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COMPARATIVE EFFECTS OF RAISED BED AND TRADITIONAL FLAT BASIN ON WHEAT YIELD AND WATER PRODUCTIVITY UNDER EGYPTIAN CONDITIONS

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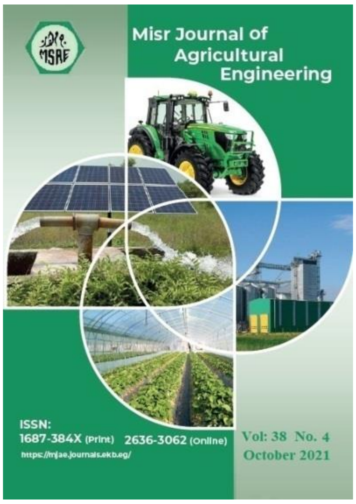

Keywords:
Wheat; Raised bed; Flat basin; Water saving

ABSTRACT

Field experiments were carried out at Sakha Agricultural Research Station in Egypt to compare the effect of the newly developed raised bed technique with different bed widths (RB130, RB100, RB80 cm) on wheat productivity to the conventional flat basin (FB) method during 2019/2020. The statistical analyses were carried out using a randomized complete block design. According to the results of statistical analysis, using RB130 cultivation gave the highest significant averages of water-saving (21.81%) and the highest averages of wheat 1000 kernels weight (50.05 g) over the FB method. However, no significant differences were found between RB130 and FB method, which produced the highest averages of grain yield, straw yield, and biological yield. Wheat sowing on FB gave the highest significant average of grain yield, straw yield, and biological yield than RB100, RB80 at 5% level of significance, but there were no significant differences in the number of kernels per spike, kernel weight spike, and harvest index ratio between wheat sowing on FB and RB130, RB100 or RB80. There were no significant differences in the number of kernels per spike, kernel weight spike, number of spikes per m2, straw yield, biological yield, and harvest index ratio at 5% level of significance between wheat sowing on RB130, RB100, RB80. But wheat sowing on RB130 produced the highest significant average of crop water productivity and grain yield than RB80 at 5%. Finally, according to the study findings, using raised beds cultivation resulted in saving irrigation water by 15~21% compared to a flat basin.

1. INTRODUCTION

Egypt has experienced severe water scarcity in recent years, despite the Nile River is the primary source of freshwater, and Egypt's agricultural sector is also regarded as one of the most water-intensive sectors (Khalifa et al., 2019). The agricultural sector consumes more than 84% of the available water resources (El-Beltagy, A.T., 2008).

Egypt's water scarcity has surpassed the 1,000 m^3/capita/year mark. Egypt's problem is figuring out how to produce enough food using less water (Swelam, 2017). According to (ICARDA, 2020) surface irrigation is currently used on the majority of Egypt's irrigated land, and it is the main irrigation system in ancient cultivated lands covering a total area of 6.5 million feddan (2.73million ha) despite its very low water efficiency in the field, this method of irrigation consumes 61% of the total water supply. Working to improve this system will save a significant amount of irrigation water, which could be used to expand horizontally.

Wheat is still the most important cereal crop in Egypt, as it is in many other parts of the world, but due to the growing population and limited crop area as well as water supplies, local production has fallen short of meeting demand. Increasing the production of both water and wheat is thus the top consideration of field irrigation and crop specialists. Planting techniques are one of the most important factors influencing wheat yield. Now, due to increasing knowledge and a desire to increase the productivity of crop water on farms, flat basin irrigation is slowly replaced by a bed furrow irrigation system popularly known as raised beds (Akbar, et al., 2016). The method was developed in the Yaqui Valley of Mexico, where it was adopted by more than 90% of farmers (Hassan, 2015). Raised bed systems have been identified as an important component of increased wheat production packages in Egypt's water management research to achieve higher productivity in irrigated agriculture. This technology was implemented in 22 governorates as part of the Egyptian government's national initiative to achieve self-sufficiency in wheat production and large-scale agricultural intensification, where Egyptian farmers successfully achieved higher yields while saving irrigation water (Swelam, 2017).

With the above facts, importance, and necessity in mind, a study was carried out to compare the effects of a raised bed and traditional flat basin on wheat crop yield and water productivity under Egypt's climatic conditions.

MATERIALS AND METHODS

Site Description

Field experiments were carried out at the Sakha Agricultural Research Station in Egypt's Kafr el-sheik Governorate during 2019/2020. The effect of the newly raised bed technique with different bed widths (80, 100, and 130 cm) on wheat productivity will be studied in comparison to the traditional basin method.

The site is located at 30° 57' E longitude and 31° 07' N latitude, with an elevation of approximately 6 meters above mean sea level. During the growing season, the wheat variety Maser 1 (*Triticum aestivum L*) was sown (It was obtained from the Sakha Research Institute) and all agricultural practices were carried out in the same manner as recommended in the farm study. Maize was the previous summer crop (*Zea maize L*). According to Klute (1987), the particle size distribution and some soil water constants are presented in Table (1).

