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RESEARCH ARTICLE

EFFECT OF UV RADIATION ON WHEAT PRODUCTIVITY UNDER WATER DEFICIT IRRIGATION

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Abstract

Water Scarcity and increasing ultraviolet radiation, especially UV-B and C bands, are direct affects of both negative climate change phenomenon and environmental pollution. Both functioned individually or synergically resulting stress in plants. Deficit irrigation and biophysical applications can be implemented to optimize the use of available water resources and increase productivity per unit area to achieve self-sufficiency of strategic crops. Pretreatedsoft wheat seeds cv. Gmeza 11 by three UV- bands "UV-BS" (A, B and C) with approximately dose (2.9×10^{3}mJ cm^{-2} ± 50), were grown till maturity on pot experiment under the winter spring of 2022/2023 season. Their response was evaluated in terms of biomass components, harvest and seed indexes, and some spike parameters, under three water deficit "WD" percentage 100, 85, 70% (W_1,W_2 and W_3) of ET_C, using split plot design. Moreover, some financial, technical and economic indicators for the efficiency of irrigation water were computed. Results affirmed that, all parameters had a stimulatory significant effect ($P \leq 0.05$) with current studied treatments. They affected positively following UV-C, B, and A, as well as, 70, 85 and 100%. This effect may be caused individually or as a result of the interaction between them. Meanwhile, the irrigation water productivity "IWP" has an opposite proportion with WD, and direct proportion with UV- BS. Thehighest values of parameters were recorded with fully irrigation, 100% & UV-A treatment, except for IWP and irrigation water return "IWR". In contrast, the lowest values were recorded at 70% &UV-C treatment, except for IWP. The results concluded that, the deficit percentage might not be increased more than 15% and UV wavelength might not be less than315nm. While the profit rate reached 61.04% at UV-A&W_1 treatment. The economic indicators, e.g., IWR and crop requirement, have a negative correlation with both UV-BS and WD.

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Introduction:-

Baladi bread made from wheat is the main ingredient on the Egyptian table for both rural and urban dwellers. Due to its importance in providing daily food as a main source of carbohydrates for the majority of the Egyptian people, therefore, wheat is called the first living crop. Soft Wheat [*Triticumaestivum* (L.)] is a member of Poaceae family, as well as, ranked as the first major cereal crop before rice and maize. It is considered as the most important strategic crop in Egypt. Where, many food industries depend on it, i.e., pasta and various other baked goods. Additionally, wheat by-products (hay and bran) are used as fodder.

On the other hand, Egypt suffers from an increasing the wheat gap size, despite, it produces about $6×10^7$ardeb≈ 9 Tg (ardeb= Egyptian mass unit equal 150kg), from an area of 3,320,477fed ≈ 1,394,588 he (fed = Feddan = Egyptian area unit equal $4200m^2$), representing about 20.37% of the total cropped area, which amounts to about $16.3×10^6$ fed in the 2021season **(FAOSTAT, 2023)**.

The wheat gap size was 14.24Tg, with only 38.73% of self-sufficiency, worth about $4.693×10^9$ \$ at 2021/2022, where, 1\$ ≈15.68 £E **(CAPMAS, 2021 and CBE, 2021).** With expected to increase this gap about 6.5% annually **(Afifi, 2022)**.

To fill this gap, the state resorts to imports, which leads to an increase the deficit in the agricultural and food trade balance, and in consequence the Egyptian balance of payments, especially in light of the increasing the prices of world food, on the one hand, and the recent decline in the £E value Vs. \$, on the other hand.

However, in light of the repercussions of the successive crises, including; (i) corona epidemic, (ii) the disruption of food supply chains, and (iii) the crisis of the Russian-Ukrainian war, where, Egypt imports about 90% of wheat imports from them, during the period from 2018-2020 (**Afifi, 2022**). Finally, the lack of global production of wheat crops as a direct effect of the negative climate change phenomenon. Where, wheat production in Egypt is expected to decrease by about 18% by 2030 as a direct effect of climate change (**El- Sawalhe, 2022**).

Therefore, it is important to seek to strengthen Egyptian food security, which it is one of the main components of national security. Through, reduce the wheat import bill and increase local production of it, in an attempt to mitigate and reduce the severity of these crises on the Egyptian economy, throughout, horizontal and vertical development programs.

Horizontal development programs represented by increasing the cultivated land area (horizontal expansion) bid several problems, e.g., climatic change (reduceing the amount of rain falling on the Nile river source, due to move the rain belt to the south) **(Mohammed *et al*., 2018)**, scarcity of fresh water resources, with expected decreasing to ≤ 400 $m^3person^{-1}$ in 2050 **(El-eshmawiy*et al*., 2022 and Morsi, 2022)**.In addition**,** the increasing competition for water resources between agriculture sector, which, use about 86.5% of the total water amount used, and other sectors **(Ibrahim, 2021)**. As well as, a huge quantity of lost water (≈ 6.438 Gm^3 in 2019) due to water conveyance system losses in open- canal from Aswan till field **(Mostafa, 2022)**.

