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Effect of Varietal Differences and Fertilizer Management on Wheat Production and Water Use Efficiency under Rain Fed Conditions

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Abstract: Field trials were conducted in Rafah, North Sinai desert under rain fed conditions (precipitation average < 250 mm). The trials aimed at evaluating five Bread wheat (*Triticum aesitivum* L.) varieties under rain fed conditions; viz. Sakha-69, Sakha-8, Giza-160, Giza-162 and giza-164. The results showed that wheat cultivars differed significantly in their yield and yield characters, i.e.; 1000-grain weight, straw and grain yield m^{-2}. The results showed that wheat cultivars differed significantly in their yield and yield characters, i.e.; 1000-grain weight, straw and grain yield ha^{-1} and Giza-164 surpassed the other cultivars in yield. In another experiment Giza-164 was grown and fertilized with three levels of nitrogen(control T_0),(T_1) (0,20 gm-^{2}N, 30 gm^{-2} N and potassium at (0, 12 g m^{-2} K_2O and 18 g m^{-2} K_2O 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 treatment compared to the control treatment (T_0). Wheat plants which received N at 20g m^{-2} and K at 12g K_2O m^{-2} significantly surpassed the other fertilizer treatments in dry matter accumulation and grain yield. The combined fertilizer application resulted in higher grain yield m^{-2} compared with the single applied N or K only. The best wheat grain yield m^{-2} was achieved when the plants were fertilized with N at 20g m^{-2} and K at 12g m^{-2} K_2O. However, further applications of both fertilizers did not report significant yield increase but depressed yields. Similar tendency was reported for water productivity (WP_{grains}, WP_{straw} and $WP_{biological}$) where varietal differences among wheat varieties and fertilizer treatments under rain fed conditions were reported. Water productivity ranged between 3.51 and 6.33 (g/mm) and the varieties could be arranged according their ability to benefit from rainfed water as Giza-164> Giza-162> Sakha-69> Giza-162> Sakha-8> Giza-160. The results revealed that Wheat plants which treated with 20g m^{-2} N and combined with 12g m^{-2} K_2O m^{-2} gave the greatest water use efficiency m^{-2}. The importance of this study is to through the light on the potentiality of increasing wheat productivity under dry land farming in semi-arid regions by proper agronomic to obtain satisfactory yields and greater water use efficiency to develop such areas.

Key words: Rain fed · Wheat · Varieties · N · K · Yield · Water use efficiency

INTRODUCTION

Wheat is leading world food crop. It ranks first amongst world's cereal crops. Wheat stability is directly and indirectly dependent upon proper irrigation and agronomic practices. 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. Rainfall rate varies in this area ranging from 130 to 150 mm on the northwestern coast and from 80 mm (west of Al-Arish) to 280 mm (at Rafah) in

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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^{-1}), [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 deficiency is well known worldwide. Potassium deficiency causes many types of abnormalities in both humans and plants. Potassium is an important nutrient for plants. Its deficiency reduces chlorophyll formation, growth, yield and tillering 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, 6, 7,19].

Thus, this work aimed at evaluating bread wheat (*Triticum aesitivum* L.) varieties and the effect of different nitrogen and potassium fertilizer levels as well as their combinations on wheat growth, yield and water use efficiency under rain fed 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 $year^{-1}$ (the current year was 200 mm) (Fig. 1) The experiment was carried out in sandy soil, pH 8.48, EC 5300 ppm, $CaCO_3$ 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 20g m^{-2} 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^2. The experimental design was a Complete Randomized Block Design with 6 replicates. Nine fertilization treatments were tested; they were three levels of nitrogen (0,20 gm-^{2} N, 30 gm^{-2} N and potassium at (0, 12 g m^{-2} K_2O and 18 g m^{-2} K_2O which represented (0, 100 and 120Kg fd^{-1}) and (0, 50 and 75 kg K_2O fd^{-1}) 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_2O) The predetermined amounts of the fertilizers were applied separately when the second wave of rain was failed in mid-January.

