Scientific Research and Essays Vol. 6(17), pp. 3697-3701, 26 August, 2011
Available online at http://www.academicjournals.org/SRE
DOI: 10.5897/SRE11.602
ISSN 1992-2248 ©2011 Academic Journals

Full Length Research Paper

The effects of water stress, manure and chemical fertilizer on grain yield and grain nutrient content in barley

Mahdi Babaeian*, Yasser Esmaeilian, Abolfazl Tavassoli, Ahmad Asgharzade and Manan Sadeghi

Department of Agriculture, Shirvan Branch, Islamic Azad University, Shirvan, Iran.

Accepted 4 August, 2011

Barley is a cool-weather cereal grain primarily produced on dryland farms in Sistan region. In order to study the effect of different proportions of manure and chemical fertilizer and water stress on grain yield and grain nutrient content in barley an experiment was conducted as split plot randomized complete block design with three replications in research field of Zabol University, 2009. Water stress treatments consisted of: water stress in grain filling stage (S_1) and control (S_2) as the main factor and different proportions of manure and chemical fertilizer treatment consisted of: 100% manure (N_1), 100% chemical fertilizer (N_2), 50% manure + 50% chemical fertilizer (N_3), 75% manure + 25% chemical fertilizer (N_4) and control (N_5) as sub factor in this experiment. Results illustrated that the effect of drought stress in grain filling stage treatment on all grain yield and yield components with the exception of ear weight, were significant. Drought stress in grain filling stage strongly decreased grain yield but its effect was not very strong on another traits. With the exception of grain number/ear and ear weight, fertilizer treatments had significant effect on grain yields and yield components. Grain nutrient content not affected by water stress but among different proportions of fertilizer treatments, 100% manure (N_1) caused to increase of these elements in grain.

Key word: Water stress, manure, chemical fertilizer, yield, barley.

INTRIDUCTION

Drought is perhaps the major factor limiting crop production world-wide (Shangguan et al., 2000) and crops with high drought resistance are crucial for maintaining yield in areas where dry seasons are common. In the Sistan region basin zone, drought is considered the main environmental constraint for plant growth and survival. In this zone, plants grown are often exposed to drought stress, caused mainly by a high evaporative demand and a low water availability. Agricultural productivity is solely dependent upon water and it is essential at every stage of plant growth, from seed germination to plant maturation (Turner, 1991). Among various factors responsible for the low yield, the water requirement for the crop is the most important because water has a direct relationship with the yield of crop as reported by Karam (1978) that increase in the irrigation interval reduced seed yield, plant height, head diameter, seed index, and seed oil content and also increased the percentage of unfilled seeds. Water stress reduces plant growth by reducing cell division and root enlargement and leads to a decline in ion transport to the root surface. Water stress during growth cycles of plants adversely affects many physiological growth process (photosynthesis, translocation of carbohydrates and growth regulators, ion uptake transport and assimilation, N_2 fixation, turgidity, respiration) and shoot and root morphology and growth (Fageria et al., 2006). In dry soil nutrients are less mobile mainly because pores are filled with air and pathways for nutrient flux from soil to root surface are less direct. Such conditions in soil limit ion

*Corresponding author. E-mail: mahdi_bbn@yahoo.com.

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

flux to root surface by diffusion and mass flow (Barber, 1995; Pugnaire and Pardos , 1999). Abiotic and biotic stresses have tremendous effects on plant growth and development and ability to take up and utilize nutrients more efficiently (Pessarakli, 1999; Alam, 1999; Baligar et al., 2001). Anwar (1995) stated that all the yield components were affected by the number of irrigations. Soriano et al. (1994) concluded that sunflower seed yield was the most sensitive to water stress after anthesis. He also emphasized the need of irrigation management under limited water supply especially during the reproductive period. The yields of many crops are greatly influenced by organic and inorganic fertilizers. Improved soil fertility is a pre-requisite for increasing crop productivity. The practice of chemical fertilizer with manure is important for sustainability of soil fertility in each region. Organic manure not only supply nutrients into the soil but also enriches the physical properties of soil. On the other hand, chemical fertilizers only supply nutrients into the soil. The poor productivity of crops grown in acid and salt affected soils is mainly due to combinations of elemental toxicities and deficiencies or unavailability of essential nutrients (Grattan and Grieve, 1999ab). Loneragan (1997) states that knowledge generated in the field of mineral nutrition has impacted on current food production and provided information needed for further advances for the 21st century. Borlaug and Dowswell (1994) concluded that 50% of the increase in crop yields worldwide was due to application of chemical fertilizers. They stated that during the 21st century, the essential plant nutrients would be the single most important factor limiting crop yields, especially in developing countries. Baligar et al. (2001) reported that as much as half of the rise in crop yields during the 20th century resulted largely from increased use of fertilizers. Fageria and Baligar (2001) and Fageria et al. (1997) reported significant increase in grain yields of lowland rice in Brazilian Inceptisols with the application of N and P. The higher nutrient use efficiency in plants must be fully explored to increase food production to feed the growing human population, and this has to be achieved without accelerating environmental degradation from excessive fertilizer use (Evans, 1998; Epstein and Bloom, 2005). The effort to measure yield response to an applied nutrient is further confounded by other factors, such as variable soil fertility levels, climatic conditions, crop rotations, and changes in production practices that affect nutrient use efficiency (Stewart et al., 2005).

