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# Two Row Barley Response to Plant Density, Date of Seeding, Rate and Application of Phosphorus in Absence of Moisture Stress

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**Abstract:** The present investigation was carried out to study the effect of seeding dates (1, 14 and 28th Dec.), plant density (200, 250, 300 plants $m^{-2}$), phosphorus levels (40, 60, 80 kg P $ha^{-1}$) and two methods of P placement (banding and broadcast). The results indicated that plant density, seeding date, rate and method of phosphorus had a significant effect on most of the measured traits and the yield determinates. It was concluded that high yields were obtained by early seeding (1st Dec), high plant density (300 plant $m^{-2}$) and P application (80 kg P $ha^{-1}$) drilled with the seed after cultivation (banded).

**Key words:** Plant density, seeding date, phosphorus, moisture

## Introduction

Barley (*Hordeum vulgare* L.) is an important winter crop in the drier, predominantly rain-fed areas of West Asia and Africa (Srivastava, 1987). More than 80% of the total land area of Jordan receives less than 200 mm rainfall (2.27 million ha) and it is called Badia region (Anonymous, 1994). Under stresses, such as drought and cold, the yield of barley is much higher than that of barley, wheat or rye (Champman and Carter, 1976). The average harvested area of barley in Jordan was around 45,000 ha (Anonymous, 1996). The grain yield of barley was low (770 kg $ha^{-1}$). Barley grain is used as feed, food and for malting purpose, while straw provides an important source of roughage. Barley production under a particular set of environmental conditions is influenced by various agronomic factors i.e. plant density, seeding date and fertilizer which are the deciding factors for canopy architecture, light interception and consequently for modifications of yield components and finally yield. 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. This 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 rough approximations of weight and land areas are used. However, the little research done using different barley seeding rates has been 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 extension, heading, grain filling and maturity (Fukai *et al.,* 1990; Dofing and Knight, 1992; Henson and Luhach, 1992) and are associated with higher tiller and spike numbers $m^{-2}$, but lower tillers and spikes number $plant^{-1}$ (Mcloed, 1982; Fukai *et al.,* 1990; Mcdonald, 1990). Grain numbers $spike^{-1}$ was found to decrease at higher seeding rates and cereal crops require an adequate supply of readily available nutrients for optimum growth and yield. Cereal crops can be quite responsive to P fertilization, particularly, where soils test low in available P. Soil analyses have shown that phosphate deficiency is widespread in the calcareous soils, which comprise over half of the total cultivated area of the Mediterranean region (Kassam, 1981). Field trials conducted on these soils have demonstrated large and economic response to phosphate fertilizers (Cooper, 1983; Harmsen, 1984).

The method, quantity and time of application of phosphate should be taken into account to obtain profitable results in crop growth. The advantage of drilling superphosphate compared with broadcasting has been reported by Loutit *et al.* (1968). The main objectives of this study were to develop management recommendations for producing two row barley planted in a Mediterranean type conditions. Field experiments were conducted on plant density, date of seeding, rate and methods of phosphorus placement.

## Materials and Methods

The Roho/Alger/Ceres 362-1-1/3/Tipper cultivar, was used in all studies conducted in North Jordan from 1998 to 2001. The overall climatic conditions of the site are typical Mediterranean weather with average monthly temperatures ranging from 3°C in January to 34°C in August. The long-term annual precipitation average for the site is 350 mm. Annual precipitation for the 1998/99, 1999/2000 and 2000/01growing seasons were 184.8, 342.0 and 270 mm, respectively. The soils of barley plants were uniform through all the locations [rocky, shallow, silty clay with a pH of 8.1 and available phosphorus ranged from 2.3 to 6.0 mg $Kg^{-1}$ extractable P (Olsen *et al.*, 1954)]. Phosphorus was supplied in the form of Triple superphosphate (21% P). The phosphate fertilizer was drilled with the seed after cultivation. Nitrogen fertilizer was applied uniformly by hand across all treatments (120 kg N $ha^{-1}$ at sowing in form of Urea (46% N) and 60 kg N $ha^{-1}$ top-dressed at start flowering). Weeds were controlled by hand as needed.

**Date and rate of seeding:** The test was conducted in split-plot design with plant density as main treatments (200, 250 and 300 plants $m^{-2}$) and seeding dates (1, 14, 28th Dec.) as sub treatment. The treatments were replicated three times. All plots consisted of four rows, 6 m long with spacing of 30 and 60 cm between rows and plots, respectively. A seeding depth of 8 cm was used.

