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EFFECT OF NUTRIENT RATIOS ON GROWTH AND YIELD OF MEDITERRANEAN BARLEY VARIETIES GROWN UNDER WATER STRESS CONDITIONS

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ABSTRACT:

Field experiment was carried out at the experimental research station of Nubaria, representing the sandy loam soil of Egypt. The study was done to evaluate the effect of nutrient ratios on growth and yield of Mediterranean barley varieties; Egyptian (Giza 126), Tunisian (Rihane), Algerian (Ras El-Mouche) and Morocco (Adrar) grown under sufficient and deficit irrigation conditions. The foliar applied nutrient ratios were used in different proportions: (19N:19P:19K), (10N:55P:10K) and (6N:6P:43K). The higher values of chlorophyll content were obtained after application of (19N:19P:19K) in Adrar followed by Rihane barley variety whereas; the lowest ones were recorded at control treatments. The maximum values of the relative water content were observed after fertilizer ratios (10N:55P:10K) under water stress. Foliar application of fertilizer (6N:6P:43K) has a great impact on the K content especially at Ras El-Mouche and Ksar. Resulted data showed that the highest values of plant height, spike length and number of spike/m2 were attained at Adrar and Ras El Mouch under water stress condition. It's clear that the biological yield was highly at Rihane after application of (19N:19P:19K) and Ksar (6N:6P:43K) under deficit irrigation condition. Grain yield decreased with increasing drought stress and while, water use efficiency increased by increasing water stress. The foliar spraying of fertilizer ratio (19N:19P:19K) was better to improve the growth and yield parameters and nutrient contents under drought stress conditions of arid and semi-arid areas of North African countries. So, the balanced fertilization is important to maintain sustainable production of barley under water stress condition.

Keywords: *NPK fertilizers, barley, water stress, grain yield, proline, nutrient content.*

INTRODUCTION:

Drought, one of the significant abiotic stresses, occurs when water potential and turgor are reduced to the point where they impair normal metabolic functions and the plant's reproductive capacity (Ahmed et al., 2014). Drought has been called one of the most severe threats to the environment the world's population faces today (Abbasi and Abbasi, 2010), (Anjum et al., 2011), It is foretold to become more prevalent and severe in many locations due to reduced rainfall and higher evaporation owing to global climate change (Diatta, et al., 2020). Plants have adopted certain mechanisms to respond to various environmental stresses. Maintenance of turgor through the accumulation of osmoprotectants, reduction in rate of transpiration and closure of stomata help to minimize the drastic effects of drought stress (Nawaz et al., 2013). Plants cultivated in open fields often encounter abiotic stresses throughout their lives, impacting their development and output, particularly for longer durations (Seleiman et al., 2021).

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Barley (Hordeum vulgare L.) ranks fifth among field crops in grain production in the world after maize, wheat, rice and soybean (FAO, 2008). In recent years, about two thirds of barley crop has been used for feed, one-third for malting and about 2% directly for food (Baik and Ullrich, 2008). Barley (Hordeum vulgare) has the widest ecological range of adaptation among the cereals, which is grown throughout the temperate and tropical areas of the world. It has low cost of production and input requirement, so it is preferred by the resource poor farmers in the country. Barley grains are considered for valuable input for productions for removing malt to be utilized in preparing, distillation, baby foods, cocoa malt and drinks. Its straw is a good quality fodder for livestock (Meena et al. 2012). Barley (Hordeum vulgare L.) is considered to be the best drought tolerant of the grain cereals, which is grown as the main annual rain-fed crop and considered as a low risk crop. (Kilic et al., 2010). In Egypt, barley is considered a main crop which is grown in both rain fed and favorable irrigated soils of the Nile Valley, but drought stress causes reduction on barley grain yield production which is harshly affected by rain-fed area conditions (Forster et al., 2004). Barley is the fourth most-produced cereal worldwide behind wheat, rice and maize. Its primary use is to serve as raw material for malt and beer, being the grain type important for such products (Wei et al. 2009). However, little attention has been focused on the effects of long-term chemical fertilization and the relation between grain yield and nutrient concentration in the grain (Hejcman et al. 2013).

Fertilizer management can strongly affect crop productivity under conditions of drought.Thus, the addition of nutrients can whichever enhance or reduction plants resistance to drought or have no effect at all, depending on the level of water availability. For instance, under drought condition, the fertilizer induced increase in plant growth results in higher water use during the early vegetative period and may have adverse effects through increasing drought stress at critical growth stages. In contrast, the raise of root growth by mineral application under drought condition may enable the removal of water and nutrients from deeper soil layers (Hussein et al. 2013). El-Zieny et al. (1990) reported that the interaction effect of K and water deficit on the uptake of N, P and K in different parts of barley plants. Foliarly applied NPK fertilizers significantly donate towards improved yield through upsurge in biomass of the plants (Ling & Silberbush, 2002). The positive effect of foliar applied nitrogen (N), phosphorus (P), and potassium (K) to sustain good leaf nutrition as well as carbon balance, and refining photosynthetic capacity is well established (Ihsan et al., 2013). Foliar application of NPK in combination was more effective as compared to alone application of N, P, K, or in combinations of two nutrients under both non-stress and water stress conditions (Noack et al., 2010). The aim of the research work was to evaluate the effect of nutrient ratios foliar application on growth and yield of Mediterranean barley grown under drought stress condition.

