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Effect of Nitrogen Level and Soil Moisture Stress on Growth, Yield, and Yield Components of "Sidi Misri 1" Wheat (*Triticum Aestivum* L.)

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ABSTRACT

The effect of nitrogen level and soil moisture stress on growth, yield, and yield components of the semi-dwarf wheat cultivar "Sidi Misri 1" was studied in a field experiment at the faculty of Agriculture Farm, Tripoli, in the 1974/1975 season.

Plant height, spike length, tillering, and number of spikes per plant were increased by increasing the nitrogen level and soil moisture content up to 40 centibars. These measurements generally decreased at the highest moisture stress (70 centibars). The maximum plant height and number of tillers per plant were obtained at the highest nitrogen level (200 kg N/ha) and the highest moisture stress (70 centibars).

The average total yield, grain yield, and straw yield were increased due to the increase in nitrogen level and irrigation when compared with the rainfed treatment. The total yield and straw production were significantly increased with the increase of soil moisture content up to 40 centibars. The highest grain yield (5.725 tons/ha) was obtained with the highest nitrogen application of 200 kg N/ha and the highest water stress of 70 centibars. Nitrogen level X water stress interaction for grain yield was significant.

The average harvest index and average grain yield per plant were highly significantly increased due to the nitrogen level and irrigation treatments.

The average number of grains per plant was increased by either increasing the nitrogen level or decreasing the soil moisture content. A highly significant interaction was found between the nitrogen level and soil moisture content in respect with the weight and number of grains per plant. The highest values of these parameters were attained with the combination of 200 kg N/ha and 70 centibars moisture stress.

The average grain weight and number per spike increased as the nitrogen level increased, and the soil moisture content decreased.

The average number of grains/m^2 highly significantly increased due to the increase in nitrogen level and the decrease in soil moisture content.

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Grain size, estimated as 1,000-grain weight, generally increased, as the nitrogen level increased and the soil moisture content decreased.

It was concluded that a combination of high nitrogen fertilization (200 kb N/ha) and an intermediate level of soil moisture stress (up to 70 centibars) might improve the grain yield of semi-dwarf wheat cultivars, such as Sidi Misri 1.

INTRODUCTION

The response of the dwarf and semi-dwarf Mexican wheats to both nitrogen and soil moisture levels has been reported under arid and semi-arid conditions (1,4,5,6). El-Sharkawy *et al.* (2) indicated positive responses in the number of tillers, dry weight, and leaf area per plant due to the increase in nitrogen fertilization from zero to 140 kg N/ha. Increasing nitrogen level significantly increased straw production, total grain yield, number and weight of grain per plant and number of spikes per plant. They also found that soil moisture content after anthesis did not significantly affect straw yield, grain yield, number and weight of grains per plant, number of spikes per plant, number of grains per spike and grain size. Plant height, spike length, tillering, grain yield and straw production were increased by increasing the nitrogen level up to 200 kg N/ha (8). Sidi Misri 1 wheat proved to be the highest yielding cultivar under high rates of nitrogen (7). Fuehring (3) reported an economic increase in grain yield by increasing nitrogen level up to 300 kg N/ha.

The present investigation was carried out, in light of previous work (2), to gain more information about the response of the semi-dwarf wheat cultivar "Sidi Misri 1" to nitrogen application under rainfed and supplementary irrigation.

MATERIALS AND METHODS

A field experiment was conducted in the 1974/1975 season at the Faculty of Agriculture Farm in Tripoli to study the combined effect of nitrogen level and soil moisture content on growth, yield, and yield components of the semi-dwarf wheat cultivar "Sidi Misri 1" (*Triticum aestivum* L.).

A split-plot design, with four replicates and sixteen treatments, was laid in a superimposed block arrangement. The main plots included four irrigation treatments as follows:

1. Rainfed (no irrigation).
2. Irrigation at 20 centibars of soil moisture tension (high soil moisture content).
3. Irrigation at 40 centibars (intermediate soil moisture content).
4. Irrigation at 70 centibars (low soil moisture content).