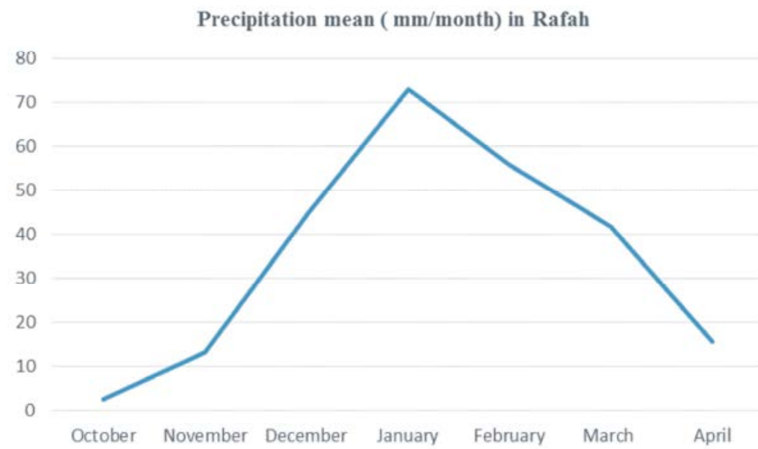


Fig. 1: Precipitation mean (mm/month) in Rafah 2010 year.

Treatment No.	
1)	(T0) Control
2)	(T1) 20g m^{-2} N
3)	(T2)30g m^{-2} N
4)	(T3)12g m-2K_2O
5)	(T4)18g m-2K_2O
6)	(T1+T3)20g m^{-2}N + 12g $m^{-2}K_2O$
7)	(T1+T4)20g m^{-2}N +18g $m^{-2}K_2O$
8)	(T2+T3) 30g m^{-2}N + 12g $m^{-2}K_2O$
9)	(T3+T4) 30g m^{-2}N + 18g m^{-2} K_2O

A vegetative sample was taken in Feb. 25. A quadrateof (0.25X0.25 m) was 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 Wettestine's formula [20].

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 m^{-2}, grain yield 1 m^2; harvest index and were determined.

Water Productivity: A rainfall of 1 mm supplies 0.001 m^3, or 1 litre of water to each square metre of the field. Thus 1 ha receives 10 000 litres.

WP_{grains}, WP_{straw} and $WP_{biological}$ are indicators of effectiveness use of rain fed irrigation for crop production. Water productivity seed was calculated according to [18] as follows: $WP_{grains, straw, biological} = Ey/Ir$

where: WP grains is the water productivity of crop grains, straw, biological (g mm^{-3} rain fed irrigation water), Ey is the economical yield (g grains, straw, biological m^{-2}) and Ir is the amount of applied rain fed irrigation water (mm^{-3} irrigation water m^{-2} $season^{-1}$).

The obtained data were subjected to the proper statistical analysis according to [21]. For means comparison, the Least Significant Difference (LSD 5%) was applied.

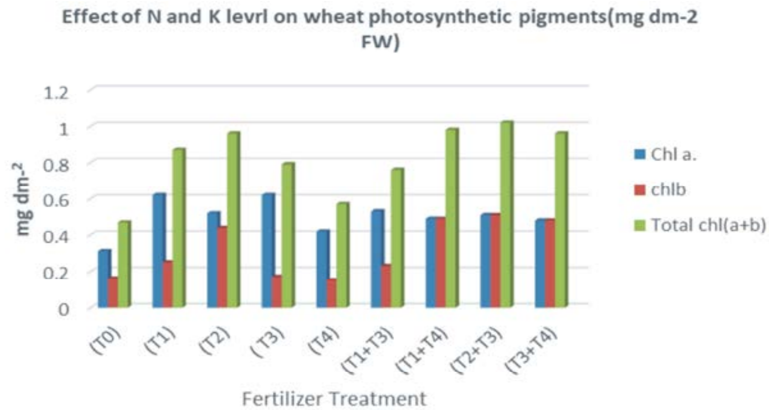
RESULTS AND DISCUSSION

Varietal Differences: Data presented in Table 1 clearly indicate the varietal differences among wheat varieties in yield characters. The grain yield ranged between 206.4 and 372 gm^{-2}, straw yield between 297 and 595 gm^{-2}, while the biological yield ranged between 504.1 and 067.4 gm^{-2}, the lower variety was Giza-160 and the greatest one was Giza-164 in the grain, straw and the biological yields (g m^{-2}). Varieties could be arranged in the following order:

