Influence of varying seeding rates and nitrogen levels on yield and yield components of barley (*Hordeum vulgare* L. cv. Rum) in the semi-arid region of Jordan

A. T. Munir

Einfluss unterschiedlicher Saatdichten und N-Niveaus auf Ertrag und Ertragskomponenten von Gerste (*Hordeum vulgare* L. cv. Rum) in der semi-ariden Region Jordaniens

1. Introduction

Barley is widely grown in the rainfed areas of the arid and semi-arid Mediterranean regions where water and N are the main limiting factors affecting agricultural production (MOHAMMAD et al., 1999). Barley is a widely distributed crop that can grow in a wide range of environmental conditions, even in semi-arid areas with 200–350 mm of annual rainfall (COOPER et al., 1987). It is the second most important crop after wheat in Jordan. Grain is used as feed, food, and for malting purposes, while straw provides an important source of roughage for animals particularly in the dry areas. Unfortunately in Jordan, the local grain yield of barley per unit area is far below the international figures. During the period 1985 to 1997, the average harvested area of barley was 52 thousand ha. The average yield was 815 kg ha$^{-1}$ (MINISTRY OF AGRICULTURE, 1997), while the average yield in major regions of the world was about 2650 kg ha$^{-1}$, therefore, more research is needed to increase the yield of barley. The most important factors responsible for the low productivity are low and poor distribution of rainfall (Oweis and Taimeh, 1996), minimal or no use of fertilizer, the planting of low yield cultivars, and improper cultivation practices (HADDAD et al., 1997). Under these cond-

Zusammenfassung


Schlagworte: Korn ertrag, Dünger, Ernteindex, Wasserstress, Ertragskompensation.

Summary

A 2-year study was conducted in northern Jordan to assess the influences of varying seeding rate and N levels on yield and yield components of barley. Seeding rate of 229 plants m$^{-2}$ produced maximum grain weight plant$^{-1}$, highest number of spikes plant$^{-1}$, grains spike$^{-1}$ and maximum thousand grain weight. Whereas at the density of 400 plants m$^{-2}$, a maximum yield of 1753.3 kg ha$^{-1}$ was obtained owing to the greater number of plants per unit area. Among N levels, the highest grain weight and grain yield was obtained under 45 kg N ha$^{-1}$. It is further inferred that there were still chances to increase the seeding rate and N levels to exploit the maximum potential of the studied cultivar.

Key words: grain yield, fertilizer, harvest index, water-stress, yield compensation.
tions, N is considered a key input affecting crop production and might be as crucial as water to growth and N uptake (JARADAT and HADDAD, 1994). As barley constitutes about 60% of the area devoted to cereals in the low rainfall zone, fertilization has a major potential impact (TURK, 1998). However, other agronomic factors must be considered for efficient and economic production. In Jordan, most of the barley planting is done by hand-broadcasting followed by one pass of a disc harrow, which incorporates seed to variable depths. Combined with poor seed quality, it may lead to diverse and erratic stands. To compensate for such losses, farmers generally apply seed at higher rates when broadcasting compared to those used with a drill. In many cases, only the roughest approximations of weight and land areas are used. However, little research has been done using different seeding rates with a drill and has suggested that there was no difference between 80 and 120 kg seed ha⁻¹ (JARADAT, 1988). Higher seeding rates, accelerate phenological traits, such as days to flag leaf extension, heading, mid grain filling and maturity (FUKAI et al., 1990; DOFING and KNIGHT, 1992; HENSON and LUKACH, 1992), and are associated with higher tiller and spike numbers m⁻², but lower tiller and spike numbers plant⁻¹ (MCDONALD, 1990; DOFING and KNIGHT, 1992). Grain numbers spike⁻¹ was found to decrease at higher seeding rates (MCDONALD, 1990; DOFING and KNIGHT, 1992). Response to several N levels with different sowing rates for barley has not been considered. Thus, such studies are needed for ascertaining the N and plant density in case of the newly developed high yielding Rum cultivar under the agroclimatic condition of North Jordan. Therefore, the present investigation was undertaken to study the influence of various seed rates and N levels on yield and yield components of barley.