Preparation of Land and Sowing of Crop

The land at the experimental site was prepared by deep Ploughing to penetrate any cultivation or salt-pan that has formed and to permit the even growth of the extensive root system of wheat plants. Then soil leveled using a laser leveling machine. Raised beds were prepared using the machine (It was obtained from the ICARDA project) that used to prepare the soil for raised bed planting as shown in Fig (1). The width of preformed beds was 80 cm with 7 defined planting rows, 50 cm with 5 defined planting rows, and 30 cm with 3 defined planting rows. The furrow spacing was 130, 100, and 80 cm. While for a traditional method the farmers' practice (flat basin) was adopted. The seed rate was kept as 119 kg per hectare.

Table (1): Some physical characteristics and some soil water constants of the studied site before cultivation

Soil Depth, cm.	Particle Size Distribution			Texture classes	FC %	PWP %	AW %	Bd g cm^{-3}
	Sand	Silt %	Clay%					
0 – 15	16.6	19.4	64.0	Clay	47.3	25.0	22.3	1.16
15 – 30	19.2	17.9	62.9	Clay	39.9	21.5	18.4	1.19
30 – 45	17.6	19.8	62.6	Clay	38.1	21.1	17.0	1.23
45 – 60	18.8	19.6	61.6	Clay	37.4	20.3	17.1	1.31
Mean	18.1	18.8	62.8	Clay	40.7	22.0	18.7	1.22

Where: FC % = Soil field capacity, PWP % = Permanent wilting point, AW % = Available water and Bd (g cm-^{3}) = Soil bulk density

Figure (1): A new machine is used to prepare the soil for raised bed planting obtained from ICARDA project to help farmers in improving wheat cultivation in Egypt.

Experimental Design

The experimental site consisted of four borders divided into four different treatment groups, with three replicates for each treatment. The detailed layout of the experimental field is shown in Fig (2). A randomized complete block design (RCBD) with three replications was used with three raised bed widths, i.e., 80, 100, and 130 cm, and the traditional flat basin (FB) method. And the statistical analysis was conducted using SAS 9.1 for Windows. The least significant differences (LSDs) were used to compare treatment means based on various variables to estimate the feasibility of bed planting to increase wheat production and save water.

Control Unit

The pump 6.5 hp with a gasoline engine and 900 L/min inflow rate at 3600 rpm under 26m water head and 75 mm inside diameter of the water outlet.

Measurements

- **Water applied**

Applied irrigation water has been managed and measured by a flow meter mounted on a small pump positioned at the irrigation entrance to the experimental plots. The applied irrigation water was measured for each plot of all treatments based on pre-and post-irrigation flow meter readings. The Tco was measured as a routine farmer's practice, avoiding submerging the ridge of the raised bed with irrigation water.

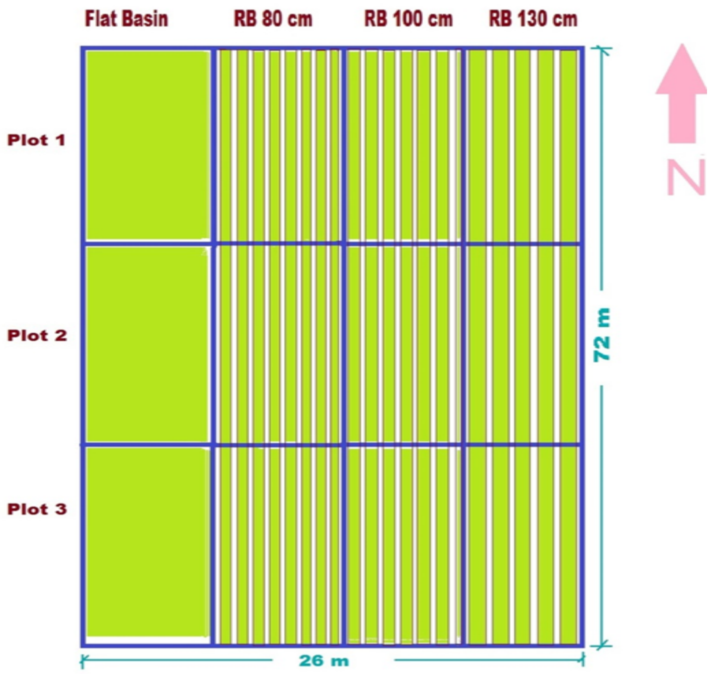

Figure (2): Layout of the experimental site

- **Water productivity (WP)**

Water productivity was calculated by dividing grain yield by overall applied irrigation water as well as described as follows (Ali, M.H., M.R. Hoque, A.A. Hassan, 2007) and (Ismail S.,1993):

$$WP = GY/ W_{app}$$

Where:

WP = Water productivity (Kg m^{-3}).

GY = grain yield (kg ha^{-1}).

W_{app}= irrigation applied water (m^3 ha^{-1}).