Giza-164> Giza-162> Sakha-69> Giza-162> Sakha-8> Giza-160. The capacity of water varies between cultivars or may differ depending on the genetic makeup and environmental conditions.

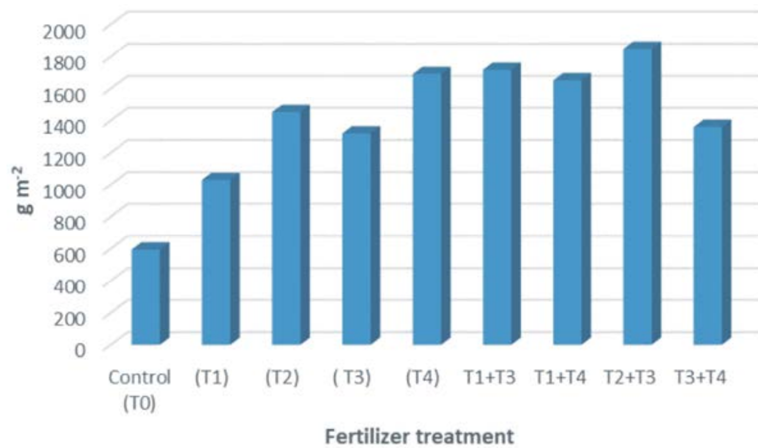
These results are line with previous studies of (Cakmak, 2009) [22] who reported that the capacity of water varies between cultivars or may differ depending on the genetic makeup and environmental conditions.

Effect of Fertilizer Treatments on Wheat Characters Photosynthetic Pigments Content and Growth Characteristics: Data presented in Table (2) 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 30g m^{-2} alone or combined with 12g K_2O m^{-2}. Also, application of 20g m^{-2} N led to a similar result. Such tendency was



(T_0) control, (T_1) 20 gm-^{2} N, (T_2)30 gm^{-2} N, (T_3) 12 g m^{-2} K_2O (T_4) 18 g m^{-2} K_2O

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



(T_0) control, (T_1) 20 gm-^{2} N, (T_2)30 gm^{-2} N, (T_3) 12 g m^{-2} K_2O (T_4) 18 g m^{-2} K_2O

Fig. 3: Effect of fertilizer treatment on wheat dry matter under rain-fed conditions (gm m-^{2})

Table 1: Effect of varietal on wheat yield characters under rain-fed conditions.

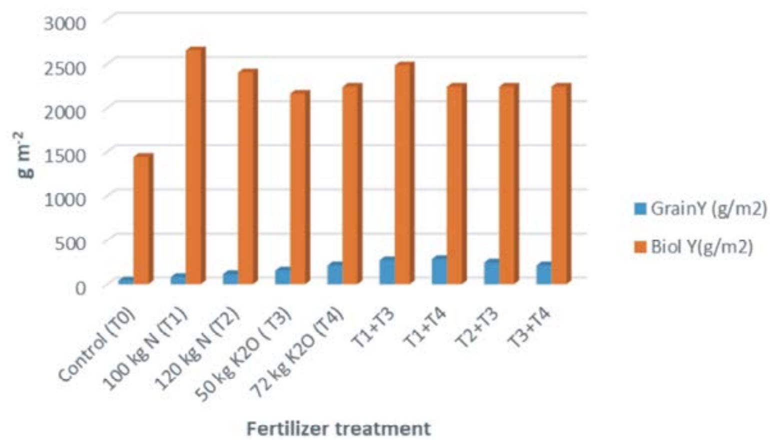
	Grain	Straw	Biological
Sakha-8	256.0	391.4	647.4
Sakha-69	322.4	420.0	742.4
Giza-160	206.4	297.7	504.1
Giza-162	310.0	493.1	803.1
Giza-164	372.0	595.4	967.4