Foregoing reasons, it must adopt a new management paradigm based on produce more yields from less water in irrigated crops. Otherwise, reduce water consumption and maximizing the production per unit of water consumed, to overcome scarcity of water in agriculture sector. This leading to significant water saving, and reallocate water thus saved to other priority areas **(Fereres*et al*., 2011).**

To cope this goal, numerous solutions are available, i.e., precision land leveling **(El-Khatib*et al*., 2014)**, developed surface irrigation system in old lands through, lining the farm ditches, marwas and mesqas, cultivating suitable crops for the climate of the area, cultivate short season crops and using the modern irrigation system (sprinkler/drip) in the newly reclaimed land **(Ibrahim, 2021)**. As well as,mulching practices **(Azad *et al*., 2015)**. Finally, practicing deficit irrigation **(Hussein *et al*., 2019).**

Deficit irrigation (DI) or water deficit (WD) is one of the means to improve irrigation water productivity (IWP) **(Rosa *et al*., 2016).** It is the practice could be achieved by applying water below the crop evapotranspiration (ET) requirement, whereby, the limited water is distributed among the growth stages according to that needed to meet maximum ET(**El-Khatib*et al*., 2014)**. DI can result in decrease crop yield, but it will remain economically feasible, as long as, the marginal benefit from reduced water cost ≥ marginal cost of reduced yield **(Chartzoulakis*et al*., 2015).**

There were two main approaches to DI strategy; High Frequency Deficit Irrigation "HFDI" where, the water is supplied to the plants below their needs, but with an irrigation frequency that restricts the water stress signs **(Duarte *et al*., 2020)**, and Controlled Deficit Irrigation "CDI", where, water is only applied in the crop development phases **(Buesa*et al*., 2013).** WD effectshave been extensively studied on several countries; under irrigated agriculture is paramount in semiarid environments**(Deng *et al*., 2006).** As well as, various crops including; Okra **(Abd El-kader*et al*., 2010**), potato **(Farrag*et al*., 2016)**, soybeans (**Sincik*et al*., 2008**), faba beans (**El-Khatib*et al*., 2014**), cowpea **(Mohammed *et al*., 2018**), wheat **(Khalil, 2013),** maize (**Adekalu1 and Okunade, 2009**), rice (**Geets and Kirk, 2009**), and lemons **(Shatanawi*et al*., 2011).**

On the other hand, vertical development programs using modern technological means to increase productivity per unit area(**Labanowska*et al*., 2016).** Priming seed "PS" with electromagnetic waves, e.g., UV radiation at different bands as a biophysical method (abiotic stress factor), is one of the most widely used techniques aimed to improve crop production **(Badridze*et al*., 2016 and Dhanya and Puthur, 2017)**. All UV ranges and bands are invisible to the human eye. Where, soft X-ray < UV < visible light. The UV spectrum divided into four bands; UV-A (long-wave; 315 to 400nm), UV-B (medium-wave; 280 to 315 nm), UV-C (short-wave; 200 to 280 nm) and vacuum UV (Radiation below 200 nm) **(Ultraviolet Lamp Systems, 2016)**.

UV radiation is a feasible, low risk and cost and an ecologically safe method **(Jisha*et al*., 2013**). Enhanced, rapid, uniform emergence of seedling with high vigour, and enriched overall growth of plants (root and vegetative mass) which will reflect in better qualitative characteristics of yield quality (protein, sugar, and vitamins)(**Ibrahim, 2016**). Moreover, generate plants that can withstand various abiotic stresses, e.g., developing plant hardiness, and enhanced plant resistance to herbivores, pathogens, pests and diseases (**Bornman*et al*., 2015**).

Therefore,in natural conditions, the effectiveness of various UV radiations of plants are varied under different stresses of environmental factors (**Iqbal and Ashraf, 2005)** ,i.e., photosynthetically photo flux density "PPF", CO_2, drought, elemental nutrition, temperature, ozone fumigation, heavy metals, the hybrid, seasonal biological rhythms, field frequencies, exposure period, and the microsite geomagnetism **(Marinkoviñ*et al*., 2008),** and with different crop species**(Mishra *et al*., 2008),**i.e.,green bean **(Fotouh*et al*., 2014),** Vignamungo and V. acontifolia**(Dwivedi*et al*., 2015)**, and sugar beet, red cabbage and fenugreek **(El-Shora*et al*., 2015)**.

Several changes in plants exhibits when seed treated by UV radiation, i.e., morphological, physiological, and biochemical **(Dhanya and Puthur, 2017).**

In view of the above facts, with keeping in view, the strategic value of the wheat crop and usefulness of biophysical applications to cope with the ever-increasing population with increasingly restrained resources and achieve self-sufficiency. The present research was planned to assess the influence of interaction between UV radiation with different bands, "UV-BS" (UV-A, B and C), and WD in terms of W_1 (100% of ET_c), W_2 (85% of ET_c) and W_3 (70% of ET_c), on some metric traits, i.e., wheat plant production (seed and hey), harvest and seed indexes, and some spike parameters. In addition, performing some financial, technical and economic indicators for the efficiency of irrigation water, to predict which treatment is economically feasible.

Materials and Methods:-

Pot experimental studies performed in garden of Agricultural Engineering Research Institute (AEnRI), Giza, Egypt (30° 02' 33.76" N latitude and 31° 12' 20.26" E longitude) under the winter spring of 2022/2023 season, to investigate the influence of exposure to the combination of two stress factors; priming seeds by UV-BS and WD on some metric traits of wheat.

Priming seeds "PS" by different ultraviolet bands "UV-BS":

1000 dry seed of wheat put on the ultravioletchamber tray, several hours prior sowing process to treat by different ultraviolet bands "UV-BS" for 20 min. with approxmetelly dose (2.9×10^3 mJcm^{-2} ± 50). The UV chamber was made from Aluminum, as a rectangular shape with dimensions of (90×45×45 cm) for length, width and height, respectively, with a top hinged door to fit different types of UV light sources. The inside chamber was totally covered with a highly reflective material (Aluminum sheet) to increase the UV intensity and to minimize any shadowing effect on irregular shaped samples **(Yaun, 2002)**.

