The Response of Barley to Nitrogen Levels and Seeding Rates Under Irrigation

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ABSTRACT

The effect of four nitrogen levels and three seeding rates on yield and yield components of the six-row barley (*Hordeum vulgare*) cultivar 'California Mariout' were studied in a field experiment that was conducted on the fine sandy soils of the Libyan coastal-strip during the 1975/76 and 1976/77 seasons.

Plant height, spike length, tillering, spike number per plant, weight and number of grains per plant were significantly increased by increasing the nitrogen level. These parameters were significantly decreased by increasing seeding rate from 60–120 kg seed/ha. Kernel size was not affected by variations in nitrogen level and seeding rate.

Total grain and straw yields were significantly increased by increasing nitrogen level. Seeding rate also increased grain and straw yields. There was a significant interaction between nitrogen level and seeding rate with regard to total grain and straw yields. The highest grain yields of 3.988 and 4.862 t/ha. were obtained from plots that were fertilized with 150 kg N/ha. and seeded with the rate of 90 kg/ha. in 1975/76 and in 1976/77 growing seasons, respectively.

INTRODUCTION

Barley is one of the major cereal crops grown in Libya in areas where the precipitation ranges between 200–600 mm during the growing season in the coastal-strip (2,3,4). However, limited acreage planted with barley is irrigated whenever underground water is available, particularly in the Oases and Jafara plane (2,4,6). The six-row cultivar 'California Mariout' (*Hordeum vulgare* L.) is the commonly grown variety under irrigation in Al-Kufra Oasis (2,6). El-Sharkawy and Sgaier (6), in a yield trial of 16 barley cultivars under irrigation in a coarse, sandy soil at Al-Kufra Oasis, found that 'California Mariout' was among the highest yielding variety with a grain yield of 4.953 t/ha.

When grown under irrigation in Arizona, USA, 'California Mariout' Cv., responded positively to nitrogen fertilization, and grain yields were improved by early or split application of N to 240 lb/acre (9,10). However, other reports showed that the optimum nitrogen rate for grain production differed greatly between barley cultivars grown under different soil moisture stresses (7,8). Luebs and Laag (8), reported that high nitrogen level increased straw but decreased grain yields of the spring barley cultivar 'Arivat' grown on sandy loam soil in California. The reduction in grain yield of that variety was attributed to higher rate of water loss through larger leaf area due

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to excess amount of nitrogen. However, the authors found that irrigation, after heading, increased grain yield.

Abdelgawad and Arafa (1) studied the effect of nitrogen fertilization on the yield and yield components of four barley cultivars. They reported that the increase in nitrogen rates from 0–60 kg N/ha. increased significantly both grain and straw yields of the four varieties. The increase in yield was attributed to the increase in spike weight and number of kernels per spike.

Day and Thompson (5) studied the effect of sowing dates and rates of seeding on grain yield of barley under irrigation in Arizona. They found that seeding rates from 39–112 kg/ha. have similar grain yields with 'Harlan' Cv., planted in November and December, whereas grain yield increased with higher seeding rate when the sowing date was delayed beyond December. In late sowing higher seeding rates are desirable in order to compensate for less tillering.

The present investigation was initiated to study the response of the barley cultivar 'California Mariout' to nitrogen levels and seeding rates on a fine sandy soil of the coastal-strip in the Libyan Jamahiriya.

MATERIALS AND METHODS

Field experiments were conducted during 1975/76 and 1976/77 seasons at the Faculty of Agriculture Farm in Tripoli to study the effects of nitrogen levels and seeding rates on yield of the barley cultivar 'California Mariout' (*Hordeum vulgare* L.). A split-plot design was laid out in a randomized complete block form with four replications. Three seeding rates of 60, 90 and 120 kg/ha. were allotted to the main plots. The sub-plots (4 × 4 m each) were assigned to four nitrogen levels of 0, 50, 100 and 150 kg N/ha. using ammonium sulphate (20% N) as a source. The fertilizer was applied in two equal splits, at complete emergence and 5 weeks after sowing. Prior to sowing, the experimental plots received 72 kg of P_2O_5/ha. as superphosphate. Barley kernels were hand-drilled in rows 30 cm apart on October 27, 1975 and on November 9, 1976. In addition to the annual rainfall, sprinkler irrigation water was added whenever needed. At harvest, random samples of 10 plants each were taken for the determination of plant height and yield components. The five middle rows were harvested for determination of total grain and straw yields.

