [12,13].In addition, the role of humic acid is well known in decreasing intensity of water stress [18]. These beneficial roles of humic acid can be used in crops such as wheat to improve economical and biological yields under both well-irrigated and water deficiency condition.

It was revealed from the data that biological yield values varied from 41.0 to 50.2 ton/ha among different genotypes and economic yield from 3.0 to 3.9 ton/ha (Figure 3 and 4). Gascogne, Sabalan and 4057 had the highest harvest indices and economic yield among the genotypes. Based on harvest index they ranked as Gascogne, Sabalan and 4057; and based on the economic yield they ranked 4057, Gascogne and Sabalan.

Correlation analysis provides information on interrelationship of important plant characters and therefore, leads to a directional model for direct and/or indirect improvement in grain yield. Although direct selection for various parameters could be misleading, indirect selection via related parameters with high heritability might be more effective than direct selection. All possible correlations were worked out in order to determine the relationship of harvest index with economic yield and biological yield separately in four experimental conditions (Table 1). Correlation between economic and biological yield was positively significant for all four irrigation and humic levels. Thus, there was a linear relationship among these traits. There was significant linear relationship between economic yield and harvest index for well-irrigated and drought stressed+humic fertilizer levels while no correlation was observed among them in the other two conditions. Correlation of biological yield and harvest index was negatively significant for well irrigated+humic fertilizer condition. But relationship between these characteristics was not a linear correlation. Applied humic fertilizer had no effect on harvest index of wheat genotypes. But decreasing of drought stress intensity by 20% was a significant effect of humic fertilizer. It also improved economic yield in terminal drought condition.

Without HF application, genotype 4057 had the highest grain yield in stressed and non- stressed environment (Table 2). This genotype had the highest MP, GMP and STI. It also had the lowest susceptibility to drought stress. Shahriari*et al*[19]concluded that humic fertilizer resulted in higher tolerance of 4057 against drought (-7 bar PEG 6000) in early growth stages. In HF application condition, Gascogne produced the highest yield after 4057 (Table 2). Numerical values of indices for Gascogne were similar to 4057. However, its grain yield increased from 3.73 ton/ha (YPi) to 4.28 ton/ha (Ysi) which was a remarkably better gain compared to 4057. At last, HF reduced average grain yield differences between stressed and non-stressed conditions from 1.0 to 0.1 ton/ha in this experiment.

There was positively significant correlation (at probe< 0.01) for STI and stress yield (Ysi) at presence of HF or without HF (Table 3). Application of HF had the same effect on relationship between STI and potential yield (Ypi) at presence of HF. These findings were in conformity with Rosielle and Hamblin [6]and Jafari*et al*[10]. It seems that application of HF led to some of changes in correlation between stress indices.

CONCLUSION

As conclusion, genotype 4057 was also selected as tolerant to terminal drought of Ardabil region, with or without HF application. It appeared that application of this natural bio-fertilizer could be promising in production of wheat and reduction of chemical fertilizer application in terminal drought conditions Ardabil region.

CONFLICT OF INTEREST

Authors declare no conflict of interest

ACKNOWLEDGEMENTS

THE IIOAB JOURNAL ISSN: 0976-3104

None

FINANCIAL DISCLOSURE

None

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