EFFECT OF RAISED BED PLANTING TECHNOLOGY ON PRODUCTIVITY, MACRO NUTRIENTS UPTAKE OF BREAD WHEAT AND SAVING IRRIGATION WATER

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ABSTRACT:

On-farm field experiments were conducted to assess the effects of planting methods (raised bed and farmer practices) on yield and macro nutrients uptake of bread wheat, as well as amount of applied water. The locations of the experiments were in ten farmers' field representing ten districts at Al- Sharkia Governorate, Egypt, durinig 2011/2012 and 2012/2013 seasons.

The obtained results could be summarized as follows:

1-Sowing wheat on raised bed was superior in its productivity compared with farmer practices (traditional sowing) at all locations under study in both seasons. The relative increase of wheat productivity for raised bed were 23.21, 24.70 and 23.98% for grain, straw and biological yield, respectively in the 1st season, as well as 34.63, 32.99 and 33.78% for grain, straw and biological yield, in the 2nd season, respectively.

2-Raised bed treatment gave the highest values of nitrogen, phosphorus and potassium uptake for grain, straw and biological wheat yield compared to farmer practices in both seasons. The relative increase of N uptake for wheat grown on raised bed were 38.85, 52.22 and 41.41% in the 1st season, as well as 49.28, 50.99 and 41.19 % in the 2nd season for grain, straw and biological yield, respectively. The relative increase of phosphorus uptake for wheat grown on raised bed were 24.23, 24.90 and 24.48 % in the 1st season and 34.41, 39.53 and 36.39 % in the 2nd season for grain, straw and biological yield, respectively in the 2nd season. The relative increase of K uptake for wheat grown on raised bed was 59.00, 47.87 and 50.08 % in the 1st season, as well as 36.53, 40.59 and 39.82% in the 2nd season for grain, straw and biological yield, respectively.

3-Raised bed treatment gave the higher saving in irrigation water more than the farmer practices treatment in both seasons. The applied water for wheat sowing on raised bed was lower than flat treatment by 1356 and 1212 m^3 ha^{-1} with savings of irrigation water by 24.1 and 23.7% in the first and second season, respectively.

INTRODUCTION

Wheat is an important cereal crops which is grown on more hectares globally than any other crops and provides a major share of the nutritional

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necessities for the growing world population (**Shapiro, 2009**). It is a staple food for about one third of the world's population (**Hussain and Shah. 2002**), being cultivated in Egypt on about 1.25 million hectare and delivering about 8.1 million ton of grain yields. However, the Egyptian government is forced to import wheat every year because of high demand supply gap. To feed the growing human population and fill the yield gaps between wheat consumption and production in Egypt, increasing production of wheat is very important. Moreover, wheat straw is an integral component of livestock feed. Increasing wheat production can be possible by increasing productivity of small holder producers by vertical extension in the old soils where wheat production is constrained by both biotic and abiotic stress.

Surface irrigation is the conventional irrigation method in about 80% of the irrigated area in Egypt. It is characterized by lower water application efficiency (45 to 50%) compared to the other methods, mainly because of water loss due to deep percolation and evapotranspiration. Farmers are usually seen to over-irrigate their fields, which leads to greater losses leading to profile drainage, which in turn increases water storage that cannot be taken up by crops. Consequently, optimal irrigation application, during the growing season, is important for increasing wheat productivity per unit of applied water without additional costs (**Swelam and Atta 2011**). When using the raised bed planting method technology, higher yield, lower water application and higher gross production water use indices for maize crop can be achieved (**Ahmad et al. 2009; Akbar et al. 2010; Ahamd et al. 2011; Zhang et al. 2012**). Regardless of irrigation intervals, several studies have shown the potential of the raised beds method in saving irrigation water and improving water use efficiency for different crops, i. e., sugar beet (**Taleghani et al. 2004**), oilseed rape (**Buttar et al. 2006**) and potato (**Harms and Konschuh 2010**). **Abd El-Halim and Abd El-Razek, (2014)**. Raised bed planting method has been shown to improve water distribution and efficiency, fertilizer use efficiency, reduces weed infestation and lodging and it also reduces seed rate without sacrificing yield (**Hobbs *et al.* 2000**). There are indications that the crop yield on raised beds can be further increased due to nutrient management and later irrigation because of the reduced hazard of lodging (**Sayre and Mornes Romos, 1997**). Changing to a raised bed planting method from traditional flat planting with flood irrigation can give water saving of 35%. It also eliminates the formation of a crust on the surface of calcareous soils (**Fahong, *et al*, 2003**). So, the present study has been carried to measure the effect raised bed planting method in ten locations on increasing wheat yield, its nutritional states and saving irrigation water in old soil of Egypt.