- **Growth and yield attributes**

At 90 and 120 days after planting, ten plants were randomly selected from each plot to assess the plant height (cm) by measuring the length of the main stem from the surface of the soil to the top of the plant. During harvesting (180 days from sowing), the number of spikes/m^2 was calculated by counting all spikes per square meter picked randomly from each plot. Fifteen plants have been randomly taken from each plot to test the next characters: -Number of kernels per spike and kernels weight per spike (g).

Plants of the one-meter square were harvested from each plot, air-dried, and weighed to measure straw, grain yield, 1000 kernels weight (g), biological yield, and the harvest index (Threshing was performed by hand, and grains were measured by a balance in kilograms and then converted into ton ha^{-1}).

RESULTS AND DISCUSSION

Irrigation Water Applied

The data in Table (2) show that there are significant (*P=0.05*) differences between treatments. For sowing on raised beds with widths of 130, 100, 80 cm, and flat basin irrigation system, the applied irrigation water was 0.446, 0.451, 0.484, and 0.570 m^3/m^2, respectively. The applied water for wheat sowing on raised beds with widths of 130,100, and 80 cm was lower than flat basin by 0.124, 0.119, and 0.086 m^3/m^2, which were further calculated to be 1240, 1190, and 860 m^3 ha^{-1}, respectively. Similarly, the volume of water applied to wheat crop under raised beds at widths of 130, 100 cm was lower than raised beds at a width of 80 cm by 0.038 and 0.033 m^3/m^2, which was further calculated to be 380 and 330 m^3 ha^{-1}, respectively.

On the other side, Fig (3) indicates that the rate of irrigation water savings (%) for wheat sowing on raised beds at widths of 130, 100, and 80 cm relative to a flat basin. Figure (4) shows the total volume of water applied in unit m^3 ha^{-1} to wheat crops under raised beds and a flat basin irrigation system, where the flat basin was the highest system that used water during the growing season.

These results are largely in line with those recorded by Swelem et al. (2018) that reported that using raised beds at the width of 120 or 100 cm with 180 kg N ha^{-1} gave the highest significant averages of wheat grain yield, also substantial water saving (15%) over the raised beds at the width of 75 cm with low N level treatments. Swelam (2017) reported that the use of raised-bed cultivation resulted in a 25 % reduction in irrigation water. Zaman et al., (2018) said that growing wheat in a raised bed saves 14.30% more water than a flatbed. Akbar et al., (2007) said that according to the data obtained from the farmers; about 36% (130 cm furrow center gap) of water was saved for wide beds and about 10% for narrow beds (65 cm furrow center gap) for wheat crops. And Akbar et al., (2010) reported that the lower water application within the PRB compared to basin treatments was found to be closely associated with bed width. The narrow beds used 3-7% less water than the basins, while the medium and wide beds used 16-17% and 18- 22% less, respectively.

Earlier studies (R. N. Ahmad and N. Mahmood, 2005; Akbar et al., 2016; Jat et al., 2011; Zaman et al., 2018) have also reported similar or higher saving in irrigation water wheat on raised beds compared flat with 15–23% reduction in irrigation water use. Such advantages stem from the fact that the use of furrows/beds accelerates the velocity at which irrigation water reaches the other end of the field and thus reduces the amount of irrigation water used, as furrows cover less than half of the field surface, resulting in fewer water losses. That indicates there were essential variables that helping save water, such as irrigation management and the design of the irrigation system used according to Kukal et al., (2010) that stated the effects of the beds are dependent on irrigation management, soil type, and bed age. And it is also likely to be affected by many factors such as soil surface levelness, depth to the water table, and field size and shape with irrigation flow rate.

Table (2): Volume of water applied to wheat crop under raised beds and flat basin

Treatments	1st Irrigation m^3/m^2	2nd Irrigation m^3/m^2	3rd Irrigation m^3/m^2	4th Irrigation m^3/m^2	Applied water /season (m^3/m^2)
Flat Basin	0.1584	0.1598	0.1361	0.1156	**0.570** ^{A}
RB 130 cm	0.1013	0.1386	0.1052	0.1005	**0.446** ^{D}
RB 100 cm	0.1083	0.1392	0.1024	0.1015	**0.451** ^{C}
RB 80 cm	0.1122	0.1500	0.1105	0.1114	**0.484** ^{B}