UV-A: wavelength > 320 nm, was delivered to dry seeds by fluorescent lamp (UV-A Philips 60W/T12) emitted 395nm, covered with 0.13mm thick cellulose diacetate filters, to ensure that the only desired UV-A passes through it. Meanwhile, enhanced UV-B radiation was provided by 30W, UV-B lamp emitted 305 nm, Qin brand (Baoji Lamp Factory, China), and it was filtered with 0.13 mm, thick polyester (Mylar type) transparent film (absorbs all radiation below 300 nm) to eliminate UV-C radiation. Finally, for UV- C: a germicidal lamp (HRA 4384-Germany) with output power of 18W, emitted at 253.7nm used. To obtain the desired spectral irradiance, throughout the UV treated process, the UV lamps were suspended above the dry seeds and carefully adjusting the distance (35cm) between the lamps and the dry seed tray.

The intensity of UV in the A, B, and C ranges was 2.42, 2.46, and 2.38 mW/cm^2, respectively, as measured with a UVX digital radiometer (UVP Inc., United States). The UV dose was calculated with hereinafter equation.

$D = L \times T$ ………………**(Bachmann, 1975)**

Where: D is UV applied dose, mJ cm^{-2}., L is UV lamp intensity, mW cm^{-2}., and T is theexposure time, sec.

Seeds:

A homogenous lot of soft wheat [*Triticumaestivum* (L.)]dry seeds cultivars Gmeza 11 were collected from Grain screening station, Al-Gemeza Research Station, El -Ghrbia Governorate,Agriculture Research Center (ARC), were allowed to grow till maturity, in polyethylene pots (30 and 35 cm for diameter and long), witch filled about 25.45kg., of the soil for 30 cm., height.

Soil:

The main data, e.g., textural, physical, chemical and hydro- physical properties of soil collected from AEnRI garden were; clay texture (61.84% clay, 27.5% silt, and 10.66% coarse and fine sand), organic matter "OM" 5.5%, ρ 1.2g cm^{-3}, electric conductivity "EC" 1.36 ds m^{-1}, pH 7.63, exchangeable Mg 4.23 m Eq l^{-1} and available N, P, and K were 24.9, 18.58 and 121.29 ppm, respectively., field capacity "FC" 34.36%, permanent wilting point "PWP" 21.65%, saturation "Sat" 45.18%, available water "AW" 12.69 % and hydraulic conductivity 4.07 mmh^{-1}. Textural class name established from the textural triangle. While, physical and chemical analyses of the experimental soil carried out according **AOAC, 2005.** FC and PWP were determined according to **Israelsen and Hansen, 1962**.

Fertilizer:

For the hollow amount of soil experiment, well decomposed farm yard manure ($20m^3$ $fed^{-1} \approx 0.012$ m^3) was mixed and incorporated two weeks prior sowing. Before sowing, single super phosphate (15.5% P_2O_5) and potassium sulfate (48% k_2O), were added and mixed with the soil at the rate of 30 and 100 kg fed^{-1} (≈ 18.2 and 60.7g) as a basal dose. Wheat plants were fertilized with 100 kg N fed^{-1} (≈ 60.7g)., in the form of urea (46%) in three equal portions, the first, second and third portions were added after 20, 34 and 48 days from sowing, respectively.

Water deficit "WD" treatment:

All pots were irrigated same at field capacity after sowing until flag leaf appeared, for uniform germination. Then, after thinning tills the end of flowering (about 17 weeks), three water regimes; well water or control 1485 cm^3 (100%) "W_1" of ET, and water stressed or water deficit "WD", 1262 cm^3 (85%) "W_2" and 1039.5 cm^3 (70%) "W_3", were applied weekly to each pot. The amount of water irrigation levels, were depended on the evapotranspiration(ET) rate for wheat under the experimental site condition ($1500m^3$ fed^{-1}) which computed according IRR-CLAC program supplied by the Central Lab. of Climate– ARC. Evaporation from the soil surface was prevented by covering with sand. Water with "EC"., of 0.5 dS m^{-1}., was applied at 18:00 GMT (Greenwich Mean Time), by graduated beaker with 1000 ml capacity water meter. To keep the soil moisture of each pot the flash water was collected in the plastic dish and applied to it. Further, irrigation was stopped two weeks prior to harvest.

Experiment procedure:

On the same day, after priming wheat seeds (about 15 seeds) of each UV -BS were sown in each pot on November 10, 2022, and harvested was done on April 28, 2023. Wheat seedlings were later thinned for uniformity in growth to 5-seedling/pot., after emergence by 15 days. Weed control was realized manually without any chemical input. Other agricultural practices i.e., sprays against insects, pests and diseases were followed throughout the growing seasons as recommended for conventional wheat planting by Ministry of Agriculture

At harvest time, plants from four pots per treatmentwere uprooted carefully from pots, sun dried for one week, then, dried for constant mass at 70 °C., for yield analysis. Replicates devoted to determining plant mass "P_m" (g). Then, spikes were separated from the stalks. The following metric traits, i.e., spike parameters included spike length "S_L" (cm) , seed mass per spike "S_m" (g), and seed No. per spike "S_n", were assessed. Seed index "SI" (1000 grain mass per g) was determined. Spike length was measured by measuring tape (100 cm), as well as, both of "P_m"and"S_m" (g) for each replicate, were recorded by a digital electrical balance with an accuracy of 0.01g to calculate wheat biomass "B_y", seed yield "S_y", hey yield "h_y" (Mg fed^{-1}) and harvest index "HI" (%) by the following eqs.

B_y or S_y (Mg fed^{-1}) $\approx$ 0.297 × P_m or S_m

$$0.297 = \frac{5 \times 4200}{\pi \times (0.15)^2 \times 10^6}$$

h_y (Mg fed^{-1}) = "B_y" (Mg fed^{-1}) - "S_y"(Mg fed^{-1})

$$\text{HI (\%)} = \frac{S_Y\left(\text{Mg fed}^{-1}\right)}{B_y\left(\text{Mg fed}^{-1}\right)} \times 100$$

Where, P_m is average plant mass after eliminated the root zone (g), S_m is average seed mass per spike (g), 5 is plants number per pot, 4200 is feddan area (m^2), π ($\approx$3.14), 0.15 is a radius of sample pot (m), and 10^6 is converted coefficient from g to Mg.

