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EFFECT OF SURFACE IRRIGATION SYSTEMS AND GROWTH STIMULANTS ON YIELD AND QUALITY OF WHEAT

Ibrahim, M.E.[(1)]; Hussein, A.M.S.[(2)]; Ali, A.A.[(1)]; Samak, A.A.[(3)] and Elkoussy, Amany H.A.[(1)]

[(1)] Crop Science Department, Faculty of Agriculture, Menoufia Univ., Egypt.

[(2)] Food Technology Department, National Research Centre, Dokki, Cairo, Egypt

[(3)] Agr. and Biosyst. Eng. Department, Faculty of Agriculture, Menoufia Univ., Egypt.

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ABSTRACT: Two field experiments were carried out at the Experimental Farm, Faculty of Agriculture, Menoufia University, Shebin El-Kom, Egypt, to study the effect of different surface irrigation systems (basin irrigation, bed irrigation and gated pipes) and foliar application of some growth stimulants (control, amino acids, humic acid, compost tea, seaweed extract and yeast extract) on yield and grain quality of bread wheat (Giza 171) during 2019/2020 and 2020/2021 seasons. Irrigation systems significantly affected on most characters studied. Using gated pipes was superior to the other irrigation systems in yield and its components (number of spikes/ m^2, number of grains/spike, 1000-grain weight, grain yield /fed and straw and biological yields/fed) and grain quality (protein, wet and dry gluten %) especially basin irrigation which registered the lowest ones. However, moisture, ash, fats and fiber percents in grains did not significantly affect by different irrigation systems. Foliar application of yeast extract or seaweed extract exhibited superiority in all yield and its components as well as grain quality (protein, wet and dry gluten %) in comparison with other tested growth stimulants especially control. Treated plants with compost tea and untreated plants recorded the highest carbohydrates in grains. However, moisture, ash, fats and fiber percents in grains did not significantly affect by various growth stimulants. The interaction between irrigation systems and growth stimulants was found to be significant for most characters studied. Significant increases in most effective yield and grain quality traits were detected by irrigated plants with gated pipes and treated with yeast extract or seaweed extract. It could be concluded that irrigated plants with gated pipes and treated with yeast extract was the best combination treatment for maximizing grain yield and its quality under similar environmental conditions of the experiment site.

Key words: Wheat, Gated pipes irrigation, Stimulants, Yield, Protein and Gluten.

INTRODUCTION

Wheat is the most important cereal crop cultivated in the world. It considered as major source of foods for most world population. Wheat holds immense significance because its grains can be milled into flour, semolina, and other essential ingredients used in bread, pastries, and pasta (Dewettinck *et al.*, 2008). Egypt is currently facing a shortage in local wheat production. The amount of wheat produced domestically fluctuates each year and only meets around 50% of the country's needs. During the 2021/2022 season, approximately 3.33 million fed was cultivated wheat, resulting in total production in 2022 about 10.0 million tons grains. Nevertheless, Egypt still needs to import around 9.0 million tons of wheat grains to meet needs according to Global Agricultural Information Network (GAIN report, 2023). Recently, Egypt has taken serious steps to reduce wheat gap. Therefore, researchers are focusing on improving the agriculture practices to increase productivity and improve water use efficiency.

Water scarcity is one of the major challenges currently facing the world. In Egypt, agricultural sector consumes about 80-85 % of the water resources for cultivating agricultural areas. Saving irrigation water is now considered a strategic goal in Egypt, due to the already scarce water resources, a large portion of the water budget is allocated to irrigating cultivated land, particularly in regions with high temperatures that

*Corresponding author: Amany.hamed603@agr.menofia.edu.eg

demand increased water consumption (El Quosy, 2013). Waterlogging and low efficiency are the major problems attendant with surface irrigation. The traditional method causes loss of large water amounts due to flooded soil with water than the plants required (Osman *et al.*, 2016). This lose can be reduced by modernized irrigation systems such as gated pipes. Surface irrigation system is become more effective with gate pipes, which incorporate a new method of distributing irrigation water into field to conserve irrigation water used (Ali and Mohammed, 2015 and Samak *et al.*, 2023). In this concern, El Berry *et al.* (2006) and Farag *et al.* (2019) reported that there are numerous advantages associated with the gated pipes system, i.e. reduce seepage and evaporation losses, conserve irrigation water quantity, improve water distribution, increase water use efficiency, low maintenance requirements, and suitable to cultivate numerous crops without making changes to the design.

Growth stimulants are substances has efficient performance on the plant's vital processes, and helping high yields and good quality products. Yeast as a biostimulant, is sources of essential amino acids and nutrients, beside contains thiamin, riboflavin, vitamins, and other growth regulating substances (Hammad and Ali, 2014). Yeast is being recognized as a new promising plant growth promoter, enhance the uptake and utilization of essential nutrients (Abou-Aly *et al.*, 2015), cause significant increases in yield and grain quality (Hammad and Ali, 2014 and Gomaa *et al.*, 2021). Seaweed and its products utilized as biostimulants in crop productivity because contains various phytohormones as well as essential macronutrients and micronutrients. These components are crucial for improving plant growth (Al-Hasany *et al.*, 2019), yield (Khashan *et al.*, 2021) and grain quality (Ismail, 2016). More than 20 variants of amino acids are to serve as building blocks of proteins (Haider *et al.*, 2021). Studies showed the beneficial effects of amino acids on promoting plant growth (Hammad and Ali, 2014) as well as yield and grain quality (El-Said and Mahdy, 2016). Humic substances consist of various organic compounds. It is playing a significant role in achieving higher yields (Mohamed *et al.*, 2016). Compost tea is widely recognized as one of the most popular derivatives of compost, known for its active organic properties. It can improve minerals uptake (El-Hamahmy *et al.*, 2014) and increase yield (Elbagory, 2023).

Therefore, it is necessary to find out the agronomic solutions to increase wheat yield and its quality to avoid the risks of dependence on importing wheat from abroad.

MATERIALS AND METHODS

Experimental procedures

Two field experiments were carried out at the Experimental Farm, Faculty of Agriculture, Menoufia University, Shebin El-Kom, Egypt during 2019/2020 and 2020/2021 seasons to study the effect of different surface irrigation systems and foliar application of some growth stimulants on yield, irrigation efficiency and grain quality of bread wheat (*Triticum aestivum*, Giza 171 cv.). The tested experimental treatments are as follow:

A- Surface irrigation systems

The experiment was irrigated five times at 25, 53, 80, 105 and 125 days from sowing (DAS) during both growing seasons. Three treatments of surface irrigation systems were applied from the first irrigation to fifth irrigation as follows:

1- Basin irrigation (traditional irrigation): The flood irrigation system is practiced in flat soil. The irrigation was done directly from the field channel.

2- Bed irrigation: The experimental plot area contains 4 beds. Bed width was 120 cm. The irrigation was done directly from the field channel.

3- Gated pipes irrigation: The design of system was similar with bed irrigation but without bunds (dikes). The irrigation was done using gated pipes. The pipes were located at the head of the irrigated field across the beds and connected directly with water pump motor. Each bed had one gate with flow rate 5 m^3/hr, installed at spacing of 120 cm.