Table 2: Effect of Fertilizer treatment on photosynthetic pigments in wheat leaves under rain-fed conditions

Treatment	Chl. a	Chl. b	Total Chl. (a+b)
Control	0.341	0.176	0.517
20g m-2N	0.682	0.275	0.957
30g m-2	0.572	0.484	1.056
12g m-2K_2O	0.682	0.187	0.869
18g m-2K_2O	0.462	0.165	0.627
20g m-2N + 12g m-2K_2O	0.583	0.253	0.836
20g m-2N +18g m-2K_2O	0.539	0.539	1.078
30g m-2 + 12g m-2K_2O	0.561	0.561	1.122
30g m-2 + 18g m-2K_2O	0.528	0.528	1.056
LSD at 0.05	0.12	0.14	0.22

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 (3) 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 18g m^{-2}K_2O alone or 20g m^{-2}N plus 12g m^{-2}K_2O accumulated the highest amount of dry matter per m^{-2} (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 nutrtional conditions which



T_0) control, (T_1) 20 gm-^{2} N, (T_2)30 gm^{-2} N, (T_3) 12 g m^{-2} K_2O (T_4) 18 g m^{-2} K_2O

Fig. 4: Effect of fertilizer treatment on wheat biological and grain yields under rain-fed conditions (gm m^{-2}).

Table 3: Effect of fertilizer treatment on wheat yield characters under rain-fed conditions.

Treatment	DM m^{-2} (g)	Plant height (cm)	No. of spikes m^{-2}	Spike weight (g m^{-2})	Biol. yield (g m^{-2})	Grain yield (g m^{-2})	HI
Control (T0)	594	64.9	98.4	206.25	1584	44.88	0.03
(T1)	1029.6	95.7	131.0	297	2915	88.33	0.03
(T2)	1452	102.3	162.3	492.25	2640	123.75	0.05
(T3)	1320	101.2	119.8	440	2376	170.5	0.08
(T4)	1689.6	101.2	143.4	473	2464	231	0.10
T1+T3	1716	99	139.8	607.2	2728	297	0.12
T1+T4	1650	102.3	138.7	495	2464	310.75	0.14
T2+T3	1848	97.9	145.9	429	2464	266.75	0.12
T3+T4	1359.6	106.7	123.4	484	2464	231	0.10
LSD at 0.05	78	12.1	26.9	57.2	253	20.35	0.02

(T_0) control, (T_1) 20 gm-^{2} N, (T_2)30 gm^{-2} N, (T_3) 12 g m^{-2} K_2O (T_4) 18 g m^{-2} K_2O

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 kg ha^{-1}. Also, Aslam [23] found that fertilizer with NPK increased dry matter 3-4 times. Zhang *et al*. [24] found that Dry-matter accumulation was consistently higher for the fertilized crops than for the unfertilized crops.

Yield Characters: Table (3) 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 m^{-2} compared with the untreated control. At the same time, the most superior treatment in these criteria was the application of 30g m^{-2}. Wheat plants which treated with 20g m^{-2}N and combined with 12g m^{-2}K_2O m^{-2} gave the heaviest spike weight m^{-2}. Greater biological yield m^{-2} was obtained due to the different fertilizer treatments compared with the untreated control. Either the single application of 20g m^{-2} N or the same treatment combined with 12g m^{-2} K_2O gave the greatest biological weight m^{-2}. The combined application of N and K out yielded heavier grain weight m^{-2} than that of single application of either fertilizer elements (Table, 3 and Fig. 4). The heaviest grain yield m^{-2} could be attained by N application at rate of 20g m^{-2}combined with 50 or 75 K_2O ha^{-1}; however, the differences between these two combinations were insignificant. Moreover, the combined fertilizer application of N at 20g m^{-2} plus K at 18g m^{-2} K_2O 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 m^{-2} compared to the untreated control (Fig. 4). The combined application of 20g m^{-2}N with 12 or 18g m^{-2}K_2O yielded the highest grain yield m^{-2} 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. These results are line with previous studies of (Cakmak, 2009)[22] who reported that application of potassium significantly improved yield components such as water potential.

