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Original article

Effect of potassium chemical and biological fertilizers on biochemical traits of corn hybrids under drought stress and determination of traits affecting grain yield

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Introduction
Nowadays, corn is recognized as a nutrition seed for human, birds and some animals. Corn is considered as an energetic nutrition. It will be graded after wheat and rice among whole the cereal according to the significance and the rate of cultivation. Breeding for environmental stress is one of the most important goals in plant breeding. Among stresses, drought stress has high influencing on limitation of maize production. Potash management under water limitation condition is an important factor to obtain high grain yield of maize. . All the plants are in contact with biological fertilizer. One of the most important effects of such a biological fertilizer is the operation enhancement in the lands which are low fertility, confronting with different land disease, and strengthening the plant against drough. In general, Plants are exposed to environmental stresses. Water and Potassium availability are two major factors for crop production under different conditions. In this study, correlation and stepwise regression of biochemical traits with grain yield of corn hybrids under drought stress conditions and application of potassium chemical and biological fertilizers are investigated.

Materials and methods
This study was performed to evaluate the effects of chemical and biological potash fertilizers and drought stress Biochemical characteristics and Grain yield of *Zea mays* varieties in 2014 - 2015 in Dehloran, Iran. The experiment was conducted as split split plots in randomized complete blocks design with three replications. The treatments included drought stress (normal irrigation, cutting irrigation at 12 leaf stage and at tassel emergence) as main factor, potassium sulfate application in three levels (100% potassium sulfate, 70% potassium sulfate fertilizer with 30% fertile-2 fertilizer, and 50% potassium sulfate fertilizer with 50% fertile-2 fertilizer) as sub plots and three corn hybrids (AS71, NS640 and CORDONA) as sub sub plots. Finally, the data was analyzed by the MSTAT-C.

Results and discussion
The results of data analysis showed that the occurrence of stress had a negative effect on some biochemical traitsand and corn yield. Creating stress in the emergence stage of coronal grass compared with the stress in the 12 leaf stage, had more impact on the evaluated indicators. Consumption of biological and chemical fertilizers of potash by modifying the effects of drought stress had a positive effect on biochemical traits and grain yield. Application of 50% chemical potash+ 50 % seed incubation by Fertil-2 led to 10% increasing of kernel yield, Between studied genotypes, AS71 and NS640 showed highest (10717 kg/ha) and lowest (5887 kg/ha) means, respectively. According to interaction between treatments, it was founded that highest kernel yield (12130 kg/ha) was obtained by AS71 under optimum irrigation conditions + 50% urea fertilizer with 50% fertile-2 fertilizer treatment. Grain yield with proline content, chlorophyll a and b had a positive and significant correlation. The results of stepwise

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regression showed that the effects of chlorophyll a, proline content and catalase and superoxide dismutase enzymes activity on grain yield had a significant effect.

Conclusions

According to the results of this research and due to the extreme sensitivity of the biochemical characteristics in water stress conditions, and the relationship of these traits with grain yield, it is necessary to prevent the occurrence of water stress at critical stages of plant growth. Combined use of biological potash fertilizers with chemical potash fertilizers were more effective than chemical fertilizers and significantly increased grain yield. In general, due to the changes in the traits, supplying 50% of needed fertilizer in form of potash fertilizer combined with Barvar-2 fertilizer and AS71 in optimal irrigation conditions were selected as the best experimental treatments.

Keywords: Chlorophyll, Corn, Environmental stress, Enzymes, Fertile-2 fertilizer

Table 1. Minimum and Maximum temperature, Relative Humidity and monthly Precipitation in the Ilam region in the west of Iran in 2015.

Month	Minimum temperature (°C)	Maximum temperature (°C)	Precipitation (mm)	Minimum RH (%)	Maximum RH (%)
August	33.26	48.82	1	11.32	29.00
September	31.75	44.72	0	14.39	31.23
October	25.87	38.79	1.5	17.97	37.70
November	15.97	25.33	184.1	47.23	85.40
December	9.15	19.79	58.5	42.83	85.00

Table 2. Physico-chemical properties of the soil of the experimental field

Soil depth	EC	pH	Organic carbon	K	Soil texture analysis			
					Clay	Silt	Sand	Texture
cm	$dS.m^{-1}$		%	mg/kg	---------- % ---------			
0-30	3.7	7.51	0.73	128	14	28	5	Loam sandy

