Evaluation of the response of rice cultivars in some functional and physiological traits using different nutritional sources (chemical, organic) under drought stress conditions

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Abstract

A factorial experiment was performed as a randomized complete block design with three replications in Sari Research Farm during 2016-2017. Three levels of stress, including drought stress on the time of tillering initiation (15 days after transplanting), in remobilization stage (the end of flowering and the beginning of grain filling stage), and no drought stress (control), were considered as the main factors. Four fertilizer sources, including vermicompost, Azolla compost, humic acid, and chemical fertilizers of nitrogen, phosphorus, potassium, along with two local Tarom and Shirodi cultivars, were considered as the sub-factor. The maximum paddy seed yield was obtained in the non-stress condition using humic acid in Shirodi and local Tarom cultivars. The highest harvest index in the first year under non-stress conditions was obtained from the use of humic acid fertilizer resources in the Shirodi cultivar (54.08%), and the maximum concentrations of chlorophylls a, b, and total chlorophyll were obtained under non-stress conditions. With applying stress, especially drought stress at the complete heading stage, the chlorophyll concentration significantly reduced, so that under drought stress at the heading stage, chlorophyll a, b, and total chlorophyll concentrations reduced by 3.8, 2.6, and 3.3, respectively, compared with the control. In Shirodi cultivar maximum protein yield under non-stress conditions in the first year was 62.36%, and the minimum protein yield in the second year under drought stress at the complete heading stage was 47.14%. Therefore, based on the results, the use of humic acid is recommended to obtain the maximum functional and physiological traits of the studied rice cultivars under drought stress**.**

Keywords: cultivar, drought stress, physiological properties, paddy grain yield, fertilizer resources

Mehdiniya Afra, J., Y. Niknejad, H. Falah Amoli, and D. Barari Tari. 2022. 'Evaluation of the response of rice cultivars in some functional and physiological traits using different nutritional sources (chemical, organic) under drought stress conditions'*. Iranian Journal of Plant Physiology 12*(4), 4299- 4310.

Introduction

Drought is considered as one of the most important factors limiting plant growth worldwide and the most common environmental stress that has limited production in approximately 25% of the world's lands (Lesk et al., 2016; Fathi and Tari, 2016). Rice is one of the most sensitive plants to

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Received: April, 2020
Accepted: December,2022

water shortage and has the highest water requirement among cereals (Tao et al., 2006; Yang et al., 2008). Drought stress occurs to some extent, in 50% of the world's rice production lands (Ndjiondjop et al., 2010). It is one of the significant risks to the successful production of crops, especially rice, in the world, which can occur at any time during the growing season. Hence, one of the main challenges in agriculture is to produce more food with less water (Singh, 2003; Tuyen and Prasad et al., 2008).

On the other hand, leaf chlorophyll is one of the most important indicators of environmental pressures on the plant. Among the reasons for the reduction in chlorophyll content under drought stress conditions is the degradation of chloroplast thylakoid membranes and optical oxidation of chlorophyll due to the increased activity of reactive oxygen species (Jnandabhiram et al., 2012; Fathi et al., 2022), so that with increasing drought stress intensity or reducing the potential of soil water, the process of chlorophyll pigment degradation is also accelerated (Sheteawi and Tawfik, 2007).

Compost is a mixture of organic matter rotted by microorganisms that, in a warm, humid environment and under aerobic conditions, provide the plant with nutrients that can be used (Razavipour, 2004). Researchers stated that the use of Azolla compost makes nutrients readily available for the plant, which finally increases the rice yield (Kavitha and Subramanian, 2007). Azolla is a free-range aquatic fern commonly found in rice farms, streams, and ponds (Rehana et al., 2003). The application of Azolla compost with the practical matter for rice farms has been investigated in many countries and has been shown to affect yield traits positively and increase the total biomass of rice (Razavipour et al., 2018).