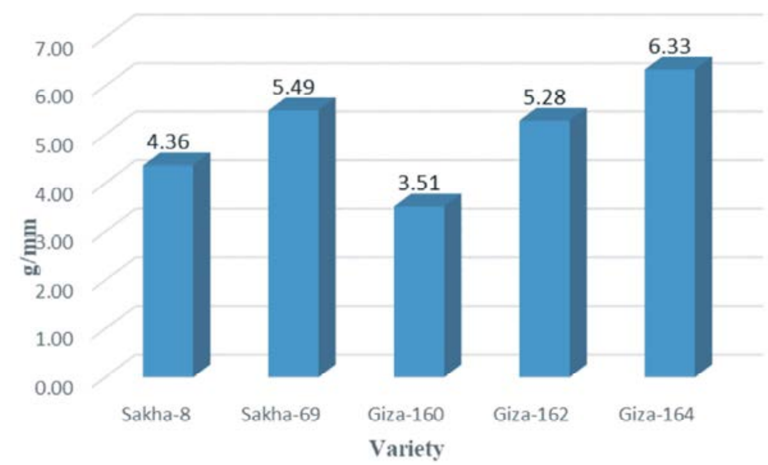


Fig. 5: Effect of wheat varietal differences on rain fed water productivity of grains (g/mm)

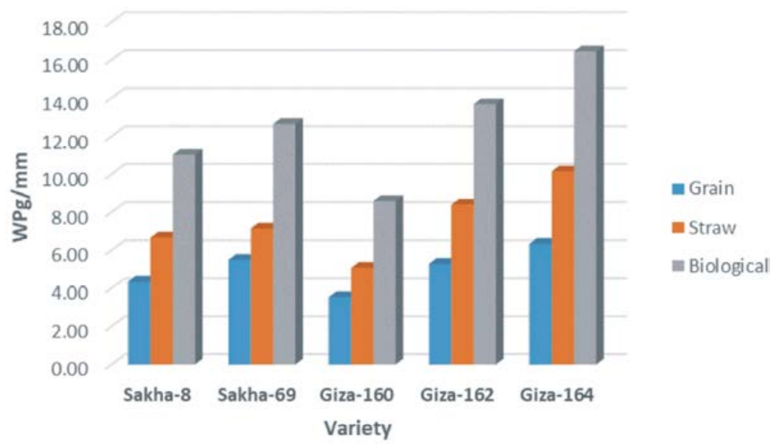


Fig. 6: Effect of varietal differences on rain fed water productivity of wheat (g/mm)

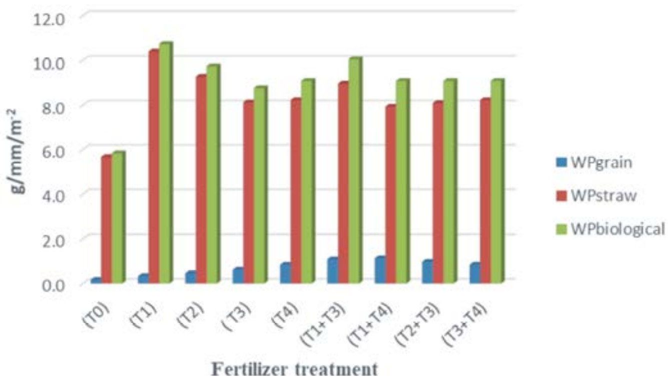
Water Productivity under Rain Fed Conditions

Effect of Variety: A rainfall of 1 mm supplies 0.001 m^3, or 1 litre of water to each square meter of the field. Thus 1 ha receives 10 000 litres.