As a final point, the following eqs., were used to calculate some and financial indicators, i.e., total revenue "T_R" (£E fed^{-1}), total production cost "T_C" (£E fed^{-1}), net return "N_R" (£E fed^{-1}), cash flow rate "CFR", profit rate "P_R" (%) as follows:

T_R (£E fed^{-1}) = [S_y(Mg fed^{-1})×Farm gate price (£E Mg^{-1})]+ [h_y(Mg fed^{-1})× Farm gate price (£E Mg^{-1})].,

T_C = Land preparing cost + Seeds and sowing cost+ Fertilizer cost + Pesticide cost + Harvesting cost + Irrigation cost + General expenses + Rent.,

N_R (£E fed^{-1}) = T_R (£E fed^{-1}) - T_C (£E fed^{-1}).,

$$\text{CFR} = \frac{T_R}{T_C}.,$$

$$P_R\ (\%) = \frac{N_R}{T_C} \times 100.$$

Meanwhile, technical and economic indicators for the efficiency of irrigation water, i.e., irrigation water productivity "IWP" (Kg m^{-3}), irrigation water return "IWR" (£E m^{-3}) and crop requirement -the quantity of water required to produce a unit of crop or water requirements per Mg- "CR" (m^3Mg^{-1}) were computed with hereinafter eqs.

$$\text{IWP (Kg m}^{-3}) = \frac{"S_Y"\ (\text{Mg fed}^{-1}) \times 10^3}{\text{Applied water (m}^3\ \text{fed}^{-1})}$$

$$\text{IWR (£E m}^{-3}) = \frac{"N_R"\ (\text{LE fed}^{-1})}{\text{Applied water (m}^3\ \text{fed}^{-1})}$$

$$\text{CR (m}^3\ \text{Mg}^{-1}) = \frac{10^3}{\text{IWP (kg m}^{-3})}$$

Statistical analysis:

Pot experiments include 9 treatments which were the combination of three bands of UV (UV-BS) × three applied water quantities (WD). In brief, the experimental design was a split-plot design with four replicates and two factors. Main factor: UV-BS; UV-A, B and C, and second factor: WD; W_1, W_2 and W_3. All data generated from the pot experiments were subjected separately to the proper statistical analyses of variance (ANOVA), according to the procedures outlined by **(Gomez and Gomez, 1984)**. Mean comparison between treatments and their interactions was determined using least significant difference (LSD) test at a 0.05 probability significance level using SPSS software for windows release 11.5; SPSS/Inc., Chicago IL, USA.

Results and Discussion:-

Results of seed yield "S_y" (Mg fed^{-1}) as influenced by UV-BS and WD are presented in Fig.1. While, the values of harvest index "HI" (%) can be calculated from the same figure. Where, HI denoted as the crop efficiency to switch photosynthesized products into an economically valuable form.

The attained results revealed that the increase in $S_y$more pronounced and significantly affects with priming seeds "PS" by UV-A, compared with which produced from the others. Also, water stresseffected significantly on it. The lowest values of S_y (2.34 and 1.98Mg fed^{-1}) at W_1, (2.13 and 1.85 Mg fed^{-1}) at W_2 and (1.88 and 1.64 Mgfed^{-1}) at W_3, with HI (53.21 and 53.01%), (52.13and 50.00%) and (50.70and 45.42%) at the same previous arrangement, were produced at PS by UV-B and C, compared with highest value of S_y (2.67Mg fed^{-1}) and HI (54.58%) recorded with PS by UV-A at fully irrigation (W_1). The S_y was increased significantly and gradually by increasing water level from W_3 to W_2 or W_1 at all UV-BS. For example, S_y increased by (14.2, 13.57 and 12.88%) and (20.26, 24.75and 21.11%) when plants irrigated at the level of W_2 and W_1, consecutively as compared with those irrigated at the level W_3, at UV- A, B and C., respectively. A positive effect on HI was caused at PS by UV-A. Where, PS by UV-A and C obtained maximum and minimum values of HI (54.58, 53.60 and 50.80%) and (53.01, 50.00 and 45.42) at W_1, W_2 and W_3 respectively. Generally, WD had negative effects on both of theS_y and HI at variant UV- BS. Enhanced WD from W_3 to W_2 or W_1 lead to increase HI about 105.22, 103.38 and 109.17%, or 106.93, 105.33 and 114.3% at UV-A, B and C respectively.Reduction of seed yield due to UV radiation and WD was previously reported **(Feng*et al*., 2007)**.