Vermicompost is known as an organic soil modifier to increase plant growth and grain yield (Raja Sekar and Karmegam, 2010). Vermicompost has high water and nutrient absorption and storage capacity due to its high porosity, adequate ventilation, and drainage. Its use in sustainable agriculture increases the population and activity of beneficial soil microorganisms, which provides plant nutrients such as nitrogen, phosphorus, and soluble potassium, leading to an improvement in the growth and yield of crops (Padmavathiamma et al., 2008; Arancon et al., 2004).

Humic acid is one of the stimulants of vegetative growth, reproductive growth, and quantitative and qualitative yield in plants. Humic acid increases grain yield by improving grain yield components (Vanitha et al., 2014).

Despite numerous studies on identifying drought-tolerant and susceptible cultivars, functional properties, and some physiological properties of Shirodi and Tarom cultivars under drought stress and treated with vermicompost, Azolla compost, humic acid, and conventional nitrogen, phosphorus, and potassium fertilizers have not been investigated. On the other hand, it is necessary to use inputs that increase plant resistance to drought stress conditions. Therefore, this study was conducted to investigate the effects of nutritional system (chemical and organic) of vermicompost, Azolla compost, humic acid, and application of chemical nitrogen, phosphorus, and potassium fertilizers on some functional traits of rice cultivars under drought stress.

Materials and Methods

Location and soil properties

An experiment was conducted in the research farm at Dasht-e Naz Agricultural Company located in Sari, Iran, at the latitude of 36˚46', the longitude of 53˚10', and altitude of 11 meters above the sea level, in the crop years 2016 and 2017. The soil sampling was randomly carried out from the depth of 0 to 30 cm to determine the soil characteristics in this experiment. The chemical properties, such as pH and electrical conductivity, were measured (Nelson et al., 1983) followed by measuring the organic carbon by the Walckel-Black method (Nelson et al., 1983), total nitrogen content by the Kjeldahl method (Bremner, 1996), absorbable potassium content by the ammonium acetate method with molar concentration of 1, (Helmke and Sparks, 1996), and microelements using DTPA method (Loeppert, 1996). The analysis results are illustrated in Table 1. Before the experiment, the elements present in the vermicompost, Azolla compost, and humic acid samples were also tested and the results are reported in Tables 2 and 3.

Table 1
Physicochemical properties of the experimental location soil

E.C ds m^{-1}	pH	O.C %	O.M %	N %	P mg kg^{-1}	K mg kg^{-1}	Cu mg kg^{-1}	Fe mg kg^{-1}	Zn mg kg^{-1}	Mn mg kg^{-1}	Soil texture
2.97	7.08	1.03	0.98	0.10	12	91	0.5	1.02	0.6	4.1	Silt clay

Table 2
Properties of vermicompost and Azolla compost fertilizers

Type input	E.C ds m^{-1}	pH	N %	P %	K %	Cu mg kg^{-1}	Mn mg kg^{-1}	Zn mg kg^{-1}	Fe mg kg^{-1}
Vermicompost	11.82	5.14	2.1	1.39	0.043	8	15	59	1400
Azolla compost	13.6	7.73	2.11	1.78	0.081	36	209	298	955

Table 3
Properties of organic fertilizers Humabon (Humic acid) tested

Type input	O.M %	N %	P %	K %	Cu mg kg^{-1}	Mn mg kg^{-1}	Zn mg kg^{-1}	Fe mg kg^{-1}	Fulvic acid	Humic acid
Humabon	20	2	3	0.098	68	100	500	2000	15.5	0.072

Experimental design and treatments

The experiment was conducted as the split plot factorial in the completely randomized design with three replications. In this experiment, the drought stress, as the main factor, was applied at three levels, including drought stress at the time of tillering initiation (15 days after transplanting), in the remobilization stage (the end of flowering and the beginning of grain filling stage), and no drought stress (control). Two cultivars of rice (Shirodi and local Tarom) and the nutritional system types were considered as the sub-factors. Four levels of nutrition types in the study include vermicompost (6 tons per hectare), Azolla compost (8 tons per hectare), Humabon humic acid (4.5 liters per one thousand liters of water) procured from Asia Bon Kesht Co., and the ordinary chemical fertilizers, i.e. Nitrogen, Phosphor, and Potassium obtained from urea, triple superphosphate, and potassium sulfate sources, respectively.