B- Growth stimulants

Six treatments of growth stimulants were sprayed twice at 45 and 60 DAS as follows: control, amino acids (0.5 g/L), humic acid (0.5 g/L), compost tea (50 ml/L), seaweed extract (0.5 g/L) and yeast extract (2.5 g/L). Amino acids applied as commercial substance namely "Amino total 20.65 %". Potassium humate 70% was used as a source of humic acid. Aerated compost tea was prepared from mature compost of rice straw mixed with farmyard manure at rate of 10% w/w. The system was continuously aerated using air pump for 3 days brewing cycle to produce compost tea at Soil, Water and Environment Research Institute, ARC, Egypt. Brown seaweed extract applied as commercial substance namely Acadian (*Ascophyllum nodosum*). Yeast extract (*Saccharomyces cerevisiae*) was prepared from dry pure yeast powder. It was activated by molasses "as low-cost source of carbon" to obtain higher reactive yeast cells, and incubated at room temperature (28 C°). Then this media was frozen and thawed (three cycles) to release out the bio-constituents from yeast cells (Park *et al.* 1997). Treatments were arranged in a strip plot design with three replications. The irrigation systems were randomly distributed in the vertical strip plots, while growth stimulants were occupied in the horizontal strip plots.

Experimental site description

Soil samples were collected randomly from the topsoil (0-30 cm) prior to sowing in order to estimate various physical and chemical properties of the soil. The analysis was as the methods outlined by Jackson (1973) and Page *et al.* (1982) as shown in Table (1).

Crop management practices

The experimental field was tilled twice using chisel plow, and then a laser leveling machine was leveled soil with slope 0.10%. The ridger was using to made beds (120 cm width) only in beds and gated pipes systems. The area allocated for the basin irrigation system was left flat without furrowing. Each sub plot area was 48 m^2. In all experimental plots, sowing was done by hand drill tool with space of 15 cm between rows using a rate of 300 grains/m^2 on 8th and 5th November in the first and second seasons, respectively. The recommended fertilizers rate for wheat growth under experiment locality was applied.

Table 1. Physical and chemical properties of the experimental soil.

Season	Particle size distribution (%)			Texture grade	pH	ECe (dS m^{-1})	OM (%)	BD (g cm^{-3})	
	Sand	Silt	Clay						
2019/20	34.2	28.6	37.2	Clay loam	7.89	0.67	1.80	1.22	
2020/21	35.9	28.7	35.4	Clay loam	7.77	0.61	1.77	1.21	
Season	Soil moisture (%)			Macronutrients (ppm)			Micronutrients (ppm)		
	Field capacity	Permanent wilting point	Available water	N	P	K	Fe	Zn	Mn
2019/20	40.2	19.8	20.4	36.8	10.7	309.6	2.98	0.97	2.09
2020/21	39.8	19.6	20.2	38.4	11.3	305.6	3.31	0.89	2.21

pH: Soil reaction (measured in 1:2.5, soil: distilled water suspension), ECe: electrical conductivity of soil saturated paste extract, OM: Organic matter content, BD: bulk density.

Measurements

I- Yield and its components

Yield and its components characters were determined at maturity stage. Ten guarded spikes were taken from each experimental plot to estimate number of grains/spike. Number of spikes/ m^2 and 1000-grain weight were determined from central m^2 in each plot. In addition, grain, straw and biological yields of central m^2 in each plot were estimated and converted to ton/fed.

II- Grain quality

Grain samples of first and second seasons were mixed (as an average of the two seasons) to estimate grain quality parameters. Grains were manually cleaned, tempered to reach 14% moisture content, then milled. The chemical compositions (moisture, protein, fat, ash and crude fiber %) were determined in whole grains according to AOAC (2019). Carbohydrates were calculated by difference method. Wet and dry gluten of wheat flour dough were determined according to the method of AACC (2010).

Statistical analysis

Data of measurements were analyzed using analysis of variance according to the methods described by Gomez and Gomez (1984). The statistical analysis was done using CoStat package program, version 6.4 (Cohort software, USA). The differences between the means of different treatments were tested using Duncan's multiple range test (Duncan, 1955) at probability 5%.

RESULTS AND DISCUSSION

I- Yield and its components

Yield and its components characters are presented as affected by tested irrigation systems (Table 2), growth stimulants (Table 3) and their interactions (Figures 1-6) during 2019/2020 and 2020/2021 seasons.

I-A. Effect of irrigation systems

Data reported in Table (2) reveal that number of spikes/m^2 was significantly affected by irrigation systems. The data showed that the highest increase was obtained by gated pipes system with increases 4.63 and 10.52%, respectively as compared with bed and basin irrigation systems as an average of the two seasons. In this concern, Kumar *et al.* (2023) reported that sowing wheat in wide bed irrigated with gated pipes treatment considerably outperformed in terms of number of spikes, resulted from a higher proportion of biomass being assigned to tillers, which in turn resulted from a greater leaf area, allowing the plant to absorb more solar energy for dry matter consistence through photosynthesis. Other researchers reported that wheat plants significantly differed in their spikes number when using different irrigation methods such as gated pipes (Kumar *et al.*, 2023) and bed system (El-Seidy *et al.*, 2015 and Si *et al.*, 2023) compared to conventional irrigation.

Table 2. Yield and its components of wheat as affected by irrigation systems during 2019/2020 and 2020/2021 seasons.

Irrigation systems	Number of spikes/ m^2	Grains No./spike	1000-grain weight (g)	Grain yield /fed (ton)	Straw yield/fed (ton)	Biological yield/fed (ton)
2019/2020 season						
Basin irrigation	367.06 c	58.55 c	47.96 c	3.254 c	4.592 c	7.846 c
Bed irrigation	377.44 b	62.64 b	49.00 b	3.524 b	5.421 b	8.945 b
Gated pipes irrigation	395.33 a	64.69 a	49.71 a	3.695 a	5.643 a	9.338 a
2020/2021 season						
Basin irrigation	341.50 c	58.12 b	48.12 c	3.181 c	4.603 b	7.784 c
Bed irrigation	370.33 b	62.04 a	49.06 b	3.414 b	5.712 a	9.126 b
Gated pipes irrigation	387.06 a	62.65 a	50.20 a	3.605 a	5.885 a	9.491 a

Form the results in Table (2) it can be noticed that irrigation wheat plants using gated pipes seemed to be the most effective method for increasing number of grains per spike and 1000-grain weight than the other tested systems. The differences between gated pipes and bed irrigation did not reach the level of significance for number of grains per spike (in one season). The increases in grains number and/or grain weight might be attributed to enhance photosynthetic pigments. Other researchers mentioned that spike characters were increased by irrigation using gated pipes (Kumar *et al.,* 2023) and bed system (El-Seidy *et al.,* 2015) compared to traditional irrigation.

The data indicated that significant increase in grain yield/fed was obtained by irrigated wheat plants with gated pipes more than bed and basin irrigation systems in the two seasons. This increase was amounted to 5.22 and 13.44%, respectively as an average of the two seasons. The superiority of grain yield/fed obtained from using gated pipes was the logical resultant of the increases in all yield components, and might be attributed to the reduction in leaching losses (El Awady *et al.,* 2009) and enhancement nutrients uptake (Ali and Mohammed, 2015). In this respect, Farag *et al.* (2019) and Kumar *et al.* (2023) found that grain yield was increased by irrigated wheat plants with gated pipes system compared to traditional irrigation.

