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Evaluation Effect of Macro and Micro Nutritional Elements on Quantitative and Qualitative Characteristics of Oat Crop (*Avena sativa* L.)

Moslem Monjezi-Zadeh, Habibolah Roshanfekr, Payman Hassibi*, Behzad Sorkhi

Department of Agronomy and Plant Breeding, Faculty of Agriculture, Shahid Chamran University, Ahvaz, Iran.

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ABSTRACT

In order to assessment the effect of micro and macro nutrients on agro physiological traits of oat crop a research was conducted via split plot experiment based on randomized complete block design with three replications at Agricultural Research Station, Faculty of Agriculture, Shahid Chamran University of Ahvaz, along 2013-2014. The main factor included different complex of macro and micro nutrient elements at two level [F_1: application 114 $kg.ha^{-1}$ nitrogen from 46% source of urea, application 16.8 $kg.ha^{-1}$ phosphorus from the source of super phosphate, 29.1 $kg.ha^{-1}$ potassium from the source of potassium sulfate; F_2: application of macro elements (N, P, K) along with a mixture of micro elements contain 0.8 $kg.ha^{-1}$ iron, 0.88 $kg.ha^{-1}$ zinc, molybdenum 0.1 $kg.ha^{-1}$, copper 0.2 $kg.ha^{-1}$, boron 0.1 $kg.ha^{-1}$ and manganese 2.0 $kg.ha^{-1}$]. Sub-factor consisted of four genotypes (G_1, G_2, G_3 and G_4) of oat crop. According result of analysis of variance effect of different fertilizer management, genotypes and interaction effect of treatments on all measured traits (instead ash concentration) was significant at 1% probability level. Assessment mean comparison result of interaction effect of treatments showed maximum amount of all measured traits (instead ash concentration) concentration was noted for F_2G_3 and lowest one belonged to F_1G_2 treatment, it could be concluded F_2G_3 treatment has positive effect on all the characteristics under study and increases the seed yield.

