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Full Length Research Paper

The effect of chemical and cattle fertilizer on yield and yield constituent of barley (*Hordeum vulgare*)

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In order to study the effect of the interaction of manure and chemical fertilizer on yield and yield component of barley, an experiment was conducted as split plot design on randomized complete block design with three replications in research field of Zabol University, 2008. Different proportions of manure and chemical fertilizer treatments were composed of 100% manure (F_1), 100% chemical fertilizer (F_2), 50% manure + 50% chemical fertilizer (F_3) and control (F_4) as the main plot. Use of micro nutrient elements were composed of Iron Sulfate (N_1), Zinc Sulfate (N_2), Manganese Sulfate (N_3) and control (N_4) as sub plot in this experiment. Results showed that the effect of different proportions of manure and chemical fertilizer treatment on grain yield and yield components properties with the exception of grain number/ear, were significant. Nutrient treatments had a significant effect on grain yield and yield components in barley and among this nutrient use of Fe (N_1) had maximum effect on grain component of barley.

Key words: Barley (*Hordeum vulgare)*, chemical fertilizer, manure, yield.

INTRODUCTION

Barley (*Hordeum vulgare*) is a fast growing, cool season, annual grain crop that can be used as a forage or as a cover crop to improve soil quality. Mineral nutrition alone has contributed significantly to increase crop yields during the 20th century. Borlaug and Dowswell (1994) reported that 50% of the increase in crop yields worldwide during the 20th century was due to application of chemical fertilizers. They also stated that during the 21st century, the essential plant nutrients would be the single most important factor limiting crop yields, especially in developing countries. Stewart et al. (2005) reported that average percentage of yield attributable to fertilizer generally ranged from about 40 to 60% in the USA and England and tended to be much higher in the tropics. Although, micronutrient elements are needed in relatively very small quantities for adequate plant growth and production, their deficiencies cause a great disturbance in the physiological and metabolic processes in the plant (Bacha et al., 1997). 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). Macro and micronutrients deficiencies have been reported for different soils and crops (Hussain et al., 2006). Soylu et al. (2005) reported significant increase in number of spikes m^{-2} in wheat with foliar application of different micronutrients individually or in combination. Six micronutrients that is, Mn, Fe, Cu, Zn, B and Mo are known to be required for all higher plants (Welch, 1995).

In another study, Abd El-Wahab (2008) stated that micronutrients such as iron, manganese and zinc have important roles in plant growth and yield of aromatic and medicinal plants. He reported micronutrients, especially Fe and Zn which act as metal components of various enzymes and are also associated with photosynthesis, and protein synthesis and Iron has important functions in plant metabolism, such as activating catalase enzymes. Iron is mainly present in the form of insoluble Fe (III), therefore, unavailable to higher plants, particularly in neutral and alkaline soils (Shao et al., 2007). Havlin et al.

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Table 1. Chemical analysis of soil of experiment.

Mn (mg l^{-1})	Zn (mg l^{-1})	Fe (mg l^{-1})	Ca (meq l^{-1})	P (meq l^{-1})	K (meq l^{-1})	N (meq l^{-1})	EC (ds m^{-1})	pH
0.32	1.615	0.03	12.1	1.56	317	0.027	1.8	7.2

(1999) reported that iron is critical for chlorophyll formation and photosynthesis and is important in the enzyme systems and respiration of plants; manganese is involved in the enzyme systems related to carbohydrate and nitrogen fixation in legumes and zinc is essential for sugar regulation and enzymes that control plant growth. Zinc is one of the eight essential trace elements which is necessary for the normal healthy growth and reproduction of crop plants (Parker and Thomason, 1992). Zn is a vital element for wheat growth and it activates some enzymes such as carbonic anhydrase, dehydrogenase, proteins and peptidase. Soleimani (2006) reported increase in biological yield for foliar application of zinc.

Another study showed that use of zinc in blue sage (*Salvia farinacea L.*) enhanced the length of peduncle, length of main inflorescence, number of inflorescence and florets, and fresh and dry weight of inflorescences/ plant (Nahed and Balbaa, 2007). A similar effect of Zn supply on this parameter was also reported on *Matricaria chamomilla* (Grejtovský et al., 2006). The positive effects of Fe and Zn on plant may be due to their effects as a metal component of some enzymes or regulatory for the others. Moreover, they have essential roles in plant metabolism (Abd El-Hady, 2007). The recycling and the use of nutrients from organic manure have been given more consideration for insuring sustainable land use in agricultural production development. The positive influence of organic fertilizers on soil fertility, on crop yield and quality has been demonstrated in the works of many researchers (Stefanescu, 2002; Hoffman, 2001; Sattar and Hossain, 2001). Organic materials are a good source of plant nutrients and have a positive effect on improvement of the soil physical structure. Application of animal manures to agricultural fields is a widely used method of increasing soil organic matter and fertility. Most solid livestock manures can be applied directly to crop fields or piled for composting. In organic farming, N is supplied through organic amendments in the form of manure. Applying organic N fertilizer without prior knowledge of N mineralization and crop needs can result in nitrate-nitrogen (NO_3–N) leaching below the root zone and potential groundwater contamination.