2. Materials and Methods

Field experiments were conducted in the 1996/97 and 1997/98 seasons, at the Jordan University of Science and Technology (JUST) in northern Jordan (32° 34' N latitude; 36° 01' E longitude; and 520 m altitude) on a silt clay soil (very fine montmorillonitic, thermic, typic, chromoxeret) with an organic matter content of 1.6 % and pH of 8.1. Calcium carbonate content is 15 % at the soil surface. Ca is the most dominant exchangeable cation followed by K, Mg and Na (KHREASAT et al., 1998). The overall climatic conditions of the site are typical Mediterranean weather with average monthly temperature ranging from 3 °C in January to 34 °C in August (JARADAT, 1988). The plot area in both years had been planted to barley during the previous cropping year. Respective values for nitrate-N were 2.7 and 2.1 PPM. According to criteria for dry land soils in the region (RYAN and MATAR, 1990), soils were deficient in N and barley is likely to respond to fertilizer application. As a standard procedure for such trials, and in line with farmers’ practice, the site was tilled with a disc harrow. As P was not a variable, triple super phosphate was added at 40 kg P₂O₅ ha⁻¹. N was applied as Urea (46 % N) half at the time of sowing and the other half was applied at onset of stem elongation (appearance of terminal spike). The experiment was laid out in split plot design keeping seeding rate as main treatment (R1 = 229, R2 = 286, R3 = 343 and R4 = 400 plants m⁻²) and N levels (0, 15, 30 and 45 kg ha⁻¹) as sub-treatment in three replications. The test crop was a six row barley cv. Rum, a variety produced in CIMMYT (Centro Internacional de Mejoramiento de Maiz y Trigo), characterized by high tillering, high yielding, and drought tolerance (AL-BATSH, 1997). Planting was on 18 Nov. (1996) and 21 Nov. (1997). The respective harvest dates were 20 May (1997) and 3 June (1998). Individual plots were 4 by 4 m, separated by 0.5 m buffer area. Weeds were removed by hand as needed. Harvesting was done by hand-sickle. The whole plot measurements of total biological yield were taken. Seed yield was estimated from threshed sub-samples. Thirty spikes from each plot were selected for determining thousand grain weight. The data for each trait were subjected to analysis of variance (main effects and interaction). Where effects were significant at the 0.05 probability level, the least significant difference (LSD) was calculated to determine the significance of differences between the means, using the MSTAT-C computer program (Michigan State University).

3. Results and Discussion

Annual precipitation of the 1996/97 and 1997/98 growing seasons were 248 and 292 mm, respectively. In the first growing season, rainfall was 11 mm lower than the long-term average (237 mm), whereas in the second season was 55 mm higher than the long-term average. No significant interaction between seasons was detected. Therefore, the presented results are means across the two growing seasons.
3.1 Nitrogen Effect

N application had a significant effect on all variables measured.

Grain yield, grain weight spike\(^{-1}\), grain number spike\(^{-1}\), spike length, fertile tillers plant\(^{-1}\), spike m\(^{-2}\) and plant height were increased by N application, while the 1000 grain weight and harvest index were decreased. Among various N levels, 45 kg N ha\(^{-1}\) (N3), significantly out yielded (3.77 g plant\(^{-1}\) and 1674.9 kg ha\(^{-1}\)) other levels (N0, N1 and N2), owing to the highest number of spikes plant\(^{-1}\) (2.71), spike length (4.61 cm) and number of grains spike\(^{-1}\) (47.98) though it had the lowest thousand grain weight (32.55 g). Several researchers have found that an increase in N application generally increases the grain number spike\(^{-1}\) (TURK and AL-JAMALI, 1998), spike length (ABD EL-LATIF and SALAMAH, 1982), fertile tillers plant\(^{-1}\) (FRANK et al., 1992), spike number m\(^{-2}\) (LAUER and PARTRIDGE, 1990), plant height (PENNY et al., 1986), and reduces the 1000 grain weight (NEEDHAM and BOYED, 1976), and harvest index (GARDENER and RATHJEN, 1975).

N had a significant effect on grain yield (Table 1). The increase in yield was directly related to more spikes being produced per plant, longer spikes and higher number of grains per spike (Table 2). At the low N rate (N1), the yield advantage was 32 % over that for the N0, but at the high N rate (N3), the yield advantage was 65 %. It was observed that when an attempt was made to increase one yield component there was a compensatory decrease in others.