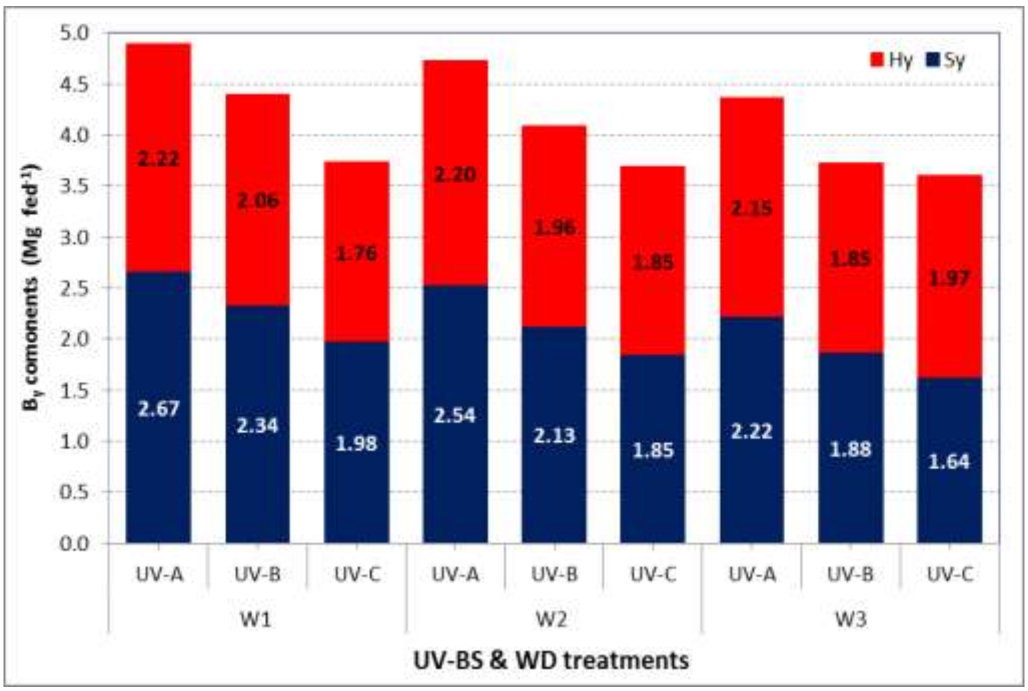

Fig.1:- Histogram illustrating effects of UV-BS & WD on wheat biomass components. .

UV-BS and WD effects on some spike parameters, e.g., spike length "S_L" (cm), seed mass per spike "S_m" (g) and seed No. per spike "S_n", were represented in Table 1.

These results showed that both of PS by UV-B or C and increasing WD lead to decrease the measured spike parameters S_L, S_m and S_n. Significant effect for the UV-BS on S_L was observed. UV-A caused a favorable effect on that trait. Where, S_L grow about 27.58 and 45.55% from PS by UV-C to UV-B and UV-A at W_1, and about 14.29 and 35.24% at W_2, as well as, about 31.12 and 43.45% at W_3. Meanwhile, the growth of S_L means reached to 2.46 and 4.23 cm, since PS by UV-C to UV-B and UV-A. On the other hand, with references to WD (%) results showed that "S_L" was significantly affected by WD. Where, WD has a negative proportion with S_L. W_3 (70% ET) ranked last in terms of S_L means (11.24cm), meanwhile, W_1 (100% ET) has the heights means of S_L (13.84cm). The significant effect of the interaction between UV-BS and WD on S_L was observed. PS by UV-A, improved the utilization of the highest irrigation level (W_1) reflected on accomplishing the tallest spike (16.2cm)., Table (1).

Table (1):- Some spike parameters (spike length "S_L", seed mass per spike "S_m" and seed No. per spike "S_n") affected by ultraviolet bands "UV-BS" and amount of irrigation water "WD".

	"S_L" (cm)				"S_m" (g)				"S_n"			
	UV-A	UV-B	UV-C	Mean	UV-A	UV-B	UV-C	Mean	UV-A	UV-B	UV-C	Mean
W_1	16.20	14.20	11.13	13.84	8.98	7.82	6.44	7.75	83.56	71.23	60.96	71.92
W_2	14.20	12.00	10.50	12.23	8.49	7.07	6.01	7.19	77.33	64.65	56.74	66.24
W_3	12.91	11.80	9.00	11.24	7.41	6.11	5.20	6.24	64.67	56.67	50.12	57.15
Mean	14.44	12.67	10.21	12.44	8.29	7.00	5.88	7.06	75.19	64.18	55.94	65.10
LSD. Data 0.05												
UV-BS	*				*				*			
W	*				NS				*			
UV-BS ×W	*				*				*			
*: Significant effect at 0.05 NS: Non significant effect at 0.05												

Moreover, results in the same table, illustrated that, using both of another type of UV-A and WD lead to decrease the means of S_m and S_n. Where, S_m decreased to about 1.16 and 2.54g from PS by UV-A to UV-B, and UV-C, at W_1, and about 1.42 and 2.48g at W_2, as well as, about 1.3 and 2.21g at W_3. Besides, S_n decreased from 83.56, 77.33 and 64.67 at PS by UV-A, to 71.33, 64.65, and 56.67 at PS by UV-B and to 60.96, 56.74, and 50.12, at PS by UV-C at W_1, W_2, and W_3 respectively. Further, it is evident from the data represented that pronounced decreases in both S_m and S_n were achieved as a result of increase WD. Wherein, S_m and S_n had a negative direct proportion with WD at al UV-T. The highest values of them were recorded at W_1, meanwhile, the lowest values of them were recorded at W_3. With regard to obtain results demonstrated, data indicated clearly that both of S_m and S_n were affected significantly by different type of UV. Also, they were affected significantly by WD, except S_m. Significant effects of UV-BS × WD were found in all spike parameters.

Thousand – grain mass or seed index "SI" (g) is an essential character that directly improves the economic yield (≈ wheat seed yield). Concerning the effects of PS by UV-BS, obtained results show clearly that, there were a direct negative relation between SI and both of UV wavelength and WD. Where, PS by UV-A and B, lead to enhanced SI (g) under different level of WD. Further, it is evident from data, that there a pronounced decrease in SI was achieved as a result of increased WD. The maximum value of SI (78.77g) was attributed at UV-A & W_1 treatment. Furthermore, PS by UV-C & W_3 treatment recorded the minimum value of SI (47.41g). Both differences between UV-B and C, at W_2 and W_3 as well as, between UV-A and B, at W_3 did not reach to a significant level (Fig.2).

