CHAPTER ONE

INTRODUCTION

Barley (*Hordeum vulgare*), a member of the grass family, is a major cereal grain grown in temperate climates globally. It was one of the first cultivated grains, particularly in Eurasia as early as 10,000 years ago (Zohary, *et.al* 2000).It is grown as a commercial crop in one hundred countries world -wide and is one of the most important cereal crops in the world. Barley assures the fourth position in total cereal production in the world after wheat, rice, and maize, each of which covers nearly 30 % of the word`s total cereal production (FAO, 2004).Barley has been used as animal fodder, source of fermentable material for beer and certain distilled beverages, and component of various health foods. It is used in soups and stews, and in barley bread of various cultures. Barley grains are commonly made into malt in a tradition and ancient method of preparation. It is the important and oldest cereal grain cultivated for food. It is a cool season crop but it can tolerate high temperature if the humidity is low. The major production areas are: Europe, North Africa, Ethiopia, Near East, USSR, China, India Canada and the USA. (GUPTA 2010).

As the plant density increases, the competition for resources especially for nitrogen also increases that badly affect the ultimate yield. Provision of additional nitrogen can be hypothesized to further enhance the yield by increasing plant population but to an optimum level. Further higher nitrogen can lead to the lodging of plants at higher seed rate (Nazir *et al*., 2000).

Nitrogen occupies a conspicuous place in plant metabolism. All vital processes in plants are associated with protein, of which nitrogen is an essential constituent. Consequently to get more crop production, nitrogen availability is essential in the form of chemical fertilizers. Proper use of nitrogen is also considered for farm profitability and environment protection (Makowski *et al*,. 1999).

In Sudan, barley (*Hordeum vulgare*) was grown in extremely negligible areas along the Nile valley in the northern states. Henceforth, it received limited attention research work in Sudan, involved mainly in the agronomy of grain production (Ibrahim and Imam, 1974). It was reported to be one of the winter crops that was successfully grown as forage in central and northern Sudan (Imam, 1972, Ibrahim and Imam , 1975) and produced high yield of good quality forage (Khair *et al*. 2000;Salih *et al* . 2006 ; Khair , 2007) . The yield potential of barley grains in Sudan was 3.4 t/ha in Hudeiba and 2.2 t/ha in Khartoum and Gezira states (Ibrahim and Imam, 1975). The corresponding biomass yields for the above mentioned grain yields were 6.8 and 4.4 t/ha, respectively (Lazim 1973).

The objectives of this study were:

To investigate the effect of nitrogen and seeding rate on forage barley.

To investigate the effect of nitrogen and seeding rate on grain barley.

CHAPTER TWO

LITERATURE REVIEW

2.1 Importance of barley:

Barley is the fourth important cereal crop, cultivated successfully in a wide range of climate. This crop has potentials for growing under drought and saline conditions. It requires less input like, fertilizer, irrigation, and insecticides. In the world, barley is increasingly being used as cattle feed (Nessa, *el.,al* 1998). It is a dual purpose crop for grain and forage production. Smith (2009) reported that barley produces good-quality silage or hay, but because of lower tonnage, usually produces lower yields of total digestible nutrients per acre than the other small grains.

At all stages up to milk stage , barley could maintain crude protein at more than 10% as the high crude protein of barley was accompanied with low crude fiber content throughout the growth period (Khair, *et al* ., 2004). When the quality of barley was compared with other forage crops in Sudan, crude protein at milk stage was a little lower than that of tropical forage legumes (Khair 1999) and higher than that of Abu Sabein in summer (Khair,1999) and in winter (Khair, *et al* ., 2000).

In Sudan, livestock form an important component of the agricultural sector .Livestock population is estimated as 108 million head, (40.8 million sheep, 31.66 million goats, 4.8 million camels and 30.93 million cattle) as reported by MAF, (2017). Despite this large number of animals, the range condition of the country is poor and very much deteriorated to cope with animal needs. The estimated available forage production is about 105.2 million ton dry matter per annum from natural rangelands, crop residues, irrigated forage and concentrates (Abusuwar, 2004). Excluding the irrigated forage, and concentrates all these animal feeds suffer drastically from low quality. From these sources of forage more than 98 % of the animal feed is contributed by natural ranges during the wet season and crop residues in rain – fed areas at the beginning of the dry season . A considerable portion of that forage, however, is not accessible to livestock due to shortage of drinking water within grazing areas during the dry season. The estimated animals requirement are about 213.2 million ton per annum (Abuswar 2004). This indicates a forage deficit of about 51 % annually. To fill this forage gap and to meet the rising forage demand, more efforts are needed to increase forage supply by range improvement and expanding the area for irrigated forage production. Khartoum State is the most forage growing area in Sudan. Due to the continuously high demands, forage is growing there throughout the year. Abu Sabeen is primarily a summer crop that produces adequate yields in summer. Despite its suboptimal winter yields (Khair *et al.,* 2001) it is grown untimely during the winter due to the lack of any appropriate winter annual forage crop.

