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THE EFFECT OF INTEGRATED FERTILIZATION ON THE GROWTH AND YIELD OF SOME GENETIC VARIETIES OF YELLOW CORN UNDER WATER STRESS

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ABSTRACT

A field experiment was conducted in Faculty of Agriculture, University of Kufa fields in a silty-clay soil during 2019-2020 seasons to study the effect of integrated fertilization, genetic varieties and irrigation periods on yield and growth of yellow corn. RCBD designed was used distribute treatments randomly in a factorial experiment. The first factor was the complete recommended dose of integrated fertilizer (N 300kg.h^{-1}, P 80kg.h^{-1}and K 80kg.h^{-1}) as A1, half recommended dose of integrated fertilizer with bacterial fertilizer (*Azospirillum, Azotobacter*) and organic fertilization at 4 ton.h^{-1} as A2 and half recommended dose of integrated fertilizer with fungal fertilizer (*Trichoderma harzianum Rifai*) with organic fertilization at 4 ton.h^{-1} as A3. The second and third factors were the genetic varieties of yellow corn (Sara, 5018) as B1, B2 and irrigation periods of 7, 10 and 14 days as a C1, C2 and C3 respectively. Results showed that there was significant effect of integrated fertilization, genetic varieties, irrigation periods and their interactions on the increasing the readiness of some nutrients in soil and the content of these nutrients in plant which led to increase growth and yield. A2 treatment was exceled A1 significantly in plant height, chlorophyll concentration, leaf area, dry weight, the weight of 500 grain, the average of grain number in each cob corn and grain yield (3.88, 15.5, 18.30, 22.64, 10.28, 30.66 and 8.14% respectively). Results also showed that the 5018 genetic variety was exceled Sara variety in some studied traits (plant height, chlorophyll concentration, leaf area and grain yield) by 2.98, 11.5, 3.27 and 5.30% respectively. The different time period of irrigation was affected the readiness of N, P and K elements in soil and plant when 7 day period was exceled 10 and 14 day periods and decreased nitrogen, phosphorous and potassium concentration in soil by 5.35, 10.48%, 19.66, 38.66%, 6.50 and 10.52% respectively and by 39.67, 14.05%, 4.92, 10.36%, 8.08, 16.89% in plant leafs respectively. The interaction treatment between A2, B2 and C1 was exceled A1, B1 and C3 treatment and increase the average of plant height, leaf area, dry weight and grain yield by 17.68, 47.61, 80.89 and 24.49% respectively.

***Keywords*:** integrated fertilization, yellow corn, genetic varieties, water stress.

Introduction

Yellow corn (*Zea mays* L.) is one of main grain crops worldwide and ranked third in terms of importance after wheat and rice (FAO, 2012). Recent studies have shown the value of adding nutrients to the soil to make it ready for plants which considered an economical and sustainable method to avoid the shortage of these nutrients in the soil (Zhang Zuo, 2011). There are many factors that affect the readiness of elements in soil for instance, the Iraqi soil is characterized by its low content of organic matter, high pH and it contains a high percentage of carbonate minerals, in addition to excessive use of chemical fertilizers, low water levels and non-use of modern technologies in agriculture. Therefore, there is a growing interest in developing an integrated plant nutrition system (IPNS) that maintains and enhances soil productivity through the balanced use of all nutrient sources, including chemical, organic and biological fertilizers. Whereas, organic fertilizers are the effective source of micro-organism activity in soil as well as they has their role in increasing nutrient readiness (Al-Gothary and Ali, 2011). Biological fertilizers influence the growth and yield due to the role of nitrogen and different plant growth regulators that released by microorganisms which increase root system and considered as a partial alternative to the use of mineral fertilizers (Hassan, 2015) as well as the different response of plant varieties to different fertilization treatments depending on plant genotype (Al-Hilfy and Al-Tememi, 2017).