MATERIALS AND METHODS

A field experiment was set up on farmers' fields with the full participation of farmers at different locations (Al-Sharkia Governorate, Egypt) during the two winter seasons, 2011/2012 and 2012/2013 to study the effect of raised bed planting technology and conventional method (flat) on wheat yield

(*Triticum aestivum L.*) cultivar Sids 12. Soil of the experimental field was sampled to determine particle size distribution and chemical analyses before planting according to the standard methods **(Ryan et al., 1996)** and the results are presented in Table (1).

The experimental plots were arranged in two planting methods (raised bed and flat) with four replicates in ten different locations (Zagazig, Qnayat, Menya Al_Qamh, Mashtool, Abu Hammad, Belpis, Diarb Negm, Hehya, Abu Kabir and Faqous) in Al- Sharkia Governorate, Egypt. In the raised bed treatment wheat was planted on slightly raised bed 7 m length and 1.2 m wide separated by furrows, 25 cm deep and 30 cm wide at the top where the irrigation water was applied.

Surface irrigation was used with a calibrated cutthroat flume to measure water amounts for all plots. A standard rectangular cut-throat flume was installed at the inlet of the irrigation plots under free flow conditions. The depth of the water (Ha) was monitored and the discharge (Q) was determined using the equation Q = CHa 1.56 where C is a fixed coefficient of the flume. FT (flat treatment) followed the normal practice where the farmer fills the basins frequently without taking into account the crop's requirements. However, amounts and timing were recorded.

Cultivar Sids 12 was sown at the rate of 100 and 150 kg ha^{-1} for raised bed and flat treatments, respectively from 15th to 28th November in both seasons. The area of each plot was 84 m^2.

Fertilizers used were based on the recommendations of the regional extension service, 180 kg N, 36 kg P_2O_5 and 58 kg K_2O ha^{-1}. Nitrogen fertilizer as ammonium nitrate (33.5 % N), Phosphorus as superphosphate (15% P_2O_5) and Potassium as potassium sulphate (48% K_2O) were applied. Both phosphorus and potassium were added during soil preparation. Nitrogen was applied two times during the lifecycle of wheat 1st time 2/3 amount before the first irrigation and before the second irrigation. All cultural practices were carried out according to the recommendation of the wheat research department.

Plants of each plot were harvested, weighed to determine grain, straw and biological yields as well as harvest index.

Plant samples of grain and straw were digested to determine N, P and K. Nitrogen was determined using micro Kjeldahl ,while phosphorous was determined colourimetrically using ammonium molybdate and ammonium metavanadate according to the procedure outlined by **Ryan *et al.*,(1996).** Potassium was determined using the flame spectrophotometry method **(Black, 1982).** N, P and K uptake of grain, straw and biological yield were calculated. In each plot, the amounts of water applied were measured.

Table (1) Some physical and chemical properties of the studied soils at two seasons.