2.2 Environmental requirements:

Barley is the major cereal crop in many dry areas of the world and is vital for the livelihood of many farmers. It is grown in environments ranging from the deserts of the Middle East to the high elevations of Himalayas (Hayes *et al*., 2003). The crop can be grown on many soil types including well drained, fertile loamy and lighter clay soil. It has very good heat and drought tolerance, making it a valuable plant for semiarid areas. Barley is also the most salt-tolerant among cereal crops. It thrives in cool, dry condition (Smith, 2009). It is sensitive to acidic soil condition and pH should be maintained at 7.5 or higher.

2.3 Nitrogen Fertilization:

Nitrogen is commonly the most limiting nutrient for crop production in the major world`s agricultural areas, therefore adoption of good N management strategies often result in large economic benefits to farmers .Among the plant nutrients, nitrogen plays a very important role in crop productivity (Zapata and Cleenput , 1986; Ahmed, 1999; Miao *et al.,* 2006; Oikeh *et al.,* 2007;Worku *et al.,* 2007). The most important role of nitrogen in the plant is its presence in the structure of protein and nucleic acids, which are the most important building and information substance from which the living material or protoplasm of every cell is made (Alam and Haider, 2006).

Nitrogen is required in large quantities by plants. It is absorbed by plant roots as $N\bar{O}_3$ or NH^{+}_4 ions. The nitrogen content of plant tissue is usually more than that of any other nutrient absorbed by plants. It is needed to form chlorophyll, proteins and many other essential plant growth molecules (Blackmer, 2000). The amount of nitrogen that a barley crop needs to maximize yield and quality depends on the seasonal conditions, soil type and rotational history of the soil as well as the potential yield of the crop (Ayoub *et al*., 1994).Nitrogen (N) availability is a key factor in the production of food, feed, and fiber. The provision of plant – available N through synthetic fertilizer in the 20th and 21st centuries has substantially contributed to feeding and clothing of an ever – increasing human population. Supply of N to grain crops is known to favor tillering (Evans *et al*., 1975), where the number of ears per hectare mainly depends on seed density and tillering capacity (Mengel and Kirkby , 2001). Nitrogen is involved in plant protein synthesis, a process that may determine yield of crop.

Improvement in nitrogen use efficiency (NUE) may increase net returns to the produce and, at the same time, reduce the amount of N lost to the environment and its negative consequence. Nitrogen use efficiency is defined as grain yield per unit of N available to the crop, and it is the product of two primary components: the efficiency of recovery of available N from soil (often called N uptake efficiency, UPE) and the amount of grain yield produced per unit of N taken up by the crop (often called N utilization efficiency, UTE). Further , UTE is a function of the amount of dry matter produce per unit of N taken up (biomass production efficiency , BPE) and the partitioning efficiency of the dry matter produce to economic grain yield (harvest index, HI) . (Ortize – Monasterio, *et al*., 1997).

Defoliation removes nitrogen accumulated in plant aerial parts. In crop regrowth after defoliation (Pandey, 2005; Tian *et al.*, 2012) using supplementary N fertilizer after forage removal, therefore, is a common practice in dual-purpose system in many areas (Pandey , 2005; Tian *et al*., 2012). Sij *et al*., (2011) found a linear increase in forage production of wheat with increasing pre-plant N application. In their study, wheat grain yield increased as N rate increased. Tian *et al*., (2012) evaluated the effect of N top dressing rates (0, 60 and 120 kg N ha^{-1}) on grain yield recovery of wheat after forage removal. They reported no significant effect of N topdressing rate on grain yields of wheat. They effect N fertilization on barley regrowth after top dressing has not been extensively investigated. Optimization of N use will result in enhanced N use efficiency, which is economically viable and environmentally sound (Ladha *et al*., 2005).

Application of organic and inorganic nitrogen fertilizers to barley , increased plant height , number of tillers/m^{2} , length and flag leaf blade area and total chlorophyll , as well as yield and its components (Gaballa *et al.*, 2009) Nitrogen fertilization increased plant growth parameters, yield and its components, chlorophyll content of leaves of barley plants (Abdalla and Maha ; 2004; El – Moselhy and Zahran, 2003; Kotab and Gaballa , 2007).Increasing the nitrogen fertilization level up to 200kg N/ha gave the highest values for all vegetative attributes. In Saudi Arabia, AL-Otaiby (2003) found small effect of increasing nitrogen fertilizer rates on forage yield and its components. He also found that increasing nitrogen fertilizer rates significantly increased the plant height, number of tillers/m^2, number of plants / m^{2}, protein content and green forage yield. Nitrogen consistently increased dry matter and grain yield, generally being significant up to 80 kg/ha^{-1} (Ryan *et al*., 2009).Barley silage has a high demand for plant nutrients and very responsive to N fertilization (Mckenzie, *et al*., 1998).

