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Research Article

THE EFFECT OF HUMIC ACID APPLICATION AND HARVEST TIME OF FORAGE ON GRAIN AND FORAGE YIELD OF DUAL PURPOSE BARLEY

Shabnam Nadimpoor and *Mani Mojaddam
Department of Agronomy, College of Agriculture, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran
**Author for Correspondence*

ABSTRACT
In order to investigate the effect of different levels of humic acid and harvest time of forage on the forage and grain yield of dual purpose barley a split plot experiment in the form of randomized complete block design with three replications was carried out in the experimental research field of Ahvaz Islamic Azad University in the region of Veis in 2013-2014. The experiment factors included three levels of humic acid (H0: 0, Hi: 500ppm, H2: 1000ppm) as the foliar spray randomly in the main plots and three levels of forage harvest time (C0: lack of green forage harvest, C1: green forage harvest at the beginning of stem elongation without removing reproductive meristem of main stem, C2: green forage harvest in the middle of stem elongation and removing reproductive meristem of main stem) randomly in the main plots. The results showed that grain yield, number of spike per area unit, number of grains per spike and forage dry weight significantly increased as the humic acid concentration increased. The results also showed that delay in the harvest of green forage significantly decreased the grain yield. The highest rate of grain yield in barley belonged to H2 treatment by 329.07 g/m^2 and the lowest rate belonged to H) by 257.36 g/m^2. The highest rate of grain yield by 314.81 g/m^2 belonged to the treatment with lack of forage harvest (C0) and the lowest rate of grain yield by 255.03 g/m^2 belonged to the treatment with forage harvest in the middle of stem elongation (C2). The highest weight of dry matter by 247.3 g/m^2 belonged to C2 treatment and the lowest weight by 139.1 g/m^2 belonged to C1 treatment. With regard to the measured components it can be said that the consumption of humic acid with concentration of 1000 ppm and the forage harvest at the beginning of stem elongation were superior to the other treatments in dual purpose cultivation (forage + grain).

Keywords: *Barley, Humic Acid, Harvest Time, Forage and Grain Yield*

INTRODUCTION

Grain is the most important crop and a buffer between humanity and hunger. Grin supplies 70% of the food of human beings all over the world. Among the grain crops barley has the widest range of adaptability and is more tolerant than other kinds of grain in coping with drought, salinity, and alkalinity stress. Wide ecological adaptation, innumerable availability for feeding humans and livestock and production of high quality malt are the major factors causing the constant cultivation and production of barley in successive centuries (Noor and Siadat, 2007). Pastures in Iran are estimated to be 90 million hectares that produce about 10 million tons of forage annually. This amount of forage can supply the food for only 16 million animal units while 56 million livestock unites are dependent on the forage of such postures (Lebaschi *et al.,* 1993). Therefore, the pastures in country by tolerating more than 3.5 times as much as their capacity particularly the cord and winter pastures have taken a regressive trend and consequently have been declining (Lotfali *et al.,* 1993). Khuzestan Province is not an exception and since there are about 10 million constant and moving livestock in this province during the winter that are facing a severe shortage of forage in November, December, and January, planting grain such as dual purpose barley (grain and forage harvest) can be one of the fundamental solutions to the forage supply for the livestock during this season (Kajbaf and Radmehr, 1991). The forage harvest in grain is usually followed by the decrease of economic yield (grains) but if the forage harvest is done with decent management and considering certain points, acceptable grain yield in addition to proper crop will be obtained with regard to the nutritional value of grain (Mojadam, 1997). Christian *et al.,* (1989) reported that winter wheat pasture can be useful if: 1. Grazing is mild; 2. There is less livestock stepping; 3. Plant lodging occurs without harvesting or grazing; 4. The weather condition is moderate during grazing. The forage harvest with regard to the time, intensity and the frequency of harvesting has a significant effect on forage yield. Rahimian and Khazaei (1992) reported that the forage harvest led to the increase of grain yield. Prasad and Mockerji (1988) concluded that delay in harvesting oat forage led to the decrease of 1000-grain weight and grain yield. Gardner and Vegan (1959) compared the effect of forage harvest and livestock grazing and found that delay in grazing and forage harvest had similar effects and both methods of forage harvesting caused the decrease of grain production and plant height. Humic acid is an important fertilizer which is consumed by plant. It is a natural polymer containing H^+ positions related to acidic factors of Carboxyl Benzoic and phenol (Cation exchange sites). This acid is a complex organic macromolecule which is formed through chemical and bacterial phenomena in soil and is the final result of humification. It has a relatively high molecular weight between 104 to 106 Dalton and carbon forms 50% of its molecular weight (Sardashti *et al.*, 2007). The overall purpose of this research is to investigate the effect of forage harvest at different times compared with normal cultivation (lack of harvest) on the grain yield and forage yield, the effect of different concentrations of humic acid on grain yield and forage yield, and the interactive effect of different treatments of forage harvest and different concentrations of humic acid on grain yield and forage yield. According to Balakonbahan and Raja (2010) humic acid changes the plants growth through physiological change of plant and by improving physical, chemical, and biological properties of soil. Ayes and Goslar (2005) reported that humic acid increased the growth, height, and biological yield of plant via increasing the plant nitrogen content.

