

## Effect of Fertilizer Management on Wheat Growth and Yield Under Semi-Arid Conditions

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**Abstract:** Field trials were conducted in Rafah, North Sinai desert under rain fed conditions (precipitation average < 200 mm). Bread wheat (*Triticum aestivum* L.) C.V. Giza-164 was grown and fertilized with three levels of nitrogen (0, 100 and 120 kg ha<sup>-1</sup> and potassium at (0, 50 and 75 kg ha<sup>-1</sup>) as well as their combinations. The obtained results showed that wheat leaves significantly contained greater amounts of photosynthetic pigments (chl. a, chl. b) due to fertilizers applied as split doses (5 - 6 times) compared to the control treatment the untreated control. Wheat plants which received N at 100 kg ha<sup>-1</sup> and K at 50 kg K<sub>2</sub>O ha<sup>-1</sup> significantly surpassed the other fertilizer treatments in dry matter accumulation and grain yield. The combined fertilizer application resulted in higher grain yield ha<sup>-1</sup> compared with the single applied N or K only. The best wheat grain yield per hectare was achieved when the plants were fertilized with N at 100 kg ha<sup>-1</sup> and K at 50 kg K<sub>2</sub>O ha<sup>-1</sup>. However, further applications of both fertilizers did not report significant yield increase but depressed yields. The importance of this preliminary study is to through the light on the potentiality of self-sufficiency of wheat for such areas which depends on the costly food supply from other parts. It could be concluded that dry land farming in semi-arid regions needs different management to obtain satisfactory yields to develop such areas.

**Key words:** Fertilizer • Rain fed wheat • Yield

### INTRODUCTION

In Egypt, rain belt is restricted in the coastal areas especially the northern parts which are classified as semi-arid regions with poor sandy or saline soil. Rain-fed agriculture exists in North Sinai and Marsa Matrouh in Egypt [1]. Rain-fed agriculture in the Egyptian North coast constitutes an important part of the existent economic activities. Rain fall rate varies in this area ranging from 130 to 150 mm in the northwestern coast and from 80 mm (west of Al-Arish) to 280 mm (at Rafah) in the northeast. Some attempts were conducted in such regions to explore the potentiality of crop production such as lentil and wheat under rain fed conditions and promising findings in this respect were obtained by [2]. The West Asia and North Africa (WANA) region is an enormous and diverse area. About 20 - 30% of wheat is irrigated and the rest is under rainfed conditions. North Sinai could be categorized as Arid zone < 250 mm mean annual rainfall and

productivity of wheat in rainfed areas is still low (0.5 - 1.5 t ha<sup>-1</sup>), [3]. Pereira, [4] pointed out that crop production in rain-fed agriculture relies on seasonal rain fall, often shows a grim picture of a fragile environment due to drought, soil degradation, low rain (water) use efficiency, poor infrastructure, and inappropriate policies. This rate decreases after 20 km south of the Mediterranean in both areas [5]. Few field crops are cultivated in the rain-fed areas in Egypt, mainly lentil, barley and wheat, in addition to few fruit trees. There are several serious threats being faced by rain-fed areas, where most of it are farmed using the old, traditional, and primitive soil and crop management practices. Khalifa *et al.* [6] indicated that in North Sinai, barley is cultivated every year, which resulted in low productivity. Similar situation was found in Marsa Matrouh, for wheat productivity under rain-fed conditions [7]. All winter-sown crops are exposed to many risks because of their small canopy and low evaporative demands in winter months, increasingly exposed to

drought in the spring or early summer when evaporative demand is high, mostly at flowering and grain filling stages, and are largely dependent on the stored soil moisture to complete their growth cycles [8].

The agronomic practices under dry land farming are greatly differed from those of the traditional irrigated farming [9]. Fertilizer rates under rainfed conditions should be adjusted because when excess amounts of fertilizer are applied, the vegetative growth of the plants would be promoted much more at the early periods and water stress may be occurred at later periods, consequently the effective grain filling period would be affected [10]. Under rainfed conditions wheat plants obviously respond to nitrogen [10, 11, 12], application of fertilizers [8, 13, 14], early sowing Oweis *et al.* [14] and increased plant density [15]. Potassium fertilization is now often involved in the new fertilizer programs of many productive cereals [16]. Many reports indicated that complete fertilization with N, P and K to wheat is preferred than the single application of each is employed [12].