Nitrogen fertilization has got a profound influence on the agricultural and biological traits of the plant. Nitrogen is the basic component of protoplasm. It plays an important role in the synthesis of many chemical compounds (including proteins and enzymes), which translates into the processes involved in the growth and development of plants (Carrubba, 2009 , Khan, *et al*.,(2012) and Khalid, 2013).

2.4 Seed rate and plant populations:

Plant density is a major factor determining the ability of the crop to capture resources and generate yield. It can be developed by using a suitable seeding rate. Growth and yield of wheat are affected by environmental condition and can be regulated by sowing time and seeding rate (Ozturk *et al*., 2005) Seeding rate has an important role in the success of dual-purpose systems. Hadjichristodoulou (1991) suggested that a higher seeding rate can increase forage yield and stabilize grain yield of cereals in dual-purpose system . In the southern Great plains of the United States, wheat intended for dual-purpose management is sown at 1.5 to 2 times greater seeding density than what was used in grain-only system (Edwards *et al*., 2011). Khalil *et al* ., (2011) reported that a seeding rate of 150kg ha^{-1} along with 160kg ha^{-1} produced the maximum forge dry matter and biological yield of wheat .

2.5 Rates and Method of sowing

The rate of sowing barley varies from 4 to 8 pecks per acre, depending on the variety, the fertility of the soil, the available moisture supply in the soil, the method of sowing, the condition of the seeded, and whether or not it is to be used as companion crop. Heavier rates are necessary when barley is sown broadcast, and when the seedbed is not properly prepared. On the other hand, lower rates are used when (a) the soil is lacking in fertility, (b) the soil is deficient in moisture or in areas where rainfall is low, (c) barley is used a companion crop to establish a new seeding, and (d) it is desirable to reduce the hazard of lodging. When sowing rates are reduced, the plants tiller more, a stronger type of straw develops, plumper kernels are produced, and there is less competition between the barley and the new seeding of grasses and legumes. There is also some evidence that there is less injury from scab and blight diseases in thinner stands because more sunshine can reach the plants when this situation prevails. In areas where barley is pastured or cut for hay, heavy rates of sowing are used. (Delorit and Ahlgren 1959).

2.6 Plant population and crop yield relationship

Plant population density is defined in terms of number of plants per unit area of land (Willey and Heath, 1969). Determination of the lowest plant population is necessary for optimal yield (optimal plant population) is a major agronomic goal (Carpenter and Board, 1997). Optimizing the sowing rate of an arable crop is crucial for maximum return on the investment in seed (Pilbeam *el al* 1991). Therefore it is desirable to define the relationships between plant populations and crop yield quantitatively (Willey and Heath, 1969).

Yield responses to sowing density are basically consequences of inter- and intra-plant competition for water, nutrients and light (Akinola and Whiteman, 1975).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Site of experiment:

The experiment was conducted at the experimental farm of the College of Agricultural Studies, Sudan University of Science and Technology (shambat), in Khartoum State, during the winter season 2017/2018. Shambat is located between latitudes (latitude $15^{\circ}.40^{'}$ North and longitude $32^{\circ}.32^{'}$ East) and altitudes of 380 meters above sea level. The climate is characterized by semi-desert tropic with a low percentage of humidity and average rainfall of 158 mm per annum and temperature of $20.3C^{\circ}$ – $36.1C^{\circ}$ and clay Celtic soil (Khairy, 2010). The soil at Shambat site is heavy clay, pH 7.5-8 as described by (Abdelgader, 2010).

3.2 Experimental procedures:

The experiment was planted on the 7th of December 2017, the experiment comprised of 16 treatments which were a combination of four nitrogen levels viz., 0,93,186 and 279 kg urea/ha, 0N,1N,2N,and 3N, respectively, and seed rates viz., 48,72,96 and 120 kg seed/ha, S1,S2,S3 and S4, respectively. The treatments were arranged in a randomized complete block design with three replicates. The net plot size was 5×3.5m consisted of 4 ridges spaced 0.7m apart. Phosphorus fertilizer in the form of triple supper phosphate (TSP) was applied at the rate of 93kg P_2O_5/ha as basal dose before sowing. Phosphate fertilizer and seeds were hand drilled in furrows on top of the ridges. The experiment was irrigated immediately after planting and thereafter every 7-10 days. The two middle were used for measurement of forage and grain yield attributes, and were divided into parts. The first part was used for forage production, while the second was used for yield and yield components .The two areas (2×1.4 each) were separated by an area of 0.5m, as well as 0.25m from each of the middle rides. All plots were kept free of weeds by hand weeding.