RESULTS AND DISCUSSION

Nitrogen application significantly increased plant height in both seasons, whereas seeding rates up to 120 kg/ha. had no significant effect on plant height (Table 1). Without nitrogen fertilization, the mean plant heights were only 54.7 and 54 cm in 1975/76 and 1976/77, respectively. On the other hand, application of N at the rates of 50, 100, 150 kg/ha. enhanced plant height with mean corresponding values of 57, 76, 78 cm in 1975/76 and 76, 79, 84 cm in 1976/77.

Tillering was significantly increased by the addition of nitrogen (Table 2). The average number of tillers per plant were 1.90, 2.25, 3.23, 3.33 in 1975/76, and 2.10, 3.20, 3.30, 4.23 in 1976/77 for 0, 50, 100 and 150 kg N/ha., respectively. Increasing seeding rates significantly decreased tillering in both years. The average number of tillers per plant were 3.09, 2.69, 2.26 in 1975/76 and 4.22, 3.21, 2.19 in 1976/77 for 60, 90, and 120 kg seed/ha., respectively.

As with tillering, nitrogen levels and seeding rates significantly affected the number of spikes per plant (Table 3). The average number of spikes per plant were 1.83, 2.06, 2.98, 3.13 in 1975/76 and 1.91, 2.85, 2.95, 3.62 in 1976/77 for 0, 50, 100 and 150 kg N/ha., respectively. It is apparent that increasing nitrogen rates greatly

Table 1 Effect of nitrogen level and seeding rate on plant height in (cm) of barley at maturity.

Nitrogen level kg N/ha.	Seeding rate kg/ha.							
	1975/76				1976/77			
	60	90	120	Mean[a]	60	90	120	Mean[a]
0	53.33	56.88	53.78	54.66	60.25	56.00	45.85	54.03
50	58.08	62.50	50.38	56.98	67.30	77.23	75.50	75.58
100	80.35	71.85	75.18	75.80	73.10	84.60	78.85	78.85
150	81.58	76.00	77.40	78.33	81.85	85.70	83.60	83.72
Mean	68.33	66.81	64.18		72.31	75.88	70.95	

[a]L.S.D. for nitrogen level: (0.05) = 7.84, (0.01) = 10.59 cm (in 1975/76); and (0.05) = 5.81, (0.01) = 7.83 cm (in 1976/77).

Table 2 Effect of nitrogen level and seeding rate on number of tillers per plant of barley.

Nitrogen level kg N/ha.	Seeding rate kg/ha.							
	1975/76				1976/77			
	60	90	120	Mean[a]	60	90	120	Mean[a]
0	1.85	1.95	1.90	1.90	3.25	1.75	1.30	2.10
50	2.65	2.80	1.30	2.25	4.70	2.80	2.10	3.20
100	3.75	2.70	3.25	3.23	3.45	3.80	2.65	3.30
150	4.10	3.30	2.60	3.33	5.48	4.50	2.70	4.23
Mean[b]	3.09	2.69	2.26		4.22	3.21	2.19	

[a]L.S.D. for nitrogen level: (0.05) = 0.57, (0.01) = 0.79 (in 1975/76); and (0.05) = 0.99, (0.01) = 1.33 tillers (in 1976/77).
[b]L.S.D. for seeding rate: (0.05) = 0.48 (in 1975/76); and (0.05) = 1.07, (0.01) = 1.62 tillers (in 1976/77).

Table 3 Effect of nitrogen level and seeding rate on number of spikes per plant of barley.