Crop management

Based on the instruction of the Rice Research Institution and considering the soil test results, nitrogen, phosphorus, and potassium fertilizer requirements were utilized as 150, 75, and 90 kg/ha for Shirodi cultivar and 100, 50, 50 kg/ha for local Tarom cultivar.

Half of the nitrogen was applied before the cultivation, and the rest was used at tillering. Phosphorus and potassium fertilizers were utilized along with nitrogen prior to cultivation as well. Local Tarom cultivar is amongst the best quality rice varieties with long grains, great scent, taste and, cooking attribute, creamy white color. Shirodi cultivar is an improved dwarf with a medium growth rate, and is dull cream in color when it is raw. It is also considered as one of the cultivars of the north region, having medium scent, taste, and cooking attribute. Some agricultural characteristics of the cultivars are mentioned in Table 4.

Table 4
Some agronomic characteristics of rice cultivars tested

Cultivars	Grain length after baking	Grain length before baking	Number of effective tillers per square meter	Growth period	Bush height	Flavor of rice
Local Tarom	14.04	7.01	189	104	158	Great
Shirodi	9.91	7.39	283	123	94	Medium

The organic fertilizers of Azolla compost and vermicompost were used and mixed with soil before the preparation stage in every plot, and humic acid was sprayed in the early stage of tillering and retransition stage. The transplanting was carried out for Shirodi and Tarom cultivars at the distances of 25×25 and 20×20 cm, respectively in plots of 3×3 m and on 12 planting lines. The plots were lined with plastic sheet to prevent the lateral penetration of water. Concerning the average precipitation in this season and the meteorological statistics of the last year, a shelter was provisioned for precipitation. The rainfall throughout the months of the crop season was reported to be 74.2 mm, and the drought stress was implemented through the defined treatments according to the moisture variation signals in the hairy soil cleavage (Cabuslay et al., 2002; Hadian, 2010). The volume of the consumed water was recorded using a water meter. Weeding was accomplished manually in two stages (20 and 38 days after transplanting), and pest control was carried out based on the instruction of Rice Research Institution.

Measurements

To determine the rice paddy yield in 2 square meters, after eliminating the border effect, 32 and 50 plants were harvested from each plot for Shirodi and Tarom cultivars, respectively, and then their yield was calculated based on 14% of the moisture content.

The grain protein yield was obtained from multiplying grain yield by protein content. Chlorophyll content in leaf samples was measured through spectroscopy using a spectrophotometer (UNICO 2800) (Arnon, 1967) and based on the following equations:

Chl.a (mg/g FW) = (12.25 A663.2) – (2.79 A646.8)

Chl.b (mg/g FW) = (21.50 A646.8) – (5.1 A663.2)

Chl.T (mg/g FW) = Chl.a + Chl.b

where Chl.a, Chl.b, Chl.T, and A indicate the concentrations of chlorophyll a, chlorophyll b, the total chlorophyll, and absorption rate of a specific wavelength, respectively.

Statistical Analysis

The data were analyzed using SPSS software; the whole data of the two crop years were evaluated by the Bartlet test, and no significant effect was found in this regard. The analysis of data variances was performed by MSTAT-C and SAS software version 9.1. Means were compared at 5% level of probability by the LSD test (Steel and Torrie, 1980).

Results

Paddy grain yield

The variance analysis results indicated that interaction effects of drought stress treatments, cultivar, fertilizer resources, and the year were significant on the paddy grain yield at one percent level of probability (Table 5).