Table 3. Analysis of variance biochemical character and grain yield of corn hybrids under the conditions of application of potassium fertilizers and drought Stress.

		ms						
S.O.V	df	Grain yield	Grain Protein	Chl. a	Chl. b	Proline content	Superoxide dismutase Enzyme	Catalase Enzyme
Block	2	4860.90	0.0005	0.0001	0.0001	0.006	91.15	0.019
Stress (S)	2	23591177.36**	9.54**	7.51**	0.51**	0.29**	248462.77**	2204.26**
error	4	3069.10	0.0006	0.0005	0.0002	0.003	99.02	0.014
Fertilizer (F)	2	6724400.18**	3.96**	0.43**	0.016**	0.008**	12284.89**	473.38**
S*F	4	44079.90**	0.77**	0.11**	0.05**	0.006**	1636.51**	14.72**
error	12	3314.10	0.00016	0.00001	0.0001	0.003	98.98	0.23
Corn hybrids (H)	2	178000206.38**	0.87**	0.83**	0.29**	0.17**	54009.78**	2048.32**
S*H	4	2820945.07**	0.021**	0.001**	0.006**	0.022**	1061.06**	201.58**
F*H	4	225953.90**	0.021**	0.024**	0.004**	0.008**	216.52**	5.90**
S*F*H	8	151481.87**	0.003**	0.014**	0.002**	0.007*	586.98**	5.34**
error	36	4607.25	0.00025	0.0005	0.0005	0.003	99.18	0.32
CV (%)	-	*1.79*	*0.47*	*2.47*	*1.03*	*0.54*	*1.25*	*0.36*

ns, * and **: Non-significant and significant at the 5% and 1% levels of probability respectively.

Table 4. The effect of interactions between Drought Stress and Fertilizer and corn hybrids on Biochemical character and Grain yield.

Stress	K	corn hybrids	Grain yield (kg.ha $^{-1}$)	Grain Protein (%)	Chlorophyll a	Chlorophyll b	Proline content	Catalase Enzyme	Superoxide dismutase Enzyme
		H1§	11860^{b}	9.36^{q}	1.93^{f}	0.855^{e}	0.0194^{d-g}	140.8^{r}	755.2^{gh}
	F1	H2	6161^{o}	9.10^{s}	1.85^{g}	0.709^{hi}	0.015^{g}	130.5^{v}	688.2^{l}
		H3	9013^{j}	9.28^{r}	1.95^{ef}	0.822^{e}	0.0177^{fg}	138.4^{s}	732.2^{ij}
		H1	12020^{a}	10.66^{hi}	2.57^{a}	1.149^{a}	0.0208^{c-g}	138.6^{s}	749.4^{ghi}
S1†	F2	H2	6725^{n}	10.34^{n}	2.19^{d}	0.816^{e}	0.0173^{fg}	126.8^{w}	664.6^{m}
		H3	10540^{d}	10.48^{l}	2.42^{c}	1.083^{b}	0.0188^{d-g}	133.3^{u}	729.9^{j}
		H1	12130^{a}	10.64^{i}	2.48^{b}	0.992^{c}	0.0206^{c-g}	135.8^{t}	710.8^{k}
	F3	H2	6684^{n}	10.16^{o}	1.97^{e}	0.767^{f}	0.0168^{g}	123.5^{x}	644.4^{n}
		H3	10510^{d}	10.35^{n}	2.45^{bc}	0.939^{d}	0.0186^{efg}	131.3^{v}	689.6^{l}
		H1	10320^{e}	10.38^{m}	1.67^{j}	0.770^{f}	0.0247^{cde}	165.8^{i}	831.5^{e}
	F1	H2	5069^{r}	10.12^{p}	1.35^{mn}	0.640^{j}	0.0178^{fg}	156.4^{n}	759.6^{g}
		H3	8784^{k}	10.34^{n}	1.61^{k}	0.757^{fg}	0.0235^{c-f}	163.8^{j}	824.9^{e}
		H1	11080^{c}	10.68^{h}	1.76^{h}	0.739^{fgh}	0.0259^{bc}	162.6^{k}	825.4^{e}
S2	F2	H2	5830^{p}	10.35^{n}	1.47^{l}	0.593^{k}	0.0186^{efg}	150.7^{p}	740.2^{hij}
		H3	9908^{f}	10.47^{j}	1.76^{h}	0.716^{ghi}	0.0249^{cde}	160.3^{l}	824.5^{e}
		H1	11100^{c}	10.68^{h}	1.69^{ij}	0.735^{fgh}	0.0264^{bc}	158.8^{m}	795.0^{f}
	F3	H2	5830^{p}	10.34^{n}	1.39^{m}	0.583^{k}	0.0194^{d-g}	142.8^{q}	727.8^{j}
		H3	9908^{f}	10.54^{k}	1.71^{i}	0.706^{hi}	0.0252^{cd}	153.4^{o}	781.7^{f}
		H1	8198^{m}	10.96^{f}	1.18^{q}	0.732^{fghi}	0.0333^{a}	202.7^{a}	972.4^{a}
	F1	H2	4432^{s}	10.65^{i}	0.90^{t}	0.478^{m}	0.0204^{c-g}	177.9^{f}	864.8^{d}
		H3	8403^{l}	10.92^{g}	1.13^{r}	0.722^{ghi}	0.0316^{ab}	199.9^{c}	957.5^{a}
		H1	9275^{hi}	11.44^{c}	1.33^{no}	0.709^{hi}	0.0358^{a}	201^{b}	938.8^{b}
S3	F2	H2	5306^{q}	11.10^{e}	0.97^{s}	0.522^{l}	0.0215^{c-g}	173.9^{g}	827.5^{e}
		H3	9177^{i}	11.42^{c}	1.30^{op}	0.689^{i}	0.0352^{a}	200^{c}	870.7^{d}
		H1	9319^{gh}	11.69^{a}	1.32^{nop}	0.711^{hi}	0.0347^{a}	194.6^{d}	921.4^{c}
	F3	H2	5298^{q}	11.15^{d}	0.95^{s}	0.543^{l}	0.0211^{c-g}	170.1^{h}	816.1^{e}
		H3	9420^{g}	11.56^{b}	1.28^{p}	0.695^{hi}	0.0345^{a}	190.9^{e}	917.4^{c}