Keeping in view the aforementioned facts, this project was designed to determine the effect of water stress and different proportion of manure and chemical fertilizer on some properties of barley and nutrient availability, uptake, transport, and accumulation, interactions between nutrient supply and drought stress response in barley in Sistan region.

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. The treatment comprised of two levels of irrigation, W_1= do not irrigation in grain filling stage, W_2= control) in main plot and five levels of different proportion of chemical fertilizer and manure N_1= 100% of manure (60 ton/ha) N_2= 100 % chemical fertilizer (urea 250 kg/ha, super phosphate triple 200 kg/ha and oxide potassium 100 kg/ha), N_3= 50% of manure + 50% of chemical fertilizer, N_4= 75% of manure + 25% of chemical fertilizer and N_5= control in sub plot. All treatments were exerted before sowing. Experiment plots were seeded with Sistan cultivar with 25 cm row to row distance and 2 cm between plants. Barley was planted manually in October 2008. 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 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 grain Fe, Zn and Mn content. For measuring grain nutrient content (Fe, Mn and Zn) barley grain samples were collected after harvesting time then washed, oven dried, ground and extracted with wet acid digestion method and analyzed for elemental content of Fe, Mn and Zn by Atomic Absorption Spectrophotometer, model-2380 (Jones and Case, 1990).

The data were analyzed using MSTATC software; mean comparison was done using Duncan Multiple Comparison at 5% probability level.

RESULTS

Yield components

Water stress and proportions of manure and chemical fertilizer had significant effect on 1000-grain weight as shown in Table 2. Exertion of water stress in compare with control (not exertion of water stress) reduced 1000-grain weight of barley as amount of 9/75 % (Table 3).

Table 2. Analysis of variance for yield and yield components, grain nutrient concentration.

S.O.V	d.f	Grain yield (g/m^2)	1000-grain weight (g/m^2)	Ear weight (g)	Grains per ear	Fe (ppm)	Zn (ppm)	Mn (ppm)
Mean square								
Replication	2	700.90^{ns}	2.65^{ns}	0.194^{ns}	34.31^{ns}	0.002^{ns}	0.308^{ns}	0.028^{ns}
Water stress	1	304480.60**	72.54**	0.091^{ns}	39.65**	0.008^{ns}	0.18^{ns}	0.003^{ns}
Error a	2	142.27	0.0002	0.036	12.31	0.004	0.065	0.007
Proportions of manure and chemical fertilizer	4	27151.01 **	27.5 **	0.056^{ns}	4.64^{ns}	0.004*	0.19*	0.0118*
Interaction	4	6647.55**	4.34 ^{ns}	0.045^{ns}	11.77^{ns}	0.008^{ns}	0.121^{ns}	0.184^{ns}
Error b	16	2120.64	2.27	0.034	5.01	0.006	0.06	0.0036
CV	-	15.88	4.23	11.62	6.67	12.93	11.15	21.23

*, ** significantly 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 grain nutrient concentration.

Treatment	Grain yield (g/m^2)	1000-grain weight (g/m^2)	Ear weight (g)	Grains per ear	Fe (ppm)	Zn (ppm)	Mn (ppm)
Water stress							
Grain filing stage	189.12^{b}	34.12^{b}	1.54^{a}	32.39^{b}	0.623^{a}	2.276^{a}	0.282^{a}
Control	390.61^{a}	37.23^{b}	1.65^{a}	34.69^{a}	0.634^{a}	2.121^{a}	0.289^{a}
Proportions of manure and chemical fertilizer							
100% of manure	260.6^{b}	33.52^{b}	1.47^{a}	32.46^{a}	0.668^{a}	2.387^{a}	0.338^{a}
100% chemical fertilizer	248.04^{b}	36.75^{a}	1.69^{a}	34.70^{a}	0.606^{c}	2.119^{ab}	0.245^{bc}
50% of manure + 50% of chemical fertilizer	386.66^{a}	37.85^{a}	1.65^{a}	33.18^{a}	0.624^{b}	2.228^{ab}	0.295^{bc}
75% of manure + 25% of chemical fertilizer	330.87^{a}	37.02^{a}	1.65^{a}	34.14a	0.640^{ab}	2.323^{a}	0.315^{ab}
Control	106.18^{a}	240.9^{a}	26.63^{ab}	49.91^{bc}	0.604^{c}	1.937^{b}	0.235^{c}

