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Wheat Production under Water-Limited Sandy Soil Conditions Using Bio-Organic Fertilizer Systems

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WHEAT crop production and improvement under unfavorable conditions is an important aim for plant breeders, who are looking for genetic diversity in which stress tolerance and high yield can be combined. Sandy soils in dry land areas are marginal for crop production. Two field experiments were conducted during 2003/2004 and 2004/2005 successive winter seasons in a private sandy soil farm at El-Katta Region, Giza Governorate to evaluate three local wheat (*Triticum aestivum* L) varieties *i.e.*, Sids 1, Giza 168 and Sakha 69 under some of chemical, organic and bio-fertilizer systems. The agronomic aspects of adding organic and bio-fertilizers application to soil on growth and yield parameters are also discussed. The results showed the importance of applying organic manure with bio-fertilizers compared with chemical fertilizers. Statistical analysis of the data indicated that there were significant differences among the fertilizer treatments for most studied traits. The variation among the three wheat cultivars in its response to fertilizer treatments was found. The Sids 1 cv. gave the highest mean values over the two seasons for all studied traits except protein content in grains. Data evidenced that the second season recorded the highest value for most studied characters among the three used varieties. The correlation coefficient between varieties of wheat yield and its components was highly positive significant under these conditions.

Keywords : *Triticum aestivum*, Sandy soil, Organic fertilizer, Bio-fertilizers.

Wheat (*Triticum aestivum* L.) is the main diet for the Egyptian population. In Egypt, wheat is the main winter cereal crop and is widely distributed all over the country; cultivated area = 2.64 million feddans (one feddan = 4200 m^2) and the mean production of wheat in Egypt in the valley and Delta regions about 2.49 ton/fed. The population of Egypt is increasing at a high rate of about 2.5 % per year; and on the other hand the increase in food production is much less than this. The country imported about 40 % of the total consumption of wheat or about 4.5 million tons in 2004 year (Ministry of Agriculture, Egypt). It is hoped to reduce this gap by increasing yield per unit area, since it is not possible currently to increase the area of wheat cultivation. This can be achieved by a complex treatment series of production factors, out of which the most important are the utilization of high yielding and drought stress tolerant wheat cultivars and by applying the most favorable cultural practices.

Improving low input tolerance of wheat has long been a major objective of most breeding programs, wheat breeders are looking for the genetic diversity in which low input and high yield can be combined. Genetic improvement in grain yield has been demonstrated under both favorable and stress conditions over a period of several decades (Blum, 1989).

The moisture stress imposed at the different growth stages *i.e.,* vegetative growth stage or flowering stage or grain filling stage and/or all growth stages together; reduced significantly all vegetative, yield and yield components characters (Kassab & El-Zeiny, 2005). Available soil water is the principal factor that limits the yield potential of wheat and its response to N (Garabet *et al.*, 1998).

Unfavorable conditions continue to be a challenge to agricultural scientists, despite many decades of research. The impact of water stress could be more accurately predicated with a clear picture of the relationships between growth stage and plant response to stress. The magnitude of yield reduction from water deficits in wheat depends upon the growth stage at which the water deficiency occurs and the severity and duration of the deficiency. Many literature data suggest that wheat has stages in its development, which are not equally sensitive to water stress. Internodes elongation and heading stages of growth are particularly sensitive to water stress (Salter & Goode, 1967). The crown root initiation, flowering and dough mature stages were the critical growth stages in the life cycle of dwarf wheat (Misra *et. al.*, 1969). Moisture stress in the vegetative period reduces the number of tillers, while irrigation after dough did not increase yield as mentioned by Chauhan *et al.* (1970)

Sandy soils in dry land areas are marginal for crop production. They are coarse-textured of low fertility, with very poor organic matter content and water holding capacity. In Egypt, about 93 % of the total area is sandy soils with organic matter less than 1 %. Low soil fertility is one of the major factors limiting wheat production and productivity in Egypt. This is common in many tropical cropping systems where fertilizer use is low and little or no agriculture residues are returned to the soil for maintaining soil fertility. Recently, great attention has been devoted to cultivate field crops in new reclaimed sandy soils. In general, under such unfavorable condition soil characterized as low fertile, low organic matter content and high leaching rate and thus the productivity of most crops in not economically. Farmers have to apply high rates of chemical fertilizers to maintain satisfactory yield.