3.3 Land Preparation:

The area of the experiment was prepared by disc plough; disc harrow, leveled and then divided into 70cm ridges. The gross plot area (17.m^2) and consisted of 4 ridges.

3.4 Source of seed:

Seeds of barley, a local variety used in the study were obtained from Shambat Research Station.

3.5 Data recorded:

3.5.1 Days to 50% heading:

Days to 50 % heading was taken as the number of days from sowing to the day when about half of the plants in the plot were heading.

3.5.2 Plant height: (cm)

Plant height was measured in centimeter from the ground surface to the tip of the spike excluding the awns, randomly taken from five plants in the centre of ridge in each plot and then the average was taken.

3.5.3 Culm density/m^2:

Number of plants in an area, earmarked (the yield area) were counted and then plants /m^2 were recorded.

3.5.4 Number of leaves / plant:

The number of leaves per plant was counted for five plants of barley randomly selected, and the average was determined.

3.5.5 Tiller per plant:

After 40 days from sowing tillers were recorded for five plants randomly and then the average was taken.

3.5.6 Chlorophyll content (%):

Five plants were taken randomly using a device (SPAD), and then the average was taken.

3.5.7 Fresh matter yield (t/ha)

At harvest, was weighed in field immediately after cutting, the fresh weights were determined in the yield area by using a spring scale, and a sub-sample of (500 gram) was taken from each experimental unit and bagged for dry matter determination. Fresh matter sub-samples were oven-dried at 80^0C for approximately forty eight hours to a constant weight.

3.5.8 Dry matter yield (t/ha)

The dry matter yield of each plot was calculated by multiplying the percentage dry matter of oven-dried sub-samples by the harvested fresh matter of each plot and converted to ton per hectare.

3.5.9 Number of spikes per $m^{2:}$

Number of spikes per m^2 was recorded by counting the number of kernels produced in one m^2.

3.5.10 Number of grains per spike:

The number of grains per spike was taken randomly form 10 plants calculated and then the average was taken.

3.511 Thousand grains weight (g):

1000 seeds were counted randomly, then weight in gram per plot.

3.5.12 Biomass (t/ha):

The biomass was determined by weighing the yield of area of the total air dried sample and transformed to ton per hectare.

3.5.13 Grain yield t/ha:

The grain yield was obtained by weighing an area, earmarked (the yield area).

= Wight of seeds ÷ yield area×1000kg ×1000kg ÷10000m^2

3.5.14 Harvest index (%):

The harvest index is the weight of the economical yield as related to the biological yield.

HI = Grain yield ÷ Biomass × 100

3.9.15 Statistical analysis:

Data were statically analyzed according to factorial randomized complete block design using GEN STAT package. Means were separated by least Significant Difference (L.S.D) (Gomez, and Gomez, 1984).

CHAPTER FOUR

RESULTS

Growth attributes and yield of forage barley:

4.1 Number of days to 50% heading:

The analysis of variance showed that there is a highly significant effect of nitrogen fertilizer on number of days to 50% heading, but seeding rate did not significantly affect the number of days to 50% heading (Table 1). Highest number of days to 50% heading (58.75) was observed at seeding rate of 120 kg/ha while the lowest number of days to 50% heading (57.17) was observed at seeding rate 72 kg/ha. The highest number of days to 50% heading were observed at zero nitrogen level (0N application) followed by 93 kg/ha while the lowest number of days to 50% heading was recorded at 186kg/ha and 279kg/ha, (Table 2). The interaction of seeding rate and nitrogen levels was found to be not significant.

4.2 Plant height (cm):

Plant height was not significantly different for seeding rate, while nitrogen levels were highly significantly affected (Table 1). Tallest plants (81.8 cm) were observed at seeding rate of 48 kg/ha while shortest, plants (75.1 cm) were recorded at seeding rate of 120 kg/ha, Nitrogen fertilization has pronounced effect on plant height of barley. Tallest plants were observed at nitrogen levels of 279 kg/ha followed by 186 kg/ha and 93 kg/ha while the shortest plants were recorded at zero level of nitrogen (Table 2). The interaction of seeding rate and nitrogen levels were found to be not significant.

4.3 Culm density /m^2:

Culm density /m^2 statistically was not significantly affected by seeding rate, but was highly significantly affected by nitrogen levels (Table 1). The highest plant density (268.3) was observed at seeding rate of 96 kg/ha, while the lowest plant density (226.8) was observed at seeding rate of 48 kg/ha. The highest plant density were observed at nitrogen levels of 279 kg/ha, followed by 186kg/ha and 93 kg/ha, while the lowest culm density/m^2 was recorded at zero level of nitrogen (Table 2). The interaction of seeding rate and nitrogen levels was not significant.