Wheat production in range lands in Egypt has been studied Ozoris *et al.*, [17, 18] meanwhile, very few experiments have been conducted under rainfed conditions [2, 19, 6, 7].

Thus, this work aimed at evaluation the effect of different nitrogen and potassium fertilizer levels as well as their combinations on wheat growth and yield under rainfed conditions in North Sinai.

## MATERIALS AND METHODS

Two field experiments were conducted during two successive winter seasons in Rafah, North Sinai Governorate during 2009 and 2010 winter seasons. In the

first season, the first effective rain wave in the district was delayed till mid- January and during April, the Khamasine winds blew up and wheat plants were damaged. Thus, the obtained data were not processed. The following procedures are concerned with the second season. The first effective rain failed in Nov. 29, the average precipitation in the area is 250 mm year<sup>-1</sup> (the current year was 200 mm) (Fig. 1). The experiment was carried out in sandy soil, pH 8.48, EC 5300 ppm, CaCO<sub>3</sub> 4.8 %, OM 0.68 %, (Na 14.1, K 0.13, Mg 1.67 mel/100 gm soil), P 1.6 ppm, (Fe 1.6, Mn 0.5, Zn 3.1 and Cu 0.3 ppm). The soil was ploughed in mid-Nov., then the experimental field was left till the first effective rain failed and the soil was moistened to the depth of 50 cm Bread wheat grains, variety Giza-164 were drilled at the rate of 100 kg ha<sup>-1</sup> just after seeding, another plough was carried out vertically on the furrows which held at the first plough to insure seed covering. Plot size was 10.5 m<sup>2</sup>. The experimental design was a Complete Randomized Block Design with 6 replicates. Nine fertilization treatments were tested; they were three levels of nitrogen (0, 100 and 120 kg N ha<sup>-1</sup>) and three levels of K (0, 50 and 75 kg K<sub>2</sub>O ha<sup>-1</sup>) as well as their combinations. Nitrogen fertilizer levels were applied in the form of ammonium sulphate (20.6% N) while potassium fertilizer was applied as potassium sulphate (48-52% K<sub>2</sub>O). The predetermined amounts of the fertilizers were applied separately when the second wave of rain was failed in mid-January.

A vegetative sample was taken in Feb. 25. Ten plants were taken at random from each plot to determine the total dry weight per plant. At the same time, a fresh plant leaves were taken to determine photosynthetic pigments content. The pigments were extracted using 85% aqueous acetone then the contents of chl. a, chl. b and carotenoids were calculated using Von Wettstine's formula [20].

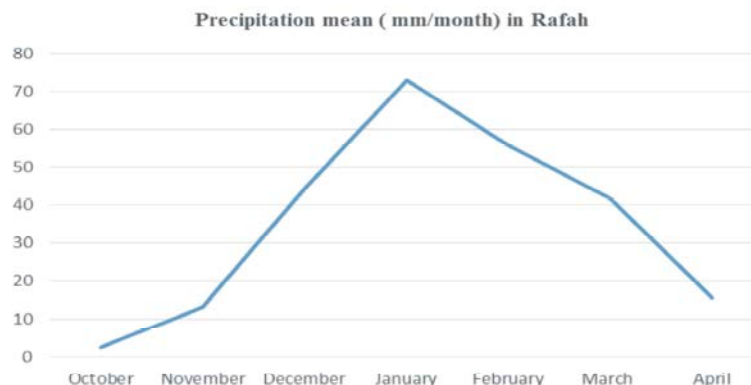


Fig. 1: Precipitation mean (mm/month) in Rafah 2010 year.

Harvest was carried out in April, 27. A square meter of each plot was harvested to determine plant height, the biological yield, spike number and weight  $\text{m}^{-2}$ , grain yield  $1 \text{ m}^2$ ; harvest index and grain yield per feddan and hectare was calculated. The obtained data were subjected to the proper statistical analysis according to [21]. For means comparison, the Least Significant Difference (LSD 5%) was applied.