Several studies indicated that wheat grain yield shows high response to nitrogen application and moisture supply (Sharma *et al.*, 1992; Awad *et al.*, 2000; Sadek, 2000 and Abo-Warda, 2002). The coincident application of organic manures and bio-fertilizers is frequently recommended firstly for improving biological, physical and chemical properties of soil and secondly to get clean agricultural products free of undesirable high doses of heavy metals and other pollutants.

Organic manures contain higher level of relatively easily available nutrient elements, which are essentially required for plant growth. Moreover, it play an important role to improve physical soil properties (Bhandari *et al.*, 1989). Many researchers investigated the nutrient value of organic manure and bio-fertilizers for crop production and indicated that it could be used successfully (Kabesh *et al.*, 1989; Selim *et. al.*, 1998; Soliman *et. al.*, 2001 and El-Mekser, 2004).There exists a large volume of literature reporting the efficiency and effectiveness of the organic fertilizer FYM and other organic nutrient sources in maintaining soil fertility, improving crop yields and sustaining productivity and that display their increased potential when integrated with inorganic fertilizers (Grant, 1981; Mugwira, 1985 and Inckel *et al.*, 1996).

Therefore, the aims of this paper were the use of organic and bio-fertilizer resources to increase and sustain wheat productivity of sandy soil, to improve physical and biological soil properties, to evaluate the performance and increase wheat production. The paper discusses some agronomic aspects of addition farmyard manure and application to soil on wheat production under water-limited sandy soil conditions

Material and Methods

Field experiments were conducted to use organic and bio-fertilizer resources to increase and sustain agricultural productivity of water-limited sandy soil for wheat crop. This study was carried out in a private farm (sandy soil and very poor inorganic matter, nutrients, water holding capacity and high leaching rate.) at West of El-Katta Region, Giza Governorate, Egypt, during the two successive winter seasons of 2003/2004 and 2004/2005. The experimental soil was sandy in texture. The soil mechanical and chemical properties were analyzed according to the method described by Chapman & Pratt (1978) and results presented in Table 1.

TABLE 1. Physical and chemical analyses of the experimental soil.

Variable	Seasons	
	2003/2004	2004/2005
Mechanical analysis		
Sand %	96.29	96.28
Silt %	3.11	3.11
Clay %	0.60	0.61
Soil texture	*Sandy*	*Sandy*
Chemical analysis		
Calcium carbonate %	2.22	2.59
Soil reaction pH	7.59	7.50
Organic matter %	0.50	0.51
E.C ds./m^{-1}	0.11	0.11
Soluble N ppm	36.62	40.08
Available P ppm	4.30	4.26
Exchangeable K ppm	21.52	26.29

In case of chemical fertilization phosphorus was added at rate of 200 kg/fed. as a calcium super-phosphate (15.5 % P_2O_5) and 100 kg/fed. Potassium sulfate (48 % K_2O) was applied prior to sowing, and nitrogen fertilizer was added at rate of 75 kg/fed. as ammonium nitrate (33.5 % N) four imes; the first one 21 days after sowing and then every 7- 10 days. As for bio-fertilizer treatment; grains were coated with the multistrains bio-fertilizer (containing dissolved bacteria) + gum three hours before sowing. Farmyard manure was added as an organic fertilizer during seed bed preparation at the rate of 20 m^3/fed. and its maturity was detected by narrowing C/N ratio (approximately 20/1). Its chemical composition is shown in Table 2.

TABLE 2. Chemical composition of used organic farmyard manure.

