Plant Archives Vol. 20, Supplement 2, 2020 pp. 1017-1022 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

FURROW IRRIGATED RAISED BED (FIRB) TECHNIQUE FOR IMPROVING WATER PRODUCTIVITY IN IRAQ

Hadeel A. Jabbar[1], Alaa S. Ati[1] and Abdulkareem H. Hassan[2]

[1]Department of Soil Science, College of Agricultural Engineering Sciences, University of Baghdad, Iraq

[2]Ministry of Agriculture, Iraq

Abstract

A field experiment was conducted during the agricultural season 2017-2018. In the research station of the Ministry of Agriculture Al-Rasheed side, and within the activities and researches of the national program to develop wheat cultivation in Iraq, Two factors were experienced in the cultivation of wheat, The first factor is the method of cultivation of five treatments were used: : Treatment of the cultivation of wheat in the plots (B), Treatment of wheat crops on bed with 50 cm width (S_1), 60cm (S_2), 70cm (S_3) and 80cm (S_4), The second factor is irrigation levels depletion of 40, 60 and 80% of available water coded as W1, W2 and W3, respectively, The experiment was designed under randomized complete block design (RCBD) with three replications, The three irrigation levels were distributed in main sectors while planting treatment were distributed randomly within these blocks. wheat seeds IPA99 class were planted on raised bed and plots on 30/11/2017.A direct and continuous evaluation of the soil moisture content was carried out using sensors to measure soil moisture and following up the soil moisture changes and to determine the date of irrigation and the amount of water added. Readings were taken from the rhizosphere soil using GS3 sensors. Wheat was harvested on 12/5/2018. Treatment of wheat crops on bed with 80 cm width gave the highest average field water use efficiency reached 6.84 kg m^{-3} while BW_3 treatment gave lowest average field water use efficiency reached 1.47 kg m^{-3}. The highest average crop water use efficiency were found in S_4W_1 و S_4W_2 reached 2.06 and 2.07 kg m^{-3}, respectively, It was lowest value for crop water use efficiency at BW_3 reached 1.06 kg m^{-3}. The percentage increase in the average efficiency of crop water using for bed treatments 40.37, 57.80, 73.39 and 85.32**%** for treatments S_1, S_2, S_3 and S_4 respectively Comparison with plot treatment B. The highest average total grains yield for Treatment of wheat crops on bed with 80 cm width was 7253 kg ha^{-1}.

***Keywords*:** Furrow Irrigated Raised Bed, FIRB, improving water productivity

Introduction

Furrow Irrigated Raised Bed (FIRB) is one of the most advanced agricultural technologies and one of the most important modern mechanized (technological) farming systems that will raise the efficiency of the use of productive resources in general and water in particular, through its significant role in reducing the amount of irrigation water With a high rate and increased productivity while reducing production costs. The method includes preparing the beds of agriculture with a special machine prepared for the work of beds after plowing the land with good cultivation and laser leveling and the use of improved seeds and recommended seed rates and that the planting be done on the surface of the bed and that the date of planting be appropriate with the application of fertilization operations properly and a good management of irrigation water with the need to be The soil is suitable for the preparation of beds (low or medium permeable soil) (ICARDA, 2016). The application of this technology in Iraq started from the principle of legalizing the use of available water resources, as irrigation water is an important national wealth and its abundance and methods of use are among the most important elements necessary for the development of the agricultural sector and its prosperity. As it is the most specific factor for agricultural production, and it is one of the main pillars for achieving agricultural development and food security for society, especially as it is limited in resources and quantities and is subject to decline and scarcity.

Material and Methods

Experiment location and soil characteristics before planting

A field experiment for planting wheat crop *Triticum aestivum* L. was carried out during the agricultural season 2017-2018 at the research station of the Ministry of Agriculture - Al-Rashid district, within the activities and researches of the national program to develop wheat planting in Iraq. In silty clay loam soil texture classified into a level under the Typic Torrifluvent according to the classification of (Soil Survey Staff 2014). Some soil characteristics (Table 1) were determined according to Black (1965). This study included following treatments:

1. Method of cultivation

- Treatment of wheat crop cultivation in Blocks (B)
- Treatment of the cultivation of wheat on Beds with 50 cm width (S_1).
- Treatment of the cultivation of wheat on Beds with 60 cm width (S2).
- Treatment of the cultivation of wheat on Beds with 70 cm width (S3).
- Treatment of the cultivation of wheat on Beds with 80 cm width (S4).