The increasing N levels decreased the harvest index as the highest (38.06 %) and lowest (34.88 %) values were obtained under N0 and N3, respectively. The results are in

<table>
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<th>Fertilizer Level (N kg ha(^{-1}))</th>
<th>Seeding Rate (plants m(^{-2}))</th>
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<tr>
<td></td>
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<tr>
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<td>875.1</td>
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<td>N2</td>
<td>996.4</td>
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LSD (P≤0.05) R 35.24* N 31.75** RXN NS

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<tr>
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LSD (P≤0.05) R 0.45* N 0.31* RXN NS

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<tr>
<td>Mean</td>
<td>35.16</td>
<td>34.48</td>
<td>34.02</td>
<td>31.90</td>
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</table>

LSD (P≤0.05) R 0.57* N 0.61* RXN NS

R1, R2, R3 and R4 indicate seeding rates of 229, 286, 343 and 400 plants m\(^{-2}\), respectively. N0, N1, N2 and N3 indicate nitrogen application rates of 0, 15, 30 and 45 kg N ha\(^{-1}\), respectively. * and ** indicate significant contrasts at P ≤ 0.05 and P ≤ 0.01, respectively. NS = Not significant contrast.
accordance with those of PEARMAN et al. (1978), which suggested that the N application had increased the vegetative growth as compared to reproductive growth.

### 3.2 Seeding Rate Effect

Seeding rate had a significant effect on all variables measured in both seasons. Grain weight spike⁻¹, 1000 grain weight, plant height, grain number spike⁻¹, spike length and fertile tillers plant⁻¹ were negatively related to seeding rate. As for grain weight per plant, it tended to decrease with increases in seeding rate (Table 1). The lowest seeding rate of 229 plants m⁻² produced the maximum grain weight plant⁻¹ (3.37 g), and vice versa. This might be attributed to a higher spikes plant⁻¹ (2.33), longer spikes (4.47 cm), more grains spike⁻¹ (46.24) and heavier thousand grain weight (34.90 g). Reductions in barley grain weights have been associated with increasing seeding rates by DOFING and KNIGHT (1992). The highest (2.33) and the lowest (1.43) number of spikes plant⁻¹ was recorded under R1 and R4, respectively. The decrease in spike number plant⁻¹ in R4 was attributed to an increased competition among plants for growth factors, which finally reduced the number of effective tillers. Reduction of tillering by increasing seeding rate has been reported previously (MCDONALD, 1990). The seeding rate of 343 plants m⁻² had significantly higher (37.79 %) harvest index over other rates (Table 2), whereas the minimum (35.43 %) was noted in 400 plants m⁻². Therefore the results indicate that a higher harvest index does not necessarily indicate a higher grain yield. The increase in rates up to 334 plants m⁻² did not affect harvest index adversely but exhibited an increasing trend. However, beyond this level, the harvest index was reduced, which clearly indicates that the translocation of photosynthate towards the sink under the seeding rate of 400 plants m⁻² was affected adversely, and they were accumulated in other parts of the plant.

On the other hand, plant density, spike density (spikes m⁻²) and grain yield were directly related to seeding rate. Grain yields increased as seeding rates increased, with highest yields being obtained at 400 plants m⁻². The yield increase observed with increases in seeding rate is a function of more spikes being produced as a result of more plants being established. The influence of seeding rate on grain yield was through the increased production of spikes per unit area (Table 2), however, not through the increased production of fertile tillers per plant. This explains why main-
taining adequate plant populations is important for maximizing grain yield, given the low number of spikes produced, on average, per plant.

The seeding rates currently used for barley vary with agroclimatic zones such that in the drier areas, the recommended rate (257 plants m$^{-2}$) (TURK, 1998) are much lower than for wetter areas. Higher rather than lower seeding rates are recommended because they also allow for greater crop competition against weeds (KIRKLAND, 1993).

In general, fertility and seeding rate were directly associated with yield of barley. Thus, this study revealed that using seeding rate of 400 plants m$^{-2}$ combined with 45 kg N ha$^{-1}$ was appropriate for highest grain yield unit area$^{-1}$. It is further inferred that there was still a possibility that further increasing the seeding rate and N levels to exploiting the maximum potential of the cultivar Rum.

References

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