Thus, the current research aims to study the combined effect of integrated fertilization and plant genotype of yellow corn on the readiness of nutrients in soil which absorbed by plant under different irrigations conditions, and also study the response of two yellow corn varieties to biological, organic and chemical fertilization using different irrigation periods and its effect on yield and nutrient absorption.

Materials and Methods

A field experiment was carried out in Faculty of Agriculture, University of Kufa fields during 2019-2020 season in a silty-clay soil classified by modern American classification as a Typic Torrifluvent (Soil Survey Staff, 2006). RCBD design was used distribute 18 treatments with three replicates and 54 experimental units randomly in a factorial experiment. Field was prepared by tilling and levelling the soil using tipping plow then the field was divided into 2.3m for each experimental unit and 2.5m distance was left between plots to avoid the transfer of fertilizers and control irrigation water between treatments. Random samples of soil were taken from 0-30cm depth of field soil surface and dried up, grinded, sifted using 2mm sieve then mixed together after that, the chemical and physical characteristics of these samples were analysed.

Integrated fertilization

Three levels of integrated fertilization were used as follows: The complete recommended dose of integrated fertilizer (Urea 46% N 300kg.h^{-1}, Triple super phosphate 20% P 80kg.h^{-1} and Potassium sulfate 41% K 80kg.h^{-1}) as control treatment (A1), half recommended dose of fertilization with bacterial fertilizer (*Azospirillum, Azotobacter*) and organic fertilization at 4 ton.h^{-1} as A2 and half recommended dose of fertilization with fungal fertilizer (*Trichoderma harzianum Rifai*) with organic fertilization at 4 ton.h^{-1} as A3.

Cultivars

Two varieties of yellow corn seeds (Sara, 5018) were used in this study.

Irrigation dates

Plants were irrigated in three different dates 7, 10 and 14 days.

Three seeds of Sara and 5018 varieties were planted in 15/7/2019 in four lines for each experimental unit inside plots with 75cm distance between each line and 20cm between each planted seeds. After two weeks of seedlings emergence, plants were thinned to one plant.

Table 1 : Chemical, physical and biological characteristics of field soil before planting.

pH 1:1		7.48	
EC 1:1		2.19	dS/m^{-1}
CEC		26.3	Cmolc/kg^{-1}
Organic material		11.4	g/kg^{-1}
Nutrients	Nitrogen	38.07	mg/kg soil^{-1}
	Phosphorous	18.2	
	Potassium	245	
Soil texture		Silty-clay	
Soil separates	Clay	423	g/kg soil^{-1}
	Sand	380	
	Silt	197	
Soil bulk density		1.29	Mg/m^{-1}
Field capacity		27.5	g/kg^{-1}
Biological estimation CFU g soil^{-1}	Total bacteria		3.94 x 10^6
	Total fungi		4.21 x 10^5

Measurement of growth traits

Plant height (cm)

5 plants were taken randomly from each experimental unit and the height was measured from the surface of soil until the basis of flower then the mean of plant height was calculated.

Leaf area (m^2.plant^{-1})

5 plants were taken randomly from each experimental unit (the second line), and leaf area was calculated as follows: leaf area = square of under cob corn leaf length were 0.65 if the number of leafs 11-13 or 0.75 if the leafs number 14-16.

Measurement of chlorophyll (mg.plant^{-1})

Chlorophyll a and b was estimated using Mackinney, (1941) method when 1g of cob corn leaf was taken and cut into small pieces then crushed in a ceramic bowl with 5-10ml of 85% acetone. The filtrate solution was separated from the supernatant by centrifuge for 10 minutes and the extraction was repeated until the green color disappeared. The extracted solution was put 10-25ml tubes covered by opaque paper to avoid oxidation by light then the volume was completed by adding acetone and the absorbance was measured using spectrophotometer at 645 and 663 nanometer.

Measurement of yield traits

500 grain was taken from five plants randomly at 12% moisture then the number of grain and its weight were calculated.