2. Irrigation levels (moisture depletion from ready water)

- Irrigation after depleting 40% of available water (W1).
- Irrigation after depleting 60% of available water (W2).
- Irrigation after depleting 80% of available water (W3).

The experimental treatments arranged in Randomize Complete Block Design with three replicates.

The experiment was carried out on a land area of 5.832 m^2, its dimensions are 162 m x 36 m. The land was plowed with a flush plow, perpendicular tillage, and laser modifications and adjustments were performed.

Table 1: Physic and chemical properties of the soil

Properties	Unit	Value	
		0.0-0.2m	0.2-0.4m
PH	----	7.13	7.10
EC(1:1)	dS m^{-1}	4.00	5.30
Available N	mg kg^{-1}	41.20	40.93
Available P		11.51	11.00
Available K		197	182
Sand	g kg^{-1}	123	123
Silt		487	487
Clay		390	390
Texture		Silty Clay loam	Silty Clay loam
Bulk density	mg m^{-3}	1.34	1.34
True density		2.64	2.64
Porosity	%	49.2	49.0
Water content at F.C.	cm^3cm^{-3}	0.40	0.40
Water content at P. W.P		0.179	0.179
Available water		0.203	0.203

Agricultural operations

The field is divided into four main sections, three for beds treatments and one for block treatment. The three sections are divided into 36 experimental units, the area of the experimental unit is approximately 100 m^2 (length 10 m and width 8.50 - 9.40 m) according to the width of the bed, and the sector of the panels sector is divided into nine experimental units. For one sheet 16 m^2 (length 4 m and width 4 m), breaks of 2 m were left between the repeaters and the main parameters.

Some modifications were made to the machine * that was used to implement the experiment, which is a German machine of origin belonging to the Department of Agricultural Machinery and Machinery / College of Agricultural Engineering Sciences-University of Baghdad. After modification, the machine consists of the structure of the composite machine, the primary tillage machine (the underlying plow), the rotary smoothing machine, the sowing machine, the fertilizer machine, the groove and the groove machine. The machine works to perform the primary tillage process using sub-plow and secondary tillage (smoothing) by using a rotary smoothing machine and determining the width of the bed by controlling the distance between the guns of the opening machine and the seeding and fertilization were carried out on the bed by means of the seed machine and the fertilization machine that was altered before starting the experiment , As the five operations (plowing, smoothing, opening bed, seeds and fertilizing) were performed simultaneously, i.e. during the passage of the machine in the field once, which leads to a reduction in fuel exchange and a reduction in time, effort, costs, and work, as well as reducing the negative impact of agricultural machinery and machines.

Planting, fertilizing and harvesting

Planting: wheat seeds IPA99 class were planted in the field on November 30, 2017 for both plots and beds with a distance of 0.20 m and 0.15 m between one line and another, respectively, and with a seed quantity of 140 kg ha^{-1}.

Fertilizing: The experimental soil was fertilized with triple super phosphate fertilizer when planting 200 kg ha^{-1} by a combined machine when planting. As for urea fertilizers and potassium sulfate, they were added in two batches: the first batch in the vegetative growth stage and the second in the flowering stage, at 200 kg ha^{-1} and 240 kg ha^{-1} on Arrangement for each batch. Minor elements were sprayed in two phases: the first was the vegetative growth stage, the second was the flowering stage, with a concentration of 60 ppm, for zinc, iron, and manganese, and 20 ppm in copper. The anti-bush operation was conducted by spraying a pesticide, as well as "manual cultivation whenever the need arises.

Harvesting: Wheat plants were harvested manually on 12/5/2018 which lasted five days for all pilot units (panels and bed).

The process of assessing the moisture content of the soil was carried out continuously throughout the experiment. When the moisture content of the soil indicates the depletion of 40, 60 and 80% of the ready water, irrigation is carried out by adding the depth of water needed to reach the moisture content at the field capacity of the field soil using the moisture tensile curve of the soil and reading the allergens, The aforementioned equation was used to calculate the depth of water to be added to compensate for the exhausted moisture

The irrigation time required to bring the soil moisture to the field capacity limits is calculated using the equation he described (Allen *et al*., 1998).

$$d = (\theta_{fc} - \theta W) \times D \qquad ...(1)$$

Where:

d = depth of added water (mm).