Data illustrated in Figs. 5 and 6 show that wheat varieties differed in their ability to benefit from rain-fed during the growing season in water productivity of wheat yields (WP_{grains}, WP_{straw} and $WP_{biological}$). Water productivity ranged between 3.51 and 6.33 (g/mm) and the varieties could be arranged according their ability to benefit from rainfed water as Giza-164> Giza-162> Sakha-69> Giza-162> Sakha-8> Giza-160.

The capacity of water varies between cultivars or may differ depending on the genetic makeup and environmental conditions. Oweis *et al* [14] studied water use efficiency of rainfed and irrigated bread wheat in a Mediterranean environment and came to similar conclusion.

Effect of Fertilizer Treatments: Data presented in Table 4 and Fig 7 show the effect of fertilizer treatments on water productivity of different yield components (WP_{grains}, WP_{straw} and $WP_{biological}$). The results revealed that Wheat plants which treated with 20g m^{-2} N and combined with 12g m^{-2} K_2O m^{-2} gave the greatest water use efficiency m^{-2}. Greater biological yield m^{-2} was obtained due to the different fertilizer treatments compared with the untreated control. Either the single application of 20g m^{-2} N or the same treatment combined with 12g $m^{-2}$$K_2O$ gave the greatest biological weight m^{-2}. The combined application of N and K out yielded heavier grain weight/mm m^{-2} than that of single application of either fertilizer (Table, 4 and Fig 7). The greatest grain yield /mm m^{-2} could be attained by N application at rate of 20g m^{-2} combined with either K_2O.



(T0) control ,(T1) 20 gm-2 N, (T2)30 gm-2 N, (T3) 12 g m-2 K2O (T4) 18 g m-2 K2O

Fig. 7: Effect of fertilizer treatments on rain fed water productivity of wheat (g/mm)

Table 4: Effect of fertilizer treatments on rain fed water productivity of wheat (g/mm)

Fertilizer Treatment	WPgrain	WPstraw	WPbiological
(T0)	0.2	5.7	5.8
(T1)	0.3	10.4	10.7
(T2)	0.5	9.3	9.7
(T3)	0.6	8.1	8.8
(T4)	0.9	8.2	9.1
(T1+T3)	1.1	9.0	10.1
(T1+T4)	1.1	7.9	9.1
(T2+T3)	1.0	8.1	9.1
(T3+T4)	0.9	8.2	9.1

Ijaz *et al*.[25] reported that the beneficial effect of K under rain-fed conditions was associated with yield of grains. Transverse osmotic pressure in root system is produced when xylem parenchyma cells force out potassium into xylem vessels, reducing the ability for water to enter and creating uptake of water possible. The existence of K in the vacuole indicates the conservation of potassium and the essential osmotic. The osmotic function is unspecific since it can be controlled by several organic and inorganic osmotic in plants. Potassium is not only principal nutrient for growth of plant but it is also mandatory for health of human. In plants potassium carries out various reactions that are oxidative reductive, transfer energy, metabolic processes, metabolism of nitrogen, enzymatic reactions and composition of protein. Potassium is moreover a co-factor too for various enzymes like dehydrogenases, peroxidases, oxidases and as well as anhydrases that are needed for many plant processes.

Also, the outcomes are in lined with the finding of [26]. They find that potassium significantly affected the total tillers number. These finding were supported by [27]. They find that the length of spike is considerably affected by use of potassium.

The obtained result as are in harmony with those obtained by Aslam [23] and Khadr *et al*., [12] under rainfed conditions. Such preliminarily study showed the possibility of increasing wheat yield under rainfed conditions in North Sinai.

CONCLUSION

The importance of this study is to through the light on the potentiality of increasing wheat productivity under dry land farming in semi-arid regions by proper agronomic to obtain satisfactory yields and greater water use efficiency to develop such areas.

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