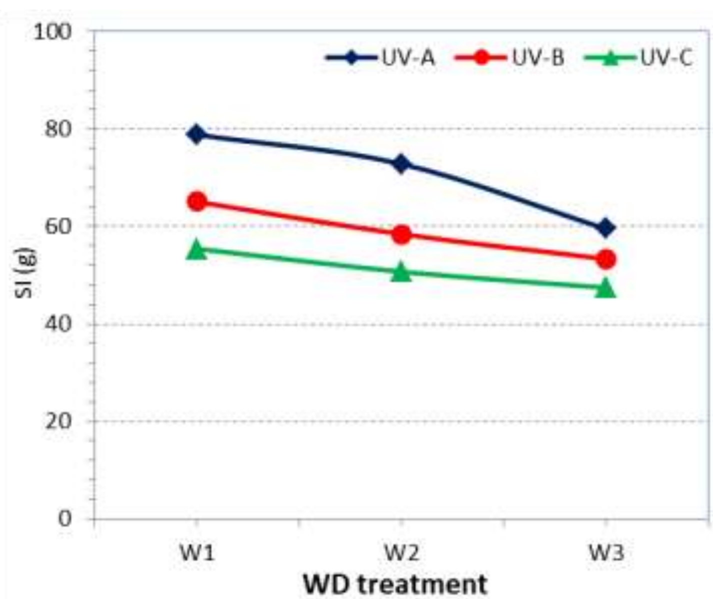

Fig.2:- SI Vs. WD at different UV-BS.

Table (2) shows that, the total production cost of wheat crop "T_C"(£E fed^{-1}) during the 2022-2023season. Data showed that the T_C≈ 17138£E fed^{-1} and the land rent represent about 5835% from T_C. This result is unusual, and conflicted with **Emarahet al., 2022**, who noted that the land rent represented about 39.33% from T_C through the last decades (2010-2020). In connection with previous observation both of **Nassaret al., 2022 and Botros, 2022** mention that the land rent was about 40.19 to 42.14% from T_C. This may be due to the £E floatation (liberalize the exchange rate) and currency depreciation in January 2023, consequently, the rent was adjusted and almost doubled, in light of increasing wheat price from 5667.67 to 10000 £E Mg^{-1}.

Total revenue value "T_R" (£E fed^{-1}), net return "N_R" (£E fed^{-1}), cash flow rate "CFR" and profit rate "P_R" (%) as affected by UV-BS & WD are represented in table (3).

The results presented in table 3 show that highest $T_R$and N_R values (27598.38 and 10460.38 £E fed^{-1}) were recorded at UV-A & W_1 treatment, while, the lowest values (17337.37 and 199.37 £E fed^{-1}) was scored at UV-C & W_3 treatment. Also, the results indicated that PS with UV-C lead to negative significant effects compared with PS with UV-A or B. Likewise, WD had negative relation with both of $T_R$and N_R.

Meanwhile data in the same table showed that, CFR ranged from a minimum value (1.01) at UV-C&W_3 treatment, and maximum value (1.61) at UV-A& W_1 treatment.

Table (2):- Total production cost "T_c" for wheat crop.

Procedure	Item	Cost (£E fed^{-1})
Land preparation	Tillage	770
	Leveling	
Cleansing of waterways		400
Seeds and sowing		960
Fertilizer price	Manure	180
	Chemical	1020
Pesticide price		150
Harvesting	Reaper binder machine	1150
	Thresher machine	1900
Irrigation		500
General expenses		108
Rent		10000
Total production cost		17138

Table (3):- Total revenue "T_R", net return "N_R", cash flow rate "CFR" and profit rate "P_R":

Treatment	"T_R"(£E fed^{-1})	"N_R"(£E fed^{-1})	"CFR"	"P_R" (%)
UV-A & W_1	27598.38	10460.38	1.61	61.04
UV-A & W_2	26269.22	9131.22	1.53	53.28
UV-A & W_3	23166.93	6028.93	1.35	35.18
UV-B & W_1	24268.13	7130.13	1.42	41.60
UV-B & W_2	22153.59	5015.59	1.29	29.27
UV-B & W_3	19596.67	2458.67	1.14	14.35
UV-C & W_1	20547.43	3409.43	1.20	19.89
UV-C & W_2	19301.82	2163.82	1.13	12.63
UV-C & W_3	17337.37	199.37	1.01	1.16

Eventually, the "P_R" recorded more than 50% (at UV-A & W_1 and W_2) treatments, where, it reaches to 61.04% at UV-A&W_1 treatment. Meanwhile, the other treatments were recorded less than 50%, where, P_R ranged from 1.16 to 41.60% (≈ 1.16 to 41.60 PT) at W_3& UV-C and W_1& UV-B treatments.

Irrigation water productivity "IWP" (kg m^{-3}), irrigation water return "IWR" (£E m^{-3}), the crop requirement "CR" (m^3 kg^{-1}) and IWP are considered as an economic indicator for the eff. of irrigation water use **(Mostafa, 2022).**

The UV-BS has been a negative correlation with IWP at all WD treatments. It had a linear correlation with IWP atW_1, while, these correlations became logarithmic at W_2 and W_3. Contrary to the former relations, and with reference to IWP data presented in figure 2 revealed that, there had positive proportions with "WD" at UV-BS treatments. Therefore, enhancing WD percentage at W_3, consequence gradually higher IWP. The highest value of IWP (2.14kg m^{-3}) was recorded at UV-A & W_3. On the other hand, the lowest value (1.33kg m^{-3}) was recorded of UV-C & W_3 treatment. IWP increased about 109.51% ± 2.3 and 117.08% ± 2.13 by decrease deficit percentage from 15 to 0%, and 30 to 0% at UV- A, B and C treatments. Eventually, WD significantly affected on IWP from W_1 to W_3, at all UV-BS, and from W_1 to W_2, at UV-A, but the difference did not approach to significant levels on other treatments (Fig. 3A).