θ_{fc} = volumetric moisture at field capacity ($cm^3.cm^{-3}$)

θ_w = volumetric moisture before irrigation ($cm^3.cm^{-3}$)

D = soil depth, which is equal to the effective root depth (mm)

Field Water Use Efficiency

Field Water Use Efficiency was calculated according to the formula mentioned in (Allen *et al*., 1998).

$$WUE_f = \frac{\text{Yield}}{\text{Water applied}} \qquad ...(2)$$

As:

WUEf: field water use efficiency (kg m^{-3}).

Yield: total yield (kg ha^{-1}).

Water applied: Water applied depth of added water (m^3 ha^{-1}).

Grain quotient

It was estimated on the basis of the grain weight (kg) for each experimental unit, and then converted the weight into kg ha^{-1}.

Results and Discussion

Water added during growth stages

Tables 2 and 3 showed the depth of the added water for each stage of wheat growth (tillering, elongation, booting, 50% spike formation, 100% flowering, grain growth, filling and physiology maturity). As well as, the duration of each stage, the depth ratio of the added water and the number of irrigations, in addition to the average one irrigation depth for moisture depletion treatments (irrigation levels) for the conventional planting method and beds planting method. It was observed from Table 2 that the depth of the water added by the conventional method (planting plots) at the first irrigation level reached to (69.0, 50.6, 68.6, 34.0 and 68.8 mm), with the irrigations number (3, 3, 2, 1 and 2) at the stages of tillering, elongation, booting, 100% flowering, grain growth and filling, respectively. The depth values of the added water at the second irrigation level (depletion of 60% of the available water) reached 61.4, 71.4, 50.0, 50.0 and 50.8 mm with the irrigations number (2, 3, 1, 1 and 1) at stages of tillering, elongation, booting, 100% flowering, grain growth and filling, respectively. As for the third irrigation level (depletion of 80% of available water) 68.8, 62.6, 66.0 and 66.4 mm with the irrigations number (2, 2, 1 and 1) at stages of tillering, elongation, booting, 100% flowering, grain growth and filling, respectively. The results of Table 2 showed that the total depth of the added water and the depth of the added water in one irrigation might vary according to the levels of moisture depletion and the stages of plant growth. In addition to the occurrence of rainfall in some growth stages, which led to an irrigation stoppage at the two stages of 50% spike formation and physiology maturity, which preserved the moisture content in the soil, this caused the irrigation operation to stop on time at those two stages.

Table 2 : Depth of water added during the wheat growth stages for moisture depletion treatments at flood irrigation (conventional wheat planting)

Irrigation treatments	Plant growth stages	Tillering	Elongation	Booting	50% spike formation	100% flowering	Grain growth, filling	Physiology maturity
BW1	Duration of growth stage (days)	21	34	32	12	7	27	30
	Irrigations number	3	3	2	--	1	2	--
	Added water depth (mm)	69.0	50.6	68.0	--	34.0	68.8	--
	Depth of water added in one irrigation (mm)	23.0	16.87	34.0	--	34.0	34.4	--
	Percentage of added water (%)	23.76	17.42	23.42	--	11.71	23.69	--
BW2	Irrigations number	2	3	1	--	1	1	--
	Added water depth (mm)	61.4	71.4	50.0	--	50.0	50.8	--
	Depth of water added in one irrigation (mm)	30.5	23.8	50.0	--	50.0	50.8	--
	Percentage of added water (%)	21.51	25.18	17.63	--	17.63	17.91	--
BW3	Irrigations number	2	2	1	--	--	1	--
	Added water depth (mm)	68.8	62.6	66.0	--	--	66.4	--
	Depth of water added in one irrigation (mm)	34.0	31.3	66.0	--	--	66.4	--
	Percentage of added water (%)	26.08	23.73	25.02	--	--	25.17	--