Parameters		Zagazig		Qnayat		Menya Al Qamh		Mashtool		Abu Hammad		Belpis		Diarb Negm		Hehya		Abu Kabir		Faqous	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
pH*		8.10	7.89	8.17	8.24	8.25	8.11	8.33	8.06	8.14	7.85	8.09	7.99	7.78	7.65	8.00	7.77	8.40	8.21	8.38	8.19
EC**dSm		1.22	1.45	1.65	1.72	2.87	2.66	2.96	3.11	3.43	3.21	4.14	3.85	2.16	2.25	5.17	5.33	2.44	2.76	3.38	3.56
OM		1.55	1.65	1.48	1.39	1.35	1.48	1.58	1.66	1.42	1.64	1.55	1.62	1.68	1.72	1.41	1.65	1.67	1.78	1.51	1.66
$CaCO_3$		3.24	3.11	2.88	3.12	2.98	3.14	2.49	2.88	3.78	3.64	3.24	3.55	3.14	3.46	3.12	3.75	3.14	3.55	2.89	3.14
Sand	%	15.35	16.44	18.33	17.25	14.72	15.78	18.76	17.23	27.53	29.14	25.31	26.44	16.24	17.56	17.66	18.25	18.24	19.12	16.33	17.45
Silt		35.35	38.26	36.28	36.44	34.88	37.28	37.77	35.46	36.64	37.16	34.72	36.28	33.18	35.18	38.33	36.25	36.19	37.18	36.77	38.25
Clay		49.30	45.30	45.39	46.31	50.40	46.94	43.47	47.31	35.83	33.70	39.97	37.28	50.58	47.26	44.01	45.50	45.57	43.70	46.90	44.30
Soil texture		Clay		Clay		Clay		Clay		Silty clay		Silty clay		Clay		Clay		Clay		Clay	
Cations and anions																					
Ca		5.99	6.20	8.09	8.45	15.19	13.98	13.39	13.85	15.99	15.44	18.58	16.17	7.19	7.33	25.19	25.33	9.39	10.12	14.89	15.12
Mg		3.59	4.98	6.59	6.72	6.39	6.11	5.59	7.94	11.59	10.25	11.39	12.08	6.99	7.02	15.98	13.02	8.39	8.66	9.99	13.14
Na		2.40	2.95	1.60	1.85	6.76	6.23	9.63	8.80	6.53	6.22	10.94	9.77	6.67	7.74	9.89	14.60	6.14	8.64	8.49	7.03
K		0.16	0.14	0.16	0.13	0.32	0.28	0.40	0.45	0.16	0.15	0.46	0.37	0.46	0.24	0.16	0.18	0.16	0.14	0.16	0.21
CO_3		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HCO_3		5.59	6.12	5.29	5.79	7.99	7.44	5.24	6.59	6.64	7.40	7.59	6.88	2.24	4.54	5.99	5.25	4.79	5.12	6.16	6.31
Cl		3.99	4.90	3.00	3.47	10.99	9.75	10.19	10.25	10.59	10.44	16.39	15.96	7.89	6.15	22.57	23.14	8.79	7.84	18.38	19.44
SO_4		2.56	3.25	8.15	7.89	9.68	9.41	13.58	14.20	14.65	14.22	17.39	15.55	11.18	11.64	22.66	24.74	10.50	14.60	8.99	9.75
Available macronutrients																					
N		38.24	29.24	36.45	31.55	35.62	30.24	20.64	28.48	15.42	20.33	35.22	28.66	36.82	35.25	38.12	35.44	39.18	33.66	42.12	40.25
P	(ppm)	7.41	7.51	6.63	8.90	15.83	13.25	13.91	12.50	7.93	8.12	8.97	10.00	9.75	11.25	11.07	13.25	5.72	7.25	13.26	12.50
K		375	324	366	345	685	557	285	265	350	311	300	290	380	399	175	225	245	240	320	299

*soil: water susp., 1:2.5 ** soil paste

RESULTS AND DISCUSSION

Bread wheat yield

Data presented in Table 2 reveal that the wheat sowing on raised bed was superior to farmer practices (traditional sowing) in all locations under study in both seasons. The average mean values were 8.89, 9.68 and 18.57 t ha^{-1} for grain, straw and biological yield grown on raised bed, respectively compared to 7.21, 7.77 and 14.98 t ha^{-1} for the same yields sown with traditional sowing, respectively in the first season. Whereas, the average mean values were 9.50, 10.21 and 19.71 t ha^{-1} for grain, straw and biological yield grown on raised bed, respectively compared to 7.06, 7.68 and 14.73 t ha^{-1} for such yields grown with traditional sowing, respectively in the second one. The relative increase of wheat productivity resulted from raised bed were 23.21, 24.70 and 23.98 % for grain, straw and biological yield, in the 1st season respectively, also 34.63, 32.99 and 33.78 % to grain, straw and biological yield, respectively in the 2nd one. Results in Table 2 show that the grain yield was increased by using raised bed planting method compared to traditional sowing treatment (farmer practices) with difference between them as follows 3.14, 1.10, 0.79, 1.47, 0.28, 2.53, 2.50, 1.76, 1.75 and 1.42 t ha^{-1} for same ranked order of different locations in Table 2, respectively in the 1st season, also 3.93, 2.30, 3.21, 2.32, 2.14, 1.32, 1.77, 2.21, 2.09 and 3.22 t ha^{-1}, respectively in the 2nd one. The increase of wheat productivity on raised beds was possibly due to exposure of more surface area to incident solar radiation in raised bed than in flat conventional treatments. The higher temperature on raised bed planting method can help in early germination and seedling emergence, particularly in winter season crops such as wheat. These findings are in agreement with those obtained by **Hossain, et al., (2006)** who found that raised bed produced higher number of plants and spikes per square meter and maximum grain and straw yield than conventional methods. Also, **Alam, (2012)** concluded that grain yield was higher in raised bed planting system than conventional method due to increase in yield components.