4.4 Number of leaves/plant:

Seeding rate and nitrogen fertilizer did not significantly affect the number of leaves per plant (Table 1). The interaction of seeding rate and nitrogen levels were found to be not significant.

4.5 Number of tillers/plant:

Number of tillers was not significantly affected by seeding rate, but was significantly affected by nitrogen levels (Table 1). High number of tiller (2.0) was observed at seeding rate of 48 kg/ha while less number of tillers (1.7) was observed at seeding rate of 120 kg/ha. The maximum number of tillers was observed at nitrogen levels of 279 kg/ha, followed by 186 kg/ha and 93 kg/ha. At zero level of nitrogen minimum number of tellers was recorded (Table 2). No significant interaction was found between seeding rate and nitrogen levels.

4.6 Chlorophyll content (%):

Chlorophyll content was not significantly affected for seeding rate while it was significantly affected by nitrogen levels (Table 1).The highest content of chlorophyll (41.82%) was recorded at seeding rate of 48 kg/ha, while the lowest content (38.97 %) was recorded at seeding rate of 72 kg/ha (Table 2). Chlorophyll content as affected by nitrogen fertilization, highest values at nitrogen level 279 kg/ha, followed by 186 kg/ha, and 93 kg/ha, while the lowest chlorophyll content was recorded at zero level of nitrogen,(Table 2).The interaction of seeding rate and nitrogen levels was found to be not significant.

4.7 Fresh matter yield (t/ha):

The results showed that the Fresh forage yield was highly significantly affected by nitrogen levels, but was not significantly affected by seed rate (Table 1), the highest fresh forage yield (11.83 t/ha) was recorded at seeding rate of 48 kg/ha while lowest fresh forage yield (10.53 t/ha) was recorded at seeding rate of 72 kg/ha, the highest fresh forage yield was recorded at nitrogen level of 279 kg/ha, followed by 186kg/ha and 93 kg/ha, while the lowest fresh forage yield was recorded at zero level of nitrogen,(Table 2).The interaction of seeding rate and nitrogen levels was not significant.

4.8 Dry matter yield:

The analysis of variance showed a highly significant effect of nitrogen fertilizer on dry forage yield but was not significantly affected by seeding rate (Table 1). The highest dry forage yield (3.10 t/ha) was recorded at seeding rate of 96kg/ha while lowest dry forage yield (2.72 t/ha) was recorded at seeding rate of 72 kg/ha. Dry forage yield as affected by nitrogen fertilization, gave the highest values at nitrogen level of 279 kg/ha, followed by 186 kg/ha and 93 kg/ha while the lowest dry forage yield was recorded at zero level of nitrogen, (Table 2). The interaction of seeding rate and nitrogen levels was found to be not significant.

Table (1): Mean square values of seeding rate and nitrogen fertilization on growth and yield of forage barley (2017/2018 Season).

Source of variation	d.f	Days to 50% heading	Plant height (cm)	Density / m^2	Number of leaves / plant	Number of tillers/ plant	Chlorophyll content (%)	Fresh matter (t/ha)	Dry matter (t/ha)
Rep	2	3.40	98.46	2573.0	3.15	0.11	7.67	24.20	0.59
Seed rate(S)	3	5.854ns	104.40ns	4219.0ns	0.756ns	0.29ns	16.673ns	3.52ns	0.30ns
Nitrogen (N)	3	29.63**	2480.53**	26016.0**	0.31	1.22**	271.03**	292.82**	17.23**
S*N	9	2.00ns	58.97ns	1829.0ns	0.46ns	0.08ns	8.69ns	7.01ns	0.42ns
Residual	30	1.97	86.85	2009.0	0.54	0.09	6.41	7.87	0.44
SE±	-	0.41	2.69	12.94	0.21	0.09	0.73	0.81	0.19
C.V%	-	2.4	11.9	18.1	12.3	17.0	6.3	25.1	22.7
L.S.D	-	1.17	7.77	37.37	0.61	0.25	2.11	2.34	0.55

d.f: degree of freedom

*= significant at 0.05 probability level

**= high significant at 0.01 probability level.

Ns= not significant at probability level.

Table (2): Mean comparison of parameters studied for growth and yield of forage barley (2017/2018 Season).