The sub-plots were assigned to the nitrogen application levels in the form of ammonium sulphate (20% N) as follows:

1. Zero Kg N/ha (no nitrogen fertilization).
2. 100 kg N/ha added in two splits: at planting and two weeks after planting.
3. 150 kg N/ha added in three equal splits: at planting, and two and four weeks after planting.
4. 200 kg N/ha added in four equal splits: at planting, two weeks after planting, four weeks after planting, and at the heading stage.

Sidi Misri 1 wheat cultivar (*Triticum aestivum* L.) was seeded on 20 November, 1974, in rows 30 cm apart in plots 5.0 × 2.1 m at a rate of 100 kg N/ha. Superphosphate (18 % P_2O_5) was applied as a basic treatment to all plots at a rate of 500 kg/ha.

Sprinkler irrigation was used to supplement the rainfall, except the rainfed plots,

Table 1 Recorded rainfall during the 1974/1975 season at the Faculty of Agriculture Farm, Alfateh University, Tripoli, L.P.S.A.J.

Month	Rainfall (mm)
November (28–30)	3.4
December	200.0
January	79.3
February	56.4
March	38.3
April	5.5
May	—
June	—
Total	382.9

whenever the tensiometer reading reached its value according to the main plot treatments. The recorded amount of rainfall received during the period of this experiment (from 28 November, 1974, until 22 June, 1975) is given in Table 1.

At maturity, five plants were sampled at random from each plot for growth determinations which included the average values for plant height and spike length (in centimeters) and number of tillers and spikes per plant. These samples were also used for the determination of the yield components; namely, grain yield per plant (in grams), number and weight of grains per spike (in grams), number of grains/m^2, and grain size (1,000-grain weight) in grams.

The plots were harvested on 22 June, 1975, and the total yield (grain plus straw), grain yield, and straw yield (in tons/ha), and the harvest index (percentage of grain to total yield) were recorded.

RESULTS AND DISCUSSION

I. Effects on plant growth

The data of Tables 2, 3, 4 and 5 indicated that the average plant height, average spike length, average number of tillers per plant, and average number of spikes per plant were similarly affected by the nitrogen level and irrigation treatments. These

Table 2 Effect of nitrogen levels and irrigation on average plant height of wheat (cm).

Nitrogen levels (kg/ha)	Irrigation treatments				
		Irrigation at			
	Rainfed	20 c.b.	40 c.b.	70 c.b.	Mean[a]
0	45.73[c]	57.68	55.25	54.43	53.89
100	67.75	78.10	77.90	72.33	73.92
150	69.75	81.00	85.00	82.65	79.73
200	75.85	86.20	89.18	93.68	86.23
Mean[b]	64.67	75.87	86.83	75.77	—

[a] L.S.D. for nitrogen levels: (0.05) = 2.72 & (0.01) = 3.65 cm.
[b] L.S.D. for irrigation treatments: (0.05) = 3.85 & (0.01) = 5.54 cm.
[c] L.S.D. for interaction: (0.05) = 5.45 & (0.01) = 7.30 cm.

Table 3 Effect of nitrogen levels and irrigation on average spike length of wheat (cm.)

Nitrogen levels (kg/ha)	Irrigation treatments				
		Irrigation at			
	Rainfed	20 c.b.	40 c.b.	70 c.b.	Mean[a]
0	5.00	6.33	6.00	6.18	5.88
100	7.00	7.83	8.08	8.05	7.74
150	7.50	8.90	9.68	9.75	8.96
200	9.40	10.18	10.55	10.83	10.24
Mean[b]	7.23	8.31	8.58	8.70	—

[a] L.S.D. for nitrogen levels: (0.05) = 0.37 & (0.01) = 0.49 cm.
[b] L.S.D. for irrigation treatments: (0.05) = 0.32 & (0.01) = 0.46 cm.

Table 4 Effect of nitrogen levels and irrigation on average number of tillers per plant of wheat.