Keywords*:* *Chlorophyll, Dry matter, Harvest index, Starch.*

***Corresponding Author:** Payman Hassibi ✉ p.hassibi@scu.ac.ir

INTRODUCTION

Oat is one of the important forage cereals in temperate areas and economically is ranked as one of the eight important crops in the world (Walsh *et al*., 2003). Oats are mainly grown in temperate and cool sub-tropical environments (Dost, 1997; Bhatti *et al*., 1992). Genetic variation among genotypes is very important for plant breeding (Talebi *et al*., 2009). Oats are largely used in cattle breeding and have occurred in human diet for a long time, mainly as oatmeal and rolled oats, but the positive physiological effects of oat products were recognized just rather recently (Pirjo *et al*., 2003). Oats are a rich source of soluble fiber, well-balanced proteins, several vitamins and the minerals essential for the human health (Charalampopoulos *et al*., 2002; Esposito *et al*., 2005). In addition to their importance in the diet, oats antioxidants may also contribute to the stability and the taste of food products (Peterson, 2001). Oats provide more protein, fiber, iron and zinc than other whole grains (Sangwan *et al*., 2014). Oat is regarded as most important cereal crop throughout the world and used as an important source of the essential nutrients for the human consumption (Boczkoswka and Tarczyk, 2013). Oat (*Avena sativa* L.) is a highly important and economic crop and in world, it ranks sixth in cereal production after wheat, rice, maize, barley and sorghum (FAO, 2012). The genus *Avena* belongs to the Poaceae family. It is also used as multipurpose crop for grain, pasture and forage. It is considered to be one of the best dual purpose cereal crops that fit well into the platter of human and cattle as well. For oats to classify as a dual purpose crop, it should have high green fodder and grain yield harvested from the same crop where the first cut is taken for fodder and subsequently the crop is harvested at the time of grain maturity. Increased oat consumption is often enhanced due to nutritional attributes including antioxidants and high soluble fiber (Rasane *et al.,* 2015). Oats is good source of antioxidants like *avena nthramides*, alpha- tocopherol, alpha-tocotrienol and also total dietary fiber including beta-glucans (Oliver *et al.,* 2010). Latest research have analyzed the oat consumption effects on health and benefits on health are beyond reducing cardio vascular risk like diabetes, controls blood-pressure levels, lowers blood cholesterol concentrations, controls and maintains weight and gastro-intestinal health (Clemens, 2014). Bergen *et al*. (1991) reported that the optimal stage of harvest for barley and oat to maximize forage yield and quality traits is the soft-dough stage. Although oat forage yield nearly doubles from the boot to hard dough stage, ADF (acid detergent fiber) and NDF (neutral detergent fiber) values with maturity increase and forage quality rapidly declines (Mut *et al*., 2006). Chapko *et al*. (1991) indicated that distinctive breeding program for forage quality cannot be continued and then grain oat genotypes may satisfy forage needs. Most of the previous studies were showed that late-maturing genotypes had higher forage yield than early-maturing genotypes (Riveland *et al*., 1977; Chapko *et al*., 1991; Aydin *et al*., 2010). Before embarking on a breeding program, assessment of germ plasm collection for key agronomic traits, seed quality and defensive traits, flowering, maturity, plant height, protein content, oil content, primary branches, number of capsules, resistances to pests and diseases, drought and cold tolerances and other worthwhile traits is important (Krull and Berlaug, 1970). Stuthman and Marten (1972), Chapko *et al*. (1991) and Aydın *et al*. (2010), however, reported a negative association between forage yield and quality. Stage of maturity at harvest for forage has the greatest effect on forage yield and quality of cereals (Cherney and Marten, 1982; Bergen *et al*., 1991; Juskiw *et al*., 2000). Mineral fertilizers played a great role towards improving crop yields but main constraint in achieving proven crop potential is imbalanced use of fertilizers, particularly low use of P as compared to N. The optimum rates of P application play a vital role in improving yields of most crops (Cisar *et al*., 1992). Application of chemical fertilizers has been almost a common method for the improvement of crop productivity over the last century. Strong historical association could be found between crop yields and nitrogen fertilizer (Zhang *et al*., 2015). Nitrogen is one of the major macronutrient leading to increased vegetative and reproductive growth (Hawkesford, 2014). Macro and micronutrients deficiencies have been reported for different soils and crops (Hussain *et al*., 2006). Six micronutrients that is, Mn, Fe, Cu, Zn, B and Mo are known to be required for all higher plants (Welch *et al*., 1995). Results of a broad-based study conducted in 815 irrigated wheat growing regions of Iran between 1995 and 1996 showed that addition of each micronutrient (Fe, Zn, Cu, and B) or a combination of Fe + Zn + Cu + B to NPK fertilizer increased grain yield (Malakouti, 2000). Abd El-Wahab (2008) stated that micronutrients such as Fe, Mn and Zn have important roles in plant growth and yield of aromatic and medicinal plants. Ozcan *et al*. (2017) by evaluate macro and micro element contents of oat grains reported the highest Zn and Cu contents of oat grains were found in TL76 (37.68 $mg.kg^{-1}$) and TL67 (8.67 $mg.kg^{-1}$). Locations had significant effect on all macro and micro nutrient concentrations of oat grains. Also suggest that oat grains could serve as a good source of mineral elements. Mut *et al*. (2015) were compared one hundred oat varieties of worldwide origin and reported significant differences between the tested oat genotypes were noticed for the following traits: the plant height, hay yield, crude protein, acid detergent fiber (ADF), neutral detergent fiber (NDF), Total digestible nutrients (TDN), relative feed value (RFV) and some mineral contents (Ca, K, P and Mg). Generally, the highest yielding genotypes were European origin in this study. Sisko, Akiyutaka, Longchamp, Sanova, Flamingslord, Matra and Revisor were identified as the high hay yield potential genotypes, however, it was not to case for quality traits. Consequently, some form of commercial mineral supplement would be required to oat-based forage production systems or oat should be grown in mixtures with legumes to fulfill livestock needs in effective feeding. Micronutrient elements deficiency, including iron, zinc, and manganese in plants and crops has a worldwide spread. Continuous cultivation, excessive annual consumption of phosphate fertilizers, erosion, leaching, and other conditions of calcareous soils such as excessive calcium bicarbonate, alkaline pH, non-consumption of the fertilizers containing micronutrient elements and organic fertilizers decrease their reserves in soil, and consequently reduce the yield (Malakouti and Tehrani, 2005). Bameri *et al*. (2012) by study the effects of foliar micronutrient application (F_1=Fe 2.5 lit/1000 form Iron sulphate, F_2= Zn 2.5 lit/1000 form Zinc sulphate, F_3= Mn 2.5 lit/1000 form Mn sulphate, F_4= Fe + Mn 1.5 lit/1000, F_5= Zn + Mn 1.5 lit/1000, F_6= Fe + Zn 1.5 lit/1000, F_7= Fe + Zn + Mn 1lit/1000, F_8= Fe 4 lit/1000 form Iron sulphate and F_9= control were applied) on growth and yield of wheat reported that micronutrient application significantly affected plant height, number of spike per plant, number of grain per spike, 1000-grain weight, seed yield, biological yield and harvest index. Application of Mn + Fe had the highest positive effect on yield components and seed yield. The combination of Zn + Fe + Mn and control gave the lowest values of most studied traits. A balanced fertilization program with macro and micronutrients in plant nutrition is very important in the production of high yield with high quality products (Sawan *et al*., 2001). Qasempour Alamdari and Mobasser (2014) by examine the effect of macro and micronutrient fertilizers on the growth and yield of rice (*Oryza sativa* L.) under calcareous soils reported soil pH decreased by using NPK + S + Zn fertilizers (0.32) compared to the control plot. With decreasing soil pH all the agronomic characteristics of rice plant and its grain yield increased significantly, except 1000-grain weight. The number of filled grain (119) and total number of seed per panicle (127) and grain yield (4376 kg.ha^{-1}) reached at the maximum values when NPK + S + Zn fertilizers applied together. Rice grain yield was increased 1483 kg.ha^{-1} by this treatment compared to control plot (2893 kg.ha^{-1}). The current study was conducted to evaluate the effects of micro and macro nutrients application of different genotypes of oat crop on quantitative and qualitative characteristics.