Table (2) Effect of planting method on wheat productivity grown in different locations in both seasons

Parameters / Locations	Yield productivity (t / ha)						Relative increase (%)		
	Raised beds			Farmer practices					
	Grain	Straw	Biol.	Grain	Straw	Biol.	Grain	Straw	Biol.
First season									
Zagazig	10.77	11.95	22.72	7.63	8.21	15.84	41.15	45.55	43.43
Qnayat	8.60	9.15	17.75	7.50	7.78	15.28	14.67	17.61	16.16
Menya Al Qamh	8.64	9.68	18.32	7.85	8.12	15.97	10.06	19.21	14.72
Mashtool	7.90	8.73	16.63	6.43	7.11	13.54	22.86	22.78	22.82
Abu Hammad	8.57	9.10	17.67	8.29	8.85	17.14	3.38	2.82	3.09
Belpis	10.03	10.91	20.94	7.50	8.32	15.82	33.73	31.13	32.36
Diarb Negm	6.78	7.12	13.90	4.28	4.59	8.87	58.41	55.12	56.71
Hehya	10.02	10.75	20.77	8.26	8.53	16.79	21.31	26.03	23.70
Abu Kabir	8.96	9.88	18.84	7.21	8.00	15.21	24.27	23.50	23.87
Faqous	8.59	9.56	18.15	7.17	7.64	14.81	19.80	25.13	22.55
Mean	8.89	9.68	18.57	7.21	7.77	14.98	23.21	24.70	23.98
Second season									
Zagazig	9.64	10.95	20.59	5.71	6.21	11.92	68.75	76.33	72.70
Qnayat	11.23	12.15	23.38	8.93	9.23	18.16	25.88	31.64	28.81
Menya Al Qamh	9.28	9.97	19.25	6.07	6.81	12.88	52.94	46.40	49.48
Mashtool	8.75	9.33	18.08	6.43	7.11	13.54	36.11	31.27	33.57
Abu Hammad	8.57	9.10	17.67	6.43	7.05	13.48	33.33	29.08	31.11
Belpis	10.33	10.91	21.24	9.10	9.74	18.84	13.45	12.01	12.71
Diarb Negm	8.78	9.12	17.90	7.01	7.59	14.60	25.32	20.16	22.64
Hehya	9.71	10.45	20.16	7.50	8.42	15.92	29.52	24.11	26.66
Abu Kabir	8.71	9.43	18.14	6.62	7.25	13.87	31.68	30.07	30.84
Faqous	10.00	10.66	20.66	6.78	7.34	14.12	47.37	45.23	46.26
Mean	9.50	10.21	19.71	7.06	7.68	14.73	34.63	32.99	33.78

Straw yield also increased by using raised bed method compared to farmer practices with a difference between them were 3.24, 1.37, 1.56, 1.62, 0.25, 2.59, 2.53, 2.22, 1.88 and 1.92 t ha^{-1} for the same order of different locations in Table 2, respectively in the 1st season as well as 4.74, 2.92, 3.16, 2.22, 2.05, 1.17, 1.53, 2.03, 2.18 and 3.32 t ha^{-1} in the 2nd one, respectively. Higher yield in raised bed-planted wheat was possibly due to wider spacing, which provided better light conditions in the canopy for photosynthesis than with wheat on flat layout. **Connor *et al.* (2003)** reported that raised bed sowing showed significantly higher grain yield as compared to flat method. **Talukder (2004)** and **Ram *et al.* (2012)** also reported that raised bed method showed significantly higher grain yield than the conventional one.

N uptake of wheat

Data in Table (3) illustrate that the raised bed treatment gave the highest values of nitrogen uptake for grain, straw and biological wheat yield compared to farmer practices in both seasons. The average mean values of all locations were 207.54, 53.87 and 261.41 kg N ha^{-1} for grain, straw and biological wheat grown on raised bed, respectively compared with 149.47, 35.39 and 184.86 kg

N ha^{-1} for such parts of wheat grown on flat treatment, respectively in the first season. In the second season, the average mean values of raised bed were 219.21, 57.48 and 276.69 kg N ha^{-1} for grain, straw and biological compared to 147.01, 35.97 and 182.98 kg N ha^{-1} for the same parts of wheat grown on flat treatment, respectively. The relative increase of N uptake for wheat grown on raised bed were 38.85, 52.22 and 41.41 % in the 1st season, 49.28, 50.99 and 41.19 % in the 2nd one for grain, straw and biological yield, respectively.