As the data presented in Table (2), straw and biological yields/fed were significantly increased by irrigation with gated pipes systems compared to bed and basin irrigation systems. The differences between gated pipes and bed irrigation systems for straw yield /fed did not reach the level of significance in the second season. Basin irrigation produced the lowest values in this respect. Kumar *et al.* (2023) observed that the significant impact of gated pipes on the vegetative growth and nutrients uptake suggested that straw and biomass yields may have increased as a result.

A-II. Effect of growth stimulants

The obtained result in Table (3) showed that application of any growth stimulants caused significant increase in spikes number as compared with the control. The highest increase was recorded by seaweed extract and yeast extract without significant differences between them in the second season. This increase was amounted to 18.40 and 16.57%, respectively compared to untreated plants as an average of the two seasons. The superiority of seaweed extract and yeast extract might be due to their nutritional and hormonals components. Numerous studies found significant increases in number of spikes of wheat by application of seaweed extract (Al-Hasany *et al.,* 2019 and Khashan *et al.,* 2021) and yeast extract (Hammad and Ali, 2014 and Gomaa *et al.,* 2021) compared to control.

It is evident that there is variation among the tested growth stimulants for number of grains per spike and 1000-grain weight in both seasons. The highest values were recorded by yeast extract followed by seaweed extract without significant differences between them in some cases. This superiority of such treatments might be attributed to a greater amount of assimilates which contributed to dry matter accumulation. However, untreated plants recorded the lowest values. Application of compost tea, amino acids and humic acids recorded intermediate values. In this respect, other investigators reported significant increases in spike characters due to application of yeast extract (Hammad and Ali, 2014 and Gomaa *et al.* 2021), seaweed extract (Khashan *et al.,* 2021), compost tea (Afify *et al.,* 2022), humic acid (Anwar *et al.,* 2016) and amino acids (Hammad and Ali, 2014) compared to control.

The obtained data in Table (3) showed that application of growth stimulants recorded significant increases in grain yield /fed compared to untreated plants. As an average of data of both seasons, application of yeast extract, seaweed extract, compost tea, humic acid and amino acids achieved increase percentages reached 11.11, 8.72, 7.66, 5.64 and 5.10%, respectively above the control treatment. The obtained results clearly reflected the vital role of these stimulants especially yeast extract and seaweed extract in improving yield components. These results are consistent with reports of other researchers who found that application of yeast extract (Gomaa *et al.,* 2021), seaweed extract (Al-Hasany *et al.,* 2019 and Khashan *et al.,* 2021), compost tea (Elbagory, 2023), humic acid (Anwar *et al.,* 2016) and amino acids (Hammad and Ali, 2014) exhibited increasers in wheat grain yield compared to untreated plants.

Table 3. Yield and its components of wheat as affected by growth stimulants during 2019/2020 and 2020/2021 seasons.

Stimulants	Number of spikes/ m^2	Grains No./spike	1000-grain weight (g)	Grain yield /fed (ton)	Straw yield/fed (ton)	Biological yield/fed (ton)
2019/2020 season						
Control	339.22 d	58.57 d	47.28 e	3.304 d	4.504 e	7.809 d
Amino acids	375.11 c	62.34 bc	48.26 d	3.457 c	4.992 d	8.448 c
Humic acid	373.78 c	61.37 c	48.88 c	3.447 c	5.118 cd	8.565 c
Compost tea	392.67 b	61.67 c	48.84 c	3.506 bc	5.573 b	9.079 b
Seaweed extract	404.11 a	63.23 b	49.68 b	3.549 b	5.874 a	9.424 a
Yeast extract	394.78 b	64.60 a	50.40 a	3.681 a	5.251 c	8.933 b
2020/2021 season						
Control	330.22 d	58.33 d	47.86 d	3.175 e	4.804 d	7.980 d
Amino acids	358.00 c	60.93 bc	49.06 bc	3.352 d	5.210 c	8.562 c
Humic acid	362.78 c	60.49 c	49.38 b	3.396 c	5.093 c	8.490 c
Compost tea	372.67 b	61.01 bc	48.86 c	3.467 b	5.709 b	9.176 b
Seaweed extract	388.56 a	62.02 ab	49.55 ab	3.493 ab	6.000 a	9.493 a
Yeast extract	385.56 a	62.85 a	50.03 a	3.518 a	5.583 b	9.101 b

The data showed that there were significant differences among the tested growth stimulants in their straw and biological yield/fed as observed in Table (3). Seaweed extract followed by compost tea had substantial increase than other growth stimulants and control. The differences in straw yield might be imputed mainly to variation in tillers number and plant height. Spraying of seaweed improved nutrient mobilization and partitioning, thereby resulted in increased growth and dry matter production (Zodape *et al.,* 2009). In this concern, other investigators found significant increases in straw and biological yields of wheat by application of seaweed extract (Al-Hasany *et al.,* 2019), yeast extract and amino acids (Hammad and Ali, 2014), compost tea (El-Hamahmy *et al.,* 2014) and Elbagory, 2023) and humic acid (Mohamed *et al.,* 2016) compared to untreated plants.

A-III. Effect of the interaction

Significant interaction between irrigations systems and growth stimulants for number of spikes/ m^2, number of grains / spike, 1000-grain weight, grain yield /fed and straw and biological yields/fed are illustrated in Figures (1-6).

Data illustrated in Figure (1) showed that the highest significant values of number of spikes/m^2 were obtained when plants were irrigated with gated pipes and sprayed with seaweed extract (418.00 and 407.00) and yeast extract (408.67 and 400.00) in the first and second seasons, respectively. However, the lowest significant values (325.00 and 313.33) in the first and second seasons, respectively were obtained when plants were irrigated with basin system and untreated with any growth stimulants. The positive effect of superior treatments might be attributed to their roles in increasing the amounts of metabolites synthesized by wheat plants which promoted the numbers of tillers. The superior combination treatments caused increases amounted to 29.62 and 26.70%, respectively as an average of both seasons compared to inferior combination.

Data illustrated showed that the highest values of number of grains / spike (67.20 and 63.79) in

Figure (2) and 1000-grain weight (51.02 and 51.32 g.) in Figure (3) were obtained when plants were irrigated by gated pipes and sprayed with yeast extract. This superiority might be related to greater photoassimilates which contributed to dry matter accumulation during vegetative stage and this in turn to increase the grains number and weight. Meanwhile, the lowest ones were obtained by wheat plants that irrigated by basin system and unsprayed with any stimulants.

Data illustrated in Figure (4) indicated that plants showed several responses to different irrigation systems and growth stimulants for grain yield/fed. Irrigated plant with gated pipes and treated with yeast extract found to be the most effective combination treatment in increasing grain yield / fed in both seasons. Also, plants irrigated with the same system took the second rank when treated with seaweed extract and compost tea without significant with yeast extract in the second season. The increase from gated pipes × yeast extract treatment amounted to 30.77 and 27.99 % more than the yield produced from untreated plants grown under basin irrigation system in the first and second seasons, respectively. The increases in grain yield / fed resulting from superior treatments may be due to their positive effects on yield components.

It is clear from that wheat plants exposed their highest straw yield/fed (Figure 5) biological yield /fed (Figure 6) when plants treated with seaweed extract and irrigated with gated pipes or bed irrigation in both seasons. On the other side, the lowest values were recorded from wheat plants irrigated with basin irrigation without application of any stimulants in both seasons. Increases from application of seaweed extract amounted to 41.47% under gated pipes and 35.49 % under bed irrigation for biological yield more than the yield produced from inferior treatment, as an average of both seasons. This increase was mainly to increasers in straw yield/fed.