Comparison of the mean effects of drought stress and cultivar along with the consumption of fertilizer sources showed that the maximum paddy grain yield (6017.93 kg/ha) was observed in non-stress conditions with humic acid consumption in Shirodi cultivar. Also, under treatment with common fertilizers of nitrogen, phosphorus, and potassium, drought stress in the early stages of tillering and remobilization (end of flowering and the beginning of seed filling) decreased the paddy grain yield by 25.88 and 33.46%, respectively compared to the control (non-stress).

Table 5
Analysis of variance of mean effects of drought stress, cultivars, and fertilizer sources on some characteristics of rice cultivars: results of two years

Sources of Variance	df	Paddy Grain Yield	Chlorophyll a	Chlorophyll b	Total Chlorophyll	Harvest Index	Protein Seed Yield
Year	1	2086098.8**	0.01500625ns	0.01460069ns	0.0592111ns	688.53**	0.02586ns
Year error	4	16221.3	0.00668472	0.01842222	0.0146757	2.0052	0.0439472
drought stress	2	4403710.8**	0.1012631**	0.04172708**	0.271834**	225.1490**	24.6983**
Year * drought stress	2	14909.97ns	0.000208ns	0.000069ns	0.00007ns	26.9463**	0.00549ns
Drought stress error	8	3483.3	0.00067222	0.00355764	0.002778	3.06646	0.21139ns
cultivar	1	193723946.3**	30.534834**	53.79000069**	165.3796**	1484.175**	183.896**
Year* cultivar	1	661.1ns	0.000069ns	0.000069ns	0.002111ns	7.91484*	0.00007ns
drought stress * cultivar	2	2581391.4**	0.00250069*	0.00029653ns	0.0011021ns	23.3019**	4.99806**
Year * S * C	2	52910.2**	0.000069ns	0.000069ns	0.00021ns	20.59541**	0.00174ns
Fertilizer sources	3	2555451.1**	0.3211118**	0.10363218**	0.7891278**	54.62233**	53.8944**
Year* Fertilizer sources	3	4596.6ns	0.000069ns	0.00044ns	0.000056ns	40.01663**	0.00211ns
drought stress* Fertilizer sources	6	38571**	0.00255208**	0.00051134ns	0.0018118ns	7.18765**	0.76051**
YR * drought stress * Fertilizer	6	16624.9ns	0.000208ns	0.0000162ns	0.00007ns	7.99876**	0.00141ns
Cultivar* Fertilizer sources	3	820272.5**	0.00203958*	0.00581551*	0.0044056ns	3.492186ns	2.09606**
YR* C* F	3	15389.2ns	0.000255ns	0.0000069ns	0.000056ns	24.76728**	0.00174ns
S * C* F	6	31801.3**	0.00046181ns	0.00027523ns	0.0003965ns	3.8955*	0.448613*
YR * S * C * F	6	14378.4ns	0.000255ns	0.0000347ns	0.000076ns	7.10949**	0.00106ns
Experimental error	84	10357.5	0.00065417	0.00217837	0.002412	1.576969	0.208856
CV (%)		2.14	1.11	2.52	1.18	2.88	2.24

(*, **, and ns show) significant difference at 5%, 1%, and no significant difference, respectively.

In the control or no drought stress conditions, the highest paddy grain yield was obtained with an average of 3803.63 kg/ha in the local Tarom cultivar by using humic acid fertilizer resources. Moreover, under treatments with common nitrogen, phosphorus, and potassium fertilizers, drought stress during the tillering and remobilization stages (end of flowering and the beginning of grain filling) reduced the yield by 8.6% and 10.15%, respectively (Table 6).

Comparison of the mean effects of the year, drought stress, and cultivars showed that the highest rate of paddy grain yield was obtained in Shirodi cultivar under non-stress conditions in the first year while the lowest rate of paddy grain yield was obtained in drought stress conditions at remobilization stage (the end of flowering and the beginning of grain filling stage) in local Tarom cultivar in the second year (Fig. I).