Mean with the same letters are not significantly different at P=0.05

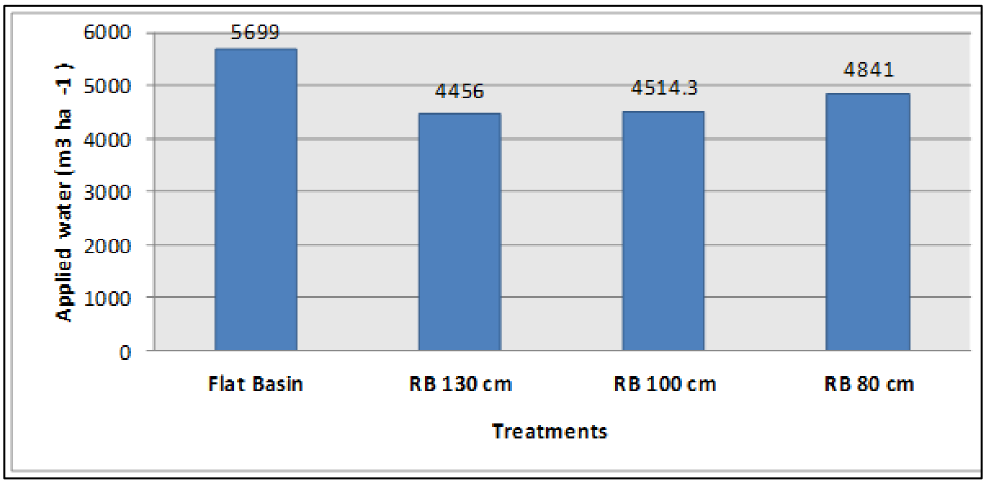

Figure (3): Total volume of water applied to wheat crop under raised bed and flat basin

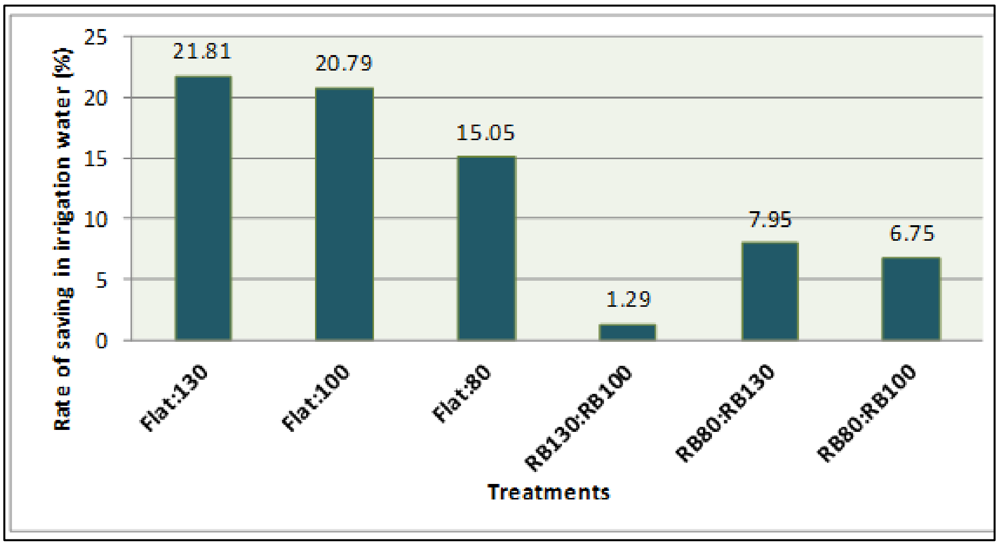

Figure (4): Rate of saving in irrigation water (%) under the raised bed and flat basin

Crop Water Productivity

The water-saving in raised beds system directly relates to the productivity of the water as shown in Table (3). Data in Table (3) reveal that the water productivity of the wheat crop was significantly higher for RB 130 cm than RB 80 cm at a 5% level of significance, while there weren't significant differences between RB130, RB100 cm, and FB for wheat. And also, there weren't significant differences between FB, RB100 cm, and RB80 cm at a 5% level of significance. The highest average water productivity was obtained by growing wheat on RB 130 cm with a value of 1.7863 kg/m^3, while the average water productivity for FB, RB 100, and RB80 cm were 1.508, 1.413, and 1.208 kg/m^3 respectively. Thus, wider beds are preferred to narrow beds, because it reduces un-cropped furrow area, increases land-use efficiency, and saves water irrigation, which has improved crop water productivity.

These results are in agreement with those of Zaman et al., (2018) who indicated that maximum water use productivity (1.67 kg·m^{-3}) was seen in the raised bed, although a minimum (1.21 kg·m^{-3}) observed in flatbed irrigation. Roth et al., (2005) showed that wheat cultivated on raised beds with furrow irrigation provided 1.96–1.99 kg of grain per m^3 of water, but only 1.34–1.41 kg of grain on flat planting in the underground well irrigation region and 0.8–1.0 kg of grain on flat cultivation in the Yellow River flood irrigation region, WUE based on the quantity of grain produced per m^3, improved by 40–90% on raised beds, mostly because more water was used by flat while planting with flood irrigation.

Swelam (2017) also indicated that applied water saved approximately 1.30 m^3/ha, and farmers' incomes increased by more than 10%. Water productivity potential has improved from 1.0 kg/m^3 to 1.5 kg/m^3. Through encouraging and implementing this proven technology, water savings in Egypt for wheat cultivation alone could hit more than 1.5 billion m^3/year. With the large-scale implementation of such action by growers, at least 6 billion m^3 of applied water could be preserved in the county's water supply for winter and summer crop rotation.