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

Grain yield was reduced when water stress was applied at any stage of development (grain formation) due to lower 1000-grain weight. Soil moisture stress at pre-heading stage resulted in loss of grain yield that was mainly attributable to decreased grain weight (Ashraf and O'Leary, 1998). França Neto et al. (1993) in soybean and Perez et al. (1999) in dry bean reported a similar effect of drought stress applied during seed filling. The highest 1000-grain weight was obtained in the N_3 (50% of manure + 50% of chemical fertilizer) treatment and minimum of 1000-grain weight was recorded in N_1 (100% manure) and N_5 (control) treatment as shown in Table 3. This result corroborated the earlier findings of Mentler et al., (2002) in corn. Water stress and fertilizer proportions and interaction of them did not have any significant effect on ear weight of barely (Sistan cultivar). The grains per ear were affected by water stress exertion in filling stage, while fertilizer proportions and interaction of them did not have any effect on grains number per ear (Table 2). Exertion of water stress in compare with control treatment decreased the grains number about 6.63% (Table 3). Iqbal et al. (1999) stated that the maximum reduction in number of grains per ear due to moisture stress has been recorded at flowering stage. Ashraf and O'Leary (1998), reported that water deficit reduced the yield and yield component in wheat but the maximum reduction in all parameter occurred under terminal drought. In another researches Nielsen and elson (1998) and Nuez et al. (2005) also identified the number of pods per plant as the principal cause of yield losses of bean subjected to drought stress, followed by the number of seeds per pod and seed weight.

Grain yield

Water stress and proportions of manures and chemical fertilizer was significant on barely grain yield ($P < 5\%$) (Table 2). Mean comparison showed that applied water stress in filling stage in comparison with control treatment, result in the increase of grain yield about 51/58% as shown in Table 3. Similarly, Ashraf et al. (1998) attributed this observation in wheat. This result corroborated the earlier findings of Castaeda et al. (2006) they reported higher sensitivity of dry bean to drought stress at the pod formation stage. Leinhos and Bergmann (1995) cultivated barley in pots and exposed to drought stress, which caused a significant decrease in grain yield. The maximum grain yield was recorded by the application of N_3 (50% manure + 50% chemical fertilizer) and N_4 (75% manure + 25% chemical fertilizer) treatment respectively with 386/66 and 330/87 g/m^2 and minimum amount of grain yield was obtained at N_5 (control) treatment with average 223 /15 g/m^2 but there was no significant different between N_1 (100% manure), N_2 (100% chemical fertilizer) and N_5 (control) as shown in Table 3. Son and Buresh (1994) reported that use of manure in combination with urea increase seed yield at rice. An earlier study by Eghball and Power (1999) on the effect of placement of composted and non-composted manure on corn yield and N uptake showed significant treatment effects on biomass yield, grain yield and N uptake. Similarly, Mentler et al. (2002) stated that use of chemical fertilizer in combine with manure increase grain yield of corn. Singh et al. (1997) Stated that the proper combination of organic and chemical fertilizers enhances the growth and development of the crop.

Fertilizer management can strongly affect crop productivity under conditions of drought. Thus, the addition of nutrients can either enhance or decrease plants' resistance to drought, which have no effect at all, depending on the level of water availability. Drought reduces both nutrient uptake by the roots and transport from the roots to the shoots, because of restricted transpiration rates and impaired active transport and membrane permeability.