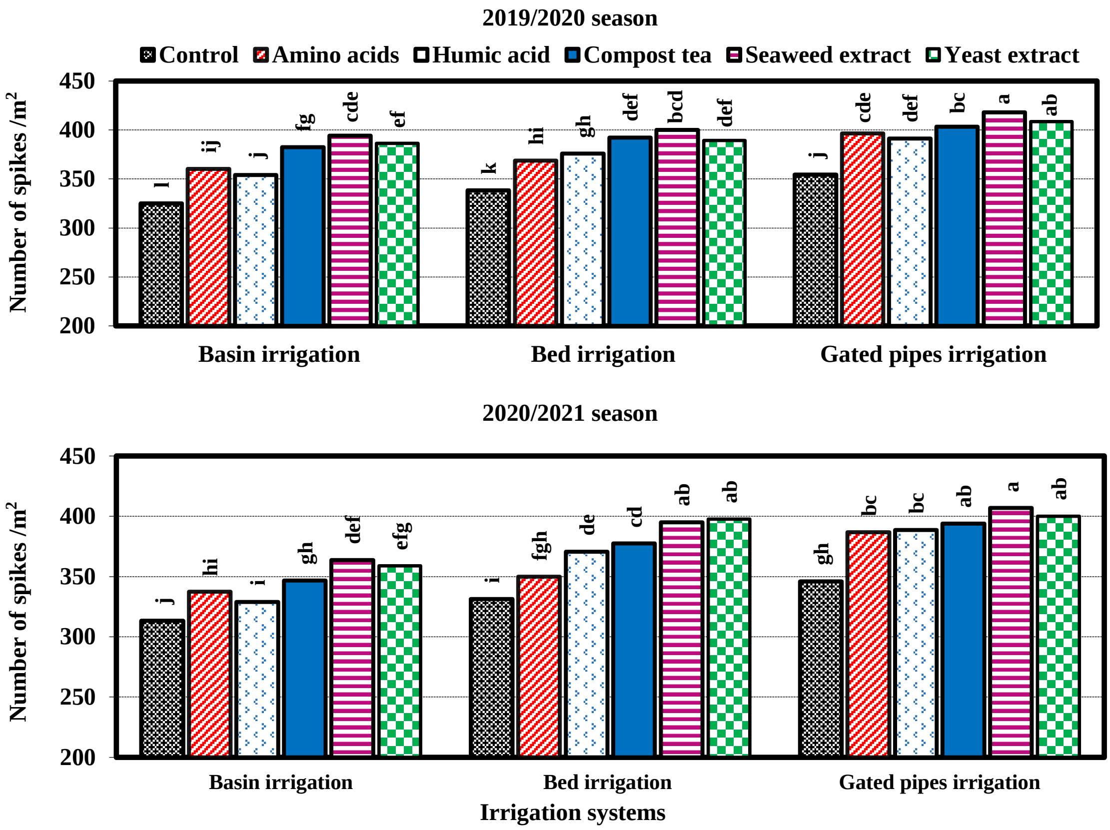

Fig. 1. Effect of the interaction between irrigation systems and growth stimulants on number of spikes /m^2.

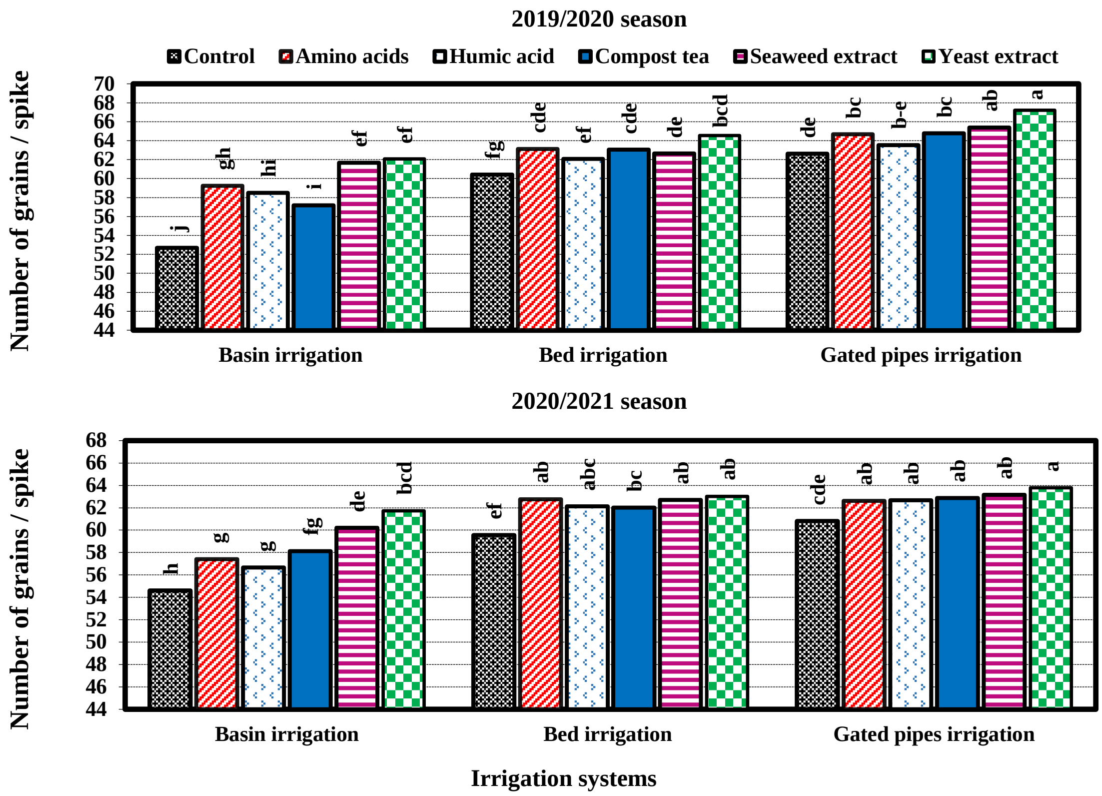

Fig. 2. Effect of the interaction between irrigation systems and growth stimulants on number of grains/spike.