MATERIALS AND METHODS

Field and Treatments Information

In order to assessment the effect of micro and macro nutrients on agro physiological traits of oat crop a research was conducted as split plot experiment based on randomized complete block design with three replications at Agricultural Research Station, Faculty of Agriculture, Shahid Chamran University of Ahvaz, along 2013-2014. The main factor included different complex of macro and micro nutrient elements at two level (F_1: application 114 kg.ha^{-1} nitrogen from 46% source of urea, application 16.8 kg.ha^{-1} phosphorus from the source of super phosphate, 29.1 kg.ha^{-1} potassium from the source of potassium sulfate; F_2: application of macro elements (N, P, K) along with a mixture of micro elements contain 0.8 kg.ha^{-1} iron, 0.88 kg.ha^{-1} zinc, molybdenum 0.1 kg.ha^{-1}, copper 0.2 kg.ha^{-1}, boron 0.1 kg.ha^{-1} and manganese 2.0 kg.ha^{-1}). Sub-factor consisted of four genotypes (G_1, G_2, G_3 and G_4) of oat crop. Properties of genotypes mentioned in table 1.

Table 1. Properties of studied genotypes

	Identification or pedigree selection source		
G1	Weib/Flipper	IR60"s CRD	EU_Unknow
G2	MN98148/OA982-6 MN03115 FL04Ab292		
G3	IL 95-8226/IL 9591-128 IL 00-8439	FL04Ab222	
G4	Jay/4/P8669C2/3/WIX6141-2/ND881374/ND880107	P9741A41-4-6-86 FL04Ab258	

Farm Management

Different Micro-fertilizers (Fe, Zn, Mo, Mn, Cu, B and Mg) are mixed together in one-kilogram packages made by Oligo green magic, dissolved in water and then sprayed onto the soil and then mixed with it. In order to supply the oat nutrient demand, the fertilizers include super phosphate (84 kg), potassium sulfate fertilizer (62 kg) and one third of urea (68.68 kg) as base were used. Also micro elements including Fe, Zn, Mo, Cu, B and Mg were used as a base with mixed soil.

Measured Traits

Measured traits including shoot dry weight, spike length, stomatal conduction rate (were estimated by Prometer device; TΔ model, made in Uk) per $cm.s^{-1}$, SPAD value calculated with chlorophyll meter (SPAD-502 model, Minolta, Japan), respiration, photosynthesis (CO_2 assimilate) and speed of transpiration of the leaves (were measured by Leaf chamber analyzer device or LCA4, brand EDC, made in England). Also leaf area index was estimated with using Leaf area meter device. Protein, amount of organic matter and percentage of crude ash were measured by using an approximate degradation method and burning in an electric furnace along 550°C for three hours and a half. Amount of fiber were estimated with Association of Analytical Chemistry method with fibertec device (AOAC, 2000). The following formula was used to calculate fiber percentages:

Equ. 1. CF= W_2-W_1/W_3×100.