Nitrogen level kg N/ha.	Seeding rate kg/ha.							
	1975/76				1976/77			
	60	90	120	Mean[a]	60	90	120	Mean[a]
0	1.80	1.95	1.75	1.83	2.85	1.65	1.25	1.91
50	2.45	2.55	1.20	2.06	4.15	2.45	1.95	2.85
100	3.60	2.60	2.75	2.98	3.25	3.40	2.20	2.95
150	3.95	3.05	2.45	3.13	4.50	3.75	2.60	3.62
Mean[b]	2.94	2.54	2.04		3.69	2.81	2.00	

[a]L.S.D. for nitrogen level: (0.05) = 0.65, (0.01) = 0.88 spike (in 1975/76); and (0.05) = 0.55, (0.01) = 0.74 spike (in 1976/77).
[b]L.S.D. for seeding rate: (0.05) = 0.52 spike (in 1975/76); and (0.05) = 0.78, (0.01) = 1.19 spike (in 1976/77).

Table 4 Effect of nitrogen level and seeding rate on spike length in (cm) of barley.

Nitrogen level kg N/ha.	Seeding rate kg/ha.							
	1975/76				1976/77			
	60	90	120	Mean[a]	60	90	120	Mean[a]
0	4.33	3.93	4.33	4.20	4.90[c]	4.35	3.33	4.19
50	4.25	4.53	4.00	4.26	6.38	4.25	4.83	5.15
100	5.68	4.38	4.60	4.88	5.28	6.20	5.38	5.62
150	5.60	5.10	4.70	5.13	6.28	6.25	6.28	6.26
Mean[b]	4.96	4.48	4.41		5.71	5.26	4.95	

[a]L.S.D. for nitrogen level: (0.05) = 0.55, (0.01) = 0.74 (in 1975/76); and (0.05) = 0.68, (0.01) = 0.92 cm (in 1976/77).
[b]L.S.D. for seeding rate: (0.05) = 0.44 cm (in 1975/76).
[c]L.S.D. for interaction: (0.05) = 1.18 cm (in 1976/77).

enhanced spike production. On the other hand, increasing seeding rate significantly reduced spike production. The average number of spikes per plant were 2.94, 2.54, 2.04 in 1975/76 and 3.69, 2.81, 2.0 in 1976/77 for 60, 90 and 120 kg seed/ha., respectively.

Spike length responded positively to nitrogen application and negatively to seeding rate (Table 4). Increasing nitrogen level significantly increased spike length in both years. The average spike length was 4.20, 4.26, 4.88, 5.13 cm in 1975/76 and 4.19, 5.15, 5.62, 6.26 cm in 1976/77 for 0, 50, 100 and 150 kg N/ha., respectively, whereas, increasing seeding rate significantly decreased spike length. The average spike length was 4.96, 4.48, 4.41 cm in 1975/76 and 5.71, 5.26, 4.95 cm in 1976/77 for 60, 90, 120 kg seed/ha., respectively. However, there was a significant N level × seeding rate interaction in 1976/77. The shortest spike (3.33 cm) was produced with 120 kg seed/ha. and without nitrogen application.

Table 5 shows that the total yield of barley (grain + straw) was significantly increased by increasing nitrogen level 150 N/ha. and by increasing seeding rate 120 kg seed/ha. in both years. The main total yields were 4.906, 7.018, 8.563, 9.456 t/ha. in 1975/76 and 3.853, 6.604, 7.870, 9.510 t/ha. in 1976/77 for 0, 50, 100 and 150 kg N/ha., respectively. The total yield averages for 60, 90, 120 kg seed/ha. were 6.144, 7.763,

Table 5 Effect of nitrogen level and seeding rate on total yield (grains + straw) ton/ha. of barley.