Nitrogen levels (kg/ha)	Irrigation treatments				
		Irrigation at			
	Rainfed	20 c.b.	40 c.b.	70 c.b.	Mean[a]
0	1.23[c]	1.60	2.08	1.68	1.64
100	2.18	2.33	2.83	2.35	2.42
150	2.65	2.93	4.08	4.00	3.41
200	2.40	3.73	4.28	4.08	3.62
Mean[b]	2.11	2.64	3.31	3.03	—

[a] L.S.D. for nitrogen levels: (0.05) = 0.41& (0.01) = 0.55 tiller/plant.
[b] L.S.D. for irrigation treatments: (0.05) = 0.29 & (0.01) = 0.42 tiller/plant.
[c] L.S.D. for interaction: (0.5) = 0.82 & (0.01) = 1.10 tiller/plant.

Table 5 Effect of nitrogen levels and irrigation on average number of spikes per plant of wheat.

Nitrogen levels (kg/ha)	Irrigation treatments				
		Irrigation at			
	Rainfed	20 c.b.	40 c.b.	70 c.b.	Mean[a]
0	1.08	1.60	1.83	1.58	1.52
100	2.18	2.15	2.83	2.28	2.36
150	2.50	2.93	3.93	3.75	3.28
200	2.33	3.43	4.10	3.90	3.44
Mean[b]	2.02	2.53	3.17	2.88	—

[a] L.S.D. for nitrogen levels: (0.05) = 0.39 & (0.01) = 0.53 spike/plant.
[b] L.S.D. for irrigation treatments: (0.05) = 0.37 & (0.01) = 0.54 spike/plant.

measurements were generally increased by increasing the nitrogen level up to 200 kg N/ha and the soil moisture tension up to 40 centibars. However, these measurements were generally decreased by further increase in the soil moisture tension above 40 centibars. A highly significant interaction was obtained between the nitrogen level and soil moisture tension in the cases of plant height and tillering. The maximum

Table 6 Effect of nitrogen levels and irrigation on average total yield (grain plus straw) in tons/ha of wheat.

Nitrogen levels (kg/ha)	Irrigation treatments				
		Irrigation at			
	Rainfed	20 c.b.	40 c.b.	70 c.b.	Mean[a]
0	1.025	3.600	5.000	3.575	3.300
100	5.925	10.650	12.000	9.950	9.631
150	7.675	13.000	15.875	14.400	12.738
200	7.900	15.175	17.375	15.825	14.069
Mean[b]	5.631	10.606	12.563	10.938	—

[a] L.S.D. for nitrogen levels: (0.05) = 1.233 & (0.01) = 1.653 tons/ha.
[b] L.S.D. for irrigation treatments: (0.05) = 1.374 & (0.01) = 1.976 tons/ha.

average plant height was obtained under both the highest nitrogen level (200 Kg N/ha) and the highest soil moisture tension (70 centibars). However, the largest average number of tillers per plant resulted from the highest nitrogen level and the soil moisture tension of 40 centibars. These results confirmed the previous findings reported by El-Sharkawy *et al.* (2).

II. Effects on yield and yield components

Table 6 shows that the average total yield of wheat (grain plus straw) was highly significantly increased by the increase of both the nitrogen level up to 200 kg N/ha and the soil moisture up to 40 centibars. However, with further increase in the soil moisture tension, nonsignificant reduction in the average total yield was noted.

The average grain yield was highly significantly increased by the increase of nitrogen level (Table 7). Moreover, this average was highly significantly increased due to irrigation as compared with the rainfed treatment. There was a significant N level X soil moisture stress interaction. The highest grain yield of 5.725 was attained with 200 kg N/ha and 70 centibars of soil moisture tension.

Table 8 reveals the positive effect of nitrogen level and soil moisture tension on the average straw yield. A highly significant increase was obtained for the average

Table 7 Effect of nitrogen levels and irrigation on average grain yield of wheat (tons/ha).