CF: Crude fiber, $\mathbf{W_1}$= Weight of crucible with sample before ashing, $\mathbf{W_2}$= Weight of crucible with sample after ashing, $\mathbf{W_3}$= Weight of sample.

In order to measure the concentration of seed starch, the spectrophotometer was used. The starch content was read at 485 nm and the standard curve was plotted. Then, the amount of adsorption in the plant samples was read and the starch content was obtained by placing in the linear equation. The phenol-sulfuric acid method was used to determine the soluble carbohydrates (Dubois *et al*., 1956). Measurement was performed by a spectrophotometer device (samples were read at 490 nm). At ripening stage, in each plot separately, four intermediate lines were harvested by the Dos, observing the margins on both sides of one square meter. After final harvest the number of spikelets per spike, number of seed per spike, seed yield per unit area, total dry matter yield, harvest index and seed weight were measured.

Statistical analysis

The data was analyzed by SAS (Ver. 9) software. The means comparisons were compared by Duncan test at 5% probability level.

RESULT

Organic matter Concentration

According result of analysis of variance effect of different fertilizer management, genotypes and interaction effect of treatments on organic matter concentration was significant at 1% probability level (Table 2). Mean comparison result of interaction effect of treatments indicated that maximum organic matter concentration (95.29%) was noted for F_2G_3 and minimum of that (76.41%) belonged to F_1G_2 treatment (Table 3).

Fiber Concentration

Result of analysis of variance revealed effect of different fertilizer management, genotypes and interaction effect of treatments on fiber concentration was significant at 1% probability level (Table 2). As for Duncan classification made with respect to interaction effect of treatments maximum and minimum amount of fiber concentration belonged to F_2G_3 (31.99%) and F_1G_2 treatment (18.06%) (Table 3).

Ash Concentration

Result of analysis of variance indicated effect of different fertilizer management and genotypes on ash concentration was not significant but interaction effect of treatments was significant at 1% probability level (Table 2).

Table 2. Result analysis of variance of fiber, ash, soluble sugar, organic matter, spad, LAI, yield of dry matter, wet yield

S.O.V	df	Organic matter	Fiber	Ash	SPAD index	LAI	Soluble sugar	fresh weight yield	Dry matter yield
Block	2	0.18^{ns}	0.25^{ns}	1.43^{**}	0.33^{ns}	0.14^{ns}	0.02^{ns}	791.77^{ns}	0.01^{ns}
Fertilizer (F)	1	157.38^{**}	302.74^{**}	0.005^{ns}	753.93^{**}	6.72^{**}	3225.96^{**}	5986.10^{**}	1977.98^{**}
Error I	2	2.11	0.41	0.069	351.12	0.12	0.0003	636.09	0.41
Genotype (G)	3	287.8^{**}	58.16^{**}	0.098^{ns}	144.07^{**}	0.71^{**}	1136.24^{**}	26702.58^{**}	815.83^{**}
F × G	3	7.4^{**}	9.42^{**}	0.03^{**}	45.76^{**}	0.39^{**}	827.22^{**}	632.53^{**}	67.51^{**}
Error II	12	0.59	0.49	0.014	0.51	0.11	1.74	34.79	0.57
CV (%)	-	0.9	2.72	11.4	1.39	1.08	1.2	0.94	2.6

^{ns}, * and **: non-significant, significant at 5% and 1% probability level, respectively.

According result of mean comparison maximum of ash concentration (23.58%) was obtained for F_1G_2 and minimum of that (4.70%) was for F_2G_3 treatment (Table 3).

Spade Index (SPAD)

Based on the results of analysis of variance, the effects of different fertilizer management, genotypes and interaction effect of treatments on spade index were significant (P <0.01) (Table 2). Compare different level of interaction effect of treatments showed that the maximum and the minimum amount of spade index belonged to F_2G_3 (71.91) and F_1G_2 (52.50) treatments (Table 3).