Nitrogen level kg N/ha.	Seeding rate kg/ha.							
	1975/76				1976/77			
	60	90	120	Mean[a]	60	90	120	Mean[a]
0	3.900	5.469	5.350	4.906	3.706[c]	4.156	3.675	3.843
50	5.588	7.394	8.069	7.018	7.268	5.343	7.206	6.604
100	7.050	8.338	10.300	8.563	5.550	8.987	9.081	7.870
150	8.038	9.862	10.463	9.456	6.843	10.144	11.550	9.510
Mean[b]	6.144	7.763	8.547		5.837	7.156	7.875	

[a]L.S.D. for nitrogen level: (0.05) = 0.994, (0.01) = 1.340 tons/ha (in 1975/76); and (0.05) = 1.629, (0.01) = 2.196 tons/ha (in 1976/77).
[b]L.D.S. for seeding rate: (0.05) = 1.544 tons (in 1975/76).
[c]L.S.D. for interaction: (0.05) = 2.823 tons (in 1976/77).

Table 6 Effect of nitrogen level and seeding rate on grain yield ton/ha. of barley.

Nitrogen level kg N/ha.	Seeding rate kg/ha.							
	1975/76				1976/77			
	60	90	120	Mean[a]	60	90	120	Mean[a]
0	1.531	2.312	2.381	2.075	1.706[c]	1.831	1.738	1.758
50	2.463	3.013	2.906	2.763	2.631	2.250	3.175	2.685
100	2.763	3.694	3.450	3.303	2.031	4.219	3.881	3.377
150	3.056	3.988	3.825	3.624	2.956	4.862	4.713	4.180
Mean[b]	2.431	3.253	3.140		2.331	3.294	3.375	

[a]L.S.D. for nitrogen level: (0.05) = 0.431, (0.01) = 0.581 ton (in 1975/76); and (0.05) = 0.740, (0.01) = 0.998 ton (in 1976/77).
[b]L.S.D. for seeding rate: (0.05) = 0.637 ton (in 1975/76).
[c]L.S.D. for interaction: (0.05) = 1.279 tons (in 1976/77).

8.547 t/ha. in 1975/76 and 5.837, 7.156, 7.875 t/ha. in 1976/77. A significant interaction was found between nitrogen level and seeding rate in the growing season of 1976/77. The lowest total yield (3.675 t/ha.) and the highest (11.550 t/ha.) obtained with the highest seeding rate of 120 kg seed/ha. and the zero and 150 kg N/ha., respectively.

The average grain yield was significantly increased by the increase in nitrogen level and seeding rate in both years (Table 6). The corresponding average grain yields for 0, 50, 100, 150 kg N/ha. were 2.075, 2.763, 3.303, 3.624 t/ha. in 1975/76 and 1.758, 2.685, 3.377, 4.180 t/ha. in 1976/77. Seeding rates of 60, 90, 120 kg seed/ha. produced average grain yields of 2.431, 3.253, 3.140 t/ha. in 1975/76 and 2.331, 3.294, 3.375 t/ha. in 1976/77. However, there was a significant nitrogen level × seeding rate interaction in the 1976/77 growing season. The highest grain yield of 4.862 t/ha. was achieved by the highest nitrogen level of 150 kg N/ha. and the seeding rate of 90 kg seed/ha. It appears, therefore, that 90 kg seed/ha. seeding rate is optimum for grain production of the barley cultivar 'California Mariout' when enough nitrogen was added to the sandy soil of the coastal–strip under irrigation. This conclusion is also substantiated by the highest grain yield value of 3.988 t/ha. obtained in the 1975/76 season with 90 kg seed/ha. seeding rate and 150 kg N/ha.

Table 7 reveals the positive effect of nitrogen level and seeding rate on the average straw yield. As with the total and grain yield, nitrogen level increased straw yield in both years. The average straw yields were 2.831, 4.256, 5.263, 5.831 t/ha. in 1975/76 and 2.086, 3.917, 4.492, 5.331 t/ha. in 1976/77 for 0, 50, 100 and 150 kg N/ha., respectively. The average straw yields for 60, 90 and 120 kg seed/ha. seeding rates were 3.713, 4.513, 5.406 t/ha. in 1975/76 and 3.508, 3.865, 4.496 t/ha. in 1976/77. A significant interaction was observed between nitrogen level and seeding rate in the growing season 1976/77. The lowest straw yield (1.930 t/ha.) and the highest (6.836 t/ha.) were obtained with the highest seeding rate of 120 kg seed/ha. and the 0 and 150 kg N/ha., respectively. This response coincides with that of the total yield (Table 5).