**Rate and method of phosphorus application:** This test was conducted in split-plot design with rates of phosphorus as main treatments (40, 60, 80 kg P $ha^{-1}$) and placement methods (banding or broadcast) as sub treatment. Either the phosphate fertilizer was drilled with the seed after cultivation (banded) or broadcast and rotovated into the surface layer just before sowing (broadcast). The plot size was the same as the date and rate of seeding test. The seeding dates were 1st Dec for 1999, 2000 and 2001. The seeding rate used was 250 plants $m^{-2}$.

**Irrigation:** Permanent tensiometers were inserted horizontally at 150 mm depth into one lysimeter from each treatment. The tensiometers were read at 11 and 16 h daily. The soil moisture content was calculated from the moisture release characteristics of the soil. To prevent moisture stress soils were maintained between 70 and 90% of field capacity (Rowarth *et al.*, 1997) by the application of 18 mm of irrigation water when tensiometers indicated that the moisture stress had reached 70% of field capacity. Irrigation ceased before 9, 8 and 8 days before harvest in 1999, 2000 and 2001, respectively.

**Measured variables:** Seed yield (kg $ha^{-1}$), seed weight $plant^{-1}$ (g), 1000 seed weight (g), spikes $m^{-2}$, grains $spike^{-1}$, spike length (cm), plant height (cm) and days from sowing to 50% flowering.

**Statistical analysis:** Data for each trait were analyzed for a randomized complete block design (RCBD) with split–plot arrangement according to Steel and Torrie (1980). Comparisons between means were made using least significant differences (LSD) at 0.05 probability level.

## Results and Discussion

No significant interaction among seasons was detected, probably due to irrigation being used. The main source of yield variation in the Mediterranean region is variation in rainfall. Therefore, these results are means across the three growing seasons.

**Plant density:** As the plant density increased from 200 to 300 plant $m^{-2}$, the grain weight $plant^{-1}$, 1000 seed weight, grains $spike^{-1}$ and spike length decreased. The values of the above yield attributes were significantly higher at 200 plants $m^{-2}$ population level. Plants density (spikes $m^{-2}$) and grain yield were directly related to plant density. Grain yields increased as plant density increased, with highest yields being obtained at 300 plant $m^{-2}$. The increase yield observed with increase in plant density is a function of more spikes being produced as a result of more plants being establishment. The influence of plant density on grain yield was through the increased production of spikes per unit area (Table 1). However, not through the increased production of fertile tillers $plant^{-1}$.

High plant density promoted phenological development, with flag leaf extension and heading occurring 7 days earlier in the high seeding rate (300 plant $m^{-2}$) than in the low (200 plant $m^{-2}$). Turk and Tawaha (2002) also found that plant from a low seeding rate headed significantly latter than those from higher seeding rates.

**Seeding date:** Seed yield of barley was influenced significantly by date of sowing (Table 1). The maximum seed yield of 1900 kg $ha^{-1}$ was obtained by sowing barley on 1st Dec, which was found superior to the latter dates of sowing with progressive delay in sowing beyond 1st Dec. a yield reduction of 11.7 and 25.4% was recorded with successive delays in seeding every 14 days interval. The reduction in seed yield due to delay in sowing could also be attributed to shorter growth period at the disposal of the late sown crop as the time taken by the crop to mature decreased with delay in sowing. The delay in barley sowing date greatly reduced grains $spike^{1}$, spike length, 1000 seed weight, seed weight $plant^{-1}$ and also decreased the days from sowing to first flowering. These results are in general agreement with Tawaha *et al.* (2001) and they reported that shorter growing period might result in less dry matter accumulated and fewer spikes and tillers $plant^{-1}$, which reduced seed yield.

Table 1: Yield, yield components and phenological traits of two row barley as affected by date and rate of seeding

| Treatments | Seed yield ($kg\ ha^{-1}$) | Seed weight $plant^{-1}$ (g) | 1000 seed weight (g) | Grains $spike^{-1}$ | Spikes $m^{-2}$ | Plant height (cm) | Spike length (cm) | Day to 50% flowering (day) |
|---|---|---|---|---|---|---|---|---|
| Plant density (Plants $m^{-2}$) | | | | | | | | |
| 200 | 1408.3 | 7.1 | 40.3 | 39.7 | 406.7 | 135.3 | 10.0 | 93.0 |
| 250 | 1603.3 | 5.7 | 37.3 | 35.7 | 446.7 | 145.0 | 7.3 | 88.7 |
| 300 | 1983.3 | 4.8 | 35.3 | 31.7 | 543.3 | 150.7 | 5.3 | 85.7 |
| LSD ($P \leq 0.05$) | 198 | 0.8 | 1.7 | 3.3 | 40.0 | 4.7 | 1.8 | 3.0 |
| Date of seeding | | | | | | | | |
| 1st Dec | 1900 | 7.2 | 41.0 | 40.3 | 506.7 | 148.7 | 9.3 | 95.0 |
| 14th Dec | 1678.3 | 5.6 | 38.0 | 35.0 | 463.3 | 143.3 | 7.3 | 90.3 |
| 28th Dec | 1416.7 | 4.7 | 34.0 | 31.7 | 426.7 | 139.0 | 6.0 | 82.0 |
| LSD ($P \leq 0.05$) | 221 | 0.7 | 1.3 | 3.1 | 33.0 | 3.3 | 1.2 | 5.0 |
| Interaction | NS | NS | NS | NS | NS | NS | NS | NS |