Leaf area index (LAI)

Result of ANOVA showed effect of fertilizer management, genotypes and interaction effect of treatments on LAI was significant at 1% probability level (Table 2). Between different levels of interaction effect of treatments the maximum LAI (8.50) was observed in F_2G_3 and the lowest one (6.43) was found in F_1G_2 treatment (Table 3).

Soluble sugars

Based on the results of analysis of variance, the effects of fertilizer management, genotype and interaction effect of treatments on soluble sugars were significant (P <0.01) (Table 2). Among different level of interaction effect of treatments maximum soluble sugars (155.10 $mg.gr^{-1}$ leaf) was obtained for F_2G_3 and minimum of that (96.00 $mg.gr^{-1}$ leaf) was for F_1G_2 treatment (Table 3).

Fresh weight yield

According result of analysis of variance effect of different fertilizer management, genotypes and interaction effect of treatments on fresh weight yield was significant at 1% probability level (Table 2). Compare different level of interaction effect of treatments showed that the maximum and the minimum amount of fresh weight yield belonged to F_2G_3 (13971.68 $gr.m^{-2}$) and F_1G_2 treatment (9637.00 $gr.m^{-2}$) (Table 3).

Dry matter yield

Based on the results of analysis of variance, the effects of fertilizer management, genotypes and interaction effect of treatments on dry matter yield were significant (P <0.01) (Table 2). According mean comparison result of interaction effect of treatments the maximum dry matter yield (2418.86 $gr.m^{-2}$) was observed in F_2G_3 and the lowest one (1680.63 $gr.m^{-2}$) was found in F_1G_2 (Table 3). According to the results of correlation between traits in stem elongation stage, the highest positive and significant correlation was found between dry weight and organic matter ($r=0.92^{**}$), as well as dry weight and fresh weight yield, and positive correlation with organic matter, spade index and leaf area index (Table 4).

Table 3. Means comparison effect of treatments on fiber, ash, soluble sugar, organic matter, spad, LAI, yield of dry matter, wet yield

Treatment	Organic matter (%)	Fiber (%)	Ash (%)	Spad index
Fertilizer (F)				
F_1	82.64^b	22.27^b	17.35^a	50.40^b
F_2	87.77^a	29.38^a	12.23^b	65.60^a
Genotype (G)				
G_1	80.78^b	23.43^b	19.21^b	60.70^b
G_2	78.05^c	22.85^b	24.91^a	56.25^c
G_3	91.91^a	28.63^a	8.08^d	62.20^a
G_4	90.08^a	28.40^a	9.92^c	62.85^a
G × F				
F_1G_1	79.22^e	19.93^d	20.77^b	58.20^{ab}
F_1G_2	76.41^f	18.06^e	23.58^a	52.50^c
F_1G_3	88.53^b	26.84^c	11.47^e	53.30^b
F_1G_4	86.42^c	25.27^c	13.57^d	57.60^{ab}
F_2G_1	82.35^d	28.79^b	17.64^c	63.20^{ab}
F_2G_2	79.70^e	25.77^c	20.30^b	59.20^{ab}
F_2G_3	95.29^a	31.99^a	4.70^g	71.91^a
F_2G_4	93.73^{ab}	30.96^{ab}	6.26^f	68.1^{ab}

*Similar letters in each column show non-significant difference at 5% probability level in Duncan's multiple rang test.

Continue Table 3.

Treatment	LAI	Soluble sugar ($mg.gr^{-1}$ leaf)	fresh weight yield ($gr.m^{-2}$)	Dry matter yield ($gr.m^{-2}$)
Fertilizer (F)				
F_1	6.63^b	98.40^b	10812.58^b	1893.66^b
F_2	7.69^a	121.50^a	12628.20^a	2209.54^a
Genotype (G)				
G_1	6.83^a	101.14^c	11012.17^b	1931.09^c
G_2	7.00^a	97.40^d	10451.83^c	1829.38^d
G_3	7.63^a	127.91^a	12624.17^a	2296.69^a
G_4	7.18^a	113.15^b	12793.50^a	2149.25^b
G × F				
F_1G_1	6.56^{bc}	97.35^{ef}	10083.33^e	1770.50^f
F_1G_2	6.43^c	96.00^f	9637.00^f	1680.63^g
F_1G_3	6.76^{bc}	100.73^d	11267.67^c	2174.53^c
F_1G_4	6.70^{bc}	99.15^{dc}	12253.33^c	1948.99^e
F_2G_1	7.10^{bc}	104.93^c	11941.00^d	2091.67^d
F_2G_2	7.56^{ab}	98.80^{dc}	11266.67^c	1978.13^e
F_2G_3	8.50^a	155.10^a	13971.68^a	2418.86^a
F_2G_4	7.60^{ab}	127.15^b	13333.66^b	2349.51^b

*Similar letters in each column show non-significant difference at 5% probability level in Duncan's multiple rang test.