Grain yield (Mg.h^{-1})

Total yield was calculated after harvesting all experimental units in addition to the five plants which were taken previously then the average of each plant yield was calculated (Pendleton and Seif, 1961).

Results and Discussion

Plant height (cm)

Results of Table 2 showed the effect of adding integrated fertilization, yellow corn varieties and irrigation periods on the average of plant height. Adding integrated fertilizer was affected significantly the average of plant height and gave 182.80, 189.89 and 184.02 respectively at A1, A2 and A3 with increasing ratio 3.88% and 0,67% for A2 and A3 in comparison with A1 (control treatment). Results also showed that bacterial fertilization (*Azospirillum, Azotobacter*) + organic fertilization increased plant height, this because the bacteria produce growth regulators such as IAA which has a major role in cell elongation and reflect positively on plant height and partially compensated chemical fertilization which is important economically and ecologically. These results are consistent with the findings of

Hassan, (2015) and Al-Bahrany, (2015) who found that adding biological and organic fertilization increased yellow corn height.

Table 2 showed that 5018 genotype gave the highest plant height value 188.30cm compare to 182.85cm in Sara genotype with increasing ratio amounted 2.98% and this increasing may occurred due to the ability of 5018 genotype to form a larger vegetative growth. Chiad and Elsahookie, (2011) reported that different genotypes of yellow corn were differed in its requirements of nutrients and tolerance to non-biological stresses. The long time between irrigation periods in early stages of plant growth led to significant decreasing in the average of plant height when recorded 193.31, 184.62 and 178.79cm for irrigation periods C1, C2 and C3 respectively. Exposure of plants to water stress during vegetative growth stage was reflected negatively and inhibit the average of cell division which result in decreasing plant height, and the water stress with high temperature made photometric breakdown of oxygen which led to low plant height. These results are in agreement with Ibrahim Kandi, (2007) and Zaidi et al., (2008) who mentioned decreasing in the height of yellow corn plants when the time period between each irrigation increase.

Leaf area ($m^2.plant^{-1}$)

Table 3 showed the effect of integrated fertilization, genetic varieties and irrigation periods and their interaction on the average of leaf area of yellow corn. Leaf is one of the main parts of plant and play a major role in producing grain yield, thus, the measurement of leaf area is considered as one of important physiological trait which effect plant growth. Adding integrated fertilization was affected the average of leaf area significantly when reached 0.377, 0.446 and 0.395 $m^2.plant^{-1}$ at the adding levels A1, A2 and A3 respectively with increasing ratio of 18.30%, 4.77% at A2 and A3 compare to A1. The increasing in leaf area may occurred in different treatments when adding (*Azospirillum, Azotobacter*) + organic fertilization and the half recommended dose of fertilizers due to the role of adding fertilizers in the readiness of nutrients in soil which led to increase the surface area of leaf. Results also showed that 5018 genotype was significantly exceled in leaf area and gave $0.411m^2.plant^{-1}$ in comparison with $0.398m^2.plant^{-1}$ in Sara genotype with increasing ratio of 3.27%. The reason for this increasing is due to 5018 genotype has more leaf area and stay green for long time and these findings are in agreement with Al-Khaleel, (2011) who reported that different genotypes of yellow corn were differed in its requirements of nutrients and tolerance to non-biological stresses. Exposure of plants to water stress during vegetative growth stage was decreased significantly and the average of leaf area reached 0.450, 0.405 and $0.359m^2.plant^{-1}$ for C1, C2 and C3 respectively. This is due to the reduction in growth processes represented by the division and expansion of plant cells, as the reduction of leaf area is one of the mechanisms that plants resorts to it to resist the low water content. The decrease in leaf area may occur in response to drought by reducing the emergence of young leafs and accelerating plant aging and leaf fall (Prasad et al., 2008) and the results of current study are consistent with Verma and Verma, (2010) who found big decreasing in yellow corn leaf area when exposure to long time between irrigations.