Nitrogen levels (kg/ha)	Irrigation treatments				
		Irrigation at			
	Rainfed	20 c.b.	40 c.b.	70 c.b.	Mean[a]
0	0.075[c]	0.350	0.675	1.025	0.531
100	1.275	2.975	2.775	2.750	2.444
150	2.150	3.963	4.575	4.950	3.909
200	2.100	5.450	5.325	5.725	4.650
Mean[b]	1.400	3.184	3.338	3.613	—

[a] L.S.D. for nitrogen levels: (0.05) = 0.536 & (0.01) = 0.718 ton/ha.
[b] L.S.D. for irrigation treatments: (0.05) = 0.441 & (0.01) = 0.634 ton/ha.
[c] L.S.D. for interaction: (0.05) = 1.071 tons/ha.

Table 8 Effect of nitrogen levels and irrigation on average straw yield of wheat (tons/ha).

Nitrogen levels (kg/ha)	Irrigation treatments				
		Irrigation at			
	Rainfed	20 c.b.	40 c.b.	70 c.b.	Mean[a]
0	0.950	3.250	4.325	2.550	2.769
100	4.650	7.675	9.225	7.200	7.188
150	5.525	9.038	11.300	9.450	8.828
200	5.800	9.725	12.050	10.100	9.410
Mean[b]	4.231	7.422	9.225	7.325	—

[a] L.S.D. for nitrogen levels: (0.05) = 0.920 & (0.01) = 1.232 tons/ha.
[b] L.S.D. for irrigation treatments: (0.05) = 1.014 & (0.01) = 1.458 tons/ha.

straw yield with the increase of nitrogen level up to 200 kg N/ha and the increase of moisture tension up to 40 centibars. However,with further increase in the soil moisture tension above that level, a highly significant reduction occurred in the average straw yield.

The average harvest index (percentage of grain to total yield) was highly significantly affected by both the nitrogen level and irrigation treatments (Table 9). There was a significant increase in the harvest index at the two levels of nitrogen, 150 and 200 kg N/ha. In addition, this index increased as the soil moisture tension increased. These variations in the harvest index coincided with those in grain and straw yields (Tables 7 and 8).

The average grain yield per plant, as indicated in Table 10, was highly significantly increased with both nitrogen fertilization and irrigation, especially at the two higher nitrogen levels (150 and 200 kg N/ha) and the two higher soil moisture tensions (40 and 70 centibars). A highly significant interaction was found between nitrogen level and soil moisture tension. The maximum average grain yield per plant (9.165 g) resulted from the highest nitrogen level and the lowest soil moisture content. On the other hand, the lowest value (0.770 g) was obtained from the non-fertilized and non-irrigated treatments.

The data of Table 11 indicated that the average number of grains per plant was highly significantly affected by the nitrogen level and the moisture tension treat-

Table 9 Effect of nitrogen levels and irrigation on average harvest index (grain to total yield %) of wheat.

Nitrogen levels (kg/ha)	Irrigation treatments				
		Irrigation at			
	Rainfed	20 c.b.	40 c.b.	70 c.b.	Mean[a]
0	7.13	9.15	11.35	24.98	13.15
100	21.33	28.43	22.48	27.30	24.88
150	28.15	30.85	28.75	34.50	30.56
200	27.10	35.78	30.10	36.63	32.40
Mean[b]	20.93	26.05	23.17	30.85	—

[a] L.S.D. for nitrogen levels: (0.05) = 4.72 & (0.01) = 6.32%.
[b] L.S.D. for irrigation treatments: (0.05) = 2.26 & (0.01) = 3.24%.

Table 10 Effect of nitrogen levels and irrigation on average grain yield per plant of wheat (g).

Nitrogen levels (kg/ha)	Irrigation treatments				
		Irrigation at			
	Rainfed	20 c.b.	40 c.b.	70 c.b.	Mean[a]
0	0.770[c]	1.160	1.120	1.390	1.110
100	1.690	3.145	4.495	3.985	3.330
150	2.335	5.170	6.740	6.555	5.200
200	3.000	4.700	8.570	9.165	6.359
Mean[b]	1.949	3.544	5.231	5.274	—

[a] L.S.D. for nitrogen levels: (0.05) = 0.975 & (0.01) = 1.307 g/plant.
[b] L.S.D. for irrigation treatments: (0.05) = 1.207 & (0.01) = 1.736 g/plant.
[c] L.S.D. for interaction: (0.05) = 1.949 & (0.01) = 2.611 g/plant.

ments. This number was increased by increasing the nitrogen level and decreasing the soil moisture content. In addition, a highly significant interaction was observed between nitrogen levels and soil moisture tension. The highest number of grains/plant resulted from the application of 200 kg N/ha at 70 centibars soil moisture tension. This response coincided with that of weight of grains/plant, the harvest index, and the total grain yield.