It was also observed from the results that the depth of one irrigation has increased after the stages of tillering, elongation for all moisture depletion treatments, in order to increase the depth of the added water to 0.4 m. As the depth has been doubled from 0.2 m to 0.4 m in order to meet the plant's water requirements, in addition to the cause of increasing the depth of added water with the plant growth stages progress (booting, 100% flowering and grain growth and filling). The increasing water addition was because the plant needs water and food to build tissues, growth and increase its size, in addition, these stages require high food and water requirements to build plant tissues, especially grain formation, which led to an increase in the plant's consumption of water. Table 3 showed the depth of water used during the wheat growth stages for moisture depletion treatments (40, 60 and 80%) of the available water by planting beds of furrow irrigation. It can be observed that the depth of added water is (89.8, 51.4, 34.8, 34.4 and 68.0 mm) at stages of tillering, elongation, booting, 100% flowering, grain growth and filling, with the irrigations number reached (3, 3, 1, 1 and 2) for each growth stage, respectively, at the first irrigation level (depletion of 40% of the available water). As for the depth of added water to deplete 60% of the available water, it reached 81.2, 49.2, 50.0, 48.0 and 48.4 mm at stages of tillering, elongation, booting, 100% flowering, grain growth and filling, with the irrigations number reached (2, 2, 1, 1 and 1) for each growth stage, respectively. Moreover, at depletion 80% of the available water, the depth of added water reached 58.2, 63.2, 62.8 and 63.6 mm at tillering, elongation, booting, grain growth and filling, with the irrigations number reached (1, 2, 1 and 1) for each growth stage, respectively.

Table 2 : Depth of water added during the wheat growth stages for moisture depletion treatments at furrow irrigation (conventional wheat planting)

Irrigation treatments	Plant growth stages	Tillering	Elongation	Booting	50% spike formation	100% flowering	Grain growth, filling	Physiology maturity	Total added water depth (mm)
	Duration of growth stage (days)	21	34	32	12	7	27	30	
SW1	Irrigations number	3	3	1	--	1	2	--	290.4
	Added water depth (mm)	89.8*	51.4	34.8	--	34.4	68.0	--	
	Depth of water added in one irrigation (mm)	29.93	17.13	34.8	--	34.4	34.0	--	
	Percentage of added water(%)	32.26	18.46	12.50	--	12.36	24.43	--	
SW2	Irrigations number	2	2	1	--	1	1	--	283.6
	Added water depth (mm)	81.2*	49.2	50.0	--	48.0	48.4	--	
	Depth of water added in one irrigation (mm)	40.6	24.6	50.0	--	48.0	48.4	--	
	Percentage of added water(%)	29.34	17.77	18.06	--	17.34	17.49	--	
SW3	Irrigations number	1	2	1	--	--	1	--	263.8
	Added water depth (mm)	58.2*	63.2	62.8	--	--	63.6	--	
	Depth of water added in one irrigation (mm)	58.2	31.6	62.8	--	--	63.6	--	
	Percentage of added water(%)	23.49	25.50	25.34	--	--	25.67	--	

* The moisture in the irrigation of the first germination has been reached to the saturation limits to ensure the bed's moisture and to success the seed germination process

The results in Table 3 showed a decrease in the irrigations number when applying the beds technique by furrow irrigation for the three levels of irrigation and then decrease the depth of total added water compared to the conventional method (planting in plots) except the tillering stage, which its depth of added water was higher than the conventional method. These findings resulted due to the irrigation of the first germination of the beds method, which its depth of added water reached to the moisture content of the soil at the saturation, and not to the moisture content of the soil at the field capacity as in the plots planting, in order to give the largest amount of water used for the side drainage and horizontal movement of water, to ensure full moisture of the top surface of bed and at the entire width of the bed and then ensure the seedlings emergence. Table 3 also showed an increase in the depth of added water in one irrigation for the stages of booting, 100% flowering, grain growth and filling over the stages of tillering, elongation. This was due to increase in the depth of added water to 0.4 m and the increase in the water requirements of the plant. As its growth, stages progress because of increased root depth, spread, and increased its efficiency in absorbing water and nutrients and increasing the leaf area, which increased the amount of water lost from the plant by transpiration. Furthermore, the reason for the low number of irrigations for the beds planting method compared to the plots method was due to the increase in the wetness area, where the fully moisturizing of the experimental unit (plots) and without any reducing factor for the planted area. Then the evaporation rates from the soil surface increase, which is reflected for water used to provide the water needs of the plant.

Table 3 : Depth of water added during the wheat growth stages for moisture depletion treatments at furrow irrigation (conventional wheat planting).

