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Effect of Sowing Date and Nitrogen Fertilization on Growth, Yield and Yield Components of Barley (*Hordeum vulgare* L.)

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ABSTRACT: Among the agronomic practices, planting time and nitrogen fertilization are the prime factors that limit crop production to its full extent. Field experiment was conducted at the Agricultural Research Station of King Abdul Aziz University at Hada Al-Sham during 2012 and 2013 seasons to investigate the effect of sowing date (November 05, November 20 and December 05) and nitrogen rates (0,100 and 200 kgha^{-1}) on growth and yield of barley. Statistical analysis of gained data presented significant effect of nitrogen levels on barley growth and yield parameters. November 20plantation outcompeted the rest of the planting times and produced superior plant height, 1000 grain weight, plant dry biomass, grain weight and chaff weight while November 05 produced higher number of spikelets spike^{-1} and harvest index compared to November20 and December 05plantation. The highest level of nitrogen fertilizer (200 kgha^{-1} leads to an increase in plant height, number of spikesm^{-2}, spike weight, spike length, number of spikeletsspike^{-1}and 1000 grain weight. Delay in plating time such as December 05reduced vegetative and reproductive growth period thus results in lower biological and grain yield, number of spikesm^{-2}, number of spikeletsspike^{-1}, harvest index, 1000 grain weight, nitrogen and protein content. Significant interaction of sowing dates × nitrogen fertilization were also recorded for several studied traits. Barley growth and yield contributors were positively correlated to grain nitrogen and protein content.

KEYWORDS: Barley, Fertilizer rate, Grain yield, Sowing date.

1 INTRODUCTION

Barley (*Hordeumvulgare* L.) was cultivated for the very first time in history around 1000 years ago as the reports of archeologist suggest its trace analysis from the Fertile Crescent of Eurasian agriculture (Saisho and Purugganan, 2007). Currently barley is used for multiple purposes such as, animal feed, malt manufactures, human food and cover crop to improve soil fertility and structure (Ghanbari *et al*., 2012). Its importance derives from the ability to grow and produce in marginal environments, which are often characterized by drought, low temperature and salinity (Baum *et al*., 2004; Lakew *et al*., 2011; El-Awady and El-Tarras., 2014). It is second only to wheat as the most important nutritional grain crops grown in low rain fed arid land environments (El-Awady and El-Tarras., 2012).Expansion of agriculture area have many limitations (Parry *et al*., 2011) so, current goal could only be achievable through enhancing crop productivity by better management and adjusting planting time to optimum(Reynolds *et al*., 2011).

A significant threat to crop production and food security is the predicted increase in frequency of extreme climate events such as heat waves and droughts (Easterling *et al*., 2000; Semenov, 2007). Episodes of unusually high temperature and low rainfall can decrease considerably grain yields (Wheeler *et al*., 1996; Porter and Semenov, 2005). Barley is notably susceptible to heat stress at meiosis and anthesis stages (Sakata *et al*., 2000). Under rainfed conditions, barley frequently suffer from drought resulting in a significant loss of yield (Hossain *et al*., 2012a).

Planting date and N fertilizer significantly affect barley grain yield, grain protein and kernel plumpness (O'Donovan *et al*., 2011). The differences in production of early and late sown crops may be due to favorable temperatures at different growth stages which may increase photosynthetic rate, assimilates the supply for seed and seed growth rate in early sown crops than late planting (Rashid *et al*., 2010). Delayed planting decreases barley grain yield (Singh and Singh 2005) while increasing grain protein content (Kavitha *et al*., 2012). Nitrogen fertilizer is considered a key input affecting crop production and might be as crucial as water to growth and nutrient uptake (Jaradat and Haddad, 1994). Inadequate N inputs can reduce grain yield and quality below acceptable level sowing to lodging and disease (O'Donovan *et al*., 2015; Ding *et al*., 2015), while excessive N inputs usually produce undesirable high protein levels (O'Donovan *et al*., 2015). While Weston et al. (1993) found that higher protein concentration with N rates more than 150 kg N ha^{-1}. Zia et al. (1991) illustrated that the use of corrected N fertilizer can increase crop yield of barley upto 50%. Rashid *et al* (2010) indicated that the maximum grain yield of barley 4293 kg ha^{-1} was harvested from 60-90 kg N ha^{-1}. An adequate application of nitrogen fertilizer can enable the plant to establish canopy in short time which can significantly contribute in light interception, photosynthesis and grain filling (Al-Barrak, 2006; Ding *et al*., 2015).As far as plant productivity in arid regions is far below than the potential yield due to many factors of which planting date being the most important factor affecting the productivity (Faki *et al*., 1990; Zia *et al*., 2014).