MATERIAL AND METHODS

1-Experimental design

Field experiment was conducted during winter season of 2019 and 2020 to study the effect of fertilizer application on the biochemical change and yield of Mediterranean barley varieties grown under water stress condition at the Experimental Research Farm of National Research Centre, Nubaria region, Egypt (latitude 30.87 N, and longitude 31.17 E, and mean elevate 21 m above sea level). The experimental area was classified as parched locale with cool winter and sweltering dry summer winning in the experimental area. There was no effective rainfall (low intensity) that can be taken into consideration throughout the two growing seasons. The soil of experimental site is classified as sandy

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soil. The field capacity and available water of the experimental soil was 17.2 and 11.8 ml /100g soil, respectively. Soil pH was 7.91; electrical conductivity 0.96 dS m^{-1} and available N, P and K were 2.76, 0.53 and 18.8 mg/100 g soil, respectively. The grains of the all cultivated barley varieties were obtained from National gene bank of Tunisia. The soil was prepared as usually done in traditional cultivation. All agronomic practices were followed during the growing season as recommended by the Agricultural Research Centre, Ministry of Agricultural and Soil Reclamation, Egyptian.

2-Irrigation Treatments

Three drip irrigation regimes were applied as a percentage of the crop evapotranspiration (ETc) computed according to Allen et al. (1998)

$$\mathbf{ETc = ETo \times Kc}$$

Where: ETc = crop water requirements (mm d^{-1}), ETo is the reference evapotranspiration (mm d^{-1}) and Kc = crop coefficient. ETo was determined according to Allen *et al.* (1998) as follows:

$$\mathbf{ETo = Epan \times Kp}$$

Where: Epan is the evaporation from a class A and Kp is the pan coefficient.

The plants in all plots were irrigated at 10 days intervals by different amounts of water. The amounts of irrigation water were determined by using the following equation:

$$\mathbf{IWA = \frac{A \times ETc \times Ii}{Ea \times 1000}}$$

Where: IWA is the irrigation water application (m^3), A is the plot area (m^2), ETc is the reference evapotranspiration (mm day^{-1}), Ii is the irrigation intervals (day), and Ea is the application efficiency (%). The amount of irrigation water application (IWA) was controlled through a plastic pipe (spiles) of 50 mm diameter. One spile per plot was used to convey water for each plot. The amount of water delivered through a plastic pipe was calculated according to Israelsen and Hansen (1962).

$$\mathbf{Q = CA\sqrt{2gh}\,10^{-3}}$$

Where: Q is the discharge of irrigation water (l sec^{-1}), C is the coefficient of discharge, A is cross section area of irrigation pipe (cm^2), g is gravity acceleration (cm sec^{-2}) and h is the average of the effective head of water (cm). The amounts of irrigation water applied were "900 and 450" m^3 fed^{-1} to fulfill sufficient irrigation (SI) and deficit irrigation (DI), respectively. Irrigation treatments were started after full emergence (after 15 days from sowing date).

3-Barley cultivars

The Mediterranean barley varieties were used for the field experiment are Egyptian variety (Giza 126 and Ksar), Tunisian variety (Rihane), Algerian variety (Ras El-Mouche) and Morocco variety (Adrar).The seeds of the selected varieties obtained from National gene bank of Tunisia. Sowing dates were November 25^{th} 2019 and replicated in November 20^{th} 2020 winter season. The soil preparation was done as the traditional cultivation.

4-Fertilization treatment

The nutrient ratios (19N:19P:19K), (10N:55P:10K) and (6N:6P:43K) foliar applied (2%) twice during the

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growth period of barley plant after 40 and 60 days from sowing date. All plots received the recommended dose of NPK fertilizers as soil application.

5- Estimation at heading stage

Chlorophyll content

Leaf greenness present in a plant was determined with the Minolta-SPAD Chlorophyll Meter (Minolta Camera Co., Osaka, Japan). The SPAD-502 chlorophyll meter measures the chlorophyll absorbance in the red and near-infrared regions and calculates a numeric SPAD value which is proportional to the amount of chlorophyll in the leaf **Minolta (1989)**.

Relative water content

Leaf relative water content (RWC) was evaluated by **Castillo (1996)** for every dry spell period. For these ten fully matured leaves of five plants/plot (2 leaves per plant) were selected from the same heights and their fresh weight (FW) was recorded. The leaves were drenched into refined water under low lighting conditions for 24 h to gauge their immersed weight. After recording turgescence weight (TW), leaves were dried at 75 °C for 48 h and their dry weights (D.W) were measured. RWC was calculated by using formula: RWC = (FW-DW)/(TW-DW) × 100

Determination of proline

First, 0.4 g of fresh plant material was homogenized in 1.5 ml of distilled water and then incubated in water bath at 100 °C for 30 min. Then, the samples were cooled to room temperature (22 °C) and centrifuged for 10 min at 4 000 rpm. Next, 1 ml of a 1% solution of Ninhydrin in 60% acetic acid was added to 0.5 ml of the supernatant and incubated at 100 °C for 20 min. After cooling to 22 °C, 3 ml of toluene was added and the samples were shaken and left in the dark for 24 h for phase separation. One ml of proline extract was introduced to a cuvette and the absorbance was measured by spectrophotometer at a wavelength 520 nm according to **(Bates *et al.* 1973).**

6- Yield components estimation

At harvest in both years, the total area of each plot was harvested to determine potential grain yield (Yp) and stress yield (Ys) per plot and then converted to grain yield ton acre^{-1}. Ten individual plants were selected at harvest time as random from the middle of each plot to estimate:

Plant height (cm): Height of 10 random plants per plot measured as a distance from the bases of the culms to the tips of spikes. Data collected was averaged to be per plant.