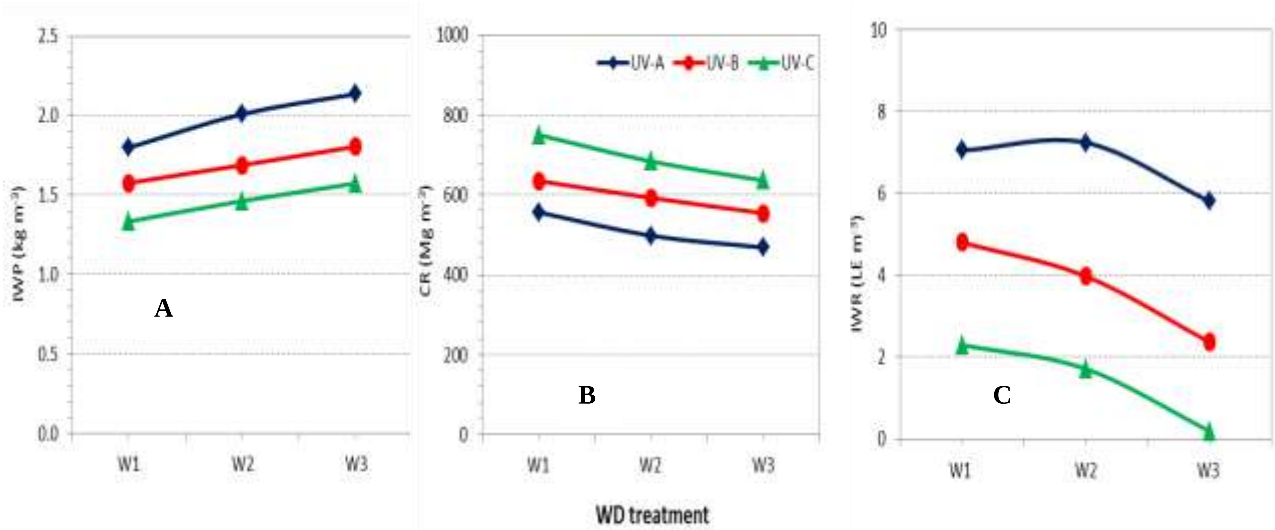

Fig.3:- Effect of UV-BS and WD on some economic indicators for the eff. of irrigation water use; a) IWP (kg m^{-3})., b) "CR" (m^3 Mg^{-1})., and IWR (£E m^{-3}).

IWR has been a negative correlation with both of UV-BS and WD. The IWR decreased about (2.24 and 2.51 £Em^{-3}), (3.26 and 2.26£Em^{-3}) and (3.43 and 2.17 £Em^{-3}) by PS with UV-A to UV-B and C at W_1, W_2 andW_3 respectively. Similarly, IWR decreased from (7.04, 4.80 and 2.30 £Em^{-3}) to (5.80, 2.37 and 0.19£Em^{-3}) by increasing WD from W_1 to W_3, at PS with UV-A, B and C, respectively. The IWR significantly affected by UV- BS from UV-A to UV-B and from UV-B to UV-C at all WD treatments (Fig. 3B).

The crop requirement "CR" (m^3 kg^{-1}) is reciprocal IWP. About 556.15m^3 was required to produce Mg of wheat at UV-A & W_1. The CR was decline to 468.18m^3 at UV-A & W_3 treatment. While, this amount increased to 749.82 and 635.67m^3 at W_1 and W_3, to produce Mg of wheat by PS with UV-C (Fig. 3C).

Solar radiation controls the functioning of terrestrial ecosystem by controlling photobiological processes (photosynthesis, photoperiod, phototropism, etc.). High radiation intensities and spectral composition changes may affect important processes in plants **(Costa *et al*., 2012)**.

The Sun emits ultraviolet light at all three bands UV-A, B and C. But, due to the absorption by the first Ozone layer of the atmosphere, about 99% of ultraviolet rays that reach the earth's surface is UV-A. Almost, 100% of the UV-C rays and 95% of UV-B rays is filtered by Earth's atmosphere. There are three potential targets for UV radiation in plant cells, the genetic system, the photosynthetic system and membrane lipids (**Costa *et al*., 2012**). In recent decades, an increase in the flux of UV-B and C radiations, at the earth's surface due to ozone layer degradation on troposphere by trace gases ,i.e., chlorofluorocarbons (CFC_s), NO_x, chlorine, bromine, etc. **(Caldwell *et al*., 2007)**. Both of them have potentially adverse effects on plant development and agricultural production by decreasing both of biomass production and S_y **(Feng*et al*., 2007).**

The influence of UVaffects the biomembranes dielectric characteristics. Therefore, UV increases the electro potential of biomembranes, through increasing the energy balance, by transforming energyindependent of its origin, into electrical **(Abd El-Rahman 2019).** Consequently, a wide range of biological changes in plants, i.e., biochemical (intensification of the exchange of materials and activation of different stress related metabolic processes, i.e., enzymatic, non-enzymatic antioxidant systems, ascorbic acid, glutathione, tocopherol), physiological, morphological, anatomical, growth responses of plants and pigment accumulation, were attributed to elevated UV radiation UV-B and/or C radiation**(Feng*et al*., 2003**). Several researchers were exploring the mode of action of UV-B radiation at the molecular level in maize **(Dhanya and Puthur 2017).**

UV-C (short wave 200 to 280 nm) is the most energetic and harmful to the DNA **(Balouchiet al., 2009)**. While, UV-B (medium wave 280 to 315nm) enhance the production of reactive oxygen species (ROS) and induce oxidative stress, which causes structural damage to macromolecules and may even result in cell death **(Badridze*et al*., 2016)**.