Keeping in view the importance of sowing date and nitrogen level in barley growth and yield, the present study aimed to determine the optimum planting time and nitrogen level for successful barley production under arid land conditions of Saudi Arabia. Effect of these treatments was also studied on grain quality contents and were correlated with barley growth and yield.

2 MATERIALS AND METHODS

EXPERIMENTAL SITE AND TREATMENTS

A field experiment was carried out for two consecutive seasons of 2012-13 and 2013-14 at the Agricultural Experimental Research Station of King Abdulaziz University (KAU) located at Hada Al-Sham valley, 100 km North East of Jeddah (21^{o} 48′ 3″ N, 39^{o} 43′ 25″ E). The agro-climatic conditions data were collected from the meteorological station located at the experimental site (Table 1). This experiment was carried out in order to examine effect of sowing dates (November 05, November 20 and December 05) and different rates of nitrogen fertilizer (0,100 and 200 $kgha^{-1}$) on growth, grain yield and yield components of barley. Randomized Complete Block Design with split plot arrangement was used with three replicates. Main plots were assigned for sowing dates and sub plots for nitrogen levels. Nitrogen treatments were applied in split doses at 2, 4and 8 weeks after sowing. Gross plot size was 5m × 5m, and row to row distance was 15 cm. Seed rate was 150 $kgha^{-1}$. Soil was analyzed prior to planting for physiochemical analysis. Soil pH8.84, electrical conductivity 1.15 dSm^{-1}, organic matter 0.48% and nitrogen was 0.2 %. Urea, super phosphate and potassium were added to the soil before planting with the rates of 150 kg N ha^{-1}, 100 kg $P_2O_5ha^{-1}$ and 80kg K_2Oha^{-1}respectively.

PLANTING TIME

Barley was planted at three different planting dates(November 05, November 20 and December 05) for consecutive years. Sprinkler irrigation system (Rain bird auto control) was used in this study. All other recommended cultural practices were applied to treated and non-treated plots without any distinction.

STATISTICAL ANALYSIS

Two way analysis of variance (ANOVA) was employed to compute level of significance for main plots, sub plots and their interaction by using (SAS 8.1). Treatments significance was compared by using least significance LSD among treatment means.