Grain nutrient content

Fertilizer proportions application had significant effect on barley grain elements concentration ($P < 0.05$), but the water stress and interaction of them had no significant effect on grain elements concentration as shown in Table 2. Among of fertilizer proportions treatments, maximum amount of iron, zinc and manganese of grain was recorded in N_1 (100% manure) and after that more concentration of this elements was observed in N_4 (75% manure + 25% chemical fertilizer), N_3 (50% manure + 50% chemical fertilizer) and N_2 (100% chemical fertilizer) respectively (Table 3). These results are in agreement with the findings Mentler et al. (2002). Similary Rao and Sitaramayya (1997) reported that nutrient uptake by rice was increased with integrated nutrient management of rice through conjunctive use of fertilizer urea with FYM, bio-gas slurry and poultry manure. Buckman and Brady (1980) stated that organic matter acts as a reservoir of plant nutrients especially N, P, K, S and micronutrients and also prevents leaching of nutrients. Sengar et al. (2000) also reported that N, P, K uptake by rice was significantly increased by the application of N fertilizer and manure. It also improves cation exchange capacity of soil. The results showed decrease amount of manure proportion in treatments reduced concentration of these elements in barely grains.

DISCUSSION

The results of this research showed that the water stress exertion in seed filling stage decreased yield and yield components of barley. Obtained result indicated that the seed filling stage is more sensitive in barely growth stages. Water stress in seed filing stage decreased amount of photosynthesis material transfer to barley grains, thereby decreased yield and yield components. Also the result showed that 50% manure + 50% chemical fertilizer in compare with other treats had maximum positive effect on yield and yield components of barely grain.

Use of inorganic chemical fertilizers is hazardous to the soil environment. These materials cause problems not only to the soil health but also to the human health and physical environment. Also chemical fertilizers consume a large amount of energy and money. However, organic farming with or without chemical fertilizers seems to be possible solutions for these situations (Prabu et al., 2003). The integration of organic sources and synthetic sources of nutrients not only supply essential nutrients but also have some positive interaction with chemical fertilizers to increase their efficiency and thereby reduce environmental hazards. Organic farming is a production system which avoids the use of synthetic inorganic fertilizer, pesticides, and growth regulators (Reddy et al., 2005). Organic farming systems often include recycles farmyard manure for fertilization, and bio control measures for plant protection.

REFERENCES

Alam SM (1999). Nutrient uptake by plants under stress conditions. In: Handbookof plant and crops stress, ed., M. Pessarakli, pp. 285-313.

Anwar M, Rehman S, Khan S, Quarishi Z (1995). Response of sunflower varieties to different irrigation regimes during Kharif season in Peshawar Valley. Sarhad J. Agric., 11: 273-278.

Ashraf M, O'Leary JW (1998) Effect of drought stress on growth, water relations and gas exchange of two lines of sunflower differing in degree of salt tolerance. Int. J. Plant Sci., 157: 729-732.

Ashrafe MY, Ala SA, Bhatti AS (1998). Nutritional imbalance in wheat (Triticum aestivum L.) genotypes grown at soil water stress. Acta. physiol. Plant., 20(3): 307-310

Buckman HO, Brady NC (1980). The Nature and Properties of Soil, 8th ed., Eurasia Publishing House (P) Ltd., New Delhi. pp. 137-16.

Barber SA (1995) Soil nutrient bioavailability: A Mechanistic approach. New York: John Wiley & Sons Inc.

Baligar VC, Fageria NK, He ZL (2001) Nutrient use efficiency in plants. Commun. Soil Sci. Plant Anal., 32: 921-950.

Borlaug NE, Dowswell CR (1994). Feeding a human population that increasingly crowds a fragile planet. Paper presented at the 15th World Congress of Soil Science, 10–16 July, 1994, Acapulco, Mexico.

Castaêda SMC, Cordova TL, GonzᏧlez HVA, Delgado AA, Santacruz VA, Garca de los SG (2006). Espuestas fisiolgicas, rendimiento y calidad de semilla en frijol sometido a estrés hdrico. Interciencia, 31: 461-466.

Eghball B, Power JF (1999). Composted and noncomposted manure application to conventional and no-tillage systems: corn yield and nitrogen uptake. Agron. J., 91: 819-825

Epstein E, Bloom AJ (2005). Mineral nutrition of plants: Principles and perspectives, 2nd edition, Sunderland, Massachusetts: Sinauer Associations, Inc. pp: 342-351.

Evans LT (1998) Feeding the ten billion: Plants and population growth. Cambridge University Press, Cambridge, UK. pp. 238-245.

Fageria NK, Baligar VC, Jones CA (1997). Growth and mineral nutrition of plants, 2nd ed. New York: Marcel Dekker, pp. 457-463.

Fageria NK, Baligar VC (2001) Lowland rice response to nitrogen fertilization. Commun. Soil Sci. Plant Anal., 32: 1405-1429.

Fageria NK, VC Baligar, Clark RB (2006). Physiology of crop production. New York: The Haworth Press, pp: 34-318.