MATERIALS AND METHODS

Experimental Location

The experiment was carried out in the fall of 2013 – 2014 in the bank of the Karun River, in the experimental research field of Ahvaz Islamic Azad University in Veis region. The experimental field is located in Northeast part of Ahvaz at latitude 31°29´N and longitude 48°54´E and 23 m above the sea level. The region has a hot and dry climate. The research was conducted as a split plot experiment in the form of randomized complete block design with three replications and two factors of humic acid and forage harvest time. The experiment factors included three levels of humic acid (H0: 0, Hi: 500ppm, H2: 1000ppm) as the foliar spray randomly in the main plots and three levels of forage harvest time (C0: lack of green forage harvest, C1: green forage harvest at the beginning of stem elongation without removing reproductive meristem of main stem, C2: green forage harvest in the middle of stem elongation and removing reproductive meristem of main stem) randomly in the main plots. Each replication included 9 plots and thus the plan included 27 experimental units and the first and the last line of each plot were considered as the margin. Each plot included 7 rows of planting line as long as 6 m and with the space of 20cm. the distance between two plots was 1.5 m. The land preparation operation after primary irrigation included plowing, two perpendicular disks, and ultimately the leveling operation was done by the loader. Then, the desired fragments were marked by lines and the streams were created. Then the plots boundaries were specified and the ultimate leveling was done. After the ultimate leveling, 7 planting lines were created in each plot by furrower manually and the prepared seeds were placed in each planting line regularly and by hand and the soil around the furrows covered them. Irrigation was done typically based on the need and rainfall condition. During the growth season, the weeds were manually weeded. Humic acid was added to the plant as foliar spray at four-leaf stage and according to the experiment concentrations. Nitrogen fertilizer was supplied via the urea source. 50% of the nitrogen fertilizer was linearly distributed beside the planting lines concurrent with planting and the remaining half was distributed as surplus after the forage harvest in the late tillering stage. The needed phosphorus fertilizer that was about 80 kg/ha (P_2O_5) was supplied for the plant through the source of ammonium phosphate. The final harvest area after removing the margins from three middle lines was equal to 1.5 m^2 that was harvested manually by sickle and the product of each experimental unit was marked after harvesting and was put in a separate bag and then was weighed and threshed. Then the sample grains were taken from each plot and the moisture content and then the grain yield were determined. The green forage was harvested from three middle lines in an area of 2 m^2 and was weighed separately after elimination of 0.5 meter of the top and bottom of plots. In order to determine the forage dry weight, 200 g forage was randomly selected after harvesting and was kept in autoclave for 48 hours at 72°C and the weight was measured via the following equation:

Total dry weight of forage in the harvest area = total weight of fresh forage × dry weight of sample in autoclave / 200.

In order to determine the dry weight of forage, the desired forage after cutting was dried at 70°C for 48 hours and then the dry weight was measured. After the crop harvest, the traits associated with the yield and its components including the number of spike per m^2, number of grains per spike, 1000-grain weight, and grain yield were measured.

Finally the data were analyzed by SAS software and the means were compared through the Duncan's test. Excel 2007 software was used in order to draw the histograms.

RESULTS AND DISCUSSION

Number of Spikes per Square Meter

The ANOVA results (Table 1) show that the number of spikes/m^2 is significantly affected by different concentrations of humic acid and forage harvest time at 1% probability level. The interactive effect of humic acid and forage harvest time on the number of spike/m^2 is not significant. Comparison of the means through Duncan's test at 5% level (Table 2) shows that the highest number of spike/m^2 by 382.97 belongs to H2 treatment with concentration of 1000 ppm and the lowest number of spike/m^2 by 347.53 belongs to H0 treatment (control) with concentration of zero. Haghighi (2011) reported that the combination of macro and micro humic acids during the growth stage has increased the number of spike/m^2 and grain protein percentage. Moreover, Icahn (1995) reported that humic acid enhances the plants growth by clotting nutrients such as sodium, potassium, magnesium, zinc, calcium, iron, copper, etc., in order to overcome the lack of nutrients. Due to the presence of hormonal compounds, humic acid has beneficial effects on the production increase and quality improvement of agricultural products. The highest number of spike/m^2 by 388.00 belongs to the forage harvest at the beginning of stem elongation stage (C1) and the lowest number of spike/m^2 by 328.42 belongs to the forage harvest in the middle of stem elongation stage (C2) (Table 2). Delay in the forage harvest significantly reduced the number of spike per area unit. Mansourifar (1992) reported that cutting the forage in the middle of stem elongation due to the cut of apical meristem and some tillers and consequently the death of tillers during the harvest reduces the number of spike per area unit which is also evident in this experiment.