The average grain yield per plant, as indicated in Table 8, was significantly increased by increasing nitrogen level and significantly reduced by increasing seeding rates in both seasons. There was a significant nitrogen level × seeding rate interaction in the 1975/76 growing season. The highest grain weight of 5.18 g/plant was obtained with 150 kg N/ha. and 60 kg seed/ha. This trend was also observed in the 1976/77 experiment where the nitrogen level of 150 kg/ha and the seeding rate of 60 kg/ha. resulted in the highest grain weight of 6.56 g/plant.

As with the grain yield per plant, the number of grains per plant was significantly increased by increasing nitrogen level and significantly decreased by increasing the

Table 7 Effect of nitrogen level and seeding rate on straw yield tons/ha. of barley.

Nitrogen level kg N/ha.	Seeding rate kg/ha.							
	1975/76				1976/77			
	60	90	120	Mean[a]	60	90	120	Mean[a]
0	2.369	3.175	2.969	2.831	2.000[c]	2.328	1.930	2.086
50	3.213	4.375	5.175	4.256	4.633	3.094	4.024	3.917
100	4.281	4.644	6.850	5.263	3.516	4.766	5.195	4.492
150	4.981	5.869	6.638	5.831	3.883	5.274	6.836	5.331
Mean[b]	3.713	4.513	5.406		3.508	3.865	4.496	

[a]L.S.D. for nitrogen level: (0.05) = 0.708, (0.01) = 0.954 ton (in 1975/76); and (0.05) = 0.633 (0.01) = 0.854 ton (in 1976/77).
[b]L.S.D. for seeding rate: (0.05) = 1.110 tons (in 1975/76).
[c]L.S.D. for interaction: (0.05) = 0.396, (0.01) = 0.534 ton (in 1976/77).

Table 8 Effect of nitrogen level and seeding rate on grain yield per plant of barley (g).

Nitrogen level kg N/ha.	Seeding rate kg/ha.							
	1975/76				1976/77			
	60	90	120	Mean[a]	60	90	120	Mean[a]
0	3.01[c]	2.09	1.79	2.30	3.11	1.97	1.17	2.08
50	4.96	3.30	2.09	3.50	6.31	3.95	2.39	4.33
100	4.83	4.01	3.29	4.10	5.99	5.64	3.08	4.91
150	5.18	4.66	3.52	4.60	6.56	5.92	3.30	5.26
Mean[b]	4.60	3.51	2.72		5.49	4.37	2.49	

[a]L.S.D. for nitrogen level: (0.05) = 0.40, (0.01) = 0.54 grain (in 1975/76); and (0.05) = 0.90, (0.01) = 1.22 grains (in 1976/77).
[b]L.S.D. for seeding rate: (0.05) = 0.64, (0.01) = 0.97 grain (in 1975/76); and (0.05) = 1.79 grains (in 1976/77).
[c]L.S.D. for interaction: (0.05) = 0.70 (in 1975/76).

Table 9 Effect of nitrogen level and seeding rate on number of grains per plant of barley.

Nitrogen level kg N/ha.	Seeding rate kg/ha.							
	1975/76				1976/77			
	60	90	120	Mean[a]	60	90	120	Mean[a]
0	65.0	43.5	38.8	49.1	66.6	39.1	24.4	43.4
50	103.1	78.5	49.7	77.1	132.5	80.0	47.7	86.7
100	107.1	90.7	70.9	89.6	122.9	111.5	66.3	100.2
150	119.0	101.6	74.1	98.2	124.3	127.7	74.1	108.7
Mean[b]	98.5	78.6	58.4		113.5	89.6	53.1	

[a]L.S.D. for nitrogen level: (0.05) = 9.3, (0.01) = 12.5 grains (in 1975/76); and (0.05) = 17.8, (0.01) = 24.0 grains (in 1976/77).
[b]L.S.D. for seeding rate: (0.05) = 8.6, (0.01) = 13.0 grains (in 1975/76); and (0.05) = 34.4 grains (in 1976/77).