The long term effects of the combined application of organic and inorganic fertilizers in improving soil fertility and crop yield have been demonstrated by many workers (Chen et al., 1988). Recently, Wang et al. (2001) reported that organic and inorganic fertilizers showed great benefits not only for the increase in the N uptake by the plant but also in the improvement of the fodder yield. Materechera and Salagae (2002) used partially decomposed cattle and chicken manure amended with wood ash and reported that higher plant yield of fodder maize was obtained by the use of chicken manure. Manure can supply nutrients required by crops and replenish nutrients removed from soil by crop harvest. Hence, the present investigation was carried out to evaluate the effects of farmyard manure, and chemical fertilizer on yield and other quality parameters, as well as soil properties of barley grown in the Sistan region of Iran.

MATERIALS AND METHODS

This experiment was conducted in 2009 cropping at Agriculture Research Center of Zabol University. The site lies at longitude 61°29', and latitude 31°2' and the altitude of the area is 487 m above sea level. It has a warm dry climate with the mean minimum, mean maximum, and average air temperatures of 16, 30, and 29°C, respectively. The soil characteristics of Agriculture Research Center is sandy-loam in texture, pH = 7.4 and EC = 1.8 ds.m^{-1} (the soil properties prior to the experiment is shown in Table 1). The experimental design was split plot, using randomized complete block design with tree replication. Different proportions of manure and chemical fertilizers were F_1= 100% of manure (60 ton per ha) F_2= 100% chemical fertilizer (urea 250 kg/ha, super phosphate triple 200 kg/ha and oxide potassium 100 kg/ha), F_3= 50% of manure + 50% of chemical fertilizer, F_4= control as main plot and use of elements were composed of; N_1= Iron sulfate, N_2= Zinc Sulfate, N_3= Manganese Sulfate and N_4= control as sub plot in this experiment.

All treatments were exerted before sowing. Barley was planted manually in October 2008. Experiment plots were seeded with Sistan cultivar with 25 cm row to row distance and 2 cm between plants. Seeds were sown 4 cm deep. Weeds were removed by hand. After planting, irrigation was applied as required during the growing season. The barley was harvested in April 2009. For measurement of plant characteristics, two edge rows were eliminated as margin effects and one square meter of each plot was used for sampling. Data collected (obtained by combining the four center rows at each experiment unit) included: grain yield, 1000-grain weight, weight of ear, number of grain per ear and some soil characteristics such as EC and soil nutrient content. Electrical conductivity (EC) was measured with a 1:10 (soil: water) ratio. The data were analyzed using MSTATC software; mean comparison was done using Duncan Multiple Comparison at 5% probability level.

RESULTS

Grain yield

Proportions of manure and chemical fertilizer, use of nutrient and interaction with them had significant effect on barely grain yield (P<5%) (Table 2). Results showed that

Table 2. Analysis of variance for yield and yield components.

S.O.V	d.f	Grain yield	1000-Grain weight	Ear weight	Grains per ear	Biological yield
		Mean square				
Replication	2	24756.40 ^{ns}	18.58 ^{ns}	20414.69 ^{ns}	7.89 ^{ns}	86706.69 ^{ns}
Proportions of manure and chemical fertilizer	3	42471.29 **	208.11 **	85624.19 *	7.95 ^{ns}	585391.55 ^{ns}
Error a	6	12225.65	8.86	4239.68	12.19	97967.06
Nutrient	3	6460.78 *	184.74 **	86532.98 *	9.53 ^{ns}	80271.24 **
Interaction	9	5606.07 **	45070 **	9590.68 ^{ns}	5.75 ^{ns}	22069.63 ^{ns}
Error b	24	2173.99	38.09	3243.97	6.13	0.006
CV	-	20.17	18.78	3.32	8.14	14.78

*, ** Significant at the 5 and 1% levels of probability respectively and n.s (non significant).

Table 3. Mean comparison of interaction effects yield and yield components.