Table 2: Yield, yield components and phenological traits of two row barley as affected by rates and methods phosphorus application

| Treatments | Seed yield ($kg\ ha^{-1}$) | Seed weight $plant^{-1}$ (g) | 1000 seed weight (g) | Grains $spike^{-1}$ | Spikes $m^{-2}$ | Plant height (cm) | Spike length (cm) | Day to 50% flowering (day) |
|---|---|---|---|---|---|---|---|---|
| P rate ($P\ kg\ ha^{-1}$) | | | | | | | | |
| P1 (40) | 1510.0 | 4.5 | 34.0 | 34.5 | 475.0 | 131.5 | 5.0 | 93.5 |
| P2 (60) | 1735.0 | 6.0 | 36.0 | 36.5 | 515.0 | 139.0 | 7.0 | 87.5 |
| P3 (80) | 1919.5 | 8.0 | 40.0 | 42.0 | 550.0 | 147.5 | 10.0 | 82.5 |
| LSD ($P \leq 0.05$) | 179.0 | 1.3 | 2.0 | 1.6 | 32.0 | 5.1 | 1.7 | 5.0 |
| P placement methods | | | | | | | | |
| Band | 1799.7 | 7.0 | 38.7 | 39.0 | 536.0 | 141.7 | 7.3 | 80.0 |
| Broadcast | 1643.3 | 5.3 | 34.7 | 36.3 | 490.0 | 137.0 | 7.3 | 85.0 |
| LSD ($P \leq 0.05$) | 145.0 | 1.4 | 3.3 | 2.4 | 44.0 | 3.0 | NS | 5.0 |
| Interaction | NS | NS | NS | NS | NS | NS | NS | NS |

**Phosphorus placement methods:** Spike length was not affected by P placement methods. On the other hand, seed yield, spikes $m^{-2}$, seed weight $plant^{-1}$, 1000 seed weight, days to 50% flowering, grains $spike^{-1}$ and plant height were significantly greater with band placement than with the broadcast methods of phosphorus application (Table 1). The superiority of band placement was probably due to a combination of higher available soil moisture and a greater probability of roots being exposed to the fertilizer. Thus, it is inferred from the above results that seed yield of barley can be increased further with the addition of P to soils of medium available P status (10 mg Olsen's P $kg^{-1}$ soil).

**Phosphorus rate:** Phosphorus levels significantly influenced the yield attributes. The number of spikes $m^{-2}$, grains $spike^{-1}$, spike length, plant height and 1000 seed weight were significantly higher at 80 kg P $ha^{-1}$, followed by 60 kg P $ha^{-1}$. All the yield attributes were lowest at the lower phosphorus application level of 40 kg P $ha^{-1}$ (Table 2). Spencer and Chan (1991) observed that a plentiful supply of phosphorus in the early stage of growth is a vital factor for the fall development seeds. An adequate supply of P increased the carboxylase efficiency and increase the ribulose-1, 5-diphosphate carboxylase activity, resulting in an increased photosynthetic rate (Jacob and Lawlor, 1992). P levels significantly influenced seed yield. P application at 80 kg $ha^{-1}$ led to the highest yield, followed by P application of 60 kg P $ha^{-1}$. The barley yield was significantly lower at 40 kg P $ha^{-1}$. The increase in seed yield due to P application is well documented by many workers (Turk, 1997; Tawaha, 2000). Days to 50% flowering decreased significantly with P application compared with lower rates (Table 2). This could be attributed to the fact that P application increased the rate of crop development from emergence to floral initiation and advance anthesis.

It was concluded that the major constraint to increase yield is the lack of agronomic management technology suited to the varied conditions under which the crop is grown. Futthermore, input management is almost unknown to Jordanian barley farmers. As investigations researches show, however two row barley yields can be increased substantially with early seeding (1st Dec.), high seeding rate (300-plant $m^{-2}$) and P application (80 kg P $ha^{-1}$) drilled with the seed after cultivation (banded) produced maximum yield of barley crop (Table 2).

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