Treatments	Days to 50% heading	Plant height (cm)	Density / m^2	Number of leaves / plant	Number of tillers /plant	Chlorophyll content (%)	Fresh matter (t/ha)	Dry matter (t/ha)
Seed rate(kg/ha)								
S1	58.00	81.8	226.8	5.9	2.0	41.82	11.83	2.93
S2	57.17	79.8	236.8	5.9	1.7	38.97	10.53	2.72
S3	58.50	77.0	268.3	6.1	1.7	40.14	11.25	3.10
S4	58.75	75.1	256.5	6.0	1.7	40.02	11.04	2.94
Mean	58.10	78.5	247.1	6.0	1.8	40.24	11.16	2.92
LSD	1.17	7.77	37.37	0.61	0.25	2.11	2.34	0.55
Nitrogen rate(kg)								
0N	60.33	58.4	193.6	6.2	1.4	34.23	4.29	1.19
1N	58.08	77.8	223.0	5.8	1.6	39.03	10.99	3.05
2N	57.00	88.2	281.0	5.9	2.0	42.41	13.92	3.67
3N	57.00	89.4	290.9	6.1	2.1	45.29	15.45	3.78
Mean	58.10	78.5	247.1	6.0	1.8	40.24	11.16	2.92
LSD	1.17	7.77	37.37	0.61	0.25	2.11	2.34	0.55

S1 = 48kg/ha | 0N = control

S2 = 72kg/ha | 1N = 93kg/ha

S3= 96kg/ha | 2N = 186kg/ha

S4= 120kg/ha | 3N = 279kg/ha

Grain attribute and yield of barley:

4.9 Plant height (cm):

The analysis of variance showed a highly significant effect of nitrogen fertilizer on plant height, but it was not significantly affected by seeding rate (Table3). Tallest plants (81.7 cm) were observed at seeding rate of 48 kg/ha while the shortest plants (75.27 cm) were recorded at seeding rate of 120 kg/ha. Nitrogen fertilization had pronounced effect on plant height of barley. Tallest plants were observed at nitrogen levels of 279 kg/ha followed by 186 kg/ha and 93 kg/ha while the shortest plants were recorded at zero level of nitrogen (Table 4). The interaction of seeding rate and nitrogen levels was found to be not significant.

4.10 Culm density/m^{2}:

The analysis of variance showed that there is a highly significant effect for nitrogen fertilizer on culm density/m^2, but it was not significantly affected by seed rate, (Table 3). The highest plant density (338.28) was observed at seeding rate of 120 kg/ha, while the lowest plant density (257.54) was observed at seeding rate of 48 kg/ha. Culm density was affected by nitrogen fertilization. The highest plant density was observed at nitrogen level of 279 kg/ha followed by 186 kg/ha and 93 kg/ha, while the lowest culm density/m^2 was recorded at zero level of nitrogen (Table 4).The interaction of seeding rate and nitrogen levels were found to be not significant.

4.11 Number of spikes /m^2:

Seed rate did not significantly affect number of spikes/m^2; however, nitrogen fertilization highly significantly affected number of spike/m^2 (Table 3) the greater number of spikes /m^2 (331.14) was at seeding rate of 120 kg/ha, while the lowest number of spikes/m^2 (252.71) was at seeding was observed 48 kg/ha,, maximum number of spikes /m^2 was observed at nitrogen level of 279 kg/ha, followed by 186 kg/ha and 93 kg/ha while the minimum number was recorded at zero level of nitrogen, (Table 4). The interaction of seeding rate and nitrogen levels was not significant.

4.12 Number of grains per spike:

Number of grains/spike was not significantly affected by seeding rate. However, nitrogen fertilization highly significantly affected number of grains/spike (Table 3). Maximum number of grains/spike (36.23) was obtained at seeding of 48kg/ha while the minimum (34.58) was recorded of at seeding rate 120 kg/ha, highest number of grains /spike was counted at nitrogen level of 186 kg/ha, followed by 279 kg/ha and 93 kg/ha. The least number of grains /spike was counted at zero nitrogen level (Table 4). The interaction of seeding rate and nitrogen levels was found to be not significant.

4.13 1000 grain weight (g):

Seed rate did not significantly affect 1000 grains weight; however, nitrogen fertilization highly significantly affected 1000 grains weight (Table 3). Highest 1000 grains weight (41.75 g) was at seeding rate of 48 kg/ha while, the lowest1000 grains weight (40.83 g) was at seeding rate of 72 kg/ha. Maximum 1000 grains weight at nitrogen level of 279 kg/ha followed by 186 kg/ha and 93 kg/ha. The minimum 1000 grains weight at zero nitrogen level (Table 4).The interaction of seeding rate and nitrogen levels was not significant.

4.14 Biomass (t/ha):

Biomass was not significantly affected by seed rate. However; Nitrogen fertilization highly significantly affected biomass (Table 3).The highest biomass (4.67 t/ha) was at seeding rate of 120 kg/ha, while the lowest (4.28 t/ha) was at seeding rate of 96 kg/ha. Maximum biomass was at nitrogen level of 279 kg/ha, followed by 186kg/ha and 93 kg/ha. The minimum biomass was at zero nitrogen level (Table 4).The interaction of seeding rate and nitrogen levels was found to be not significant.