Total concentration of chlorophyll ($m^2.plant^{-1}$)

Statistical analysis results showed the significant effect of integrated fertilization, genetic varieties and irrigation periods and their interaction on total chlorophyll content in the leafs of yellow corn plants (Table 4). There was significant effect of adding integrated fertilization on chlorophyll concentration of yellow corn when it was amounted 1.36, 1.43 and $1.42mg.g^{-1}$ at A1, A2 and A3 levels respectively by achieving 15.5% and 4.41% of increasing in A2 and A3 compare to A1. The increasing in total chlorophyll concentration and chlorophyll type a and b in different treatments when adding bacterial + organic fertilization and half of recommended dose occur due to take enough amount of nutrients which led to improve root system growth and metabolism and finally building chlorophyll. The organic fertilizer provides energy sources such as carbon and some other nutrients which increase microorganism's activity and led to readiness of nutrients to plant and absorb nitrogen, magnesium that considered the main element of building chlorophyll (Al-Bahrany, 2015).

Results also showed that genetic variety was significantly affecting the concentration of total chlorophyll when reached 1.37 and $1.44mg.plant^{-1}$ at B1 and B2 respectively as the 5018 genotype was grater in chlorophyll concentration by 11.5% increasing compare to Sara genotype. The increasing of chlorophyll content depends on the increasing in carbon metabolism, breathing and producing carbohydrates (Chiad and Elsahookie, 2011; Bloom *et al*., 2010).

Exposure of plants to water stress during vegetative growth stage was decreased significantly and the average of total chlorophyll concentration in yellow corn plants recording 1.56, 1.41 and $1.24mg.plant^{-1}$ for C1, C2 and C3 respectively. The long periods between irrigations during growth stages of plant decreased total chlorophyll and a, b types in plant leafs and this reduction was increased when moisture content decreased in soil. The reason for that is the reducing of leaf water was accelerating plant aging and led to decrease photosynthesis to reduce opening of stomata in leafs, it also reduces the production of plant pigments including chlorophyll (Al-Salmany and Al-Musawy, 2008; Verma and Verma, 2010). Rafiee, (2012) found that the increasing in irrigation periods was significantly decreased chlorophyll content and carbohydrates.

The total of dry matter yield ($Mg.h^{-1}$)

The total yield of a plant expresses the amount of nutrients accumulated in its parts above the soil surface. Results of Table 5 showed the effect of integrated fertilization, genetic varieties and irrigation periods and their interaction on the total yield of yellow corn. The adding of integrated fertilization was increased yield significantly when it reached 13.69, 16.79 and 15.05 $Mg.h^{-1}$ at A1, A2 and A3 respectively and achieved an increasing by 22,64% and 9.93% at A2 and A3 compare to A1. The increasing in total yield in different treatments when adding fungal + organic fertilization and half of recommended dose confirms the possibility of reducing the use of mineral fertilizers by half and thus avoiding the possibility of plant damage as a result to high levels of these fertilizers and at the same time reduce cost, water pollution and give good yield. The interaction between mineral, organic and biological fertilization from different sources led to increase the vegetative growth and this is in agreement with Al-Gothary and Ali, (2011) and Al-Khaleel, (2011) findings. The 5018 genotype was gave the highest value of yield 15.70$Mg.h^{-1}$ compare to 14.65 in Sara genotype with increasing ratio 7.17% as the 5018 has more leaf area which result in increasing total yield of plant (Elsahookie, 1985). The different genotypes of yellow corn were differed in its requirements of nutrients and tolerance to non-biological stresses (Jnno, 2008).

The long periods between irrigations were significantly affected dry material in yellow corn plant when it recorded 17.74, 15.05 and 12.75$Mg.h^{-1}$ for C1, C2 and C3 respectively. The decreasing ratio reached 39.21% and 66.90% for C2 and C3 compare to C1. The provision of the water requirements of the plant led to an increase in the total yield, also good humidity allowed the crop to complete growth which is clearly indicated by increasing leaf area, dry material, grain yield, protein synthesis and increasing protoplasm. Also, physiological processes such as photosynthesis, respiration, absorption of nutrients and transfer food inside plant were improved. The long periods between irrigations was decreased total yield due to the reduction of water during vegetative growth stages that cause decreasing in physiological activity particularly photosynthesis which reflect in decreasing the absorption of nutrients and water (Doss *et al.*, 1964; Abdelmajid *et al.*, 1982; Essa, 2016).