Parameters	Organic carbon (%)	C/N Ratio	PH	E.C. $dS./m^{-1}$	Total N (%)	Available P (ppm)
Farmyard manure	12.87	21.80	7.96	2.81	0.80	84.50

The experimental soil was prepared for cultivation and divided into three equal parts as main plots. The main plots stayed with the three wheat varieties (Sids 1, Giza 168 and Sakha 69) obtained from Wheat Research Department, Field Crops Research Institute, Agriculture Research Centre at Giza, Egypt. Each main plot was divided into five sub-plots occupied by fertilizer treatments (chemical fertilizer as a control, bio-fertilizer, organic fertilizer (FYM), organic fertilizer + bio-fertilizer and organic fertilizer + chemical fertilizer). Total plot size was 12 m^2 (4 m.; length and 3 m.; width). Seeds were hand drilled in rows 20 cm apart at rate of 65 kg per fed. The dry method of planting was done on 22^{nd} and 26^{th} November in the first and second seasons, respectively. The other practices of growing wheat were properly used for the management of the experimental plots throughout the cropping season. At harvest twenty spikes were taken at random from the inner rows in each sub-plot to estimate yield attributes, while one m^2 was taken from each sub-plot to determine straw, grain and biological yield per fed. Protein % in grains was determined according to Chapman & Pratt (1978).

The experiments were designed as a randomized complete block with a split plot arrangement in three replications. All the obtained data were subjected to the regular statistical analysis of variance according to Gomez & Gomez (1984). Differences between means of treatments were tested for significant against L.S.D. values at 5% level of probability in both seasons according to Snedecor & Cochran (1980). Correlation coefficients were calculated for yield and yield components using the average of the tow seasons among the three used wheat varieties.

Results and Discussion

Plant height, spike length, number of spikelets per spike, number of grains per spike, number of grains per spikelet, 1000-grain weight, grain yield per spike, grain, straw and biological yields per feddan, harvest index and percentage of protein in grain for all the three used varieties are presented in Table 3 . The data indicated that application of various fertilization types *i.e.,* chemical fertilizer, bio-fertilizer, organic fertilizer, organic fertilizer with bio-fertilizer and organic fertilizer with chemical fertilizer caused different responses in all studied characters. The differences in the traits were more pronounced when chemical, bio and organic fertilizers were applied in a combination between them than its separate application. The effect of fertilizer types can be classified in two categories according to the least significant differences between means of them; the first group includes chemical, bio and organic fertilizer types so, there are no significant differences between them in all studied characters approximately. The organic fertilizer was the best treatment in this group which gave the highest score in all studied characters. The second group which contain the combinations between chemical, organic and bio fertilizes was more effective on all studied traits than the first one. Although, there are no significant differences between the two treatments in the second group but the chemical fertilizer with organic fertilizer application had the best effect over all the categories or treatments over the two seasons as a whole (Table 3). From the same table, the application of chemical fertilizer and organic fertilizer together increased the grain yield per feddan by 56 % and 55 % more than the separate application of these fertilizer types, respectively. Blackshaw *et al.* (2005) similarly found that the manure fertilizer increased winter wheat shoot and production. It is noteworthy that composted manure gave the highest grain protein (Deluca & Deluca, 1997 and Eghball *et al.*, 2004).

TABLE 3. Effect of fertilizer types on some growth, yield and yield attributes and protein content of wheat during 2003/2004 (1st) and 2004/2005 (2nd) seasons.

Character	Plant height (cm)			Spike length (cm)			No. of spikelets/spike			No. of grains/spike		
Year	1st year	2nd year	Ave.	1st year	2nd year	Ave.	1st year	2nd year	Ave.	1st year	2nd year	Ave.
Chemical	98.20	98.99	98.60	8.19	8.54	8.37	16.00	16.87	16.44	32.84	33.05	32.95
Bio.	97.02	98.00	97.51	8.00	8.30	8.15	15.30	16.80	16.05	31.20	32.90	32.05
Organic	101.17	103.66	102.42	9.40	9.79	9.60	16.51	17.94	17.23	38.02	39.01	38.52
Organic + Bio	103.20	104.44	103.82	11.15	12.18	11.67	20.51	21.27	20.89	63.22	65.99	64.61
Organic + Che	107.00	110.00	108.50	12.55	13.10	12.83	21.70	22.38	22.04	70.00	72.10	71.05
L.S.D. 5%	4.07	5.66	--	1.41	1.50	--	1.22	1.19	--	6.80	6.15	--

TABLE 3. Cont.