Number of Spikes m^{-2}: It was taken randomly inside each plot, and then it was transformed into spikes per square meter.

Spike weight (g): It was expressed as average of ten spikes weight from each plot.

1000-kernel weight (g): It was estimated as the weight of 1000 cleaned kernels in gram for each plot.

Biological yield: The total biomass of the harvested plants (Kg plot^{-1}), then it was transformed into ton per acre.

Grain yield: It was obtained as the weight of clean grains of the plot after threshing, and then it was transformed into ton per acre.

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Harvest index: HI =grain yield/biological yield into 100.

Water use efficiency: WUE, expressed in; (kg m^{-3}) on grain basis was determined by dividing the grain yield (kg $acre^{-1}$) by quantity of water applied (m^3 $acre^{-1}$).

7-Nutrient content analysis

At heading and harvest stage, representative leaves and grain samples were analyzed for the nutrient content (N, P, K, Ca and Fe, Mn, Zn) in barley varieties and determined according to **Cottenie *et al.,* (1982) and Motsara and Roy (2008).**

8-Statistical analysis

Data of two growing seasons were measurably broke down as a split plot design (RCBD) utilizing examination of variance (ANOVA) and the means of varieties included in this trial compared using fisher test run by (LSD) at (P = 0.05) according to **Gomez and Gomez (1984)**.

RESULTS AND DISCUSSION

Pigment content:

Table (1) illustrated the effect of foliar application of N:P:K fertilizer ratios (19N:19N:19K), (10N:55P:10K) and (6N:6P:43K) on chlorophyll content at stem elongation and ear emergency growth stages of barley varieties (Giza126, Ksar, Rihane, Ras El-Mouche and Adrar) grown under sufficient irrigation (SI) and deficit irrigation (DI) treatments. Data on hand revealed that the highest values of chlorophyll content (53.5 and 38.4) were obtained after foliar application of 19N:19P:19K and the lowest ones (44.7 and 31.1) were recorded at control treatments under sufficient and deficit irrigation treatment, respectively.

Also, it is clear to mention that the maximum values of chlorophyll (50.5 and 36.5) were observed at Adrar barley variety and the lowest values (48.5 and 36.0) recorded for Ras El-Mouch barley variety under sufficient irrigation and deficit irrigation treatments, respectively. Whereas, at ear emergency growth stages, the highest chlorophyll content (56.8 and 35.6) observed for barley Giza 126 after foliar application of 19N:19P:19K under sufficient irrigation and deficit irrigation treatments.

Data noticed that the chlorophyll content increased with increase fertilizer applied ratios under both irrigation treatments and relative to the fertilizer types. The highest increase percentage (24.6 and 26.3%) in chlorophyll content was attained at ear emergency stage after foliar application the fertilizer ratio 19N:19P:19K and the lowest one (10.7 and 15.0%) observed with foliar application of 6N:6P:43K at stem elongation stage as compare to control treatment. Regardless water stress, it is easy to arrange the fertilizer used in our experiment relative to its effect on the SPAD chlorophyll at stem elongation and ear emergency growth stages in descending order as follows: 19N:19N:19K >10N:55P:10K>6N:6P:43K> Control, respectively.

Many investigators have reported the nutritional requirements of micronutrients for some plants. They concluded that NPK fertilizers had an important physiological and biochemical functions on structure of photosynthetic pigments, metabolism of carbohydrates and protein (Badran et al., 2007) and (Farid Hellal et al., 2020).

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Table (1): Chlorophyll content of barley as affected by fertilizers application

Barley varieties	NPK ratios	Stem elongation		Ear emergency	
		SI	DI	SI	DI
Giza 126	control	41.8	29.7	45.2	29.1
	19N:19P:19K	52.6	37.6	63.3	38.1
	10N:55P:10K	48.1	35.1	60.0	36.1
	6N:6P:43K	49.0	33.3	58.7	39.0
Ksar Magrain	control	44.2	32.0	43.6	27.3
	19N:19P:19K	54.0	38.3	55.6	36.4
	10N:55P:10K	54.0	36.4	51.6	31.2
	6N:6P:43K	50.5	35.8	53.0	31.4
Rihane	control	47.3	28.8	45.5	29.7
	19N:19P:19K	54.1	40.0	50.9	35.5
	10N:55P:10K	51.9	37.1	48.4	34.2
	6N:6P:43K	47.5	36.4	46.1	34.3
Ras El-Mouch	control	44.2	32.1	44.9	27.8
	19N:19P:19K	52.6	37.9	56.4	35.3
	10N:55P:10K	48.7	36.2	48.2	31.7
	6N:6P:43K	48.5	37.8	53.2	30.9
Adrar	control	46.1	33.0	45.6	29.1
	19N:19P:19K	54.2	38.4	54.1	35.3
	10N:55P:10K	50.0	38.8	52.2	33.7
	6N:6P:43K	51.9	35.6	50.9	32.0
LSD 0.05	Varieties	1.80	1.53	1.42	1.03
	NPK ratio	1.61	1.36	1.27	0.92
	Interaction	3.26	2.77	2.58	1.86