The results show that, while the FB method achieved the highest grain yield with an average yield of (8.5907 ton/ha), it did not give the highest productivity per unit of water, where the average productivity per unit of water was 1.508 kg/m^3 because FB planting used a lot of irrigation water during the season. The RB 130 cm method, on the other hand, did not achieve the highest grain yield, which amounted to (7.9583 ton/ha), coming in second to the FB method, but it gave the highest productivity per unit of water, which was 1.7863 kg/m3, due to the reduced amount of water applied by 21.81%.

Table (3): Crop water productivity (kg/m^3) of wheat crop under raised beds and flat basin

Treatments	Productivity of irrigation water kg/m^3			Mean kg/m^3	L.S.D 0.05
	Plot 1	Plot 2	Plot 3		
Flat-Basin	**1.438**	**1.302**	**1.783**	**1.508 ^{ab}**	**0.4073**
RB 130	**1.627**	**1.785**	**1.947**	**1.786 ^{a}**	
RB 100	**1.326**	**1.584**	**1.330**	**1.413 ^{ab}**	
RB 80	**1.216**	**1.387**	**1.020**	**1.208 ^{b}**	

Mean with the same letters are not significantly different at *P=0.05*

Growth and Some Yield Attributes

Plant Height

Data presented in Table (4) shows the effect of the planting method on plant height (cm) at 90 days and 120 days after sowing. These data reveal that a significant effect was found on plant height at 90 days after sowing due to the planting method, where there were significant differences between the FB and RB130, RB100 cm at a 5% level of significance.

Also, data in Table (4) indicated that a significant effect was found on plant height at 120 days after sowing because of the planting method, there have been significant differences between FB, RB130, RB100, RB80 cm. The plant's height was higher in the FB, RB80 cm, and shorter as the bed width increased (RB100 cm, RB130 cm), possibly due to the low lateral movement of the water within the wide beds.

Previous findings of sowing methods on plant height did not agree with Soomro et al., (2017), who stated that wheat plant height (cm) was higher under the raised bed irrigation system than the traditional irrigation system. And also with Asif et al., (2020) indicated that there was a significant difference in plant height between the treatments where the highest numbers obtained in bed sowing (104 cm), followed by ridge sowing (103 cm) and then flat sowing (98 cm) in the growing period 2015-16. Also, the previous results weren't in agreement with Ata-ul-karim et al., (2016) that said the results showed the plant height (cm) at maturity was maximum within the case of raised bed planting as compared to the remainder of the sowing methods.

Table (4): Effect of sowing method on plant height

Treatments	plant height at 90 day after sowing			Mean cm	L.S.D 0.05	plant height at 120 day after sowing			Mean cm	L.S.D 0.05
	Plot 1	Plot 2	Plot 3			Plot 1	Plot 2	Plot 3		
Flat-Basin	85.1	82.7	79.3	**82.367[a]**	2.1869	103	101.5	103.9	**102.80[a]**	2.5292
RB 130	84.5	80.2	75.6	**80.100[b]**		98.9	93	93	**94.967[c]**	
RB 100	86.1	78.4	71	**78.500[b]**		97.7	97.8	94.3	**96.600[bc]**	
RB 80	87.7	81.1	79.7	**82.833[a]**		101.9	100.8	89.8	**97.500[b]**	

Mean with the same letters are not significantly different at *P=0.05*

Number of kernels per spike

The data in Table (5) shows the number of kernels per spike as a function of the planting method, with no significant (*P=0.05*) differences between treatments.

Table (5): Effect of sowing method on number of kernels/ spike

Treatments	No. of kernels/spike			Mean	L.S.D 0.05
	Plot 1	Plot 2	Plot 3		
Flat-Basin	62.33	57.27	69.53	**63.333[a]**	3.9397
RB 130	55.13	65.53	65.53	**62.067[a]**	
RB 100	64.2	58.8	67	**63.333[a]**	
RB 80	73.53	58.6	59.4	**63.844[a]**	

Mean with the same letters are not significantly different at P=0.05

Kernels weight per spike (g)

Table (6) shows the kernel weight per spike (g) as affected by the sowing method, demonstrating that there weren't significant (*p=0.05*) differences between treatments.

Table (6): Kernels weight per spike (g) as affected by planting method

Treatments	Kernels weight spike (g)			Mean (g)	L.S.D 0.05
	Plot 1	Plot 2	Plot 3		
Flat-Basin	2.865	2.558	3.418	**2.9470 a**	**0.221**
RB 130	2.751	3.387	3.282	**3.1403 a**	
RB 100	3.174	2.850	3.430	**3.1511 a**	
RB 80	3.592	2.927	2.965	**3.1615 a**	

Mean with the same letters are not significantly different at P=0.05

Number of spikes per m^2

The number of spikes per m^2 of wheat is a key yield parameter that is greatly influenced by planting techniques. At the 5% level of significance, the results in Table (7) show significant differences between FB and raised beds. While there wasn't statistically significant (*p=0.05*) differences between RB 130 cm, RB100 cm, and RB80 cm.