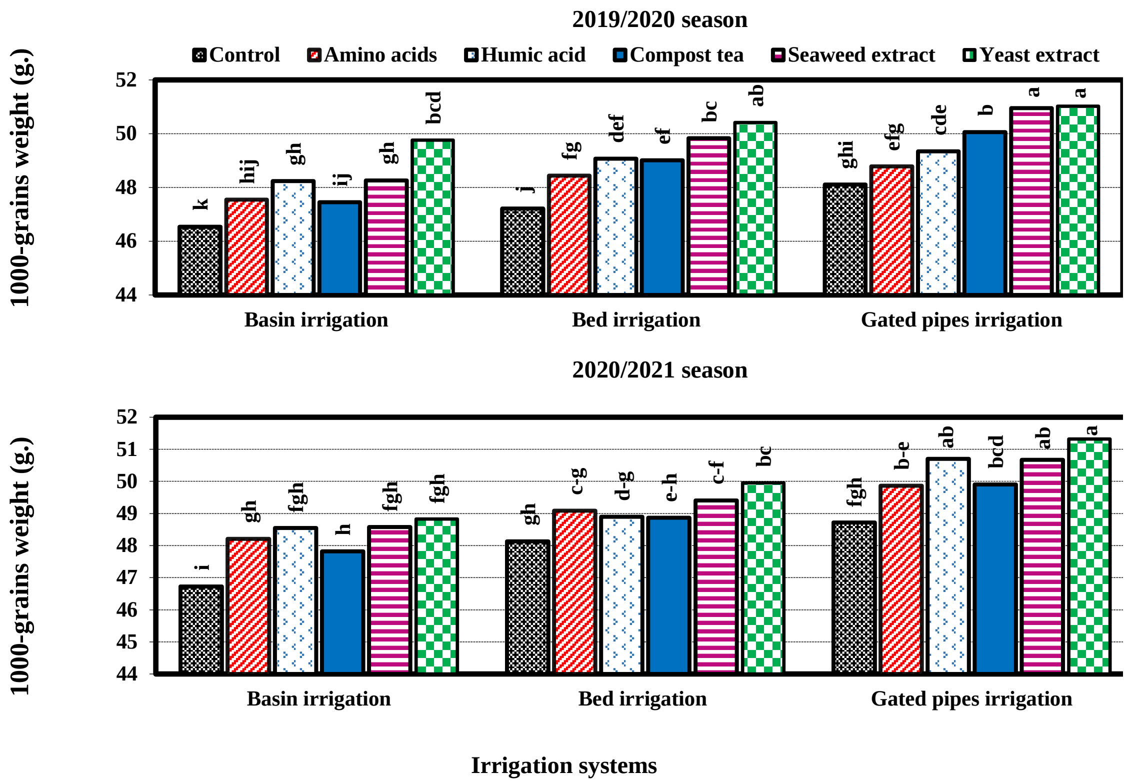

Fig. 3. Effect of interaction between irrigation systems and growth stimulants on 1000-grain weight.

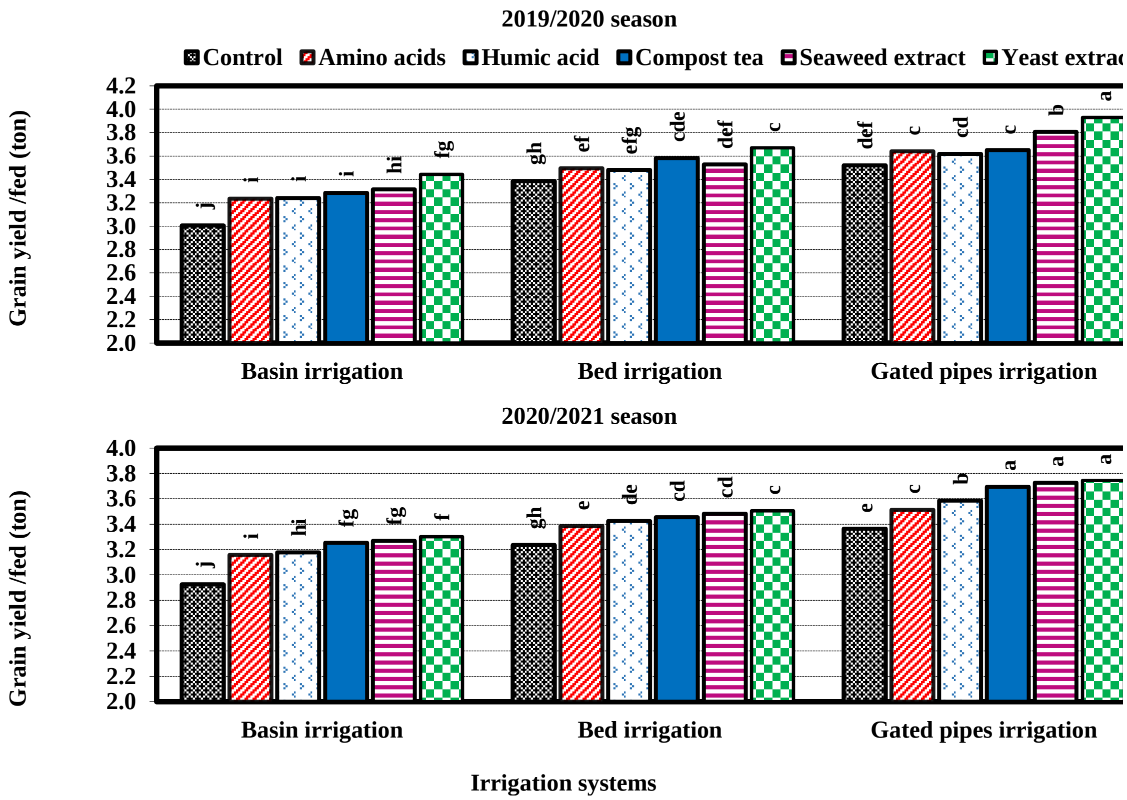

Fig. 4. Effect of the interaction between irrigation systems and growth stimulants on grain yield /fed.

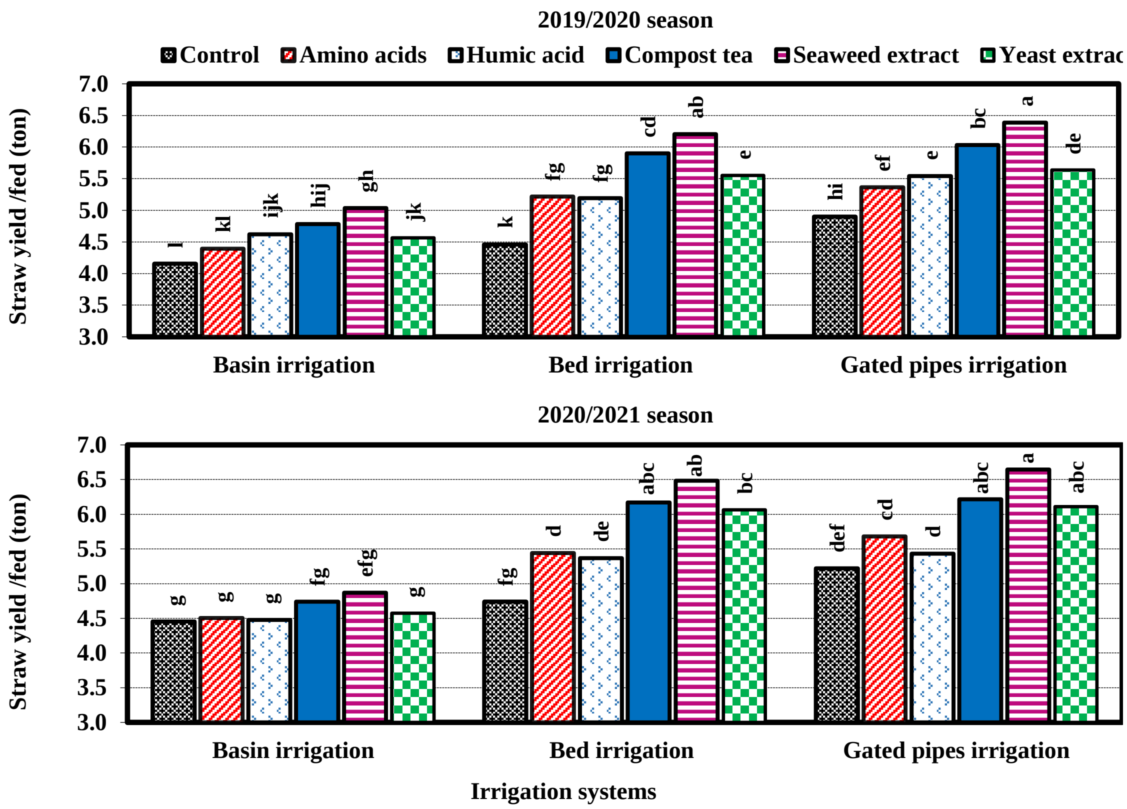

Fig. 5. Effect of interaction between irrigation systems and growth stimulants on straw yield /fed.