SI: Sufficient irrigation, **DI:** Deficit Irrigation

Relative Water Content and Proline:

Data in Table (2) indicated that, the effect of foliar application of NPK ratios (19N:19N:19K) and (10N:55P:10K) and (6N:6P:43K) as well as control treatment on the relative water content (RWC) and proline content of barley varieties (Giza126, Ksar, Rihane, Ras El-Mouche and Adrar). Data noticed that increasing water stress was associated with decrease in RWC. The maximum values (93.6 and 74.9%) of the RWC were observed after foliar application of 10N:55P:10K, while the minimum ones (82.1 and 51.9%) were observed at control of no foliar fertilizer applied under sufficient irrigation and water stress treatments, respectively. Regarding to the barley varieties as affected by fertilizer application, data noticed that Giza 126 and Ksar scored the highest values of RWC (90.4%) under SI treatment, while Giza 126 individually scored the highest values (72.6%) of RWC under DI treatment and its values were doubled the other barley varieties in same sequences whereas, the lowest ones (60.7%) were recorded at Ksar barley variety under deficit irrigation treatment.

Data noticed that proline content of the studied barley varieties was higher under water stress

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treatments over sufficient irrigation treatment. Respecting to the proline content of examined barley varieties as affected water stress and fertilizer application treatments, resulted data pointed out that barley Giza 126 scored the maximum proline content (3.54) under deficit irrigation. From the other hand, the lowest values of the proline observed at Adrar (1.15) and Rihane (1.22) under sufficient irrigation treatment, respectively. Results are in accordance with (Ahmed, et al., 2011 and Mohamed et al., 2011).

According to the foliar application of the fertilizer ratios on the proline content, estimated data indicated that the maximum values of proline content of the studied variables were recorded at control (1.78) and fertilizer ratio 10N:55P:10K (1.47) and the lowest values observed at the fertilizer ratio 19N:19P:19K (0.93) under SI treatments. Whereas, under water stress treatment (DI), the minimum values (2.46) were observed at the fertilizer ratio 19N:19P:19K and the maximum values reported for control (3.58) and the fertilizer ratio 6N:6P:43K (3.15), respectively.

Table 2: RWC and proline content of barley as affected by fertilizers application

Barley varieties	NPK ratios	Relative water content (%)		Proline (mg g F.wt)	
		SI	DI	SI	DI
Giza 126	**control**	81.90	55.50	1.47	4.11
	19N:19P:19K	93.50	81.10	0.98	3.01
	10N:55P:10K	90.30	78.60	1.98	3.14
	6N:6P:43K	95.80	75.10	1.35	3.89
Ksar Magrain	**control**	76.90	46.10	1.65	2.67
	19N:19P:19K	91.80	68.20	1.86	2.03
	10N:55P:10K	97.00	72.80	1.88	2.41
	6N:6P:43K	95.80	55.80	0.57	2.87
Rihane	**control**	86.90	50.30	2.03	3.75
	19N:19P:19K	90.30	79.00	0.39	2.54
	10N:55P:10K	89.10	76.20	0.98	2.57
	6N:6P:43K	91.90	80.50	1.47	2.79
Ras El-Mouch	**control**	85.10	62.60	2.11	3.53
	19N:19P:19K	87.30	64.50	1.02	2.51
	10N:55P:10K	96.30	71.80	1.33	2.63
	6N:6P:43K	90.80	74.70	1.63	3.14
Adrar	**control**	79.70	44.80	1.66	3.84
	19N:19P:19K	87.60	68.70	0.39	2.20
	10N:55P:10K	95.30	75.10	1.17	2.87
	6N:6P:43K	91.20	75.00	1.39	3.04
LSD 0.05	**Varieties**	1.62	2.34	0.064	0.091
	NPK ratio	1.45	2.1	0.057	0.082
	Interaction	2.94	4.25	0.116	0.165
SI: Sufficient irrigation, **DI:** Deficit Irrigation					

The highest values were of proline content of all investigated barley varieties registered in control treatment of no foliar fertilizer applied, while the lowest values were recorded after foliar application

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of fertilizer ratio 19N:19P:19K under both irrigation treatments. NPK fertilizer plays important roles in different physiological processes in the plant which were described by Lambers et al., (2000).

The role of nitrogen in protoplasm formation and all proteins e.g. amino acids, nucleic acid, many enzymes and energy transfer materials ADP and ATP (Russel, 1973). The role of phosphorus as a major nutrient element, where phosphorus compounds are of absolute necessity for all living organisms, nucleo proteins constituting the essential substances of the cell and for cell division and development of meristematic tissues (Yagodin, 1982) and potassium is important for growth and elongation probably due to its purpose as an osmaticum and may react synergistically with IAA. Moreover, it promotes CO2 integration and translocation of carbohydrates from the leaves to storage tissues (Mengel and Kirkby, 1987).