3 RESULTS AND DISCUSSION

It is well known that sowing date and nitrogen fertilizer rate influence barley growth, yield and yield components (O'Donovan *et al*., 2015; Ding *et al*., 2015). For plant height the effect of nitrogen fertilizer rateand sowing date × nitrogen fertilizer interaction were all significant ($p \leq 0.05$). Non–significant ($p \geq 0.05$) effect of sowing date was documented on plant height while its effect was highly significant ($p \leq 0.01$) on $spikesm^{-2}$, spike weight (gm^{-2}), spike length (cm) and number of $spikeletsspike^{-1}$. The effects of sowing date, nitrogen fertilizer and their interaction was significant ($p \leq 0.05$) for number of $spikesm^{-2}$, spike weight (gm^{-2}), spike length (cm), number of $spikeletsspike^{-1}$. All planting times remarkably influenced productive tillers but effect of Nov. 20 plantation was more pronounced which resulted in highest number of spikes (160,44 ha^{-1}), spike weight (217.95 gm^{-2}), spike length (7.39 cm) and 1000 grain weight (38.11 g) (Table 2). Spike number and weight was declined remarkably from moving Nov. 20 to Dec. 05. Highest plant stature, spike number, spike weight, spike length, number of spikeletsspike^{-1}, 1000 grain weight, plant weight, grain weight, chaff weight and harvest index was associated with 200 kgN^{-1} (Table 3). This study demonstrated that as nitrogen fertilizer rate increased, yield and yield components increased significantly (O'Donovan *et al*., 2011; Sainju *et al*., 2013; Ding *et al*., 2015). The previous results could be largely owing to the positive effect of nitrogen on the growth of stem and leaf area, which was reflected into taller plants thus higher green area for light interception and photosynthesis that leads to higher photo assimilates translocation and accumulated resulting in higher grain yield (Javaheri *et al*., 2014).

For nitrogen and protein contents in grain and chaff the effect of nitrogen fertilizer rate was significant while effects of sowing date and its interaction with nitrogen fertilizer was non-significant(Table 4). This study illustrate positive impact of nitrogen application on grain protein contents(O'Donovan *et al*., 2011; Sainju *et al*., 2013; Valkama *et al*., 2013a). The nitrogen rate of 200 kg Nha^{-1} produced grains which had the highest nitrogen and protein contents (2.64%-16.52%) followed by 100 kg Nha^{-1} (2.52%) and the lowest nitrogen and protein contents were produced under no nitrogen fertilizer (Table 5).

Table 1. Average air temperature and humidity at the experimental site during the crop growing season 2012~2013 and 2013~2014

Month	T_{min} (°C)	T_{max} (°C)	T_{ave} (°C)	H_{min} (%)	H_{max} (%)	H_{ave} (%)
January	10.1 (11.1)	35.8 (34.1)	23.7(22.4)	27(21)	97(98)	58(59.5)
February	6.2 (10.1)	38.3 (35.1)	22.1(22.5)	22(21)	94(98)	53(59.5)
March	12.6 (8.2)	39.4 (38.2)	27.0(23.1)	21(19)	96(98)	57(58.5)
April	13.7 (15.1)	42.4 (43.1)	29.7(29.0)	23(22)	92(98)	54(60.0)
May	18.1 (15.2)	46.1 (48.1)	33.1(31.4)	28(23)	85(98)	54(60.5)
June	18.1 (20.1)	48.7 (48.1)	33.8(34.0)	24(20)	85(98)	50(59.0)
July	19.2 (20.2)	48.2 (45.2)	33.5(32.6)	20(26)	91(96)	43(61.0)
August	19.2 (19.1)	48.2 (47.1)	33.3(33.0)	20(29)	91(98)	48(63.5)
September	19.1 (20.0	48.2 (47.3)	33.0(33.6)	20(24)	99(98)	60(61.0)
October	16.6 (19.0)	42.0 (42.1)	29.8(30.4)	22(20)	98(98)	61(59.0)
November	14.1 (16.1)	26.4 (39.0)	29.1(27.4)	26(29)	98(98)	66(63.5)
December	15.2 (11.1)	27.0 (35.1)	25.2(23.0)	21(26)	98(97)	63(61.5)

Without parenthesis: For crop season 2012~2013; With parenthesis: For crop season 2013~2014. *T*min: Minimal temperature; *T*max: Maximal temperature; *T*ave: Average temperature. *H*min: Minimal humidity; *H*max: Maximal humidity; *H*ave: Average humidity.

Table 2. Means of plant height (cm), no. of spikes/m^2, spike weight (g/m^2),spike length (cm), no. of spikelets/spike, 1000 grain weight (g), plant weight (t/ha), grain weight(t/ha), chaff weight (t/ha) and harvest index of the studied barley variety under 3 planting dates as average of the 2012 and 2013 seasons.