Irrigation treatments	Plant growth stages	Tillering	Elongation	Booting	50% spike formation	100% flowering	Grain growth, filling	Physiology maturity	Total added water depth (mm)
	Duration of growth stage (days)	21	34	32	12	7	27	30	
SW1	Irrigations number	3	3	1	--	1	2	--	278.4
	Added water depth (mm)	89.8*	51.4	34.8	--	34.4	68.0	--	
	Depth of water added in one irrigation (mm)	29.93	17.13	34.8	--	34.4	34.0	--	
	Percentage of added water (%)	32.26	18.46	12.50	--	12.36	24.43	--	
SW2	Irrigations number	2	2	1	--	1	1	--	276.8
	Added water depth (mm)	81.2*	49.2	50.0	--	48.0	48.4	--	
	Depth of water added in one irrigation (mm)	40.6	24.6	50.0	--	48.0	48.4	--	
	Percentage of added water (%)	29.34	17.77	18.06	--	17.34	17.49	--	

SW3	Irrigations number	1	2	1	--	--	1	--	
	Added water depth (mm)	58.2*	63.2	62.8	--	--	63.6	--	
	Depth of water added in one irrigation (mm)	58.2	31.6	62.8	--	--	63.6	--	
	Percentage of added water (%)	23.49	25.50	25.34	--	--	25.67	--	

*The moisture in the irrigation of the first germination has been reached to the saturation limits to ensure the bed's moisture and to success the seed germination process

Total grain quotient

The results in Table 4 indicate a significant decrease in the total grain yield with increased water stress (increased levels of moisture depletion). The W1 irrigation treatment gave the highest average of 6300 kg ha^{-1}which did not differ significantly "from the W2 irrigation treatment in which the total grain yield reached 6228 kg ha^{-1}, while the irrigation treatment gave W3 the lowest average for this quality, reached 5558 kg ha^{-1}, with a decrease of 11.78 and 10.76% compared to the irrigation treatments W1 and W2, respectively.

The results showed that the application of cultivation to the beds resulted in a significant effect in increasing the outcome, and the highest average total score in S4 treatment was 7253 kg ha^{-1}, and the average total score was 4407, 5513, 6180, and 6790 kg ha^{-1} at coefficients B, S1, S2, and S3. Arrangement. The rate of increase in the average total quotient of the terraced coefficients was 25.09, 40.23, 54.07 and 64.58% for coefficients S1, S2, S3 and S4, respectively, in comparison to the comparison coefficient (B).

In the interference factors between the cultivation method and the irrigation levels in the average total cereal yield, the interference factors S4W1, S3W2 and S4W2 outperformed, without a significant difference between them in the average total yield 7600, 7310 and 7600 kg ha^{-1}, respectively, which differed significantly "from the interference factors BW1, S1W1, S2W1 and S3, BW2, S1W2, S2W2, BW3, S1W3, S2W3, S3W3 and S4W3, which have total mean values of 4980, 5710, 6200, 7010 4370, 5490, 6370, 3870, 5340, 5970, 6050, and 6560 kg ha^{-1}, respectively. Through the results of the current study, we can say that the rate of increase in the total grain yield ranged between 25% to 64%, according to the application rate used for the streaks of the lines (beds), and the reason for this is that the wheat cultivation on high beds worked to improve the environment Soil and its physical properties and increased soil aeration by providing good puncture conditions and hence the growth and spread of the root system in order to ensure an increase in its stability in the soil and the failure of the cultivated plants on the back of the beds to lie down, which led to good vegetative growth (Peris *et al*., 2004, Soomro *et al*., 2017).

Table 4 : The effect of the cultivation method and the irrigation level on the total cereal yield (kg ha^{-1}).

Cultivation method	Irrigation levels			Average
	W_1	W_2	W_3	
B	4980	4370	3870	4407
S1	5710	5490	5340	5513
S2	6200	6370	5970	6180
S3	7010	7310	6050	6790
S4	7600	7600	6560	7253
Average	6300	6228	5558	---
LSD	Planting method= 230 *			
	irrigation levels= 178 *			
	Overlap= 399 *			