Table (7): Effect of sowing method on number of spike /m^2

Treatments	No. of spike /m2			Mean	L.S.D 0.05
	Plot 1	Plot 2	Plot 3		
Flat-Basin	460	370	520	**450 a**	**95.266**
RB 130	320	335	343	**332.67 b**	
RB 100	300	316	280	**298.67 b**	
RB 80	270	300	240	**270 b**	

Mean with the same letters are not significantly different at P=0.05

The 1000-grain weight

Table (8) shows that 1000 kernels weight (g) of the wheat crop was significantly higher for RB 130 cm than FB, RB80 cm, and RB100 cm, but was not a significant difference between RB100 cm and RB80 cm. Growing wheat on RB130 cm yielded the highest average 1000 kernels weight (g) of 50.05 (g), while FB, RB 100, and RB80 cm weighted 45.91, 48.98, and 48.97 (g), respectively. The increased weight of 1000 kernels (g) in raised beds-planted wheat may be related to the furrow spacing between raised beds, which allowed more light penetration in the canopy for photosynthesis than wheat planted on flatbeds.

Table (8): Effect of sowing method on 1000 kernels weight (g)

Treatments	1000 kernels weight (g)			Mean (g)	L.S.D 0.05
	Plot 1	Plot 2	Plot 3		
Flat-Basin	45.834	45.500	46.408	**45.91 c**	**0.7508**
RB 130	49.986	49.335	50.839	**50.05 a**	
RB 100	48.291	48.615	49.997	**48.98b**	
RB 80	48.930	48.822	49.159	**48.97 b**	

Mean with the same letters are not significantly different at P=0.05

Wheat yield and harvest index

Grain yield (ton/ha)

One of the most significant considerations deciding the adoption of a certain system of cultivation and not the other is the productivity of the cultivated area. At the 5% level of significance, the results in Table (9) show significant differences between FB and RB100, RB80 cm, and there weren't significant differences between FB and RB130 cm, nor between RB130 cm and RB100 cm. Growing wheat on FB resulted in the highest average grain yield (ton/ha) of 8.5907 (ton/ha), while the average grain yield for RB130, RB100, and RB80 cm was 7.9583, 6.3810, and 5.8443 (ton/ha), respectively. Although the RB130 cm method did not achieve the highest productivity, it maintained there weren't significant differences between it and the FB method, which gave the highest productivity, giving the RB130 cm system an adoption advantage over other raised beds. Such results are compatible in that the raised beds with a wide width provide the highest grain yield than the raised beds with a narrow width with the reports of Swelem et al., (2015), who found that sowing wheat on raised beds with widths of 100 or 120 cm gave the highest significant average of grain yield as well as harvest index compared to the narrowest raised beds width (75 cm) in the first year. In the second season, the same pattern was observed for grain, biological, and straw yields as well as harvest index.

While these results did not agree in terms of higher productivity of the wheat crop grown on a raised bed than wheat grown in a flat basin with the reports of Asif et al., (2020) that indicated the highest grain yield obtained in bed sowing (4.95 tons ha^{-1}) that is 16.36% higher than flat sowing method. Tewabe et al., (2020) said that optimal raised bed width wheat production had a 26% yield advantage at Koga and a 27% yield advantage at the Rib irrigation scheme when compared to farmer irrigation practice. Majeed et al., (2015) results showed that wheat planting on beds and nitrogen application at 120 kg ha^{-1} achieved 15.06% higher grain yield than flat planting at the same nitrogen rate. Ahmad et al., (2014) reported that the raised bed planting showed an increase of 11.2% in grain yield over the flat-sowing method. Akbar et al., (2010) reported that during the first experiment, the wide beds produced higher wheat yields (15%) than the flat basin treatment. However, average wheat yields on the medium and narrow beds were only slightly (5%) higher than in the basin during the second experiment.

Table (9): Wheat grain yield as affected by planting method

Treatments	Grain yield (ton/ha)			Mean	L.S.D 0.05
	Plot 1	Plot 2	Plot 3		
Flat-Basin	8.193	7.421	10.158	**8.5907 [a]**	2.1001
RB 130	7.247	7.954	8.674	**7.9583 [ab]**	
RB 100	5.987	7.150	6.006	**6.3810 [bc]**	
RB 80	5.885	6.712	4.936	**5.8443 [c]**	

Mean with the same letters are not significantly different at P=0.05

Straw Yield (ton/ha)

The straw yield was calculated by weighing the biological yield for a one-meter-square sample per plot and subtracting the grain weight for the same one-meter-square. At the 5%

level of significance, the results in Table (10) show a significant difference between treatments. The straw yield (ton/ha) for the FB was significantly higher than RB100 and RB80 cm, but there weren't significant differences between the FB and RB130 cm, and also weren't between RB130 cm and RB100, RB80 cm.