França Neto JB, Krzyzanowski FC, Henning AA, West SH, Miranda LC (1993). Soybean seed quality as affected by shr iveling due to heat and drought stresses during seed filling. Seed Sci. Technol., 21: 107-116.

Grattan SR, Grieve CM (1999a). Salinity-mineral nutrient relations in horticultural crops. Scientia Horticult., 78: 127-157.

Grattan SR, Grieve CM (1999b). Mineral nutrient acquisition and response by plants grown in saline environments. In: Handbook of plant and crops stress, ed. M. Pessarakli, New York: Marcel Dekker, pp. 203-229.

Iqbal M, Ahmad K, Ahmad I, Sadiq M, Ashraf MY (1999). Yield and yield components of durum wheat. (*Triticim durum*) as influenced by water stress at various growth stage. Pak.J. Bio. Sci., 2(4): 1438-1440.

Jones JB, Case VW (1990). Sampling, Handling and Analysis Plant Tissue Sample. In: Soil Testing and Plant Analysis. Westermann, R.L. (Ed.), 3rd. 1990. Soil Sci. Soc. Am. Book Series No. 3, Madison, WI., pp: 389-427.

Karam C (1978). Effect of irrigation intervals on yield components of sunflower. Field Crop Abst., 31: 90-97.

Leinhos V, Bergmann M (1995). Changes in the yield, lignin content and protein pattern of barley (*Hordeum vulgare*) induced by drought stress. Angewandie Botanik, 69(5-6): 206-210.

Nielsen DC, Nelson NO (1998). Black bean sensitivity to water stress at various growth stages. 38: 422-427.

Nẻz BA, Hoogenboom G, Nesmith DS (2005). Drought stress and distribution of vegetative and reproductive traits of a bean cultivar. Sci. Agric., 62: 18-22.

Loneragan JF (1997). Plant nutrition in the 20th and perspectives for the 21st century. In: Plant nutrition for sustainable food production and environment, eds.T. Ando, K. Fujita,T. Mae, H. Matsumoto, *S. Mori*, and *J. Sekiya*, pp. 3-14.

Pérez HP, Acosta DE, Padilla RS, Acosta GJ (1999) Effect of drought on seed quality of common bean (*Phaseolus vulgaris* L.). Agric. Téch. Méx., 25: 107-114.

Pessarakli M (1999). Handbook of plant and crops stress. New York: Marcel Dekker. Pettersson, S., and P. Jensen. 1983. Variation among species and varieties in uptake and utilization of potassium. Plant Soil., 72: 231-237.

Prabu T, Narwadkar PR, Sanindranath AK, Rafi M (2003). Effect of integrated nutrient management on growth and yield of okra. Parbhani Kranti. Orissa J. Hort., 31: 17-21.

Pugnaire FL, Pardos J (1999). Constraints by water stress on plant growth. In: Handbook of plant and crops stress, ed. M. Pessarakli, pp. 271-283.

Rao SS, Sitaramaya M (1997). Changes in total and available soil nitrogen status under integrated nutrient management of mutard. J. Indian Soc. Soil Sci., 45 (3): 445-449.

Reddy SS, Shivaraj B, Reddy VC, Ananda MG (2005). Direct effect of fertilizer and residual effect of organic manure on yield and nutrient uptake of maize (Zea mays L.) in groundnut-maize cropping system. Crop Res. Hsiao., 29: 390-395.

Sengar SS, Wade LJ, Baghel SS, Singh RK, Singh G (2000). Effect of nutrient management on rice in rain fed low land of Southeast Madhya Pradesh" Indian J. Agron., 45 (2): 315-322.

Shangguan Z, Shao M, Dyckmans J (2000). Effects of nitrogen nutrition and water deficit on net photosynthetic rate and chlorophyll fluorescence in winter wheat. J. Plant Physiol., 156: 46-51.

Singh J, Bhat SS, Sudharshan MR, Jasvir S, Sreekrishna BS (1997). Performance of Sco chili in Karnataka and its response to vermicompost. Ind. Cocoa, Arecanut Spices. J. 21: 9-10.

Soriano MA, Villalobos FJ, Fereres E, Orgaz F, Borin M, Sattin M (1994). Response of sunflower grain yield to water stress applied during different phonological stages, Abano-Padovo, Italy, p.18-22.

Stewart WM, Dibb DW, Johnston AE, Smyth TJ (2005). The contribution of commercial fertilizer nutrients to food production. Agron. J., 97: 1-6.

Turner LB (1991) The effect of water stress on the vegetative growth of white clover (*Trifolium repens L.*): Comparison of long-term water deficit and short-term developing water stress. J. Exp. Bot., 42: 311-316.