## RESULTS AND DISCUSSION

**Photosynthetic Pigments Content and Growth Characteristics:** Data presented in Table (1) and Fig. (2) show that wheat plants which received N, K and their combinations contained significantly greater concentration of chl. a, b and a+b. Due to fertilizer application chl. A and b increased as compared with the untreated control. Comparing the content of green pigments (chl. a+b) carotenoids content, the greatest ratio could be detected when N was applied at with the  $120 \text{ kg ha}^{-1}$  alone or combined with  $50 \text{ kg K}_2\text{O ha}^{-1}$ . Also, application of  $100 \text{ kg N ha}^{-1}$  led to a similar result. Such tendency was expected under water stress conditions, due to the vital role of either N or K on chlorophyll formation in wheat leaves because fertilizer application under such conditions may save better circumstances to wheat growth.

Data in Table (2) show significant effects on wheat growth characters when N, K and their combinations were applied as compared to the untreated control. Wheat plants were significantly taller when both N and K were applied than those which received single application of each. The same table shows the beneficial effect of combined application of N and K for increasing the dry matter accumulation in wheat plants. Wheat plants which fertilized with  $75 \text{ kg K}_2\text{O}$  alone or  $100 \text{ kg N}$  plus  $50 \text{ kg K}_2\text{O}$  accumulated the highest amount of dry matter per wheat plant (Fig. 3). Such increase in the different growth characters studied as compared with the untreated control may be attributed to the green pigmentation formation as well as the balanced nutritional conditions which encouraged assimilate formation and finally more dry matter was accumulated. In this respect, Ryan *et al.* [11] under rain Fed conditions showed that the total dry matter of wheat plants continued to increase with increasing N from 40 to  $120 \text{ kg ha}^{-1}$ . Also, Aslam [22] found that fertilizer with NPK increased dry matter 3-4 times. Zhang *et al.* [23] found that Dry-matter accumulation was consistently higher for the fertilized crops than for the unfertilized crops.

Table 1: Effect of Fertilizer treatment on photosynthetic pigments in wheat leaves under rain-fed conditions

Treatment	Chl. a	Chl. b	Total Chl. (a+b)
Control	0.31	0.16	0.47
100 kg N	0.62	0.25	0.87
120 kg N	0.52	0.44	0.96
50 kg $\text{K}_2\text{O}$	0.62	0.17	0.79
75 kg $\text{K}_2\text{O}$	0.42	0.15	0.57
100 kg N + 50 kg $\text{K}_2\text{O}$	0.53	0.23	0.76
100 kg N + 75 kg $\text{K}_2\text{O}$	0.49	0.49	0.98
120 kg N + 50 kg $\text{K}_2\text{O}$	0.51	0.51	1.02
120 kg N + 75 kg $\text{K}_2\text{O}$	0.48	0.48	0.96
LSD at 0.05	0.12	0.14	0.22

Table (2) summarized the effect of N and K and their combinations on yield characters. All of the single or combined fertilizer rates resulted in greater number of spikes  $\text{m}^{-2}$  compared with the untreated control. At the same time, the most superior treatment in these criteria was the application of  $120 \text{ kg ha}^{-1}$ . Wheat plants which treated with  $100 \text{ kg N}$  and combined with  $50 \text{ kg K}_2\text{O ha}^{-1}$  gave the heaviest spike weight  $\text{m}^{-2}$ . Greater biological yield  $\text{m}^{-2}$  was obtained due to the different fertilizer treatments compared with the untreated control. Either the single application of  $100 \text{ kg N}$  or the same treatment combined with  $50 \text{ kg K}_2\text{O}$  gave the greatest biological weight  $\text{m}^{-2}$ . The combined application of N and K out yielded heavier grain weight  $\text{m}^{-2}$  than that of single application of either fertilizer (Table, 2 and Fig. 4). The heaviest grain yield  $\text{m}^{-2}$  could be attained by N application at rate of  $100 \text{ kg}$  combined with  $50$  or  $75 \text{ K}_2\text{O ha}^{-1}$ ; however, the differences between these two combinations were insignificant. Moreover, the combined fertilizer application of N at  $100 \text{ kg}$  plus K at  $75 \text{ kg K}_2\text{O ha}^{-1}$  recorded the highest harvest index value. The data in the same table clearly indicate that all fertilization treatments resulted in a significant increase in grain yield  $\text{ha}^{-1}$  compared to the untreated control (Fig. 5). The combined application of  $100 \text{ kg N}$  with  $50$  or  $75 \text{ kg K}_2\text{O ha}^{-1}$  yielded the highest grain yield  $\text{ha}^{-1}$  as compared with the single applied - N only. Such superiority in grain yield may be attributed to the increased wheat potentiality through the balanced fertilization, which in turn led to a good green pigmentation, more dry matter accumulation and producing heavier spike and greater grain weight per unit area.