Table 4. Correlation between fiber, ash, soluble sugar, organic matter, spad, LAI, yield of dry matter and wet yield traits

Traits	Wet yield	Dry matter yield	LAI	Soluble sugar	Spad	Organic matter	Fiber
Dry matter yield	0.91^{**}	-	-	-	-	-	-
LAI	0.66^{**}	0.64^{**}	-	-	-	-	-
Soluble sugar	0.83^{**}	0.81^{**}	0.71^{**}	-	-	-	-
Spad	0.54^{**}	0.47^{*}	0.35^{ns}	0.57^{**}	-	-	-
Organic matter	0.90^{**}	0.92^{**}	0.52^{**}	0.81^{**}	0.41^{*}	-	-
Fiber	-0.95^{**}	-0.87^{**}	-0.71^{**}	-0.86^{**}	-0.59^{**}	-0.82^{**}	-
Ash	-0.90^{**}	-0.92^{**}	-0.52^{**}	-0.81^{**}	-0.41^{*}	-0.81^{**}	0.82^{**}

^{ns}, * and **: non-significant, significant at 5% and 1% probability level, respectively.

Biologic yield

Result of analysis of variance showed effect of different fertilizer management, genotypes and interaction effect of treatments on biological yield was significant at 1% probability level (Table 5). Assessment mean comparison result of interaction effect of treatments showed maximum biological yield (2551.50 gr.m^{-2}) was noted for F_2G_3 and lowest one (1867.93 gr.m^{-2}) belonged to F_1G_2 treatment (Table 6).

Seed yield

Based on the results of analysis of variance, the effects of fertilizer management, genotypes and interaction effect of treatments on seed yield were significant ($P < 0.01$) (Table 5). As for Duncan classification made with respect to different level of interaction effect of treatments maximum and minimum amount of seed yield belonged to F_2G_3 (916.85 gr.m^{-2}) and F_1G_2 treatment (520.90 gr.m^{-2}) (Table 6).

Seed weight

According result of analysis of variance effect of different fertilizer management, genotypes and interaction effect of treatments on seed weight was significant at 1% probability level (Table 5). Compare different level of interaction effect of treatments showed that the maximum and the minimum amount of seed weight belonged to F_2G_3 (32.40 gr) and F_1G_2 (22.36 gr) treatments (Table 6).

Harvest index

Result of analysis of variance showed effect of different fertilizer management, genotypes and interaction effect of treatments on harvest index was significant at 1% probability level (Table 5). Among different level of interaction effect of treatments maximum harvest index (35.93%) was obtained for F_2G_3 and minimum of that (27.88%) was for F_1G_2 treatment (Table 6).

Protein

Based on the results of analysis of variance, the effects of fertilizer management, genotypes and interaction effect of treatments on protein concentration were significant ($P < 0.01$) (Table 5). Assessment mean comparison result of interaction effect of treatments showed the maximum protein concentration (14.35%) was noted for F_2G_3 and lowest one (9.30%) belonged to F_1G_2 treatment (Table 6).

Table 5. Result analysis of variance of biologic yield, seed yield, seed weight, harvest index, protein, seed starch

S.O.V	df	Biologic yield	Seed yield	Seed weight	Harvest index	Protein	Seed starch
Block	2	91.68^{ns}	41.06^{ns}	0.12^{ns}	0.21^{ns}	0.27^{ns}	41.8*
Fertilizer (F)	1	716947.25**	196200.55**	149.50**	57.22**	10.81**	23583.35**
Error I	2	60.81	50.81	0.81	0.22	0.01	0.52
Genotype (G)	3	1452333.39**	46447.91**	23.68**	19.26**	14.3**	10132.88**
F × G	3	13596.26**	9284.28**	7.24**	6.18**	1.15**	2245.84**
Error II	12	68.62	59.33	0.17	0.11	0.29	0.66
CV (%)	-	0.38	1.10	1.58	1.08	4.92	0.21

^{ns}, * and **: non-significant, significant at 5% and 1% probability level, respectively.