Tables 12 and 13 show that both the average weight and number per spike was generally increased with the increase in nitrogen level and the decrease in soil moisture content. There was a highly significant difference between the unfertilized treatment, and any of the nitrogen levels. However, the values were comparable among the nitrogen levels. On the other hand, while no significant differences were obtained between the different soil moisture tensions, the rainfed treatment gave the lowest significant average values for the grain weight per spike. The average number of grains per spike was highly significantly increased with the increase of nitrogen level as compared with the unfertilized treatment. A significant increase in this average was noted at the two intermediate and low soil moisture levels (40 and 70 centibars, respectively).

The average number of grains/m^2 was increased with the increase in nitrogen level.

Table 11 Effect of nitrogen levels and irrigation on average number of grains per plant of wheat.

Nitrogen levels (kg/ha)	Irrigation treatments				
		Irrigation at			
	Rainfed	20 c.b.	40 c.b.	70 c.b.	Mean[a]
0	16.90[c]	25.05	24.45	29.50	23.98
100	36.30	65.55	91.20	76.35	67.35
150	49.15	60.80	131.65	129.50	99.03
200	65.65	109.30	171.45	179.80	131.5b
Mean[b]	42.00	71.43	104.69	103.79	—

[a] L.S.D. for nitrogen levels: (0.05) = 17.86 & (0.01) = 23.93 grains/plant.
[b] L.S.D. for irrigation treatments: (0.05) = 24.22 & (0.01) = 34.83 grains/plant.
[c] L.S.D. for interaction: (0.05) = 35.73 & (0.01) = 47.87 grains/plant.

Table 12 Effect of nitrogen levels and irrigation on average grain weight per spike of wheat (g).

Nitrogen levels (kg/ha)	Irrigation treatments				
		Irrigation at			
	Rainfed	20 c.b.	40 c.b.	70 c.b.	Mean[a]
0	0.749	0.763	0.644	0.929	0.771
100	0.812	1.479	1.568	1.788	1.412
150	0.970	1.286	1.705	1.998	1.615
200	1.292	1.443	2.134	2.383	1.813
Mean[b]	0.956	1.368	1.512	1.775	—

[a] L.S.D. for nitrogen levels: (0.05) = 0.365 & (0.01) = 0.489 g/spike.
[b] L.S.D. for irrigation treatments: (0.05) = 0.431 g/spike.

Table 13 Effect of nitrogen levels and irrigation on average number of grains per spike of wheat.

Nitrogen levels (kg/ha)	Irrigation treatments				
		Irrigation at			
	Rainfed	20 c.b.	40 c.b.	70 c.b.	Mean[a]
0	16.45	16.23	14.00	19.68	16.59
100	17.48	30.83	31.83	33.93	28.51
150	20.25	29.28	33.35	39.00	30.47
200	28.40	32.68	42.78	46.80	37.66
Mean[b]	20.64	27.25	30.49	34.85	—

[a] L.S.D. for nitrogen levels: (0.05) = 6.82 & (0.01) = 9.14 grains/spike.
[b] L.S.D. for irrigation treatments: (0.05) = 8.49 grains/spike.

Table 14 Effect of nitrogen levels and irrigation on average number of grains/m² of wheat.

Nitrogen levels (kg/ha)	Irrigation treatments				
		Irrigation at			
	Rainfed	20 c.b.	40 c.b.	70 c.b.	Mean[a]
0	170.8	767.7	1434.6	2108.4	1120.4
100	2718.9	6218.5	5573.1	5310.3	4955.1
150	4563.1	7990.1	8997.4	9414.1	7741.2
200	4643.0	10146.8	10678.1	11111.2	9207.2
Mean[b]	3023.9	6343.3	6670.8	6986.0	—

[a] L.S.D. for nitrogen levels: (0.05) = 1139.6 & (0.01) = 1527.0 grains/m².
[b] L.S.D. for irrigation treatments: (0.05) = 1001.6 & (0.01) = 1440.4 grains/m².