Character	No. of grains/spikelet			1000-grain weight (g)			Grain yield/spike (g)			Grain yield (ton/fed)		
Year	1st year	2nd year	Ave.	1st year	2nd year	Ave.	1st year	2nd year	Ave.	1st year	2nd year	Ave.
Chemi- cal	1.82	1.75	1.79	37.80	39.00	38.40	1.24	1.29	1.27	1.48	1.50	1.49
Bio.	1.80	1.75	1.78	36.00	38.10	37.05	1.12	1.25	1.19	1.41	1.42	1.41
Organic	2.05	1.96	2.01	37.81	39.30	38.56	1.44	1.53	1.49	1.49	1.51	1.50
Organic + Bio.	2.81	2.84	2.82	38.76	40.19	39.48	2.45	2.65	2.55	2.19	2.27	2.23
Organic + Che.	2.95	2.96	2.96	40.10	41.38	40.74	2.81	2.98	2.90	2.28	2.37	2.32
L.S. D. 5%	0.41	0.46	--	1.38	1.20	--	0.20	0.22	--	0.14	0.16	--

TABLE 3. Cont.

Character	Straw yield (ton/fed)			Biological yield (ton/fed)			Harvest index (%)			Grain protein (%)		
Year	1st year	2nd year	Ave.	1st year	2nd year	Ave.	1st year	2nd year	Ave.	1st year	2nd year	Ave.
Chemical	2.49	2.68	2.58	3.98	4.18	4.08	37.34	36.87	37.10	9.46	9.80	9.63
Bio.	2.35	2.48	2.41	3.76	3.89	3.83	37.54	36.95	37.25	8.15	8.60	8.38
Organic	2.50	2.68	2.59	3.99	4.19	4.09	37.40	36.82	37.11	9.50	9.82	9.66
Organic + Bio.	2.88	2.87	2.88	5.08	5.15	5.11	43.19	44.47	43.83	10.31	10.70	10.51
Organic + Che.	3.02	3.03	3.02	5.29	5.40	5.35	42.98	44.38	43.68	10.99	11.00	11.00
L.S.D. 5%	0.11	0.13	--	0.12	0.14	--	1.87	1.95	--	0.30	0.27	--

Table 4 shows the response of Sids 1, Giza 168 and Sakha 69 wheat cultivars to fertilizer types *ie.,* chemical fertilizer, bio-fertilizer, organic fertilizer, organic fertilizer + bio-fertilizer and organic fertilizer + chemical fertilizers and its effect on some growth, yield, yield components and grain protein content characters. All the studied traits such as plant height, spike length, number of spikelets per spike, number of grains per spikelet, 1000-grain weight, grain yield per spike, grain yield per feddan, biological yield per feddan, harvest index and grain protein percentage significantly differed for the three wheat cultivars in both seasons, as well as number of grains per spike in the first season only. On the other hand, the three wheat cultivars did not significantly differ in number of grains per spikelet and straw yield per feddan in both seasons. Moreover, it is clear that Sids 1 cultivar produced the highest average of the two seasons for grain yield per feddan (2.24 ton) compared to the other cultivars. The superiority of cv. Sids 1 resulted from that it had the highest grain yield per spike and its components (number of grains per spike and 1000 grains weight), while the lowest grain yield per feddan was obtained from cv. Giza 168 (1.40 ton). With regard to the protein percentage in grains, it is clear that the Sakha 69 cultivar had the highest average grain protein percentage over the two seasons, whatever, there are no significant differences between varieties in grain protein percentage in the both seasons. In the same Table the data evidenced that the second season recorded the highest value for all studied characters among the three used varieties except one case only *i.e.*, number of grains per spikelet of sids 1 cultivar, likely due to cumulative N release over years and gradual N release throughout the growing season (Deluca & Deluca, 1997 and Eghball *et al.*, 2004). The variation among wheat varieties in their response to fertilization was previously reported by Eissa *et al.* (1990); Abd El-Ghany (1997) and Hossain *et al.* (2002).