Number of Grains per Spike

The ANOVA results (Table 1) show that the number of grains per spikes is significantly affected by different concentrations of humic acid and forage harvest time at 5% probability level. The interactive effect of humic acid and forage harvest time on the number of grains per spike is not significant. Comparison of the means through Duncan's test at 5% level (Table 2) shows that the highest number of grains per spike by 27.71 grains belongs to H2 treatment with concentration of 1000 ppm and the lowest number of grains per spike by 22 grains belongs to H0 treatment (control) with concentration of zero. Sabzevari and Khazaei (2010) showed that the effect of humic acid on the number of grains per spike was significant. In this study, the highest number of grains was obtained by the consumption of 200 mg/l humic acid during the pollination stage. After that, the highest number of grain per spike was obtained through the consumption of 200 mg/l humic acid during the tillering stage and consumption of 300 mg/l humic acid during the emergence of flag leaf. Accordingly, the best concentration of humic acid for obtaining the highest number of grain is the consumption of 200 mg/l and the best foliar spray time is at 50% of tillering stage. The highest number of grains per spike by 27.28 grains belongs to the treatment without the forage (C0) and the lowest number of grains per spike by 23.81 grains belongs to the treatment with the forage harvest in the middle of stem elongation stage (C2) (Table 2). The significant decrease of number of grains per spike in the forage harvest in the middle of stem elongation can be due to the production of spikes from the secondary tillers because the secondary tillers had shorter vegetative growth period and consequently produced smaller spike with lower number of grains. This Point is confirmed by Rahimian and Khazaei (1992) about the late forage harvest.

Table 1: The ANOVA results of measured traits based on the mean squares

Grain yield	Forage dry weight	1000-grain weight	Number of grains per spike	Number of spike/m^2	df	Sources of Variations of traits
4863n.s	205.7n.s	4.919	23.26	1474.9	2	**Replication (R)**
13939*	13002**	17.113*	85.71*	2833.5**	2	**Humic Acid (H)**
801	389.8	1.443	5.026	26.2	4	**Error a**
17410*	30005**	5.191n.s	27.031*	9533.6**	2	**Forage harvest time (C)**
149n.s	452n.s	1.634n.s	0.723n.s	81.8**	4	**C*H**
1467	294.18	4.335	6.561	94.3	12	**Error b**
12.6	13.2	6.4	10	2.6	----	**C.V**

*ns, **, * mean that mean squares are respectively non-significant, and significant at 1% and 5% probability levels*

1000-Grain Weight

The ANOVA results (Table 1) show that the weight of 1000-grain in barley is significantly affected by different concentrations of humic acid at 5% probability level, but the effect of forage harvest time on it is not significant.

The interactive effect of humic acid and forage harvest time on the weight of 1000- grain is not significant.

Table 2: Means comparison of measured traits.

Grain yield (g/m^2)	Forage dry weight (g/m^2)	1000-grain weight (g)	Number of grains per spike	Number of spike/m^2	Treatment
					Humic acid
257.36b	177.6b	33.59a	22b	347.53b	**H_0= 0 ppm**
321.3a	196.5a	32.48a	26.88a	366.83ab	**H_1=500 ppm**
329.07a	205.2a	30.85b	27.71a	382.97a	**H_2= 1000 ppm**
					Forage harvest
341.81a	-	32.91a	27.28a	380.9a	**Lack of forage harvest (C0)**
310.89a	139.1b	31.45a	25.49ab	388a	**Harvest at the beginning of stem elongation (C1)**
25503b	247.3a	32.55a	23.81b	328.42b	**Harvest in the middle of stem elongation (C2)**

According to Duncan's multiple range test the means with similar letters in each column don't have significant difference at 5% level.