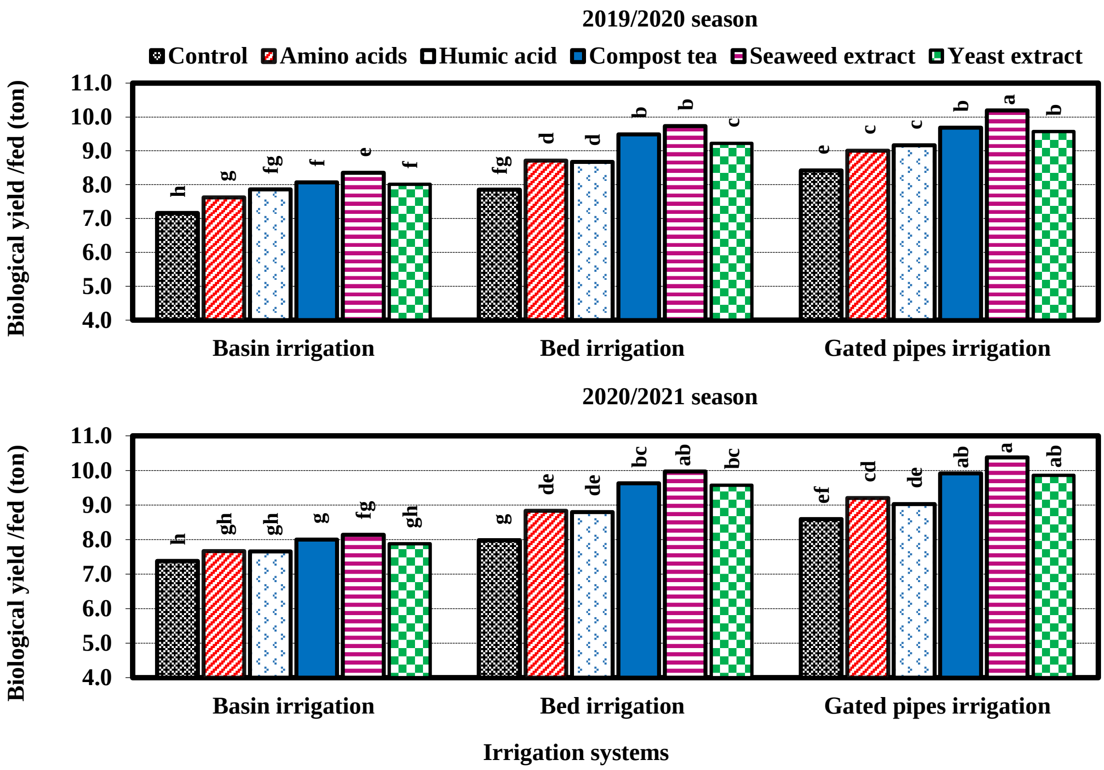

Fig. 6. Effect of interaction between irrigation systems and growth stimulants on biological yield /fed.

B- Grain quality

B-I. Effect of irrigation systems

The effect of irrigation systems on chemical composition of grain i.e., moisture, protein, carbohydrates, ash, fats and crude fiber percentages of whole meal are presented in Table (4). Moisture, ash, fats and fiber of whole meal were not significantly affected by various irrigation systems. Protein content is traditionally recognized as the most factor affecting wheat bread making quality. Irrigation with gated pipes excelled in giving the highest values with increases amounted to 8.67 and 10.97% over bed irrigation and basin irrigation which ranked last. Basin irrigation produced more carbohydrates % than bed and gated pipes systems. In this concern, Kumar *et al.* (2023) recorded significant increases in nitrogen percentage in grains (1.74%) and straw (0.59%) when wide bed furrow irrigated with gated pipes, and consequently grain protein, compared to conventional flood irrigation.

Wheat gluten consists mainly of two water-insoluble proteins (glutenins and gliadins) that play significant roles in determining the functional properties of flour (Ibarra *et al.*, 2016). Similar to protein %, mean values of wet and dry gluten percentages were significantly increased when plants irrigated with gated pipes. The increases in wet and dry gluten by gated pipes amounted to 8.75 and 11.87%, respectively more than basin irrigation system.

B-II. Effect of growth stimulants

Chemical composition of whole meal of wheat are presented in Table (5). Moisture content ranged between 11.43 to 12.30%. Differences among growth regulators were not significant for grain moisture content. The protein percentage in whole meal ranged from 13.43% to 15.03% with significant differences. Application of yeast extract exhibited the highest values without significant with seaweed extract and amino acids treatments, while the lowest one recorded by control treatment. The superior treatments caused increases amounted to 11.91, 11.02 and 9.90% more than control. These increments may be related with stimulants composition that contains essential amino acids. Haider *et al.* (2021) mentioned that more than 20 variants of amino acids are to serve as building blocks of proteins. With regard to carbohydrate %, it was noticed that control and compost tea recorded the highest significant values compared to other treatments. Concerning ash, fats and crude fiber %, data showed that there are insignificant differences among growth stimulants, where values recorded by growth stimulants were found quite close to each other. Other researchers reported that application of stimulants cause significant changes in the chemical composition of wheat grains especially large contents (protein and/or carbohydrates) such as amino acids (El-Said and Mahdy, 2016), yeast extract (Abou-Aly *et al.*, 2015), seaweed extract (Ismail, 2016), compost tea (El-Hamahmy *et al.*, 2014) and humic acid (Mohamed *et al.*, 2016) compared to untreated plants.

Gluten makes bread dough stick together and gives it the ability to retain gas. Yeast extract was the superior treatment for formation more wet and dry gluten, which reached 27.10 and 9.35%, respectively (Table 5). Seaweed extract and amino acids took the next rank for dry gluten without significant differences with yeast extract. On the hand, control treatment recorded the least content of wet and dry gluten (25.90 and 8.70%, respectively). Flour dough quality depends on many traits, include protein content and composition of high- molecular glutenin subunits. In this concern, Popko *et al.* (2018) reported that were significant increases in gluten content by treated plants with amino acids compared to untreated plants.

Table 4. Chemical composition of whole meal of wheat grains and gluten % as affected by irrigation systems.

Irrigation systems	Moisture %	Protein %	Carbohydrates %	Ash %	Fats %	Fiber %	Wet gluten %	Dry gluten %
Basin irrigation	12.36 a	13.49 c	79.38 a	1.76 a	2.69 a	2.68 a	25.36 c	8.51 c
Bed irrigation	12.05 a	14.66 b	78.44 b	1.71 a	2.60 a	2.59 a	26.73 b	9.10 b
Gated pipes irrigation	11.61 a	14.97 a	78.43 b	1.63 a	2.46 a	2.51 a	27.58 a	9.52 a

Table 5. Chemical composition of whole meal of wheat and gluten % as affected by growth stimulants.