† S1: (control), S2: (Water stress with once irrigation cut-off in 12 leaf stage), S3: (Water stress with once irrigation cut-off in flowering stage).

‡ F1: (100% chemical potash), F2: (70% chemical potash+ 30% seed incubation by Fertil-2), F3: (50% chemical potash+ 50% seed incubation by Fertil-2)

§ H1: AS71 hybrid, H2: NS640 hybrid, H3: CORDONA hybrid

Means followed by the same letters in each column are not significantly different at 1% and 5% levels, according to Duncan's Multiple Range Test.

Table 5. Correlation coefficients of measured traits

	Traits	1	2	3	4	5	6	7
1	Grain yield	1						
2	Grain Protein	0.04 ^{ns}	1					
3	Chlorophyll a	0.60**	-0.46*	1				
4	Chlorophyll b	0.74**	-0.25*	0.89**	1			
5	Proline content	0.28*	0.78**	-0.47**	-0.17 ^{ns}	1		
6	Catalase Enzyme	-0.08 ^{ns}	0.74**	-0.77**	-0.46**	0.90**	1	
7	Superoxide dismutase Enzyme	-0.05 ^{ns}	0.69**	-0.69**	-0.35**	0.88**	·0.97**	1

^{ns}, * and **: Not significant, significant at 5% and 1% probability levels, respectively.

Table 6. The results of stepwise regression analysis with yield as dependent and other traits as independent variables in corn hybrids under Drought stress condition and different fertilizer combinations.

	First step	Second step	Third step	Fourth step	Fifth step	Sixth step
Variables Entered	**Chlorophyll b**	**Proline content**	**Chlorophyll a**	**-**	**Superoxide dismutase Enzyme**	**Catalase Enzyme**
Variables Removed	–	–	–	**Chlorophyll b**	–	–
F - value	97.84	99.93	88.76	130.76	103.38	85.86
r- Square	0.55	0.72	0.77	0.76	0.80	0.82

Table 7. Regression equation coefficient between different traits and yield corn hybrids under Drought stress condition and different fertilizer combinations

Intercept	Proline content	Chlorophyll a	Superoxide dismutase Enzyme	Catalase Enzyme
-9386.31	248351.76	4159.66	23.24	83.18