Table (3) Effect of planting method on N uptake of wheat grown in different locations in both seasons

Parameters / Locations	N Uptake (kg/ha)						Relative increase (%)		
	Raised beds			Farmer practices					
	Grain	Straw	Biol.	Grain	Straw	Biol.	Grain	Straw	Biol.
First season									
Zagazig	258.48	69.31	327.79	167.79	41.05	208.84	54.05	68.84	56.96
Qnayat	206.35	45.75	252.10	149.94	35.01	184.95	37.62	30.68	36.31
Menya Al_Qamh	194.47	57.11	251.58	164.93	40.60	205.53	17.91	40.67	22.41
Mashtool	167.47	48.02	215.49	120.81	27.73	148.54	38.62	73.16	45.07
Abu Hammad	218.48	45.50	263.98	174.11	34.50	208.61	25.48	31.88	26.54
Belpis	245.64	60.01	305.65	146.94	43.26	190.20	67.17	38.69	60.69
Diarb Negm	135.66	39.16	174.82	96.39	20.66	117.05	40.74	89.59	49.36
Hehya	240.38	59.13	299.51	161.09	44.36	205.45	49.22	33.28	45.78
Abu Kabir	205.97	59.28	265.25	158.51	40.00	198.51	29.94	48.20	33.62
Faqous	202.47	55.45	257.92	154.16	26.74	180.90	31.34	107.36	42.57
Mean	207.54	53.87	261.41	149.47	35.39	184.86	38.85	52.22	41.41
Second season									
Zagazig	230.66	64.34	295.00	126.33	31.46	157.79	84.09	104.54	88.14
Qnayat	270.42	66.61	337.03	174.25	48.67	222.92	54.93	39.23	51.54
Menya Al_Qamh	223.72	50.45	274.17	121.37	31.34	152.71	83.53	62.67	79.32
Mashtool	223.81	47.44	271.25	135.65	28.82	164.47	65.28	64.08	65.07
Abu Hammad	210.81	50.26	261.07	126.49	37.71	164.20	66.67	36.52	59.87
Belpis	232.49	64.53	297.02	191.25	49.16	240.41	21.55	32.17	23.71
Diarb Negm	176.36	50.75	227.11	158.18	34.37	192.55	11.39	46.86	17.71
Hehya	223.42	63.22	286.64	165.48	42.76	208.24	35.41	48.93	38.16
Abu Kabir	205.15	55.46	260.61	142.35	25.55	167.90	43.93	115.54	54.77
Faqous	195.22	61.74	256.96	128.76	29.82	158.58	52.86	112.26	63.75
Mean	219.21	57.48	276.69	147.01	35.97	182.98	49.28	50.98	41.19

Also, data show that the nitrogen uptake of wheat grown on raised bed gave the values more than using traditional method by 58.07, 18.48 and 94.55 kg N ha^{-1} in the first season and 72.20, 21.51 and 93.71 kg N ha^{-1} in the second season for grain, straw and biological yield, respectively. These results coincide with those of **Hossain, et al., (2004)** who found that using raised beds compared to conventional method, nitrogen uptake and efficiency can be increased. They added that the maximum N uptake by the grain and straw was recorded in raised bed technology.

P uptake of wheat

Data in Table (4) demonstrate that phosphorus uptake of different wheat parts was affected by sowing on raised beds compared to traditional method (flat)

in both seasons. The average mean values of all locations were 34.15, 21.27 and 55.42 kg P ha^{-1} for grain, straw and biological wheat yield grown on raised bed, respectively compared to 27.49, 17.03 and 44.52 kg P ha^{-1} for those grown on traditional method treatment, respectively in the first season. Whereas, 36.27, 23.72 and 59.99 kg P ha^{-1} compared to 26.99, 17.00 and 43.98 kg P ha^{-1} for grain, straw and biological wheat grown on raised bed and traditional method treatment, respectively in the second season. On the other hand, the relative increase of phosphorus uptake for wheat grown on raised bed were 24.23, 24.90 and 24.48 % in the 1st season, 34.41, 39.53 and 36.39 % in the 2nd one for grain, straw and biological yield, respectively. Besides, results reveal that the P uptake of wheat grown on raised bed gave the values higher than that using farmer practices by 6.66, 4.24 and 10.90 kg P ha^{-1} in the first season as well as 9.28, 6.72 and 16.00 kg P ha^{-1} for grain, straw and biological yield, respectively in the second season. These results are in agreement with those obtained by **Talukder, et al., (2004)** who stated that the change from sowing wheat on the flat to raised beds increased nutrient uptake and efficiency.