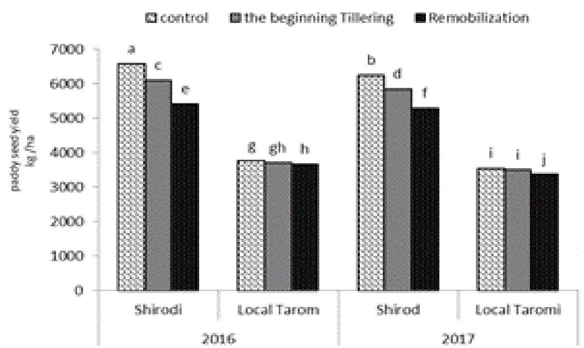

Fig. I. Effect of drought stress on paddy grain yield in rice cultivars in 2016 and 2017, according to LSD, p<0.05

Chlorophyll a, b, and total chlorophyll

The variance analysis results showed significant differences in chlorophyll contents in treatments of drought stress and cultivar, and cultivar and fertilizer resources at 5% level, but the interaction effects of drought stress and fertilizer resources was significant at 1% level. Chlorophyll b content showed a significant effect under cultivars and

Table 6
Comparison of the mean interaction effects of drought stress, cultivars, and fertilizer sources on some characteristics of rice cultivars

drought stress	cultivar	Fertilizer sources	*Paddy grain yield*	Protein Seed yield
control	Shirodi	Vermicompost	5305.63 c	56.770f
		Azollacompost	5503.76 b	63.012d
		Humic acid	6017.93 a	73.532a
		Conventional fertilizer N.P.K	4832.08 e	48.643l
	Local Tarom	Vermicompost	3625.8 k	54.647g
		Azollacompost	3665.07 jk	60.383e
		Humic acid	3803.63 l	69.418b
		Conventional fertilizer N.P.K	3546.14 kl	47.230lj
The beginning of Tillering	Shirodi	Vermicompost	4892.61 e	48.853l
		Azollacompost	5168.97 d	54.348g
		Humic acid	5396.24 bc	65.627c
		Conventional fertilizer N.P.K	4459.94 f	44.047k
	Local Tarom	Vermicompost	3568.75 kl	48.028lj
		Azollacompost	3612.25 k	51.262h
		Humic acid	3772.44 lj	54.913g
		Conventional fertilizer N.P.K	3472.78 lm	43.873k
Remobilization	Shirodi	Vermicompost	4149.51 g	48.068lj
		Azollacompost	4393.67 f	51.530h
		Humic acid	4857.35 e	55.520fg
		Conventional fertilizer N.P.K	4003.82 h	44.005k
	Local Tarom	Vermicompost	3422.69 m	46.742j
		Azollacompost	3558.01 kl	52.005h
		Humic acid	3679.78 jk	55.175g
		Conventional fertilizer N.P.K	3417.23 mn	44.055k

The same letters in each column of LSD test show no significant differences.

Table 7
Comparison of the mean interaction effects of cultivars and fertilizer treatments on some physiological characteristics of rice cultivars

cultivar	Fertilizer sources	Chlorophyll a	Chlorophyll b
Shirodi	Vermicompost	1.784 g	1.224f
	Azolla compost	1.851 f	1.254f
	Humic acid	1.953 e	1.286e
	Conventional fertilizer N.P.K	1.725 h	1.190g
Local Tarom	Vermicompost	2.707 c	2.434c
	Azolla compost	2.790 b	2.481b
	Humic acid	2.855 a	2.542a
	Conventional fertilizer N.P.K	2.646 d	2.387d