Yield parameters:

Table (3) showed the effect of mineral fertilizes differ in N:P:K ratio (19N:19P:19K), (10N:55P:10K); (6N:6P:43K) in addition to the control (untreated) on some yield parameters of barley varieties (Giza 126, Ksar, Rihane, Ras El-Mouch, Adrar) under water stress treatments.

Table 3: Mineral fertilizers effects on barley growth parameters under water stress.

Barley varieties	NPK ratios	Plant height (cm)		Spike length (cm)		Spike number /m²	
		SI	DI	SI	DI	SI	DI
Giza 126	control	75.0	50.0	8.47	5.13	274	184
	19N:19P:19K	81.7	66.7	9.80	7.13	461	307
	10N:55P:10K	85.0	71.2	9.47	6.80	470	355
	6N:6P:43K	82.7	75.0	10.13	7.47	418	288
Ksar Magrain	control	75.0	56.7	8.13	6.13	399	211
	19N:19P:19K	80.0	61.7	9.13	5.47	436	353
	10N:55P:10K	83.3	71.6	9.80	7.80	472	363
	6N:6P:43K	83.3	68.3	9.47	7.13	466	362
Rihane	control	71.7	40.0	7.13	3.80	318	213
	19N:19P:19K	83.3	60.0	9.47	6.80	376	309
	10N:55P:10K	81.4	70.0	9.80	6.13	344	291
	6N:6P:43K	86.7	75.0	9.13	8.13	418	286
Ras El-Mouch	control	71.7	53.3	6.80	5.13	321	190
	19N:19P:19K	83.3	75.0	9.47	8.13	483	285
	10N:55P:10K	79.3	73.3	9.63	6.80	399	256
	6N:6P:43K	80.0	68.3	8.80	7.13	475	267
Adrar	control	76.7	53.3	6.97	5.47	386	201
	19N:19P:19K	88.3	71.7	10.13	7.63	485	315
	10N:55P:10K	88.5	75.0	9.80	6.63	391	267
	6N:6P:43K	81.7	68.3	9.47	7.13	469	323
LSD 0.05	Varieties	7.90	5.97	0.89	1.15	34.73	30.35
	NPK ratio	NS	5.35	0.80	1.03	31.06	27.15
	Interaction	7.07	9.11	1.32	1.95	55.17	48.92

SI: Sufficient irrigation, **DI:** Deficit Irrigation

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It is clear to mention that values of the studied parameters decreased by increasing water stress. Resulted data showed that the highest values of Plant height (Adrar, 83.8), spike length (Giza 126, 9.47) and number of spike/m2 (Ksar, 443) under adequate irrigation treatment. Whereas, the studied barley varieties (Adrar, Ras El-Mouch and Ksar) produced the higher values of plant height (67.1)), spike length (6.80) and number of spike/m2 (322) under water stress, respectively. Whereas, the lowest values were attained at control (untreated).

Regardless water stress effect, the highest values of the plant height, spike length and number of spike/m2 were obtained after foliar application of the fertilizer ratio of 19N:19P:19K followed by 10N:55P:10K and 6N:6P:43K. Also, the highest plant height, spike length and number of spike/m2 were obtained at Adrar barley variety received foliar application of 19N:19P:19K under irrigation water treatments. Davary and Farah, (2014) showed that the effect of biological and chemical fertilizers was significant on all of parameters (plant height, stem diameter and total fresh and dry weight). Regarding to the mean values of the examined yield parameters (plant height, number of spike /m2, spike length), Adrar followed by Ksar scored the highest values under different water stress treatment and these values decreased with increasing water stress effect. Whereas, ignore water stress treatments, Adrar followed by Giza 126 gave the highest values. The lowest was obtained in the basil barley variety for yield coefficient. Winter, winter plants, immediately need nutrients during the early stages of establishment and growth. The primary means of this need is mineral fertilization (Mehraban, 2014). However, the use of HS or organic compounds as mineral fertilizers positively affects root growth, nutrient absorption, chlorophyll synthesis, seed germination and microbial activity.

Biological and grain yield:

Data in Table (4) illustrated the effect of foliar application of NPK fertilizer ratios on the biological, grain yield and water use efficiency (WUE) of the investigated barley varieties under water stress treatments. Data revealed that values of the biological, grain yield decreased with increasing water stress. While, the opposite was true in case of WUE that increased by increasing water stress. Data noticed that the biological and grain yield increased with increasing fertilizer applied ratios under both irrigation treatments and relative to the fertilizer types.

Data on hand revealed that the highest values of biological (6.62 and 3.15 ton fed-1) and grain yield (2.45 and 1.41 ton fed-1) were obtained after foliar application of 19N:19P:19K and the lowest ones recorded at control treatments under sufficient and deficit irrigation treatment, respectively. Also, it is clear to mention that the maximum values of grain yield (2.57 and 1.33 ton fed-1) was observed at Ksar barley variety and the lowest values (2.04 and 1.15 ton fed-1) recorded for Rihane barley variety under sufficient irrigation and deficit irrigation treatments, respectively. Regardless water stress, it is easy to arrange the fertilizer used in our experiment relative to its effect on the biological and grain yield in descending order as follows: 19N:19N:19K >10N:55P:10K> 6N:6P:43K > Control, respectively. Organic and inorganic fertilizers change the crop quality according to their different potential abilities.