Table 10 Effect of nitrogen level and seeding rate on the weight of 1,000 kernels in (g) of barley.

Nitrogen level kg N/ha.	Seeding rate kg/ha.							
	1975/76				1976/77			
	60	90	120	Mean^{NS}	60	90	120	Mean^{NS}
0	46.8	47.9	46.3	47.0	46.4	49.2	48.0	47.9
50	48.6	43.5	42.5	44.9	47.9	48.2	46.3	47.9
100	45.4	44.6	49.5	46.5	48.5	50.9	46.4	48.6
150	47.0	46.3	47.8	4.70	51.0	45.6	45.1	47.2
Mean^{NS}	46.9	45.6	46.5		48.4	48.5	46.5	

NS = Not significant.

seeding rate as shown by data of Table 9. The average number of grains per plant were 49.1, 77.1, 89.6, 98.2 in 1975/76 and 43.4, 86.7, 100.2, 108.7 in 1976/77 for 0, 50, 100 and 150 kg N/ha., respectively. On the other hand, the corresponding number of grains per plant for 60, 90, 120 kg seed/ha. seeding rates, were 98.5, 78.6, 58.4 in 1975/76 and 113.5, 89.6, 53.1 in 1976/77. These results are in agreement with previous findings with 'California Mariout' cultivar grown in Arizona (9,10), and with those reported by Abdelgawad and Arafa in Libya (1).

The grain size, as estimated by the weight of 1,000 kernels, was not significantly affected by variations in both nitrogen level and seeding rate (Table 10).

From these results under the edaphic and weather conditions which had prevailed during the execution of this experiment, it can be concluded that grain yield and its components of the six-row barley cultivar 'California Mariout' were significantly increased by the addition of nitrogen fertilizer to the fine sandy soil of the area and with increasing seeding rate to a moderate amount 90 kg seed/ha. However, such response is expected to prevail with supplementary irrigation.

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استجابة صنف الشعير (كاليفورنيا مريوط) لمعدلات التسميد النيتروجينى والبذر تحت الرى التكميلى

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المستخلص

أقيمت تجربة حقلية خلال الموسمين الزراعيين ١٩٧٥/١٩٧٦م و ١٩٧٦/١٩٧٧م بمزرعة كلية الزراعة بسيدى المصرى لدراسة تأثير معدلات التسميد النيتروجينى والبذر على نمو ومحصول صنف الشعير كاليفورنيا مريوط . وقد وجد ان زيادة معدلات التسميد النيتروجينى ادت الى زيادة معنوية فى كل من طول النباتات ، طول السنابل ، التفريغ ، عدد السنابل بالنبات ، وزن وعدد الحبوب بالنبات . بينما ادت زيادة معدلات البذر من ٦٠ الى ١٢٠ كجم /هكتار الى نقص معنوى فى هذه الصفات .

اما حجم الحبه فلم يتأثر بمعدلات كلا المعاملتين .

اما المحصول الكلى (القش + الحبوب) ، ومحصول الحبوب ومحصول القش فقد ادت زيادة معدلات التسميد النيتروجينى والبذر الى زيادة معنوية فيها جميعا . وقد ظهر تفاعل معنوى بالنسبه للمحصول بين معدلات التسميد والبذر . وظهر اعلى محصول حبوب ومقداره ٣ر٩٨٨ طن / هكتار ، ٤ر٨٦٢٠ طن هكتار فى عامى ١٩٧٥/١٩٧٦ ، ١٩٧٦/١٩٧٧م على التوالى عند اضافة ١٥٠ كجم نيتروجين / هكتار واستعمال ٩٠ كجم بذور / هكتار .