The highest significant value (9207.3 grains/m²) resulted at 200 kg N/ha (Table 14). Irrigation at any moisture tension, highly significantly increased the average number of grains/m². The rainfed treatment resulted in the lowest significant number of grains/m² (3023.9). These results confirmed those reported on grain yield per hectare, grain yield per plant, and harvest index (Tables 7, 10, and 9, respectively).

Table 15 Effect of nitrogen levels and irrigation on average grain size in grams (1000-grain weight) of wheat.

Nitrogen levels (kg/ha)	Irrigation treatments				
		Irrigation at			
	Rainfed	20 c.b.	40 c.b.	70 c.b.	Mean[a]
0	44.00	45.95	45.63	46.63	45.55
100	46.48	47.85	49.25	52.75	49.08
150	47.53	49.43	51.05	52.53	50.13
200	45.70	52.35	50.23	51.95	50.06
Mean[b]	45.93	48.89	49.04	50.96	—

[a]L.S.D. for nitrogen levels: (0.05) = 2.13 & (0.01) = 2.86 g.
[b]L.S.D. for irrigation treatments: (0.05) = 1.96 & (0.01) = 2.82 g.

The 1,000-grain weight (grain size), as shown in Table 15, was generally increased with the increase in nitrogen level and the decrease in soil moisture content. Although the different nitrogen levels gave comparable values, a highly significant increase was obtained as a result of fertilization. Similarly, irrigation caused a highly significant increase in the grain size as compared with the rainfed treatment.

From the results obtained, it may be concluded that a combination of high nitrogen fertilization (200 Kg N/ha) and a soil moisture tension up to 70 centibars might be recommended for the improvement of grain production in the semi-dwarf wheat cultivar 'Sidi Misri 1'. However, the supplementary irrigation has resulted in greater increase of grain yield, regardless of the nitrogen level.

LITERATURE CITED

1. Cavazza, L. 1974. Response of wheat varieties to fertilizer in Italy, pp. 344–349. Proceedings of the Fourth F.A.O. — Rockefeller Foundation Wheat Seminar. F.A.O. Rome.
2. El-Sharkawy, M. A., F. A. Sorour, and M. A. Abazza. 1976. Response of a newly developed variety of dwarf wheat to nitrogen level and supplementary irrigation. Libyan J. Agric. 5:17–26.
3. Fuehring, H. D. 1969. Irrigated wheat on calcareous soils as affected by application of nitrogen, phosphorus, potassium, and zinc. I. Yield composition and number of heads. Agron. J. 61:591–594.
4. Gabar, A. A., D. A. Defalla, M. H. Akasha, and H. E. Osman. 1974. The response of wheat to fertilizer under irrigated conditions in the Sudan, pp. 360–362. Proceedings of the Fourth F.A.O. — Rockefeller Foundation Wheat Seminar F.A.O. Rome.
5. Mirnezami, H. 1974. Response of wheat varieties under irrigated and rainfed conditions in Iran, pp. 350–359. Proceedings of the Fourth F.A.O. – Rockefeller Foundation Wheat Seminar F.A.O. Rome.
6. Rasio, P. A. 1974. Increased use of high yielding crop varieties, fertilizer, and irrigation in Nepal, pp. 371–375. Proceedings of the Fourth F.A.O. – Rockefeller Foundation Wheat Seminar F.A.O. Rome.

7. Sawhney, J. S. 1972. The effect of nitrogen fertilization and components of yield in wheat. Libyan J. Agric. 1:19–24.
8. Sorour, F. A., M. A. El-Sharkawy, and M. I. Shaalan. 1977. Effect of seeding rate and nitrogen fertilization on growth and yield of Sidi Misri 1 wheat cultivar. Libyan J. Agric. 6(1). (In press).