Stimulants	Moisture %	Protein %	Carbohydrates %	Ash %	Fats %	Fiber %	Wet gluten %	Dry gluten %
Control	12.30 a	13.43 d	79.32 a	1.86 a	2.70 a	2.69 a	25.90 d	8.70 c
Amino acids	11.43 a	14.76 a	78.53 bc	1.64 a	2.50 a	2.57 a	26.62 bc	9.10 ab
Humic acid	12.05 a	14.31 b	78.68 b	1.71 a	2.64 a	2.66 a	26.40 c	8.95 bc
Compost tea	12.28 a	13.80 c	79.17 a	1.72 a	2.66 a	2.65 a	26.62 bc	9.05 b
Seaweed extract	11.88 a	14.91 a	78.43 bc	1.63 a	2.51 a	2.52 a	26.68 b	9.12 ab
Yeast extract	12.09 a	15.03 a	78.36 c	1.65 a	2.48 a	2.48 a	27.10 a	9.35 a

B-III. Effect of the interaction

The interactions between irrigation systems and growth stimulants were found to be significant, as an average of the both seasons, for protein, carbohydrates, wet gluten and dry gluten %. However, the interactions were not significant for moisture, ash, fats and fiber percentages, indicating that each factor affected each trait independently. Therefore, these data were eliminated. Data illustrated in Figure (7) showed the effect of interaction on protein %. The data ranged from 13.41 to 15.72%. The highest percentages were obtained by foliar application of yeast extract when plants irrigated with gated pipes (15.72 %) and bed system (15.61 %) without significant between them. Also, plants treated with seaweed extract whether under gated pipes or bed irrigation systems took the second rank without significant with superior combination treatments. However, the lowest one was obtained generally under basin irrigation especially without application any growth stimulants (13.14%). Increment in grain protein caused by gated pipes x yeast extract and bed x yeast extract treatments amounted to 19.63 and 18.80% over the lowest one (basin × control), respectively. This superiority may be due to (i) the efficiency of gated pipes in water distribution, which led to improve nutrients uptake (Ali and Mohammed, 2015), and (ii) the application of yeast extract cause readily uptake amino acids, which allow the plants to increase protein formation (Popko *et al.*, 2018).

It was evident from Figure (8) plants irrigated with bed or basin systems and treated with compost tea produced the highest grain carbohydrates (79.60 and 79.57%, respectively) while, the lowest one (77.74 and 77.80%) was obtained when irrigated plants with bed system and treated with yeast and seaweed extracts, respectively.

It was evident from Figures (9 and 10) that wet and dry gluten % exhibited their highest values when wheat plants irrigated with gated pipes and treated with yeast extract (28.15 and 9.85%, respectively) or amino acids (28.05 and 9.80%, respectively). However, the least values of both traits (24.60 and 8.05%) were obtained when plants were irrigated with basin system and untreated with any growth stimulants. The superior combination treatment (gated pipes × yeast extract) caused increase amounted to 14.43 and 22.36% compared to inferior combination treatment (basin × control) in wet and dry gluten, respectively.

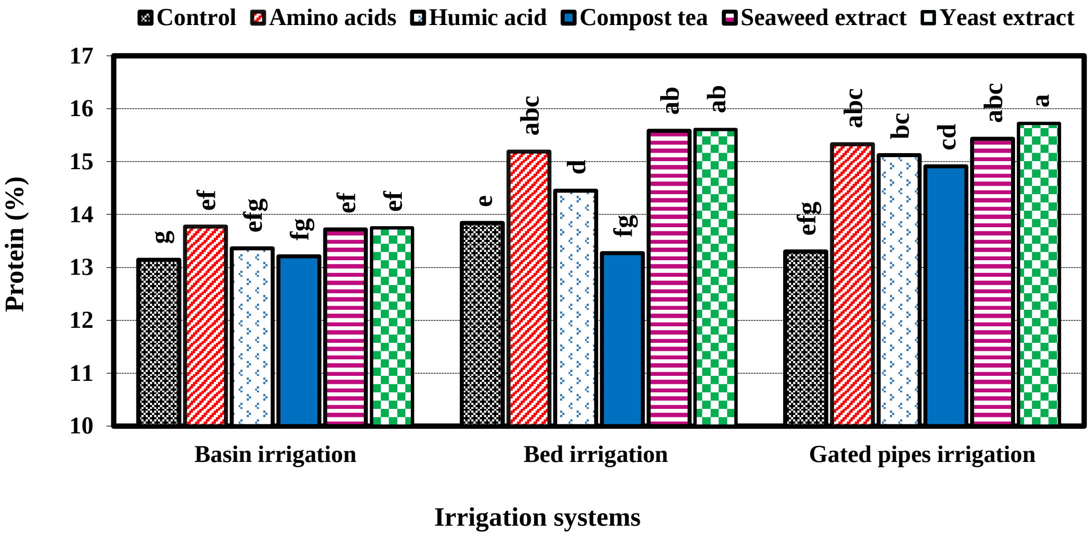

Fig. 7. Effect of the interaction between irrigation systems and growth stimulants on protein %.

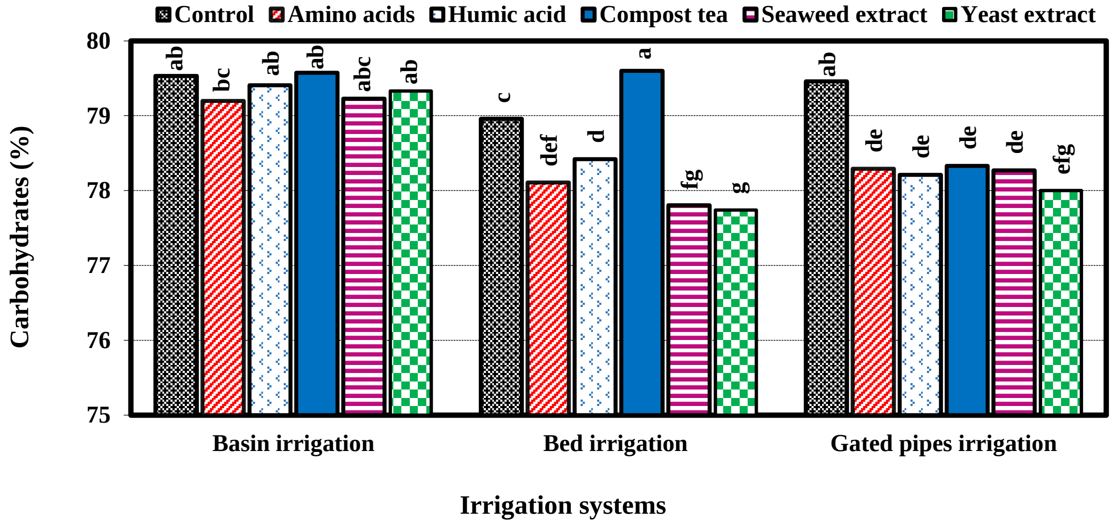

Fig. 8. Effect of the interaction between irrigation systems and growth stimulants on carbohydrates%.