Starch

According result of ANOVA effect of fertilizer management, genotypes and interaction effect of the treatments on starch concentration was significant at 1% probability level (Table 5). Compare different level of interaction effect of treatments showed that the maximum and the minimum amount of starch concentration belonged to F_2G_3 (476.20 mg.g^{-1}) and F_1G_2 (321.83 mg.g^{-1}) treatments (Table 6).

DISCUSSION

It seems that the use of micro and macro nutrients lead to increase the photosynthetic efficiency and the growth of the reproductive organs leading to higher amounts of fresh weight and dry matter in oat crop, which is associated with other studies such as Bameri *et al*. (2012) in wheat results. Iqbal *et al.* (2009) was conducted an experiment on nitrogen efficiency on the quantitative and qualitative yield of green forage in oats, concluded that using 114 kg.ha^{-1} nitrogen, 84 kg.ha^{-1} super phosphate and 62 kg.ha^{-1} potassium sulfate, the highest amount of green forage was obtained, so the use of higher levels of nitrogen led to verse and reduces the yield of fresh and dry weights in oats. It seems that the use of micro and macro nutrients has increased the leaf area and photosynthetic surface in oat, so by increasing photosynthesis rate in each genotype and reducing respiration led to improve oat yield. Meanwhile, by increasing the photosynthetic surface to absorb carbon dioxide, the efficiency of stomata increases in CO_2 absorption, which also the increases stomatal conductance. Similar result is reported by Reynolds (2000). The increase in the amount of photosynthesis, the expansion of the photosynthetic area and, consequently, the increase in the number of stomata increased the transpiration in the canopy of the crop community, which was consistent with the results of the Ayeneh (2002). Yilmaz *et al*. (1997) showed that zinc consumption significantly increased seed yield and its components, including number of seeds per spike, number of spike per square meter and 1000 seed weight, among these components, the effect on the number of spikes per square meter was greater. The crop production depends on the balance between the rate of carbon fixation during the process of photosynthesis and its rate of decline during plant respiration. The carbon dioxide in the air is the source and destination for both photosynthesis and respiration processes.

Table 6. Means comparison effect of treatments on biologic yield, seed yield, seed weight, harvest index, protein and seed starch traits

Treatment	Biologic yield ($gr.m^{-2}$)	Seed yield ($gr.m^{-2}$)	Seed weight (gr)	Harvest index (%)	Protein (%)	Starch ($mg.g^{-1}$)
Fertilizer (F)						
F1	2003.81^{b}	609.08^{b}	23.68^{b}	30.34^{a}	10.38^{b}	346.79^{b}
F2	2349.49^{a}	789.92^{a}	28.67^{a}	33.43^{a}	11.72^{a}	409.49^{a}
Genotype (G)						
G1	2077.98^{c}	660.13^{c}	25.48^{c}	31.67^{c}	9.75^{c}	354.58^{c}
G2	2010.35^{d}	594.52^{d}	23.83^{d}	29.45^{d}	9.95^{c}	334.63^{d}
G3	2316.81^{a}	782.47^{a}	28.48^{a}	33.52^{a}	13.08^{a}	425.25^{a}
G4	2301.46^{b}	760.89^{b}	26.91^{b}	32.88^{b}	11.41^{b}	398.10^{b}
F × G						
F1G1	1948.73^{g}	615.37^{f}	23.66^{f}	31.56^{cd}	9.70^{e}	337.80^{g}
F1G2	1867.93^{h}	520.90^{g}	22.36^{g}	27.88^{f}	9.30^{de}	321.83^{h}
F1G3	2082.13^{f}	648.09^{e}	24.56^{de}	31.12^{de}	11.82^{b}	374.31^{c}
F1G4	2116.46^{e}	651.38^{e}	24.13^{ef}	30.80^{e}	10.70^{c}	353.23^{e}
F2G1	2207.13^{c}	704.88^{c}	27.30^{c}	31.78^{c}	10.21^{cd}	371.36^{d}
F2G2	2152.76^{d}	668.13^{d}	25.30^{d}	31.03^{de}	10.20^{cd}	347.43^{f}
F2G3	2551.50^{a}	916.85^{a}	32.40^{a}	35.93^{a}	14.35^{a}	476.20^{a}
F2G4	2486.46^{b}	869.80^{b}	29.70^{b}	34.97^{b}	12.12^{b}	442.96^{b}

*Similar letters in each column show non-significant difference at 5% probability level in Duncan's multiple rang test.