Inorganic fertilizers are generally more soluble and available at the high plant demand, but organic manure releases minerals slowly which may not be fully available during the critical period of plant demand (Worthington, 2001). El-Ashry and El-Amin (2004) reported the effect of the interaction of water deficit and fertilization on growth, yield and mineral status of cereal crops. The obtained results were in accordance with those mentioned by Nofal et al., (2001) and Joshi et al., (2003) and Farid

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Hellal et al., (2019). With respect to the effect of fertilizers used resulted, data in Figure (1) showed that the maximum values attained mainly at 19N:19P:19K under all studied water stress treatment that negatively affected on the parameters where the opposite was true in case of WUE. Also, all lowest values were obtained at control (untreated one).

Table (4): Mineral fertilizer effects on biological yield of barley under water stress

Barley varieties	NPK ratios	Biological yield (ton fed^{-1})		Grain yield (ton fed^{-1})		Harvest	
		SI	DI	SI	DI	SI	DI
Giza 126	control	5.20	2.70	1.99	1.06	38.27	39.26
	19N:19P:19K	6.80	3.31	2.66	1.39	39.16	41.99
	10N:55P:10K	5.20	3.06	2.24	1.25	43.09	40.71
	6N:6P:43K	5.60	3.20	2.90	1.42	51.84	44.38
Ksar	control	5.00	1.82	2.05	0.92	41.04	50.42
	19N:19P:19K	6.80	3.40	2.41	1.66	35.51	48.73
	10N:55P:10K	5.20	2.23	3.00	1.64	57.65	73.43
	6N:6P:43K	5.40	3.50	2.83	1.09	52.34	31.11
Rihane	control	4.40	1.32	1.70	1.08	38.58	81.82
	19N:19P:19K	6.60	3.20	2.13	1.38	32.30	43.21
	10N:55P:10K	8.00	1.40	2.55	1.29	31.93	91.83
	6N:6P:43K	5.80	1.40	1.76	0.85	30.30	60.61
Ras El-Mouch	control	4.80	1.86	2.13	0.87	44.35	46.77
	19N:19P:19K	6.80	2.80	2.77	1.02	40.70	36.49
	10N:55P:10K	5.20	2.61	2.37	1.39	45.52	53.36
	6N:6P:43K	7.00	2.32	2.28	1.31	32.58	56.42
Adrar	control	4.40	2.33	1.61	0.82	36.56	35.19
	19N:19P:19K	6.11	3.02	2.29	1.58	37.51	52.21
	10N:55P:10K	5.87	3.06	1.91	1.30	32.48	42.38
	6N:6P:43K	5.30	2.85	3.17	1.11	59.79	38.95
LSD 0.05	Varieties	1.76	1.24	0.078	0.06		
	Nutrient ratio	1.38	0.98	0.062	0.047		
	Interaction	2.81	1.98	0.125	0.096		

SI: Sufficient irrigation, **DI:** Deficit Irrigation

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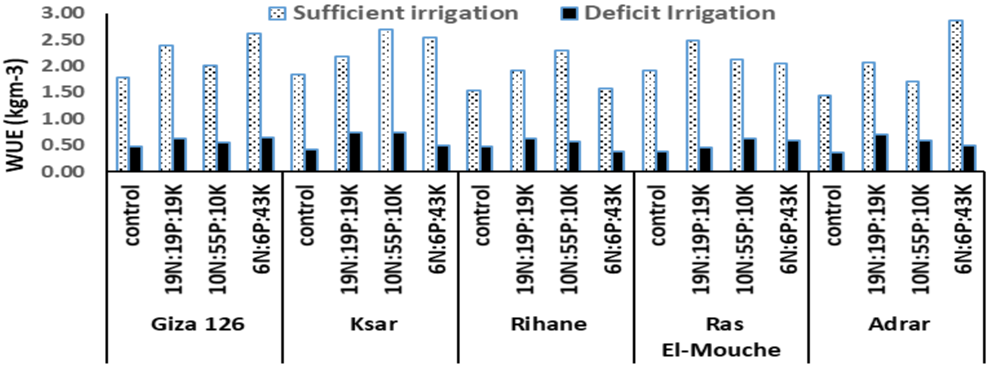

Fig (1): Nutrient ratios effects on water use efficincy of barley

Data on hand revealed that the highest values of water use efficiency were obtained after foliar application of 19N:19P:19K and the lowest ones were recorded at control treatments under sufficient and deficit irrigation treatment, respectively. Also, it is clear to mention that the maximum values of WUE was observed at Adrar barley variety and the lowest values recorded for Ras El-Mouch barley variety under sufficient irrigation and deficit irrigation treatments, respectively. Foremost among the factors acting crop yields and WUE are essential plant nutrients, especially nitrogen (N), phosphorus (P) and, to a lesser extent, potassium (K), some secondary nutrients and micronutrients. Adequate nutrition of crops, especially involving chemical fertilizers, is as vital to food security in dry areas of the world as it is globally (Roy et al., 2006).