4.15 Grain yield (t/ha):

The results showed that the seed rate and nitrogen fertilizer highly significantly affected grain yield, (Table 3) the highest grain yield (1.30 t/ha) was observed at seeding rate of 48 kg/ha, while the lowest grain yield (0.93 t/ha) was observed at seeding rate of 120 kg/ha. Maximum grain yield (1.48 t/ha) was observed at nitrogen level of 186 kg /ha, followed by 279 kg/ha and 93 kg /ha. The minimum grain yield was at zero nitrogen level (Table 4).The interaction of seeding rate and nitrogen levels was not significant.

4.16 Harvest index (%):

Seeding rate was not significantly affected harvest index, however nitrogen fertilizer highly significantly affected harvest index (Table 4). The highest harvest index (25.75%) was calculated at seeding rate of 48 kg/ha, while the lowest harvest index (22.61%) was recorded at seeding rate of 120 kg/ha. Maximum harvest index was observed at nitrogen levels of 93 kg/ha, followed by186 kg/ha and 279 kg/ha, Minimum harvest index was at zero nitrogen level (Table 4).The interaction of seeding rate and nitrogen levels was not significant.

Table (3): Mean square values of seed rate and nitrogen fertilization on growth and yield of grain barley (Season 2017/2018).

Source of variation	d.f	Plant height (cm)	Density/m^2	No .of spikes /m^2	No. of grain / spikes	1000 weight (g)	Biomass (t/ha)	Grain yield (t/ha)	Harvest index (%)
Rep	2	35.24	8519.0	9818.0	304.39	131.02	2.62	0.24	42.42
Seed rate (s)	3	169.32ns	16788.0ns	16400.0ns	5.59ns	1.97ns	0.54ns	0.79**	19.18ns
Nitrogen (N)	3	2258.23**	35055.0**	38221.0**	299.35**	45.97**	63.29**	1.29**	143.21**
S*N	9	43.39ns	5050.0ns	4861.0ns	36.75ns	8.74ns	1.15ns	0.15ns	53.85ns
Residual	29	48.69	5266.0	4981.0	35.72	5.13	1.50	0.11	26.06
SE±	-	2.01	20.95	20.37	1.73	0.65	0.35	0.10	1.47
CV%	-	9.2	24.7	24.6	16.9	5.5	27.1	29.6	20.9
L.S.D	-	5.82	60.51	58.84	4.98	1.89	1.01	0.31	4.26

d.f: degree of freedom.

*= significant at 0.05 probability level.

**= high significant at 0.01 probability level.

Ns= not significant probability level.

Table 4: Mean comparison of parameter studied on growth and yield of grain barley (Season 2017/2018).

Treatment	Plant height (cm)	Density/m^2	No .of spikes /m^2	No. of grain / spikes	1000-grain wt (g)	Biomass (t/ha)	Grain yield (t/ha)	Harvest index (%)
Seed rate(kg/ha)								
S1	81.07	257.54	252.71	36.23	41.75	4.31	1.30	25.57
S2	76.10	268.02	261.25	35.23	40.83	4.64	1.19	24.85
S3	74.35	309.30	304.70	35.22	41.00	4.28	1.09	24.55
S4	72.27	338.28	331.14	34.58	41.33	4.67	0.93	22.61
Means	75.95	293.29	281.45	35.31	41.23	4.47	1.13	24.39
LSD	5.82	60.51	58.841	4.983	1.89	1.01	0.31	4.26
Nitrogen rate(kg/ha)			`					
0N	56.63	213.93	204.47	27.94	38.33	1.43	0.50	21.51
1N	76.05	305.42	300.20	36.52	41.75	4.03	1.13	28.78
2N	83.67	321.42	318.09	38.51	42.33	5.85	1.48	25.53
3N	87.43	332.37	327.04	38.28	42.50	6.58	1.40	21.75
Means	75.95	293.29	287.45	35.31	41.23	4.47	1.13	24.39
LSD	5.82	60.51	58.841	4.983	1.89	1.01	0.31	4.26

Symbols are as defined on table 2

CHAPTER FIVE

DISCUSSION

Generally fertilizers have played an important role in growth and development. Nitrogen fertilization had significant effect on all vegetative and yield parameters of forage and grain yield of barley, except number of leaves. While the seed rates have no significant effect in all parameters, except grain yield.

In this study, nitrogen fertilization was more effective in improving forage production and grain yield when plant density was low because nitrogen fertilization promotes plant growth and elongation. The best response to nitrogen fertilization was associated with 120kg/ha, indicating that lower or higher seeding rates beyond the optimum range decreased efficiency in the utilization of nitrogen fertilizer.