Grain yield ($Mg.h^{-1}$)

The grain yield per unit area is the primary goal pursued by producer and it is an indicator of the yield of a single plant, in addition, it considered the most important field measure that gives the final evaluation of the variety and growth factors (Dwyer and Tollenaa, 1989). Results of Table 6 showed the effect of integrated fertilization, genetic varieties and irrigation periods and their interaction on grain yield of yellow corn. Adding integrated fertilization was significantly increased grain yield and give 8.97, 9.70 and 9.23 $Mg.h^{-1}$ at A1, A2 and A3 respectively and achieved an increasing ratio amounted 8.14% and 2.90% at A2 and A3 levels compare to A1 level. It can be noticed that bacterial + organic fertilization and half of recommended dose was partially compensated chemical fertilization which is important economically and ecologically and this occur because the role of bacteria in the increasing the growth, activate and develop root system of plant which increase the ability of plant to take advantage from secretions of microorganisms and the increasing and readiness of nutrients which reflect in increasing grain yield and the length of time to full the grain. These results are consistent with the findings of Hassan, (2015), Al-Bahrany, (2015), Abd and Elsahookie, (2008) and Al-Khaleel, (2011).

Results of Table 6 also showed that 5018 genotype was significantly exceled and gave highest value of grain yield amounted 9.54$Mg.h^{-1}$ compare to 9.06 in Sara genotype with an increasing ratio 30.5%. This increasing may occur due to the big leaf area of 5018 genotype has high efficiency in utilizing the light falling on it which reflect in increasing grain yield, number and the length of time to full the grain in comparison with Sara genotype (Egli, 1998).

The long periods between irrigations were significantly affected yellow corn grain yield when recorded 9.74, 9.32 and 8.85 $Mg.h^{-1}$ for C1, C2 and C3 respectively and the decreasing ratio was reached 50.4% and 10.06% for C2 and C3 compare to C1. A reduction was occurred in the yield of yellow corn as a result of decreasing water content of soil which led to emergence of deficiency symptoms of elements on plant. The reason for that is plant roots go deep into the soil and reach poor-nutrients layers of soil. The grain filling stage is the most sensitive stage to the reduction of water and exposing of plant to water stress during grain filling was not significant on yield in current study due to insensitivity of yellow corn during this stage (Unger, 1988; Mahanna, 2002; Payero *et al.*, 2006).

Table 2 : The effect of integrated fertilization, genetic varieties and irrigation periods on yellow corn plants height (cm).

Average	Irrigation periods C			Genetic variety B	Integrated fertilization A
	C1	C2	C3		
179.92	185.33	180.23	174.20	B1	A1
184.63	192.90	182.43	178.56	B2	
182.28	189.12	181.33	176.38	Average	
186.30	194.80	185.33	178.76	B1	A2
193.49	205.00	193.27	182.20	B2	
189.89	199.9	189.3	180.48	Average	
181.28	188.83	180.07	174.93	B1	A3
184.72	192.83	186.40	174.94	B2	
183	190.83	183.24	174.94	Average	

A*B*C	C			B		A			Analysis of variance
	C3	C2	C1	B2	B1	A3	A2	A1	
	178.79	**184.62**	**193.31**	**188.30**	**182.85**	**184.02**	**189.89**	**182.80**	**Mean**
6.191	**2.367**			**1.933**		**2.367**			**L.S.D 0.05**

Table 3 : The effect of integrated fertilization, genetic varieties and irrigation periods on the yellow corn leaf area ($m^2.plant^{-1}$).