Field Water Use Efficiency

Table 5 shows the effect of irrigation and moisture depletion factors on water productivity (field water efficiency) for wheat irrigation coefficients (Equation 2). The efficiency of field water use varied according to the different cultivation methods (panels and beds) and moisture depletion treatments. The highest field water use efficiency was in the S4W2 treatment as it reached 7.09 kg m^{-3}, while the lowest value for the field water use efficiency in the BW3 treatment was 1.47 kg m^{-3}. The results of the statistical analysis showed the presence of significant differences in the average efficiency of field water use for the treatments of the cultivation method used in the experiment and the rates of moisture depletion as well as the overlap between them. It is clear that the methods of cultivation methods significantly affected the "efficiency of field water use, as the treatment of planting beds (80 cm wide) gave the highest average field water use efficiency of 6.84 kg m^{-3} and the treatment of panels gave the lowest average field water use efficiency of 1.50 kg m^{-3}. The rate of increase in the average field water use efficiency for the treatments of beds cultivation was 157.33, 227.33, 297.33 and 356% at the S1W2, S2W2, S3W2 and S4W2 transactions, respectively, compared to the "block cultivation treatment". The reason for this increase is due to the application of the irrigated irrigation method, which led to the reduction of half the amount of irrigation water added in the irrigation of the furrow, as well as "the increase in the grain yield of wheat when applying the practice of irrigation, as will be mentioned later", which increased the efficiency of the use of field water, which It means that applying the practice of irrigation (agriculture on beds) is a successful irrigation management method, as it increases the efficiency of the irrigation water productivity by reducing the amount of added water and increasing the yield, which increases the efficiency of irrigation, as well as "the water needs for irrigation of the irrigation is less when compared to the irrigation of flood due to Partial wetness, reduced evaporation losses, and colds Deep and lack of surface runoff, these results agreed with the findings of Masoud

(2017), that the treatment of furrow irrigation was significantly superior to an increase of 80% compared to the treatment of conventional irrigation (flood irrigation) when planting the maize crop.

Table 5 : Effect of cultivation method and irrigation level on field water use efficiency (kg m^{-3}).

Cultivation method	Irrigation levels			Average
	W_1	W_2	W_3	
B	1.71 ± 0.01	1.54 ± 0.03	1.47 ± 0.04	1.57 ± 0.03
S1	3.85 ± 0.02	3.84 ± 0.04	4.04 ± 0.03	3.91 ± 0.04
S2	4.64 ± 0.03	4.96 ± 0.04	5.02 ± 0.01	4.87 ± 0.06
S3	5.77 ± 0.03	6.27 ± 0.03	5.59 ± 0.04	5.88 ± 0.10
S4	6.82 ± 0.02	7.09 ± 0.02	6.62 ± 0.01	6.84 ± 0.07
Average	4.56 ± 0.46	4.74 ± 0.52	4.55 ± 0.46	1.57 ± 0.03
LSD	Planting method= 0.0491 *			
	irrigation levels= 0.038 *			
	Overlap= 0.085 *			

In addition to the decrease in the depth of irrigation water and the retention of the soil content with good moisture content and the reason for the low efficiency of water use for conventional irrigation treatment is the increased washing of nutrients below the root zone. The effect of using different moisture depletion levels (irrigation levels) significantly "on the efficiency of field water use, as it was higher Average utilization efficiency A field in the treatment of W2 as it reached 4.74 kg m^{-3}, which did not differ significantly "from the third level of irrigation W3 in which the efficiency of using irrigation water reached 4.55 kg m^{-3} and at the first irrigation level the lowest average efficiency of the use of field water reached 3.40 kg m^{-3}.

References

Allen, R.; Pereira, L.; Raes, D. and Smith, M. (1998). Crop Evapotranspiration. FAO Irrigation and Drainage. Rome. Paper 65.

Black, C. (1965). Methods of soil analysis. Am. Soc. Agron. No. 9 part 1. Madison, USA.

ICARDA (2016). Enhancing Food Security in Arab Countries. Second Phase Progress Report. Amman: ICARDA.

Masoud, T.K. (2017). The effect of irrigation methods on soil moisture, water productivity and maize. Iraqi Journal of Agricultural Sciences. 48(1): 178-184.

Peries, R.; Wighrman, B.; Bluett, C. and Rab, A. (2004). Raised bed cropping in southern Victoria-A snapshot of a productive and sustainable option for waterlogging prone soils. 4th Int. Crop Sci. Cong., Brisbane, Australia.

Soil Survey staff. (2014). Keys to soil Taxonomy. United States Department of Agriculture Natural Resources Conservation Service. U.S.

Soomro, A.; Nauman, M.; Soomro, S.; Tagar, A.; Soomro, S.; Buriro, M.; Gandahi, A. and Memon, A. (2017). Evaluation of Raised-Bed and Conventional Irrigation Systems for Yield and Water Productivity of Wheat Crop. Journal of Basic and Applied Sciences, ISSN: 1814-8085, 143-149.