Table (4) Effect of planting method on P uptake of wheat grown in different locations in both seasons

Parameters / Locations	P Uptake (kg/ha)						Relative increase (%)		
	Raised beds			Farmer practices					
	Grain	Straw	Biol.	Grain	Straw	Biol.	Grain	Straw	Biol.
First season									
Zagazig	42.00	22.71	64.71	32.03	15.60	47.63	31.13	45.54	35.85
Qnayat	31.81	21.96	53.77	28.49	18.67	47.16	11.65	17.62	14.02
Menya Al Qamh	34.57	23.23	57.80	30.63	19.49	50.12	12.86	19.20	15.33
Mashtool	33.49	16.59	50.08	23.13	13.51	36.64	44.79	22.78	36.67
Abu Hammad	29.99	17.29	47.28	29.02	14.16	43.18	3.34	22.10	9.50
Belpis	37.10	24.00	61.10	25.49	18.30	43.79	45.55	31.16	39.53
Diarb Negm	25.78	17.09	42.87	17.14	11.02	28.16	50.41	55.06	52.23
Hehya	39.06	18.28	57.34	32.22	14.50	46.72	21.23	26.03	22.72
Abu Kabir	34.92	26.68	61.60	28.10	21.60	49.70	24.27	23.50	23.94
Faqous	32.74	24.86	57.60	28.68	19.86	48.54	14.16	25.16	18.66
Mean	34.15	21.27	55.42	27.49	17.03	44.52	24.23	24.90	24.48
Second season									
Zagazig	37.59	26.28	63.87	23.99	11.80	35.79	56.70	122.73	78.47
Qnayat	43.82	29.16	72.98	34.81	15.69	50.50	25.88	85.84	44.51
Menya Al Qamh	34.34	24.93	59.27	23.06	16.34	39.41	48.92	52.50	50.40
Mashtool	30.61	21.47	52.08	22.49	13.51	36.00	36.11	58.90	44.66
Abu Hammad	31.70	20.93	52.63	21.85	15.51	37.36	45.10	34.95	40.88
Belpis	41.31	24.82	66.13	35.50	23.38	58.88	16.36	6.18	12.32
Diarb Negm	33.37	19.33	52.70	28.03	18.22	46.25	19.05	6.10	13.95
Hehya	37.87	22.99	60.86	29.24	22.73	51.97	29.52	1.13	17.10
Abu Kabir	33.10	21.69	54.79	26.46	18.85	45.31	25.09	15.06	20.92
Faqous	38.98	25.58	64.57	24.42	13.95	38.36	59.65	83.45	68.30
Mean	36.27	23.72	59.99	26.99	17.00	43.98	34.41	39.53	36.39

K uptake of wheat

Results in Table (5) show that the potassium uptake of wheat grain, straw and biological yield was increased by using raised bed compared with farmer practices in both seasons. The average mean values were 39.28, 147.15 and 186.42 kg potassium ha^{-1} for grain, straw and biological wheat yield grown on raised bed, respectively compared with 24.70, 99.51 and 124.22 kg K ha^{-1} for those of wheat grown on flat treatment, respectively in the first season. While, values were 42.83, 189.74 and 232.57 kg K ha^{-1} compared to 31.37, 134.96 and 166.33 kg K ha^{-1} for grain, straw and biological wheat grown on raised bed and flat method treatment, respectively in the second one. Generally, the relative increase of K uptake for wheat grown on raised bed were 59.00, 47.87 and 50.08 % in the 1st season, 36.53, 40.59 and 39.82 % for grain, straw and biological yield, in the 2nd one, respectively. These findings are in agreement with those obtained by **Talukder, et al., (2004)**.

Table (5) Effect of planting method on K uptake of wheat grown in different locations in both seasons