The obtained result as are in harmony with those obtained by Aslam [22] and Khadr *et al.*, [12] under rainfed conditions. Such preliminarily study showed the possibility of increasing wheat yield under rainfed conditions in North Sinai.

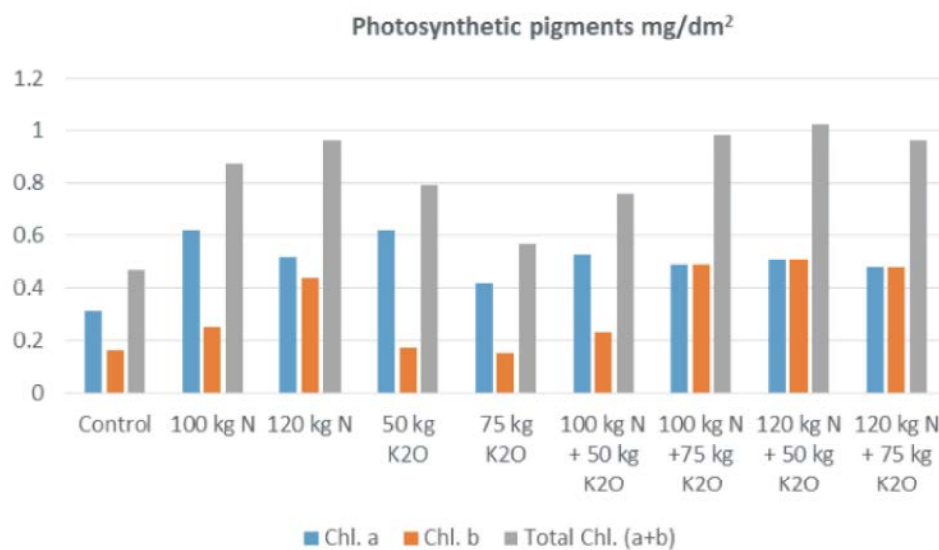


Fig. 2: Effect of Fertilizer treatments on photosynthetic pigments in wheat leaves under rain-fed conditions

Table 2: Effect of fertilizer treatment on wheat yield characters under rain-fed conditions

Treatment	DM plant <sup>-1</sup> (g)	Plant height (cm)	No. of spikes m <sup>-2</sup>	Spike weight (g m <sup>-2</sup> )	Biol. yield (g m <sup>-2</sup> )	Grain yield (g m <sup>-2</sup> )	Grain yield (t ha <sup>-1</sup> )	HI
Control	4.5	59	271	187.5	1440	40.8	0.408	0.028
100 kg N	7.8	87	361	270	2650	80.3	0.803	0.030
120 kg N	11.0	93	447	447.5	2400	112.5	1.125	0.047
50 kg K <sub>2</sub> O	10.0	92	330	400	2160	155	1.55	0.075
75 kg K <sub>2</sub> O	12.8	92	395	430	2240	210	2.1	0.094
100 kg N+50 kg K <sub>2</sub> O	13.0	90	385	552	2480	270	2.7	0.109
100 kg N+75 kg K <sub>2</sub> O	12.5	93	382	450	2240	282.5	2.83	0.126
120 kg N+50 kg K <sub>2</sub> O	14	89	402	390	2240	242.5	2.43	0.108
120 kg N+75 kg K <sub>2</sub> O	10.3	97	340	440	2240	210	2.1	0.094
LSD at 0.05		11	74	52	230	18.5	0.127	0.015