Photosynthesis and darkness respiration are different metabolic pathways in which ATP is produced to provide the energy needed for growth and preservation activities. It seems that the use of micro and macro nutrients increases the level of photosynthesis and decreases the respiration rate. Mohammadi *et al.* (2014) by study the effect of interaction of micro and macro elements [100% manure (F_1), 100% chemical fertilizer (F_2), 50% manure + 50% chemical fertilizer (F_3) and control (F_4) as the main plot and the use of micro nutrient elements treatments were: iron sulfate (N_1), zinc sulfate (N_2), manganese sulfate (N_3) and control (N_4) as sub plot in this experiment] on soil chemical properties, seed yield and feed yield in barley reported effect of different proportions of manure and chemical fertilizer treatment on seed yield, feed yield, and soil chemical properties were significant. Among soil chemical properties, pH decreased due to use of all fertilizer treatments (organic and inorganic fertilizer) and soil salinity increased due to consumption of chemical fertilizer. Micronutrient treatments had significant influence on this nutrition elements concentration and the use of iron sulfate, zinc sulfate and manganese sulfate caused increase of these elements in soil but these treatments had no influence on seed yield of barley. In general, it can be concluded that the use of manure and chemical fertilizer considerably improves yield and yield component of barley. The result in this investigation shows that the use of 50% manure with 50% chemical fertilizer produced high yield of barley in Sistan region; and between nutrient treatments, the use of iron fertilizer had more effect on quantity characteristic of barley in comparison to other fertilizer.

Harvest stage

Radley (1978) reported a great correlation between the number of endosperm cells and the seed weight in different cultivars and their fundamental role in increasing the dry matter and the final weight of the seeds. It seems the number of endosperm cells seems to increase with the use of macro and micro elements. Oat seed yield is largely dependent on starch accumulation. Considering that the seed filling period is the most important stage of biosynthesis and starch accumulation, it significantly affects the proper nutritional conditions resulting from the storage of starch, which results in increased yields. Application of micro and macro nutrients has led to the supply of oat to food and is likely to increase the protein content of the seeds due to the higher absorption of nitrogen and the reduction of amid nitrogen. Iqbal *et al*. (2009) concluded that supplying nitrogen up to 114 $kg.ha^{-1}$ would increase the yield of total oat biomass, which was consistent with these results.

CONCLUSION

According to results of the experiment, it was found that along all growth stages, the management of chemical fertilizer application has a different effect on genotypes, which can affect the absorption by the plant and the optimal use of the plant's available food. As a result, the use of micro and macro nutrients was more effective than other fertilizer levels. The use of micro and macro elements led to develop leaf area and increases photosynthesis which, over time, increases the accumulation of crop dry matter. The highest dry matter production, fresh weight and seed yield per hectare were observed in G_3 genotype, which was obtained from the interaction effect of genotype with macro and micro nutritional elements. The lowest dry matter production, seed yield and quality were observed from the effect of macro fertilizer treatments on G_2 genotype. The highest quality was observed in terms of protein and soluble sugars in G_3 genotype. According to the objectives of this experiment, it can be concluded that micronutrient application with macronutrients has had a great influence on oat growth and yield. But the different reaction of oat genotypes to these essential elements can differ in how these elements are affected. The reaction of oat genotypes, which were studied, gradually showed a different response in vegetative growth due to genetic characteristics. The effect of micronutrient elements along with macro elements on seedling growth and yield was different in oat genotypes. These results require the use of micronutrients to improve plant growth. Due to the lack of micronutrient elements in Iran agronomic soils, especially in Khuzestan province, due to the weakness of organic matter, it is necessary to use them for improve oat growing and the variation of response in agricultural oat genotypes to all types of low consumption elements. It can be effective in increasing the production efficiency per unit area in terms of plant nutrition. Since there are currently no catch levels of agronomic oat in Khuzestan and now forage needs of country are extensively supplied from abroad, attention to the development of this crop cultivation and observance of its nutritional principles, especially use micronutrients.

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