TABLE 4. Response of some growth, yield, yield components and protein content to fertilizer amongst varieties during 2003/2004 (1^{st}) and 2004/2005 (2^{nd}) seasons.

Character	Plant height (cm)			Spike length (cm)			No. of spikelets/spike			No. of grains/spike		
Year	1^{st} year	2^{nd} year	Ave.	1^{st} year	2^{nd} year	Ave.	1^{st} year	2^{nd} year	Ave.	1^{st} year	2^{nd} year	Ave.
Sids 1	120.70	122.30	121.50	11.90	12.35	12.13	17.20	18.90	18.05	70.00	71.30	70.65
Giza 168	113.69	114.46	114.08	8.90	8.98	8.94	14.50	15.89	15.19	51.91	61.48	56.70
Sakha 69	115.30	116.20	115.75	9.99	10.10	10.05	16.20	17.88	17.04	60.33	61.50	60.92
L.S.D. 5%	1.57	1.70	--	1.06	1.09	--	1.67	1.96	--	8.40	--	7.58

Character	No. of grains/spikelet			1000-grain weight (g)			Grain yield/spike (g)			Grain yield (ton/fed)		
Year	1^{st} year	2^{nd} year	Ave.	1^{st} year	2^{nd} year	Ave.	1^{st} year	2^{nd} year	Ave.	1^{st} year	2^{nd} year	Ave.
Sids 1	4.07	3.77	3.92	39.99	40.20	40.10	2.73	2.80	2.76	2.20	2.29	2.24
Giza 168	3.58	3.87	3.73	32.65	33.02	32.84	1.63	1.96	1.79	1.34	1.46	1.40
Sakha 69	3.72	3.44	3.58	36.75	37.20	36.98	2.15	2.20	2.17	1.78	1.86	1.82
L.S.D. 5%	--	--	--	3.20	3.28	--	0.38	0.39	--	0.22	0.24	--

TABLE 4. Cont.

Character	Straw yield (ton (ton/fed)			Biological yield (ton/fed)			Harvest index (%)			Grains protein (%)		
Year	1st year	2nd year	Ave.	1st year	2nd year	Ave.	1st year	2nd year	Ave.	1st year	2nd year	Ave.
Sids 1	2.90	2.99	2.94	5.10	5.28	5.19	43.15	43.37	43.26	10.36	11.03	10.70
Giza 168	2.52	2.61	2.56	3.85	4.07	3.96	34.74	35.85	35.29	9.80	9.90	9.85
Sakha 69	2.41	2.50	2.45	4.19	4.35	4.27	42.48	42.61	42.55	10.98	10.80	10.89
L.S.D. 5%	--	--	--	0.92	0.93	--	2.78	2.85	--	--	--	--

Table 5 includes the data of simple correlation coefficient between grain yield per feddan and other studied characters for all the tested varieties. The data indicated that correlation coefficients were highly significant between grain yield per feddan and plant height, spike length, number of spikelets per spike, number of grains per spike, number of grains per spikelet, 1000-grain weight, grain yield per spike, biological yield per feddan, harvest index and grain protein percentage. All of the calculated correlation coefficients were positive except one case only *i.e.*, between grains per spikelet and protein percentage in grains. Correlation coefficients were significant and/or highly significant between all studied characters except the correlation coefficients between grains per spikelet and each of harvest index and protein percentage in grains and also between straw yield per feddan and protein percentage in grains. In this concern, Rady *et al.* (1981) and Salem *et al.* (1990) found that the phenotypic correlation coefficients were highly significant and positive between wheat grain yield and each of spike grains weight, 1000 grains weight, number of grains per spike, number of spikelets per spike and straw yield per feddan.

TABLE 5. Correlation coefficients between grain yield and all studied traits amongst all varieties.