Macronutrient contents of barley grains:

Data in Table (5) showed the effect of the examined fertilizers ratios on macronutrient content of on the Mediterranean barley varieties (Giza 125, Ksar, Rihane, Ras El-Mouch and Adrar) grown under water stress treatment. Data noticed that the N, P and K content increased with increasing fertilizer applied ratios under both irrigation treatments and relative to the fertilizer types. The lowest values of N, P and K were observed under control and highest one was scored at 10N:55P:10K for phosphorus and 6N:6P:43K for potassium and calcium. The foliar application method is typically preferred because very small amounts of fertilizers are applied per unit area and decrease ground water pollution.

Many detectives concluded that foliar application of nutrients sources during growth stage increased grain and straw yields, grain weight, biological yield, grain nutrients concentration and uptake as well as grain protein content (Parvez et al., 2009, and Wazir et al., 2011). Regarding the studied barley varieties, the highest N, P and K content (2.93-Rihane, 0.165-Ksar and 0.732-Ras El-Mouch) under sufficient irrigation condition. While, under deficit irrigation treatments, the highest N, P and K content (2.79-Ksar, 0.106-Ras El-Mouch and 0.387-Ksar) as compare to other barley varieties, respectively.

These results are in arrangement Saied and Farid (2019) and Abdou et al., (2004) on fennel and Sabra (2014) found that supplying khella plants with NPK fertilization led to significant increase in nitrogen, phosphorus and potassium percentages.

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Table 5: Nutrient ratios effects on Macronutrient contents of barley grains

Barley varieties	NPK ratios	Nitrogen (%)		Phosphorus (%)		Potassium (%)	
		SI	DI	SI	DI	SI	DI
Giza 126	control	2.18	1.62	0.139	0.066	0.505	0.284
	19N:19P:19K	2.96	2.74	0.145	0.097	0.553	0.296
	10N:55P:10K	2.97	2.25	0.167	0.114	0.611	0.376
	6N:6P:43K	2.70	1.95	0.158	0.106	0.775	0.406
Ksar Migraine	control	2.07	1.83	0.135	0.075	0.55	0.253
	19N:19P:19K	3.66	3.26	0.156	0.082	0.59	0.37
	10N:55P:10K	2.98	2.41	0.194	0.124	0.612	0.399
	6N:6P:43K	2.91	2.65	0.173	0.104	0.969	0.526
Rihane	control	2.60	2.18	0.122	0.041	0.554	0.223
	19N:19P:19K	3.21	2.62	0.148	0.078	0.597	0.352
	10N:55P:10K	3.15	2.22	0.207	0.128	0.665	0.424
	6N:6P:43K	2.74	2.08	0.162	0.08	0.665	0.432
Ras El-Mouch	control	2.35	1.53	0.12	0.077	0.59	0.267
	19N:19P:19K	3.09	2.38	0.138	0.1	0.653	0.37
	10N:55P:10K	2.60	2.33	0.193	0.134	0.687	0.378
	6N:6P:43K	2.44	1.95	0.185	0.111	0.997	0.39
Adrar	control	2.53	1.75	0.132	0.046	0.572	0.304
	19N:19P:19K	3.07	2.95	0.148	0.097	0.644	0.32
	10N:55P:10K	2.92	2.74	0.188	0.11	0.679	0.378
	6N:6P:43K	2.83	2.23	0.16	0.104	0.751	0.455
LSD 0.05	Varieties	0.017	0.012	0.021	0.014	0.045	0.018
	NPK ratio	0.012	0.009	0.015	0.011	0.032	0.014
	Interaction	0.023	0.018	0.033	0.022	0.071	0.028

SI: Sufficient irrigation, **DI:** Deficit Irrigation

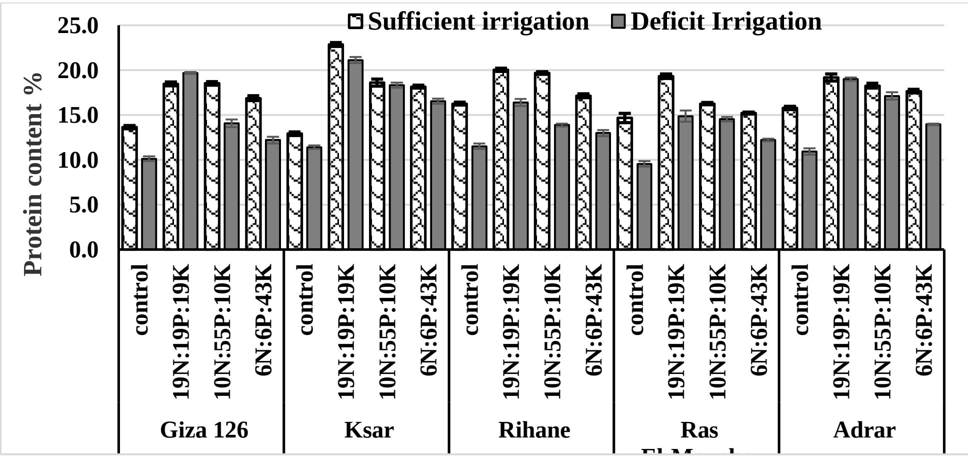

Fig (2): Nutrient ratios effects on protein contents of barley grains

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Foliar application of NPK ratio increased protein content in barley varieties under both irrigation water treatments. Under deficit irrigation treatment, the highest values of protein content registered for Ksar barley variety after application the nutrient ratio 19N: 19P: 19K over remaining treatment and the lowest values reported for control treatment without foliar application of N:P:K ratio (Figure 2).