The same letters in each column LSD test showed no significant difference in the level of 1, 5 percent

fertilizer resources at a 5% probability level. Still, total chlorophyll showed a significant impact at 1% probability level in the interaction effects of drought stress and cultivar, along with the use of fertilizer resources (Table 5). Interaction of cultivars and fertilizer resources (Table 7) showed that the highest chlorophyll a and b contents were observed in local Tarom with humic acid fertilizer resources (2.85 and 2.54 mg /fresh weight, respectively), and the lowest chlorophyll a and b contents were recorded in Shirodi cultivar under conventional nitrogen, phosphorus, and potassium fertilizer treatment (1.78 and 1.22 mg/fresh weight, respectively). The mean

Table 8
Comparison of the mean interaction effects of drought stress and fertilizer treatments on some physiological characteristics of rice cultivars

drought stress	Fertilizer sources	Chlorophyll a	Chlorophyll b
control	Vermicompost	2.298 e	1.855cde
	Azolla compost	2.358 c	1.893bc
	Humic acid	2.458 a	1.946a
	Conventional fertilizer N.P.K	2.236 f	1.822efg
the beginning Tillering	Vermicompost	2.251 f	1.825efg
	Azolla compost	2.321 d	1.871cd
	Humic acid	2.398 b	1.913ab
	Conventional fertilizer N.P.K	2.160 h	1.793g
Remobilization	Vermicompost	2.188 g	1.808fg
	Azolla compost	2.282 e	1.839def
	Humic acid	2.355 c	1.883bc
	Conventional fertilizer N.P.K	2.160 h	1.750h

The same letters in each column LSD test show no significant difference at 5% probability level

comparison of interaction effects of drought stress and fertilizer resources showed that the highest chlorophyll a under non-stress conditions was obtained from using humic acid fertilizer resources (2.45 mg /fresh weight), but the lowest was under drought stress at the complete heading stage using conventional nitrogen, phosphorus, and potassium fertilizers (2.16 mg /fresh weight) (Table 8). The results of interaction effects between drought stress and cultivars showed that the highest chlorophyll a under non-stress conditions was 2.79 mg/fresh weight in local Tarom cultivar, but the lowest value under drought stress conditions at complete heading stage was 1.78 mg/fresh weight in Shirodi cultivar (Fig. II). The simple effects of drought stress and cultivars along with the use of fertilizer resources showed that the highest total chlorophyll in local Tarom cultivar under non-stress conditions was obtained from using humic acid fertilizer resources (5.21 mg/fresh weight), but the lowest total chlorophyll was recorded in Shirodi cultivar under drought stress conditions treated with nitrogen, phosphorus, and potassium fertilizers (3.06 mg/fresh weight) at complete heading stage (Fig. III).

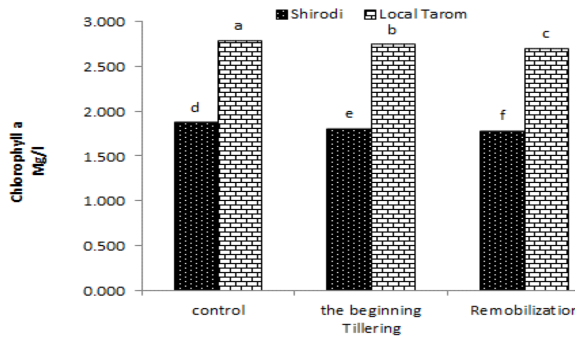

Fig. II. Interaction of the effects of drought stress and cultivars on chlorophyll contents (LSD, p<0.05).

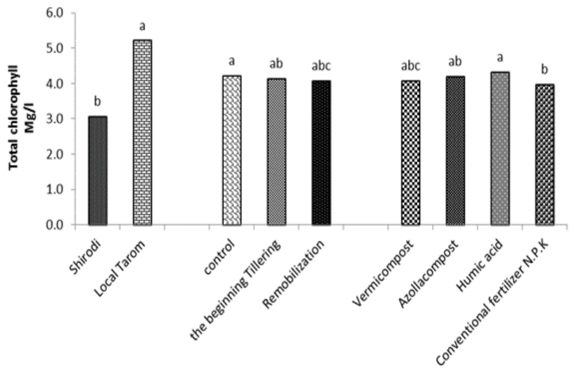

Fig. III. Simple effects of stress, cultivar and fertilizer sources on Total Chlorophyll content of two rice cultivars, according to LSD, p<0.05.