Table (10): Straw yield (ton/ha) as affected by planting method.

Treatments	Straw yield (ton/ha)			Mean	L.S.D 0.05
	Plot 1	Plot 2	Plot 3		
Flat-Basin	14.357	13.929	17.592	**15.293 [a]**	**3.7229**
RB 130	9.653	13.096	12.725	**11.825 [ab]**	
RB 100	9.262	8.450	13.844	**10.519 [b]**	
RB 80	9.815	9.538	8.364	**9.239 [b]**	

Mean with the same letters are not significantly different at P=0.05

Biological Yield (ton/ha)

The biological yield is the weight of a wheat sample taken after harvesting without the grains separated from the straw. At the 5% level of significance, the results in Table (11) show significant differences between FB and RB100, RB80 cm. At the 5% level of significance, there weren't significant differences between FB and RB130 cm, and also weren't between RB130 cm and RB100, RB80 cm.

Wheat straw and biological yields were not significantly affected by sowing on raised beds at widths of 130, 100, and 80 cm. These findings are consistent with those obtained by Swelem et al., (2018) that stated sowing methods in the first season had no significant effect on straw and biological yields of wheat. These reasons may be attributed to adequate soil water conditions for better root development, which increases water and nutrient acquisition on the RB120 or RB100 cm

Table (11): Biological yield (ton/ha) as affected by planting method

Treatments	Biological yield (ton/ha)			Mean	L.S.D 0.05
	Plot 1	Plot 2	Plot 3		
Flat-Basin	22.550	21.350	27.750	**23.883 [a]**	**4.8446**
RB 130	16.900	21.050	21.400	**19.783 [ab]**	
RB 100	15.250	15.600	19.850	**16.900 [b]**	
RB 80	15.700	16.250	13.300	**15.083 [b]**	

Mean with the same letters are not significantly different at P=0.05

Harvest index %

Harvest index percent calculated by dividing the amount of grain yield (ton/ha) by the amount of biological yield (ton/ha), and the results were expressed as a percentage. The results in Table (12) show that there weren't significant differences between treatments at the 5% level of significance.

These findings agree with those of (Saifuzzaman et al., n.d.), who stated that during these trials 2008-09, data from all locations, averaged from beds versus flat-plantings, revealed that no method was superior, at least in these trials. Despite conclusive evidence that there is no difference in yield between beds and flat plantings, the researchers involved maintained that beds should be better. In 2009–10, the comparisons were expanded to include more locations. Varieties were the same as in 2008–09, with the addition of BAW 1064 and BAW 1059. There was no consistent or significant advantage for either cultivation method (beds versus flat-plantings) or any variety used for a cultivation method in any region.

Table (12): Harvest index % as affected by planting method

Treatments	Harvest index %			Mean	L.S.D 0.05
	Plot 1	Plot 2	Plot 3		
Flat-Basin	36.333	34.759	36.605	**35.899** [a]	8.8143
RB 130	42.882	37.786	40.533	**40.400** [a]	
RB 100	39.259	45.833	30.257	**38.450** [a]	
RB 80	37.484	41.305	37.113	**38.634** [a]	

Mean with the same letters are not significantly different at P=0.05

CONCLUSION AND RECOMMENDATION

Conclusion

According to the study results, using raised beds cultivation resulted in a 15~21% reduction in irrigation water compared to a flat basin. Moreover, the rate of irrigation water savings (%) for wheat sowing on a raised bed at widths of 130 and 100 cm compared to a raised bed at a width of 80 cm was 7.95 and 6.75%, respectively, while the rate of irrigation water savings (%) for a raised bed at widths of 130 cm compared to a raised bed at a width of 100 cm was 1.29%. Growing wheat on RB 130 cm yielded the highest average water productivity of 1.7863 kg/m^3 but growing wheat on FB, RB 100, and RB80 cm gave 1.508, 1.413, and 1.208 kg/m^3, respectively. Thus, wide beds are preferred over narrow beds because wide beds reduce un-cropped furrow area, increase land-use efficiency, and save water irrigation, all of which improve crop water productivity.

The plant was taller in the FB, RB80 cm, and shorter as bed width increased (RB100 cm, RB130 cm), probably due to the low lateral moving water in the wide beds. The results show significant differences between the FB and raised beds at the 5% level of significance. The FB irrigation system had the most spikes per m^2, followed by the RB130 cm, RB100 cm, and RB80 cm irrigation systems. Raised beds of 130 cm width yielded the highest significant averages of wheat 1000 kernels weight (g) of 50.05 (g), while FB, RB 100, and RB80 cm gave 45.91, 48.98, and 48.97 (g), respectively. With no significant (P=0.05) differences in the number of kernels per spike and the kernel weight spike (g) between treatments.