Micronutrient contents of barley grains:

Data manifested in Table (6) showed effect of different complex fertilizers on the Fe, Mn and Zn content of the selected barley varieties under different water stress. Resulted data noticed that the highest values attained after 19N:19P:19K application at Adrar (181 ppm Fe), Ras El-Mouch (14.5 ppm Mn) and Ras El-Mouch (31.6 ppm Zn) and the lowest ones were observed at Ksar for Fe and Zn and Rihane for Zn under SI treatment. At water stress treatment, the highest values of Fe (80.8 ppm) registered for Barley Giza 126, Mn (6.87 ppm) for Ksar, Zn (12.5 ppm) for Rihane barley variety, respectively.

Table 6: Nutrient ratios effects on Micronutrient contents of barley grain under water stress

Barley varieties	NPK ratios	Iron (ppm)		Manganese (ppm)		Zinc (ppm)	
		SI	**DI**	**SI**	**DI**	**SI**	**DI**
Giza 126	**control**	157.3	73.5	8.57	3.08	18.4	7.0
	19N:19P:19K	165.3	96.6	13.72	4.36	19.7	7.5
	10N:55P:10K	161.3	77.1	12.43	4.12	20.4	9.7
	6N:6P:43K	160	75.9	11.5	3.87	38.1	10.5
Ksar	**control**	105.7	66.3	8.47	4.77	24.7	9.9
	19N:19P:19K	130.6	89.7	13.5	8.98	34	12.8
	10N:55P:10K	121.2	86	12.88	7.02	27.3	11.9
	6N:6P:43K	120.2	78.1	11.32	6.69	31.8	12
Rihane	**control**	109.1	37.7	12.12	5.49	18.6	10.8
	19N:19P:19K	141.6	48.5	16.63	7.38	22.2	13.8
	10N:55P:10K	134.7	44.3	14.1	6.53	20.2	12.9
	6N:6P:43K	133.4	39.7	14.41	6.17	19.1	12.3
Ras El-Mouch	**control**	132.6	40.2	11.67	4.26	22.5	10.3
	19N:19P:19K	184.1	111.7	16.81	6.03	38.7	13.9
	10N:55P:10K	172.8	90.1	14.44	5.84	34.5	11.8
	6N:6P:43K	145.4	78.2	15.08	5.61	30.5	11.6
Adrar	**control**	150.8	52.7	10.61	3.02	20	8.5
	19N:19P:19K	202.8	89.9	13.23	7.25	27.3	13.2
	10N:55P:10K	190.7	63.9	11.95	5.32	22.7	12.0
	6N:6P:43K	183	60.0	12.03	6.29	21.4	8.7
LSD 0.05	**Varieties**	10.21	0.69	1.36	0.42	1.28	0.97
	Nutr. Ratio	11.36	1.11	1.22	0.33	1.69	0.87
	Interaction	18.71	1.72	2.39	0.71	2.79	1.73

SI: Sufficient irrigation, **DI:** Deficit Irrigation

These differences between varieties may be due to its genetic structure and the mode of utilization of metabolic products. Similar results of varietal differences in chemical components of some elements

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reported by El-Habbasha et al., 2008, Ahmed, et al., 2011 and Abd El-Ghany et al., 2012 and Hellal et al., (2020). Application of 19N:19P:19K logged the highest values of Fe (165, 87.3 ppm), Mn (14.8, 6.80 ppm); Zn (28.4, 12.2 ppm) and the lowest values were obtained at control without foliar application especially Rihane and Giza 126, under sufficient and deficit irrigation water, respectively. With respect to the N:P:K fertilizers effect on the Fe, Mn; Zn of the examined barley varieties, data pointed out that 19N:19P:19K had a superior effect where the highest increased percentage values were got while the conflicting was true in case of without fertilizer in control treatment. In Nubaria areas (new cultivated areas) in Egypt, Hussein, et al. (2009) said that the concentration of different nutrients in grains slightly affected by drought treatments except the concentration of Zn which increased sharply in grains of plants subjected to drought at milk ripe stage to be one fold compared to that in plants grown under regular irrigation.

Conclusion:

Foliar application of fertilizer 19N:19P:19K has a great impact on the Chlorophyll and P, K and Ca and micronutrient content. Biological and grain yield decreased with increasing water stress and while water use efficiency increased by increasing water stress. Higher values of yield and yield parameters were attained at Adrar and Giza 126. The foliar application of fertilizer ratio 19N:19P:19K was better to improve the growth and yield parameters and nutrient contents under water stress conditions in arid and semi-arid areas of North African countries. So, the balanced fertilization is important to maintain sustainable production of barley under water stress condition.

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Conflict of Interest

The author hereby declares no conflict of interest.

Consent for publication

The author declares that the work has consent for publication.

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