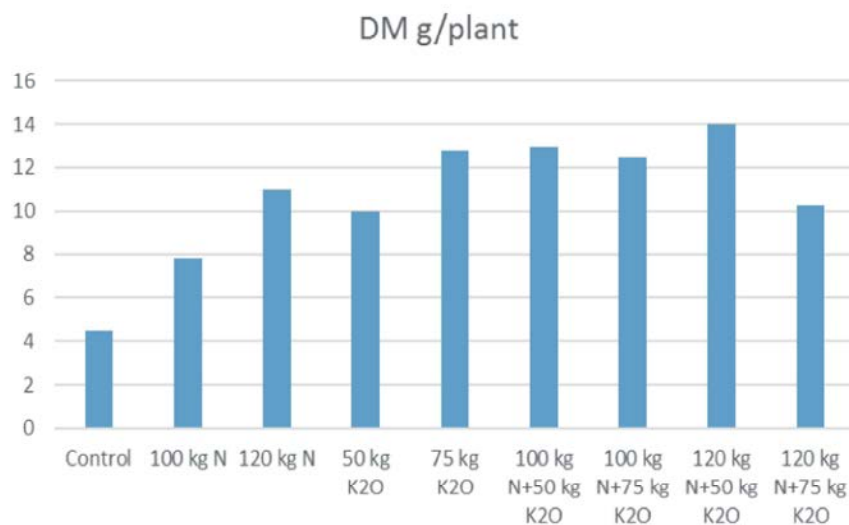


Fig. 3: Effect of fertilizer treatment on wheat dry matter under rain-fed conditions (gm plant<sup>-1</sup>)

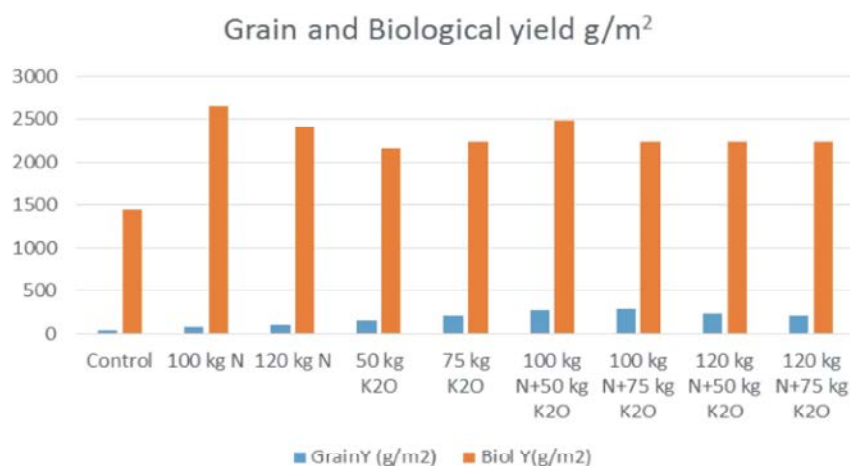


Fig. 4: Effect of fertilizer treatment on wheat biological and grain yields under rain-fed conditions (gm m<sup>-2</sup>)

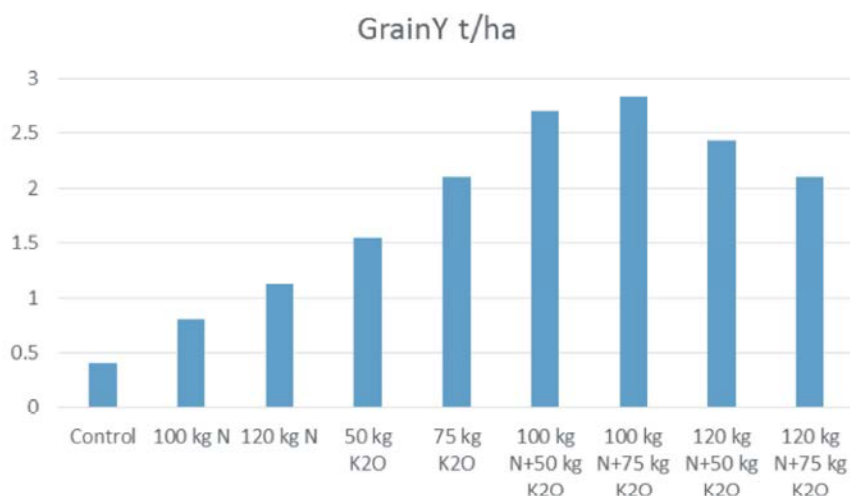


Fig. 5: Effect of fertilizer treatment on wheat grain yield under rain-fed conditions (t ha<sup>-1</sup>)

## CONCLUSION

The importance of this preliminary study is to throw light on the potentiality of self-sufficiency of wheat for such areas which depends on the costly food supply from other parts. It could be concluded that dry land farming in semi-arid regions needs different management to obtain satisfactory yields to develop such areas.

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