Harvest index

The Table of mean squares showed that the harvest index under interaction treatments of two crop years of drought stress and cultivars using fertilizer resources was significantly different at 1% level (Table 5). The mean comparison of the effects of drought stress, cultivars, and using fertilizer resources of two crop years showed that the highest harvest index in the Shirodi cultivar was obtained in the first year in the absence of stress using humic acid fertilizer resources (54.08%). The lowest harvest index was obtained in the second year under drought stress conditions at the complete heading stage in local Tarom cultivar using conventional fertilizers (nitrogen, phosphorus, and potassium) (30.82%) (Fig. IV).

Protein yield

As Table 5 depicts, protein yield showed significant change under drought stress, cultivars, and fertilizer use (p≤0.5), and drought stress and cultivars (p≤0.01) (Table 5). The mean comparison of the three effects showed that the highest protein yield in Shirodi cultivar (55.52%) occurred under non-stress conditions using humic acid fertilizer resources. However, the lowest value of protein yield in Local Tarom cultivar (43.87%) was recorded under drought stress conditions applied at tillering stage using conventional fertilizers (nitrogen, phosphorus, and potassium) (Table 6). Comparison of mean year, cultivars, and drought stress impacts showed the highest protein yield in the first year in the absence of stress in Shirodi cultivar (62.36%), but the lowest protein yield (47.14%) in the second year was recorded under drought stress at complete heading stage (Fig. V).

Discussion

In this study, drought stress at remobilization stage (end of flowering and seed filling) of different rice cultivars reduced the paddy grain yield and the highest paddy grain yield was obtained in Shirodi cultivar using different sources of organic and chemical fertilizers. Also, comparison of the yield of the two crop years showed that the highest yields of both cultivars were obtained in the first year. Extensive variations have been reported in the paddy yield and other traits of rice under both stress and non-stress conditions and as affected by fertilizers (Cong et al., 2011; Pereyra-Irujo et al., 2007; Iseki et al., 2014), where the minimum yield was generally reduced at initial paddy formation and seed filling stages. Studies on rice showed that the highest values of chlorophyll a and total chlorophyll were obtained under stress conditions while in this study, these values reduced under the

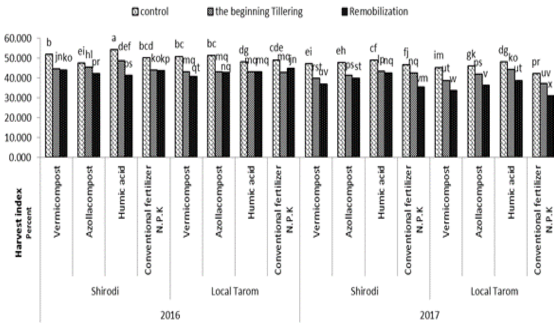

Fig. IV. The interaction of drought stress and nutritional sources , on the harvest index of rice cultivars in 2016 and 2017, according to LSD, p<0.05.