Comparison of the means through Duncan's test at 5% level (Table 2) shows that the highest number rate of 1000-grain weight in barley by 33.59 g belongs to H0 treatment with concentration of zero and the lowest rate of 1000-grain weight by 30.85 g belongs to H2 treatment with concentration of 1000 ppm. At high concentrations of humic acid due to the increase of number of spikes and number of grains per spike which is assimilates mobilization and distribution between grains, the weight of 1000-grain reduced. Hashemi and Marashi (1992) reported that the mean of 1000-grain weight is primarily determined by assimilates that are mobilized into spike during flowering stage until maturity. This, in turn, depends on the leaf area continuity after flowering stage and photosynthetic activity of spike and also source – destination relationships. The highest rate of 1000-grain weight by 32.91 g belonged to the treatment without forage harvest (C0) and the lowest rate of 1000-grian weight by 31.45 g belonged to the treatment with forage harvest at the beginning of stem elongation (C1) (Table 2).

Forage Dry Matter Weight

The ANOVA results (Table 1) show that the forage dry matter weight is significantly affected by different concentrations of humic acid and forage harvest time at 1% probability level. The interactive effect of humic acid and forage harvest time on the forage dry matter weight is not significant. Comparison of the means through Duncan's test at 5% level (Table 2) shows that the highest weight of forage dry matter by 205.2 g/m^2 belongs to H2 treatment with concentration of 1000 ppm and the lowest weight of barley dry matter by177.6 g/m^2 belongs to H0 treatment (control) with concentration of zero. Kowsar *et al.,* (1985) found in a research on wheat that the concentration of 54 mg/lit humic acid increased the root length by 50% and dry matter weight by 22% and nitrogen intake before humic acid increased significantly, as well. The results of the research are consistent by the findings of many researchers on the effect of humic acid on the root growth. Taylor and Cooper (2004) found that the consumption of humic acid as solution or powder in soil increased the length and weight of carrot root and increased the plant growth in general. The highest weight of barley dry matter by 247.3 g/m^2 belonged to the treatment with forage harvest in the middle of stem elongation stage (C2) and the lowest weight of barley dry matter by 139.1 g/m^2 belonged to the treatment with forage harvest at the beginning of stem elongation stage (C1) (Table 2). According to the reports, delay in crops harvest leads to the decrease of qualitative yield of forage plants through the increase of cell walls and lignin, the roughness of different parts of plant, and decrease of leaf to stem ratio, but the quantitative yield in area unit increases.

Grain Yield

The ANOVA results (Table 1) show that the grain yield in barley is significantly affected by different concentrations of humic acid at 5% probability level. The effect of forage harvest time on grain yield is significant at 1% probability level.

The interactive effect of humic acid and forage harvest time on the grain yield is not significant. Comparison of the means through Duncan's test at 5% level (Table 2) shows that the highest rate of grain yield by 329.07 g/m^2 belongs to H2 treatment with concentration of 1000 ppm and the lowest rate of grain yield by 257.36 g/m2 belongs to H0 treatment (control) with concentration of zero.

Humic acid causes the continuation of photosynthetic tissues and increases the grain yield. Wolf *et al.,* (1988) found that there was a positive significant correlation between grain dry weight and leaf area continuity and confirmed that the leaf chlorophyll would be as important as leaf production in determining grain yield. Naderi *et al.,* (2002) reported that humic acid via positive physiological effects such as the effect on plant cells metabolism and increase of leaf chlorophyll concentration would increase the plants yield.

The highest rate of grain yield by 314.81 g/m^2 belongs to the treatment without the forage harvest (C0) and the lowest rate of grain yield by 255.03 belonged to the treatment with forage harvest in the middle of stem elongation (C2) (Table 2). Scott *et al.,* (1989) reported that significant decrease of grain yield in forage harvest in the middle of stem elongation was mainly due to the decrease of the number of grains per spike, and the decrease of the number of spike per area unit was due to the cut of reproductive meristem of main stem. This matter in the present research significantly decreased the number of spike in area unit.

Conclusion

The results show that different concentrations of humic acid have significant effect on the number of spike per square meter, number of grains per spike, 1000-grain weight, grain yield, and forage dry weight so that the highest rate belongs to H2 treatment with concentration of 1000 ppm. Different forage harvest times also have significant effect on grain yield, number of spike per square meter, number of grains per spike, biological yield, and forage dry weight.

In general, the results of the research showed that the harvest of green forage at the beginning of stem elongation had no significant effect on the grain yield; on the other hand, delay in the forage harvest in the middle of stem elongation, due to the cut of reproductive meristem of main stem and some tillers, significantly reduced the grain yield. The highest rate of grain yield belonged to H2 treatment with concentration of 1000 ppm and the forage harvest at the beginning of stem elongation. With regard to appropriate price of the input (humic acid) and its effect on the increase of production (green forage + grain) and also the value of additional grain yield, this treatment leads to adequate forage harvest and is well preferred to other treatments in dual purpose cultivation.

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