Parameters / Locations	K Uptake (kg/ha)						Relative increase (%)		
	Raised beds			Farmer practices					
	Grain	Straw	Biol.	Grain	Straw	Biol.	Grain	Straw	Biol.
First season									
Zagazig	47.39	188.81	236.20	24.41	100.16	124.57	94.16	88.50	89.61
Qnayat	36.97	139.08	176.05	23.24	98.03	121.27	59.08	41.88	45.17
Menya Al_Qamh	38.89	144.23	183.12	26.70	103.12	129.83	45.65	39.86	41.05
Mashtool	35.21	134.44	169.65	22.49	91.72	114.21	56.56	46.58	48.54
Abu Hammad	40.27	141.96	182.23	30.68	115.94	146.61	31.27	22.45	24.29
Belpis	44.11	156.01	200.13	26.99	106.50	133.49	63.45	46.50	49.92
Diarb Negm	31.20	104.66	135.87	16.28	60.59	76.87	91.67	72.75	76.75
Hehya	44.07	167.70	211.77	28.09	114.30	142.39	56.90	46.72	48.73
Abu Kabir	37.61	151.16	188.78	23.06	102.40	125.46	63.13	47.62	50.47
Faqous	37.05	143.40	180.45	25.10	102.38	127.47	47.63	40.07	41.56
Mean	39.28	147.15	186.42	24.70	99.51	124.22	59.00	47.87	50.08
Second season									
Zagazig	42.06	208.05	250.11	23.05	112.40	135.45	82.47	85.10	84.65
Qnayat	51.07	230.85	281.92	37.65	160.60	198.25	35.64	43.74	42.20
Menya Al_Qamh	38.81	190.43	229.24	26.48	117.13	143.61	46.56	62.58	59.63
Mashtool	41.35	176.39	217.74	27.81	119.45	147.26	48.69	47.67	47.86
Abu Hammad	41.44	169.26	210.70	29.21	121.97	151.18	41.87	38.77	39.37
Belpis	46.95	198.56	245.51	41.05	180.19	221.24	14.37	10.19	10.97
Diarb Negm	36.41	171.46	207.87	33.89	137.38	171.27	7.44	24.81	21.37
Hehya	43.79	193.33	237.12	34.62	147.35	181.97	26.49	31.20	30.31
Abu Kabir	39.91	165.03	204.94	30.07	124.70	154.77	32.72	32.34	32.42
Faqous	46.53	194.01	240.54	29.84	128.45	158.29	55.93	51.04	51.96
Mean	42.83	189.74	232.57	31.37	134.96	166.33	36.53	40.59	39.82

Applied water m^3 ha^{-1}

Results in Table (6) demonstrate that the raised bed treatment gave better saving in irrigation water more than the farmer practices treatment in both seasons. The applied irrigation water varied from 4705 to 3991 with mean average 4249 m^3 ha^{-1} for wheat sowing on the raised bed compared with 5876 to 5000 with mean average 5605 m^3 ha^{-1} for sowing on flat treatment in the first season. The applied water for wheat sowing on raised bed was lower than flat treatment by 1356 m^3 ha^{-1} with savings in irrigation water by 24.1 % in the first season. This might be due to the reduction of surface evaporation in the raised bed compared to the flat technique. **Abd El-Halim and Abd El-Razek, (2014)** demonstrated that applying water through the raised bed treatment saved about 42% (mean over two seasons) of the water applied, comparable with the conventional flat treatment. Furthermore, **Aggarwal and Goswami, (2003) and Ram *et al.*, (2005)** have also reported similar or higher yields of wheat on raised beds compared with flat with 30–50% reduction in irrigation water use on beds.

Table (6) Effect of planting method on applied water (m^3 ha^{-1}) of wheat grown in different locations in both seasons

Parameters / Location	Applied water (m3/ha.)		Rate of savings in irrigation water	
	Raised beds	Farmer practices	m^3 ha^{-1}.	%
First season				
Zagazig	4705	5626	921	16.4
Qnayat	4032	5674	1642	28.9
Menya Al_Qamh	4315	5876	1561	26.6
Mashtool	4241	5112	871	17.0
Abu Hammad	4084	5781	1697	29.4
Belpis	3991	5000	1009	20.2
Diarb Negm	4348	5712	1364	23.9
Hehya	4058	5681	1623	28.6
Abu Kabir	4206	5781	1576	27.3
Faqous	4513	5807	1295	22.3
Mean	4249	5605	1356	24.1
Second season				
Zagazig	3977	4869	892	18.4
Qnayat	3920	5062	1142	22.6
Menya Al_Qamh	3937	5310	1373	25.9
Mashtool	4046	5341	1295	24.3
Abu Hammad	4006	5038	1033	20.5
Belpis	3722	4805	1083	22.6
Diarb Negm	4017	5376	1359	25.3
Hehya	3832	4967	1135	22.9
Abu Kabir	3801	5372	1571	29.3
Faqous	3784	5019	1235	24.6
Mean	3904	5116	1212	23.7

Concerning the second season, the applied irrigation water was diverse from 4046 to 3722 with mean average 3904 m^3 ha^{-1} for wheat sowing on the raised bed compared with 5376 to 4805 with mean average 5116 m^3 ha^{-1} for sowing on traditional treatment. On the other hand, the applied water for wheat sowing on raised bed was inferior to flat treatment by 1356 and 1212 m^3 ha^{-1} with savings in irrigation water by 24.1 and 23.7 % in the first and second season, respectively. The hypothesis of raised bed method is to reduce water losses and decreasing evaporation, deep percolation, surface run-off, and seepage. These advantages come from the fact that irrigation water advances faster in raised bed than in flat treatment and less water percolation loss happens. These findings are in agreement with those obtained by **Ram, *et al.* (2013)** who found that the wheat grown on raised beds had 18.8% lower applied water than flat method. Also, **Ram *et al.* (2012)** reported lower water use and high WUE in bed-planted soybean and wheat.