Treatment	Grain yield (kg/ha)	1000-Grain weight (g)	Ear weight (g)	Grains per ear	Biological yield (kg/ha)
Proportions of manure and chemical fertilizer					
100% manure	2297.7^{b}	33.93^{b}	1.28^{ab}	29.87^{a}	6214^{c}
100% chemical fertilizer	2713.5^{a}	39.26^{a}	1.44^{a}	31.34^{a}	9858.6^{a}
50% manure + 50% chemical fertilizer	2758.2^{a}	39.8^{a}	1.44^{b}	30.79^{a}	7830.4^{b}
Control	1474.6^{c}	32.85^{c}	1.25^{b}	29.57^{a}	4708.8^{d}
Nutrient					
Fe	2539.6^{a}	37.62^{a}	1.44^{a}	31.67^{a}	8344.8^{a}
Zn	2456.2^{ab}	35.76^{b}	1.44^{a}	30.25^{a}	7011.7^{b}
Mg	2219.8^{b}	35.73^{b}	1.31^{b}	30.03^{a}	6712.8^{b}
Control	2028.4^{c}	35.01^{b}	1.25^{c}	29.61^{a}	6542.5^{b}

Mean followed by similar letters in each column, are not significant at the 5% level of probability.

all proportions of manures and chemical fertilizer treatments significantly increased barley grain yield as compared to control (F_4) and the highest grain yield was obtained in the F_3 (50% manure + 50% chemical fertilizer) and F_2 (100% chemical fertilizer) treatments with mean of 2758/2 and 2713/5 kg/ha respectively as shown in Table 3. The increase in maize growth with the use of organic materials has also been observed by Silva et al. (2004). This study confirms the role of manure and chemical fertilizer in increasing grain yield of barley and the results showed that manure and chemical fertilizer can increase grain yield of barley but a combination of them has more effect on increase in grain yield.

In a recent evaluation of the direct effects of cattle manure on corn, it was verified (Silva et al., 2004) that manure increased green ear yield and grain yield in two corn cultivars. Cattle manure also increased water retention and availability, and phosphorus, potassium, and sodium contents in the soil layer from 0 to 20 cm (Silva et al., 2004). The residual effect of organic fertilizers on yield, including cattle manure, has been found to be positive in sorghum (Patidar and Mali, 2002), corn (Raramurthy and Shivashankar, 1996) and *Brassica juncea* (L.) (Rao and Shaktawat, 2002). Therefore, there was a direct effect of cattle manure on green ear yield and grain yield (Silva et al., 2004). Between nutrient treatments N_1 (Fe^{2+}), N_2 (Zn^{2+}) and N_3 (Mg^{2+}) increased barley grain yield by 20, 17/5 and 8/6% respectively as compared to control (N_4) and the highest grain yield (2539/6 kg/ha) was measured in N_1 (Fe^{2+}) as compared to other treatments as shown in Table 2.

Yield component

Obtained result showed that proportions of manures and chemical fertilizer application significantly increased barley 1000-grain weight as compared to control treatment and maximum amount of 1000-grain weight was recorded in F_2 (100% chemical fertilizer) and F_3 (50% manure+50% chemical fertilizer) with mean of 39/26 and 39/08 g respectively. Result in Table 3 showed that there was no significant difference between F_2 and F_3. Ear weight was significantly affected by manure and

chemical fertilizer treatments and the highest amount of ear weight was measured in F_2 and F_3 (1/44 g) and these treatments increased ear weight to about 15/2% as compared to control treatment (Table 3). Results in this part showed that grain number in ear was not significantly affected by manure and chemical fertilizer as shown in Table 2.

Use of nutrient and interaction between proportions of manures and chemical fertilizer and nutrient was significant on 1000-grain weight (Table 2). Between nutrient treatment N_1 (Fe^{2+}) the increase in barley 1000-grain weight as compared to control was about 7/64% and there was no significance difference between N_2, N_3 and N_4. Ear weight was affected by nutrient treatment and the highest amount of ear weight was obtained in N_1 and N_2 (1/44 and 1/42 respectively) and there was no significant different between N_1 and N_2 as shown in Table 3. Result in this part showed that use of Fe^{2+} increase ear weight to about 15% as compared to control treatment. This result corroborated the earlier findings of Mentler et al. 2002) on corn. Proportion of manure and chemical fertilizer had a significant effect on biological yield of barley and all treatments increased biological yield of barley as compared to control treatment (F_4).

This result indicated that biological yield was increased by 100% manure (F_1), 31% by 100% chemical fertilizer (F_2), 109/36% by 50% manure+50% chemical fertilizer (F_3) and 66/29% as compared to control. This result shows that maximum amount of biological yield was obtained in F_2 (100% chemical fertilizer) with mean of 985/86 kg/ha. Barley biological yield was significantly affected by use of nutrient as shown in Table 2. Similar grain yield and 1000-grain weight, highest amount of biological yield, was recorded in N_1 (Fe^{2+}) with mean of 834/48 kg/ha.

Conclusion

In general, it can be concluded that use of manure and chemical fertilizer considerably improved yield and yield component of barley. The result in this investigation showed that use of 50% manure with 50% chemical fertilizer could produce satisfactory yield of barley in the Sistan region and between nutrient treatments, use of iron fertilizer had more effect on quantity characteristic of barley in comparison to other fertilizers. Both manure and fertilizer treatments had beneficial residual effects on crop production and use from both manure and chemical fertilizer for field fertilization and production of crops was better improved.

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