The productivity of the cultivated area is one of the most important factors in deciding whether to use one system of cultivation over another. Wheat grown on FB yielded the highest average grain yield (ton/ha) of 8.5907 (ton/ha), while RB130, RB100, and RB80 cm yielded 7.9583, 6.3810, and 5.8443 (ton/ha), respectively. Besides that, there was no statistically significant difference in straw yield and biological yield (ton/ha) between FB and RB130 cm. Although the RB130 cm method did not achieve maximum productivity, it maintained that there weren't significant differences between it and the FB method, which did, giving the RB130 cm system an advantage over the other raised beds in terms of adoption. Finally, there weren't significant differences between treatments in harvest index per cent at the 5% level of significance.

Recommendation

The following recommendation has drawn for the study of the impact of the raised beds technique on wheat productivity, compared to the traditional basin method:

1. Using raised beds with a width of 130 resulted in the least amount of water applied (4456 m3 ha^{-1}), the highest average crop water productivity (1.7863 kg/m^3), and the highest significant averages of wheat 1000 kernels weight (50.05 g), as well as water savings (21.81%) over the FB and savings (7.95%), (1.29%) over raised beds with widths of 80 and 100 cm.

2. The FB method gave the highest significant averages of grain yield, straw yield, and biological yield (ton/ha), but the RB130 cm method maintained that there weren't significant differences between it and the FB method led gives the RB130 cm system an advantage in terms of adoption over other raised bed systems.

Given Egypt's water scarcity, we recommend planting winter wheat on raised beds 130 cm wide this is due to the essentially significant differences between it and traditional flat basin cultivation and the rest of raised beds cultivation methods.

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التأثير المقارن للري بالمصاطب وبالأحواض المستوية التقليدية علي إنتاجية القمح والمياه في ظل الظروف المصرية

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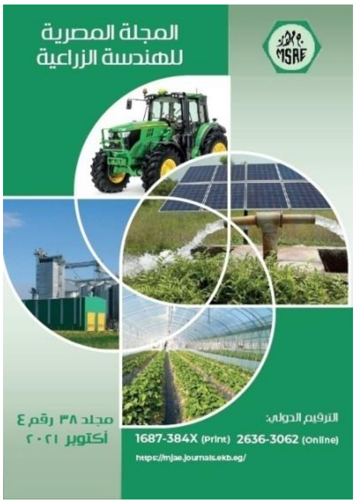

الملخص العربي

أجريت تجارب حقلية لدراسة تأثير طريقة الزراعة على المصاطب المطورة على إنتاجية القمح ومقارنتها بطريقة الزراعة التقليدية بنظام الاحواض المستوية خلال ٢٠٢٠/٢٠١٩. تم تنفيذ ثلاث معاملات لزراعة القمح على مصاطب (عرض ١٣٠, ١٠٠, ٨٠ سم) بالاضافة الى طريقة الاحواض المستوية, تم استخدام تصميم القطاعات الكاملة العشوائية. ووفقا لنتائج التحليل الإحصائي، أعطت زراعة القمح على مصاطب بعرض ١٣٠سم أعلى متوسطات معنوية لتوفير المياه (٢١,٨١٪) وأعلى متوسطات معنوية لوزن ١٠٠٠ حبة قمح (٥٠,٠٥جم) بالمقارنة بطريقة الاحواض المستوية. في حين لم تكن هناك فروق معنوية بين طريقة المصاطب ١٣٠سم وطريقة الاحواض المستوية اللتان حققتا اعلى انتاجية لمحصول الحبوب، محصول القش، والمحصول البيولوجي بالمقارنة بباقي المعاملات. أدت زراعة القمح بنظام الاحواض المستوية الى تحقيق اعلى متوسطات لمحصول الحبوب ومحصول القش والمحصول البيولوجي والذي ادى الى ظهور فروق معنوية بينها وبين طريقة المصاطب ١٠٠ و ٨٠ سم عند مستوى معنوية ٥٪ في حين لم تكن هناك فروق ذات دلالة إحصائية في عدد الحبوب لكل سنبلة، وزن حبوب السنبلة، ونسبة مؤشر الحصاد بين المعاملات الاربعة. أظهرت نتائج التحليل الاحصائي ايضا بأنه لا توجد فروق ذات دلالة إحصائية في عدد الحبوب لكل سنبلة، ووزن حبوب السنبلة، عدد السنابل لكل متر مربع، محصول القش، المحصول البيولوجي، ومؤشرات الحصاد عند مستوى معنوية ٥٪ بين طرق الزراعة على مصاطب, في حين ادت زراعة القمح بنظام المصاطب ١٣٠سم الى تحقيق أعلى متوسط معنوي لإنتاجية وحدة المياه ومحصول الحبوب بالمقارنة بطريقة المصاطب ٨٠ سم عند مستوى معنوية ٥٪. و أخيرًا وفقًا لنتائج الدراسة، أدى زراعة القمح على مصاطب إلى توفير مياه الري بنسبة ١٥ ~ ٢١٪ مقارنة بطريقة الاحواض المستوية التقليدية.

الكلمات المفتاحية:
القمح، الزراعة علي مصاطب، توفير المياه