Wheat plant was considered sensitive to UV-B radiation, enhanced UV-B radiation has a significant negative effect on all parameters related to photosynthesis (growth and biomass production) **(Balouchi*et al*., 2009 and Costa *et al*., 2012)**.

The reduction in B_y may be explained by UV-B made changes in morphological and physiological processes.Where, it altered leaf morphology through, increasing specific leaf area (SLA) and decreases its thickness **(Costa *et al*., 2012)** due to a reduction in cell expansion **(Tsukaya, 2003)**,which itaffected negatively by UV-B and/or C radiation **(Balouchi*et al*., 2009).** Consequently, the light inside the leaves was changed (≈ decrease in the Chl a/ Chl b ratio) due to decrease of total chlorophyll occurred **(Agarwal, 2007)**. Therefore, contributing to lower relative growth rates as a result of negative correlations between SLA and photosynthetic rates **(Costa *et al*., 2012)**. These explain the low results resulting from PS by UV-B and/or C **(Dhanya and Puthur 2017).**

While, UV-A between 320 and 400nm is bit absorbed by O_3. Therefore, that arrives in greater quantity to the surface of the earth, is an important photomorphogenic signal in plants, and is the least harmful.

In the same context, it is obvious from above-mentiond results that UV wavelength had significant constructive effects on all studied parameters without any exception at the 5% level of significance. Where, PS of wheat by UV-A., caused an affirmative effect on criteria of spike, plant biomass, seed yield, SI, HI and IWP.

On the other hand, the former results clarified that, all studied parameters of wheat were affected positively and significantly at the 5% level, following W_3, W_2 and W_1, except IWP.

Drought or moisture stress, is abiotic stress and considered as a major significant environmental constraint causes changes in a number of physiological and biochemical processes governing plant growth and productivity and always affects agricultural productivity **(Costa *et al*., 2012)**, where, the world loss about 51.8Tg year^{-1} from wheat due to drought **(Balouchi*et al*., 2009).**

Growth rate, stem elongation, plant height, leaf expansion and stomatal movements, reduction on B_y and HI, were reduced by decreasing the soil water potential as a result of drought stress **(Costa *et al*., 2012 and Hussein *et al*., 2019)**. These effects may be owing to drought conditions during development stage. It hase a negative effect on leaf area and their functions, i.e., number of cells through cell division and enhancing cell size through cell enlargement and turgidity. Decreasing in the leaf area owing WD, lead to reduced chloroplasts size, causes internal chloroplast membrane degradation. Therefore, reduce total chlorophyll II, and inhibiting photosynthesis rate and its activity. By harms the photosynthetic apparatus**,** restrain the transfer of the stored substance into grains, and consequent accumulation of dry matter, this can be the cause of the decrease of mass and number of seeds/spike, similar results were also realized by **Khalill, 2013**.

Moreover, WD reduce plant leaves relative water content and modifies some enzymes activity and both of sugars and proteins accumulation in the plant, then accelerated days of flowering, with disrupted them**.** On the other hand, WD during plants flowering and booting or milk – ripe stage in the grain filling period- resulted in lower plant growth , reduce assimilate for grain filling and retains location on stored assimilates to the grain which in turn led to a decrease in B_y and yield components, SI, and HI(**Mohammed *et al*., 2018**).

Over and above, plants productivity not only depends on their response to UV radiation but also depends on the interaction with other environmental factors, e.g., drought stresses. Evidence of interrelationship between UV radiation and drought stress in plants has emerged in several plants recent years **(Costa *et al*., 2012)**. Both of them stresses provoke an oxidative burst and functioned synergically (**Balouchi*et al*., 2009)**.

The combined effect of UV-B &C radiations and WD showing a reduction of plant growth and alteration of several physiological and biochemical processes **(Caldwell *et al*., 2007, and Feng*et al*., 2007)**. Both environmental factors act synergistically on plant secondary metabolism by increasing the production of flavonoids **(Hofmann *et al*., 2003)**.

Conclusions:-

For cultivar under studied, both UV-BS radiation and WD, has a stimulatory significant effect ($P \leq 0.05$) on all parameters under current studied. They affected positively following UV-C, B, and A, as well as W_3, W_2 and W_1, this effect may be individually or because of the interaction between them. Where, response of all studied parameters was obviously decreased by withholding water except IWP, and enhanced by increasing UV wavelength. Meanwhile, the IWP has an opposite proportion with WD, and direct proportion with UV wavelength.

Thehighest values of all parameters were recorded with fully irrigation W_1& UV-A treatment. In contrast, the lowest values (week straw + poor crop)were recorded at W_3& UV-C treatment.

Statistically former results showed that there were significant effects between W_1or W_2 to W_3. Meanwhile, the difference between 100 and 85% of ET_Cdid not reach to a significant level. Despite, all traits were recorded over valued at UV-A compared to UV-B and UV-C. Moreover, statistic results showed that there were significant effects between UV-B or UV-C to UV-A. However, this increase was insignificant between UV-B and UV-C.

The results concluded that, the deficit percent might not be increased more than 15%., and UV wavelength might not be less than315nm. Where increasing WD more than 15% lead to increase IWP about 17.12% while, the decreasing ratio on S_y, and N_R were reached to 18.01 and 58.63% respectively.

Meanwhile, decreasing UV wavelength less than315nm leads to decrease IWP, S_y, and N_R about (14.71 and 26.48%), (14.53 and 26.45%), and (42.99 and 77.47%) respectively. While, $P_R$reach to 61.04 PT at UV-A & W_1 treatment. The economic indicators, e.g., IWR and CR have been a negative correlation with both of UV-BS and WD.About 556.15 m^3 was required to produce Mg of wheat at UV-A & W_1 as well as, this quantity decreased to 468.18 m^3 at W_3. While it increased with decreasing UV wavelength at different WD.

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