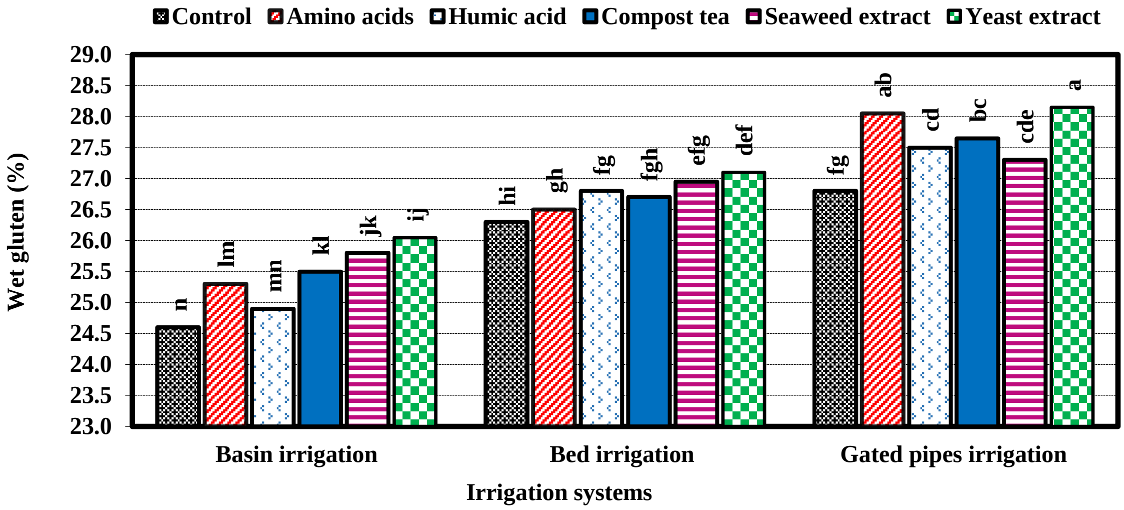

Fig. 9. Effect of the interaction between irrigation systems and growth stimulants on wet gluten %.

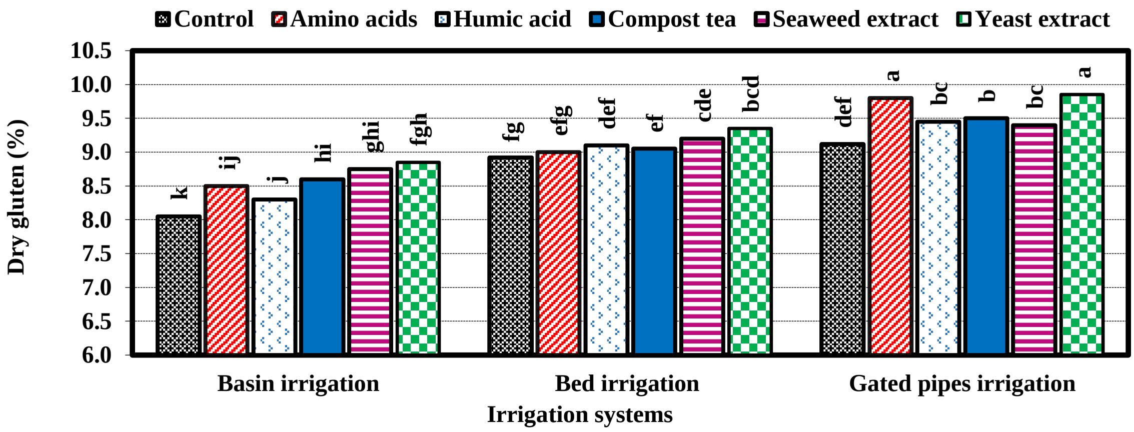

Fig. 10. Effect of the interaction between irrigation systems and growth stimulants on dry gluten%.

Conclusion

From the abovementioned results, it could be concluded that relying on gated pipe in wheat irrigation in Nile Delta lands and treated wheat plants with growth stimulants can improve yield and grain quality. Significant increases in grain yield and most effective characters of grain quality were obtained by irrigated plants with gated pipes especially when foliar sprayed with yeast extract, which is found to be the best combination treatment for maximize grain yield (3.931 and 3.745 ton /fed in the first and second seasons, respectively) under similar the environmental conditions of the experiment site.

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تأثير نظم الرى السطحى ومحفزات النمو على إنتاجية وجودة القمح

محمود الدسوقى ابراهيم(١) ، أحمد محمد سعيد حسين(٢) ، أحمد عبد الحى على(١) ، عبد اللطيف عبد الوهاب سمك (٣)، أمانى حامد عبد الرشيد القوصى(١)

(١) قسم المحاصيل - كلية الزراعة - جامعة المنوفية - مصر

(٢) قسم الصناعات الغذائية - المركز القومى للبحوث - القاهرة - مصر

(٣) قسم الهندسة الزراعية والنظم الحيوية - كلية الزراعة - جامعة المنوفية - مصر

الملخص العربى

أجريت تجربتان حقليتان بالمزرعة التجريبية لكلية الزراعة جامعة المنوفية بشبين الكوم بمصر خلال موسمي الزراعة ٢٠٢٠/٢٠١٩، ٢٠٢١/٢٠٢٠م لدراسة تأثير نظم الرى السطحى (رى الأحواض ، رى المصاطب ، رى بالأنابيب المبوبة) والرش الورقى ببعض محفزات النمو (كنترول للمقارنة، أحماض أمينية، حمض الهيومك، شاى الكمبوست، مستخلص الأعشاب البحرية، مستخلص الخميرة) علي الصفات المحصولية وجودة الحبوب لصنف قمح الخبز (جيزة ١٧١). ويمكن تلخيص أهم النتائج التي تم الحصول عليها على النحو التالي:

أشارت النتائج الى اختلاف أنظمة الرى السطحى المختبرة معنويا فى معظم الصفات المدروسة. تفوق نظام الرى بالأنابيب المبوبة فى معظم الصفات المحصولية (عدد السنابل /م٢، عدد حبوب السنبلة ، وزن ١٠٠٠ حبة، محصول الحبوب للفدان ، محصول القش والبيولوجى للفدان) وصفات جودة الحبوب (النسب المئوية للبروتين ، الجلوتين الرطب والجاف) وذلك مقارنة بنظم الرى الأخرى خاصة نظام رى الأحواض الذى سجل أقل القيم للصفات سالفة الذكر. وعلى الجانب الآخر لم تصل الفروق بين أنظمة الري إلى مستوى المعنوية لكل من صفات النسب المئوية للرطوبة والرماد والدهون والألياف بالحبوب.

تفوق الرش الورقى بمستخلص الخميرة أو مستخلص الأعشاب البحرية في زيادة صفات المحصول ومكوناته سالفة الذكر وكذلك صفات جودة الحبوب (النسب المئوية للبروتين ، الجلوتين الرطب والجاف) مقارنة بمحفزات النمو الأخرى خاصة الكنترول. فى حين حققت النباتات المعاملة بشاى الكمبوست والنباتات غير المعاملة أعلى قيم للنسبة المئوية للكربوهيدرات بالحبوب. هذا ولم تتأثر معنويا صفات النسب المئوية للرطوبة والرماد والدهون والألياف بالحبوب بمعاملات محفزات النمو المختلفة.

أظهرت النتائج معنوية التفاعل بين نظم الرى السطحى ومحفزات النمو المختبرة لمعظم الصفات المدروسة حيث تحققت زيادات معنوية في الصفات المحصولية وصفات الجودة الهامة عند اتباع نظام الرى بالأنابيب المبوبة مع الرش الورقى بمستخلص الخميرة أو مستخلص الأعشاب البحرية. لذا توصى الدراسة باتباع نظام الرى بالأنابيب المبوبة مع الرش الورقى بمستخلص الخميرة لتعظيم انتاجية القمح من الحبوب وجودته وذلك تحت الظروف البيئية المماثلة لموقع التجربة.