Effect of seeding rate:

With exception of grain yield, seeding rate had no significant effect on all variables; Plant height, number of tillers, density/m^2, fresh weight, dry weight, number of days 50% heading, number of spikes/$m^{2,}$ number of grains per spike, 1000grain weight, grain yield, biomass and harvest index. Effect of seed rate might be due to the competition for space; grain yield increased at the lower seed rate, which might be attributed to the improvement in number of tillers, grains/spike and 1000 grain weight.

Seeding rates did not affect number of tillers, plant height, density/m^2, number of spikes/m^2, number of grains per spike 1000grain weight, grain yield, biomass and harvest index. These results disagree with the finding of Iqbal *et al.,* (2012) who reported that the seeding rates affected number of tillers, plant height, density/m^2, number of spikes/m^2, number of grains per spike 1000grain weight, grain yield, biomass and harvest index.

Crop yields are generally dependent upon many yield contributing agents. Among this, number of tillers is the most important because of the contribution to the final yield. Increase number of tillers per plant is due to decrease in seeding rate.

Number of grain/spike is also an important yield contributing parameter to the final grain yield, increase number grain/spike might be due to optimum crop stand with better nutrition, as better nutrition enhance the source capacity to better fill the sink. Fresh weight, dry weight, density/m^2, number of spikes/m^2 and biomass increased with increased seed rate, but 1000 grain weights, number of grains/spike, grain yield and harvest index increased when the seeding rate was low.

Effect of Nitrogen fertilizer:

Nitrogen rates significantly affected all variables, days to 50% heading, plant height, number of tillers/plant, density/m^2, fresh weight, dry weight, number of spikes/m^2 number of grains per spike, 1000 grain weight, grain yield, biomass and harvest index, but not number of leaves/plant. Nitrogen had no significant effect on number of leaves per plant.

Plant height, number of tillers, density/m^2, number of spikes/m^2, number of grains per spike 1000grain weight, grain yield, biomass and harvest index were affected by nitrogen rates. These results confirm the finding of Iqbal, *et al* (2012) who reported that the nitrogen rates affected number of tillers, plant height, density/m^2, number of spikes/m^2, number of grains per spike 1000grain weight, grain yield, biomass and harvest index.

Days to 50% heading was reduced with fertilizer application. This might be due to the stress as the stress will enhance fast heading. This result agreed with, Hassan, *et al.,* (2016) who reported the highest number of days to 50% flowering at 0N application.

The results obtained revealed that application of nitrogen fertilizer increased fresh and dry forage yield. This might be attributed to increased plant height and number of tillers per plant, more over, nitrogen increased the photosynthetic capacity of plants, which enhances growth. This finding was confirmed by the findings of other researchers (Ellis *et al*., 1956; Singh *et al*., 1965; Raddy *et al*., 1985; Singh *et al*., 1992).

Plant height, number of tillers and chlorophyll content increased when nitrogen levels increased. Chlorophyll increased when nitrogen levels increased because nitrogen is constituent of chlorophyll.

Nitrogen fertilizer application was found to improve vegetative growth, which ultimately plant height. These results were supported by khan, *et al*, (1990); Khalil, *et al* (2002) and Rifat and Jamro, (2007).

Number of tillers per plant was significant higher with nitrogen application. This increase may be due to positive effect of nitrogen on plant height that leads to increase in number of tillers. Similar results were found by Sharma,(1973); Mohamed *et al*; (1978).

SUMMARY AND CONCLUSIONS

Major targets of this study were to investigate the effect of seeding rate and nitrogen fertilization on forage and grain yield of barley.

To accomplish these objectives, four different seeding rates (48, 72, 96 and 120 kg/ha) and four levels of nitrogen (0, 93, 186 and 279 kg /ha) application,

were studied using an experimental factorial a randomized complete block design with three replications.

The treatment of 48 kg/ha on seeding rates gave highest plant height (81.8cm), number of tillers/plant (2.0), chlorophyll content (41.82 %), fresh matter yield (11.83 t/ha), number of grains/spike (36.23), 1000 grain weight (41.75 g), grain yield (1.30 t/ha) and harvest index (25.75%).

The treatment of 279 kg/ha nitrogen level gave the highest number of tillers/plant, chlorophyll content (%), plant height (cm), culm density/m^2, fresh matter yield (t/ha), dry matter yield (t/ha), number of spikes/m^2, number of grains/spikes ,1000 grain weight(g), biomass (t/ha) and harvest index(%).

Conclusion:

Based on the findings of this study, the combined application of 48 kg/ha of seeding rate with 279 kg/ha of nitrogen application was considered to be optimum for growth and yield of barley.

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