Average	Irrigation periods C			Genetic variety B	Integrated fertilization A
	C1	C2	C3		
0.363	0.386	0.368	0.334	B1	A1
0.383	0.459	0.339	0.350	B2	
0.373	0.423	0.354	0.342	Average	
0.439	0.488	0.465	0.365	B1	A2
0.430	0.493	0.455	0.343	B2	
0.435	0.490	0.460	0.354	Average	
0.346	0.311	0.378	0.349	B1	A3
0.426	0.445	0.423	0.410	B2	
0.286	0.379	0.401	0.378	Average	

A*B*C	C			B		A			Analysis of variance
	C3	C2	C1	B2	B1	A3	A2	A1	
	0.359	0.405	0.450	0.411	0.398	0.395	0.446	0.377	Mean
0.0355	0.0134			0.0109		0.0134			L.S.D 0.05

Table 4 : The effect of integrated fertilization, genetic varieties and irrigation periods on the concentration of total chlorophyll in yellow corn plant ($mg.plant^{-1}$ fresh weight)

Average	Irrigation periods C			Genetic variety B	Integrated fertilization A
	C1	C2	C3		
1.32	1.48	1.33	1.16	B1	A1
1.39	1.57	1.41	1.20	B2	
1.36	1.53	1.37	1.18	Average	
1.43	1.58	1.41	1.29	B1	A2
1.45	1.64	1.44	1.26	B2	
1.44	1.61	1.43	1.28	Average	
1.35	1.52	1.35	1.18	B1	A3
1.48	1.61	1.50	1.33	B2	
1.42	1.57	1.43	1.26	Average	

A*B*C	C			B		A			Analysis of variance
	C3	C2	C1	B2	B1	A3	A2	A1	
	1.24	1.41	1.56	1.44	1.37	1.42	1.43	1.36	Mean
0.0481	0.01964			0.01603		0.01964			L.S.D 0.05

Table 5 : The effect of integrated fertilization, genetic varieties and irrigation periods on the total of dry matter yield ($Mg.h^{-1}$).

Average	Irrigation periods C			Genetic variety B	Integrated fertilization A
	C1	C2	C3		
13.21	15.17	13.21	11.25	B1	A1
14.18	16.26	14.16	12.13	B2	
13.70	15.72	13.69	11.69	Average	
16.22	19.26	16.19	13.21	B1	A2
17.36	20.35	17.30	14.44	B2	
16.79	19.81	16.75	13.83	Average	
14.55	17.21	14.20	12.23	B1	A3
15.57	18.23	15.23	13.24	B2	
15.06	17.72	14.74	12.74	Average	

A*B*C	C			B		A			Analysis of variance
	C3	C2	C1	B2	B1	A3	A2	A1	
	12.75	15.05	17.74	15.70	14.65	15.05	16.79	13.69	Mean
0.154	0.0477			0.039		0.0477			L.S.D 0.05

Table 6 : The effect of integrated fertilization, genetic varieties and irrigation periods on grain yield of yellow corn ($Mg.h^{-1}$).

Average	Irrigation periods C			Genetic variety B	Integrated fertilization A
	C1	C2	C3		
8.71	9.21	8.62	8.29	B1	A1
9.42	9.77	9.31	8.64	B2	
8.98	9.49	8.97	8.47	Average	
9.55	9.94	9.68	9.02	B1	A2
9.86	10.32	9.90	9.36	B2	
9.71	10.13	9.79	9.19	Average	
8.91	9.33	9.12	8.29	B1	A3
9.51	9.86	9.28	9.38	B2	
9.21	9.60	9.20	8.84	Average	

A*B*C	C			B		A			Analysis of variance
	C3	C2	C1	B2	B1	A3	A2	A1	
	8.846	**9.317**	**9.736**	**9.535**	**9.064**	**9.226**	**9.703**	**8.970**	**Mean**
0.329	**0.119**			**0.0975**		**0.119**			**L.S.D 0.05**

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