Planting date	Means									
	Plant height (cm)	No. of Spikes/ m^2	Spike weight (g/m^2)	Spike length (cm)	No. of Spikelets/spike	1000 grain weight (g)	Plant weight(t/ha)	Grain weight(t/ha)	Chaff weight (t/ha)	Harvest Index
Nov. 5	43.54 a*	135.39 b	188.01 b	6.97 b	40.44 a	34.44 a	5.31 b	1.46 b	3.36 b	28.39 a
Nov. 20	43.51 a	160.44 a	217.95 a	7.39 a	39.61 a	38.11 a	8.26 a	1.72 a	6.14 a	25.67 ab
Dec. 5	40.87 a	109.61 c	98.08 c	5.51 b	28.89 b	34.77 a	3.90 c	0.74 c	2.88 b	20.39 b
L.S.D (0.05)	2.77	18.48	22.03	1.05	5.42	3.18	0.83	0.17	0.73	6.43

**Means followed by the same letter(s) are not significantly different according to LSD (0.05).*

Table 3. Means of plant height (cm), no. of spikesm^{-2}, spike weight (gm^{-2}),spike length (cm), no. of spikeletsspike^{-1}, 1000 grain weight (g), plant weight (tha^{-1}), grain weight(tha^{-1}), chaff weight (tha^{-1}) and harvest index of the studied barley variety under three nitrogen fertilizer rates as average of the 2012 and 2013 seasons.

Nitrogen rate (Kg Nha^{-1})	Means									
	Plant height (cm)	No. of Spikesm^{-2}	Spike weight (gm^{-2})	Spike length (cm)	No. of Spikeletsspike^{-1}	1000 grain weight (g)	Plant weight (tha^{-1})	Grain weight (tha^{-1})	Chaff weight (tha^{-1})	Harvest Index
0.00	38.81 c*	126.72 b	136.25 c	5.33 c	30.78 c	34.33 a	5.09 c	1.02 c	3.65 b	21.64 c
100.00	42.83 b	128.89 b	159.17 b	6.51 b	37.89 b	36.56 a	5.78 b	1.27 b	3.97 b	24.77 b
200.00	46.29 a	149.83 a	208.62 a	7.27 a	40.28 a	36.43 a	6.60 a	1.64 a	4.75 a	28.04 a
L.S.D (0.05)	1.75	11.31	18.02	0.75	1.74	2.62	0.46	0.11	0.50	2.70

**Means followed by the same letter(s) are not significantly different according to LSD (0.05).*

Table 4. Means of grain and chaff contents of nitrogen and protein of the studied barley variety under 3 planting dates as average of the 2012 and 2013 seasons.

Planting date	Means			
	Nitrogen content in grain(%)	Protein content in grain (%)	Nitrogen content in chaff(%)	Protein content in chaff (%)
Nov. 05	2.45 a*	15.29 a	1.46 a	9.12 a
Nov. 20	2.52 a	15.74 a	1.46 a	9.14 a
Dec. 05	2.45 a	15.32 a	1.64 a	10.24 a
L.S.D (0.05)	0.18	1.15	0.29	1.82

**Means followed by the same letter(s) are not significantly different according to LSD (0.05).*

Table 5. Means of grain and chaff contents of nitrogen and protein of the studied barley variety under 3nitrogenfertilizer rates as average of the 2012 and 2013 seasons.

Planting date	Means			
	Nitrogen content in grain(%)	Protein content in grain (%)	Nitrogen content in chaff(%)	Protein content in chaff (%)
0.00	2.25 b*	14.08 b	1.27 b	7.92 b
100.00	2.52 a	15.75 a	1.61 a	10.05 a
200.00	2.64 a	16.52 a	1.69 a	10.54 a
L.S.D (0.05)	0.17	1.06	0.12	0.76

**Means followed by the same letter(s) are not significantly different according to LSD (0.05).*

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