Characters	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	Protein%
Plant height, cm (1)	0.99 **	0.89 **	1.00 **	0.78 **	0.93 **	0.98 **	0.95 **	0.91 **	0.73 **	0.54 **
Sike length, cm (2)		0.94 **	1.00 **	0.69 **	0.97 **	1.00 **	0.98 **	0.84 **	0.82 **	0.64 **
Spikelets/spike (3)			0.92 **	0.41 **	1.00 **	0.96 **	0.99 **	0.62 **	0.96 **	0.86 **
Grains/spike (4)				0.73 **	0.95 **	1.00 **	0.97 **	0.87 **	0.79 **	0.61 **
Grains/spikelet (5)					0.49 **	0.66 **	0.56 **	0.97 **	0.15 ns	-0.10 ns
Seed index, g (6)						0.98 **	1.00 **	0.68 **	0.94 **	0.82 **
Grain yield/spike, g (7)							0.99 **	0.82 **	0.84 **	0.68 **
Grain yield, ton/fed (8)								0.74 **	0.90 **	0.77 **
Straw yield, ton/fed (9)									0.38 *	0.14 ns
Harvest index, % (10)										0.97 **

In general, results indicated that the farmyard manure exhibited good potential as N sources for winter wheat production. Also, rationalizing the consumption of the chemical fertilizers by its replacing by farmyard manure and biofertilizers protects the environment from chemical pollution and its harmful effect on human and animal health and nutrition. In addition, manipulation of wheat fertilization should be considered an important component of long-term crop management and sustainable crop production systems in sandy soil. In the mean time, it produced significantly higher grain and straw yield of wheat as well as improving the soil mechanical characteristics.

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إنتاج القمح تحت ظروف الأراضى الرملية الفقيرة محدودة المياه باستخدام نظم سمادية مختلفة

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تعتبر زراعة وتحسين انتاجية القمح تحت الظروف البيئية غير الملائمة من الأهداف الهامة فى برامج تربية القمح والتى تبحث عن تباين وراثى واسع لتحمل ظروف نقص المياه مع إعطاء محصول عالى ولهذا أجريت تجربتان حقليتان خلال الموسمين الزراعيين ٢٠٠٣/٢٠٠٤ ، ٢٠٠٤/٢٠٠٥ بقرية برقاش – غرب القطا – مركز امبابة – محافظة الجيزة، حيث التربة رملية حديثة الإستصلاح غير ملحية فقيرة فى العناصر الغذائية والمادة العضوية، كما انها منخفضة فى نسبة التشبع بالمياه (٨–١٠%) بالإضافة الى أنها عالية الرشح، حيث تروى هذة الأرض بنظام الرى بالغمر عن طريق بئر منخفض الملوحة. ولقد استهدفت التجارب دراسة نمو وانتاجية محصول ثلاثة أصناف محلية من قمح الخبز وهي: سدس ١، جيزة ١٦٨ وسخا ٦٩ ومدى تحملها لمثل ظروف هذه الأراضى الفقيرة فى العناصر الغذائية بإستخدام بعض نظم التسميد العضوى والحيوى والكيماوى وبعض التوافيق بينهم. ولقد أظهرت النتائج المتحصل عليها أهمية إضافة الأسمدة العضوية مع الأسمدة الحيوية مقارنة بإضافة الأسمدة الكيماوية. كان هناك تأثير معنوى واضح لإضافة نظم التسميد المختلفة على جميع الصفات تحت الدراسة. أظهرت الأصناف الثلاثة إختلافات معنوية فيما بينها فى مدى استجابتها لنظم التسميد المستخدمة وأعطى الصنف سدس ١ اعلى القيم خلال موسمى الدراسة لجميع الصفات فيما عدا صفة نسبة البروتين فى الحبوب. أظهرت النتائج أن جميع قيم الموسم الثانى كانت أعلى من قيم الموسم الأول لجميع الصفات والأصناف تحت الدراسة فيما عدا صفة عدد الحبوب بالسنبلة للصنف سدس١ فقط. أوضحت معاملات الإرتباط بين المحصول ومكوناتة وجود علاقات إرتباطية عالية موجبة تحت ظروف الدراسة.