CONCLUSION

Finally, this study demonstrates that raised beds technology increased wheat yield by 28.92% when compared with conventional method (flat). Nitrogen, phosphorus and potassium uptake by the grain and straw was higher on raised bed when compared with flat. Raised beds also reduced the irrigation water requirement by 23.90%. Thus, in warmer areas such as Egypt where water resources are becoming limited and nutrient uptake and efficiencies are low, the use of raised beds system would be a distinct advantage.

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تاثير تقنية الزراعة على مصاطب على الانتاجية و امتصاص المغذيات الكبرى لقمح الخبز وتوفير مياه الري

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أقيمت تجربة حقلية لدى المزارعين لمعرفة تاثير طريقة الزراعة على مصاطب مقارنة بالطريقة العادية احواض مسطحة(طريقة المزارع)على كل من المحصول والمحتوى الغذائي وكذلك كمية المياه المضافة لهذه الدراسة في عشرة مواقع مختلفة في حقول المزارعين بمحافظة الشرقية مصر خلال الموسمين الزراعيين (٢٠١٢/٢٠١١)و(٢٠١٣/٢٠١٢).

ويمكن تلخيص النتائج كما يلى:

١- ان زراعة القمح المنزرع على مصاطب افضل في انتاجيته من الزراعة العادية (طريقة المزارع) في كل المواقع تحت الدراسة في كلا الموسمين . وكانت الزيادة النسبية لانتاجية القمح على مصاطب ٢٣,٢١و ٢٤,٧٠و ٢٣,٩٨% للحبوب والقش والمحصول البيولوجى على التوالي للموسم الأول. في حين كانت ٣٤,٦٣و ٣٢,٩٩و ٣٣,٧٨% للحبوب والقش والبيولوجى على التوالي للموسم الثانى.

٢- أعطت معاملة الزراعة على مصاطب افضل القيم للممتص من النيتروجين والفوسفور والبوتاسيوم في الحبوب والقش والمحصول البيولوجى مقارنة بمعاملة المزارع (الطريقة العادية) في كلا الموسمين. وكانت الزيادة النسبية للنيتروجين الممتص للقمح المنزرع على مصاطب ٣٨,٨٥و ٥٢,٢٢و ٤١,٤١% في الموسم الأول و ٤٩,٢٨و ٥٠,٩٩و ٤١,١٩% في الموسم الثاني للحبوب والقش والمحصول البيولوجى على التوالي. وكانت الزيادة النسبية للفوسفور الممتص في القمح النامى على مصاطب ٢٤,٢٣و ٢٤,٩٠و ٢٤,٤٨% في الموسم الأول في حين كانت ٣٤,٤١و ٣٩,٥٣و ٣٦.٣٩ % للحبوب والقش والبيولوجى على التوالي في الموسم الثانى. أيضا كانت الزيادة النسبية للبوتاسيوم الممتص في القمح النامى على مصاطب ٥٩,٠٠و ٤٧,٨٧و ٥٠,٠٨% للموسم الأول وكانت ٣٦,٥٣و ٤٠,٥٩و ٣٩,٨٢% في الموسم الثانى للحبوب والقش والمحصول البيولوجى على التوالي.

٣- أعطت معاملة الزراعة على مصاطب افضل القيم للحفاظ على مياه الرى مقارنة بالزراعة بالطريقة العادية (معاملة المزارع) في كلا الموسمين، فقد كانت كمية المياه المضافة للقمح النامي علي مصاطب اقل من الزراعة العادية ب ١٣٥٦و ١٢١٢ متر مكعب للهكتار مع وفر في استخدام المياه كنسبة مئوية بمقدار ٢٤,١٠و ٢٣,٧% في الموسمين الأول والثانى على التوالي. لذلك فانه عند ظروف نقص مياه الرى وقلة كفاءة الممتص من مغذيات النبات فان استخدام طريقة الزراعة على مصاطب تعتبر ضرورة ملحه.