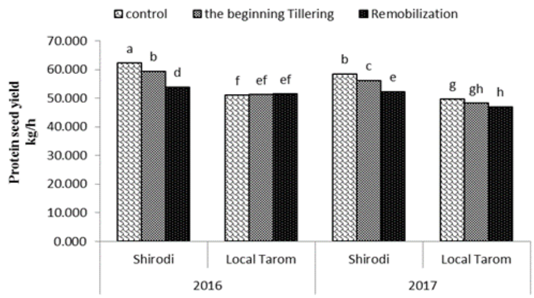

Fig. V. The interaction of drought stress on the protein seed yield of rice cultivars in 2016 and 2017, according to LSD, p<0.05.

same conditions. It seems that water shortage causes decomposing chlorophyll and glutamate, which is a precursor of chlorophyll and proline. Due to this stress, it is converted to proline and thus chlorophyll content is reduced (Hungsaprug et al., 2020; Ali et al., 2020). Also, with increasing stress and the activity of reactive oxygen species, chlorophyllase activity, and chlorophyll a sensitivity to chlorophyll b, the intensity of chlorophyll a reduction was higher (Sharma et al., 2020; Kaur et al., 2016).

Also, reduced chlorophyll under long-term stress conditions may be due to reduced nitrogen flow to tissues and changes in enzyme activities such as nitrate reductase (Lomas et al., 2004). Studies on maize have shown that chlorophyll b and total chlorophyll are reduced (Efeoglu et al., 2009). The chlorophyll content is related to the number of nutrients absorbed by the plant from the soil. Organic (vermicompost) and inorganic (chemical) fertilizers increase the content of soil nutrients, as the availability of these elements to the plant increases. The positive effect of the number of fertilization years as well as the significant interaction of this factor with vermicompost on the height and chlorophyll content of rice, was also reported in other studies (Mishra et al., 2005). Humic acid, through chelating power of elements, reducing evapotranspiration, and providing more suitable water and nutrients for the plant, can increase the production of pigments and facilitate the transfer of the photosynthetic matter of the plant (Fernández et al., 2016). Studies show that under drought stress, humic acid increases the photosynthetic activity of the plant by increasing the activity of the RuBisCO enzyme (Delfin et al., 2005).

Studies demonstrated that the rice cultivars are more sensitive at the reproductive stage, and therefore the yield is reduced under drought conditions (Ramkumar et al., 2019). Harvest index represents the physiological efficiency of crops to allocate the dry matter to the economic organs of the plant. Studies showed that manure significantly increased harvest index in maize compared to the control treatment (Farhad et al., 2009). Reduced harvest index for barley due to increased use of nitrogen fertilizers has been reported by several researchers (Assadi et al., 2020).

It seems that the reduction in protein yield under drought stress as a result of protein reaction with free radicals and the amino acid change, causes an increase in the activity of decomposing protein enzymes, reducing protein synthesis, and accumulating free amino acids (Yang et al., 2008). Reports show that foliar application of humic acid increased grain yield (Delfine et al., 2005). The use of humic acid improved plant growth, yield, grain quality and photosynthetic metabolism of wheat(Delfine et al., 2005). Protein content and protein yield increased significantly by humic acid foliar application (El-Shabrawi et al., 2015). Studies on the application of humic acid under stress conditions have shown that higher protein yield was affected by humic application due to increased availability of minerals (Ghadirnezhad Shiade et al., 2022). Based on the studies conducted, using organic fertilizers can increase the amount of grain protein and the yield of wheat protein (Sarwar et al., 2009; Majdam et al., 2015).

Conclusion

Drought caused more oxidative stress in various rice cultivars during the second year of growth than the first one. On the other hand, foliar application of humic acid could increase osmotic regulators compared with other fertilizer resources, reducing the damage caused by drought stress to some functional traits of cultivars. Humic acid, in comparison with other nutritional systems at higher levels, led to an increase in chlorophyll levels in the local Tarom cultivar compared with the Shirodi cultivar. It also caused photosynthetic stability in both cultivars with increased yield resulting in the highest yield in Shirodi cultivar in the first year. It should be noted that in the second year, significant photosynthetic radiation and a relative increase in temperature and water volume led to a reduction in yield compared with the first year.

Acknowledgments

I thank all those who helped me in the process of this research, especially the staff of the Rice Agricultural Research Center of Mazandaran Province, and also my dear friend Dr. Sadati and my dear parents for their patience.

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