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EFFECT OF WATER STRESS, BIOFERTILIZERS AND NITROGEN APPLICATION RATES ON COWPEA YIELD AND SOME WATER RELATIONS IN THE NORTH MIDDLE NILE DELTA REGION

Moursi,.E.A.; Manal A. Aziz : M.A. Aiad and R.Kh.Darwesh
Soils, Water and Environment Research Institute, ARC, Giza, Egypt.

ABSTRACT

Two field experiments were carried out at Sakha Agricultural Research station (31°o5` N latitude and 30°57` E longitude) Kafr El-Sheikh governorate during the two successive summer growing seasons 2012 and 2013 to investigate the effect of water stress through various growth stages, biofertilizers and nitrogen application rates on cowpea yield, its components, uptake of phosphorus, nitrogen and protein content in some plant organs and some water relations in the North Middle Nile Delta region. A split split plot design with four replicates was used in this present study where the main treatments were randomly assigned by irrigation treatments which were I_1 (control treatment), I_2 (withholding one irrigation at the vegetative growth stage), I_3 (withholding one irrigation at the flowering growth stage) and I_4 (withholding one irrigation at pod formation stage), where the sub-plot were randomly assigned by application of nitrogen which were three rates of application, N_1 (control treatment, without nitrogen application), N_2 (application of 15 kg N/fed.) and N_3 (application of 30 kg N/fed. which considers the recommended dose for cowpea).where the sub sub plot were randomly assigned by biofertilizers which were b_1 (without biofertilizers application) and b_2 (application of biofertilizers for the soil after emergence),

The main results of this present investigation can be summarized as follows: amount of seasonal water applied were clearly affected by irrigation treatments. The highest values were recorded under irrigation treatment I_1 comparing with other irrigation treatments I_2, I_3 and I_4 in the two growing seasons. The highest values were 2950 m^3/fed. (70.2 cm) and 2980 m^3/fed (70.95 cm) in the first and second growing seasons, respectively.

Concerning the effect of irrigation treatments on the mean values of seasonal consumptive use, the highest values were also recorded under irrigation treatment I_1 in the two growing seasons and the mean values were 1823.3 and 1846.7 m^3/fed in the first and second growing seasons, respectively. On the contrary, under other irrigation treatments, I_2, I_3 and I_4 recorded mean values which less than that recorded under irrigation treatment (I_1).

The highest mean values for both (WP) and (PIW) were recorded under stress conditions I_2, I_3 and I_4 comparing with non-stressed treatments I_1 (traditional irrigation) in the two growing seasons. also, both biofertilizers application and nitrogen rates have an effect on both (WP) and (PIW) where the highest mean values for both the two irrigation efficiencies , cowpea yield and yield components, nitrogen, phosphorus percentage and protein content were recorded under N_3 b_2 .

Concerning with the nitrogen percentage and protein content the highest overall mean values were recorded under irrigation treatment I_1 and the values are 3.336 and 3.277% for nitrogen and 20.85 and 20.48% for protein content in the first and second growing seasons, respectively. On the contrary, the lowest overall mean values were recorded under irrigation treatment I_4 the overall mean values are 3.191 and 2.942% for nitrogen and 19.94 and 18.39% for protein content in the first and second growing seasons, respectively. Also, data showed that the highest overall mean values for

phosphorus percentage in the two growing seasons were also recorded under irrigation treatment I_1 and the overall mean values are 0.201 and 0.195% in the first and second growing seasons, respectively. On the contrary, the lowest overall mean values were recorded under water stress conditions in the two growing seasons.
Keywords: water stress, cowpea yield, , Water productivity.

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp) considers one of the most important vegetable legumes due to its high protein content, heat tolerant, low fertilizer requirements and can grow easily in the new reclaimed lands. The protein content in cowpea seeds in high and rich in amino acids, lysine and tryptophan compared to cereal grains. Therefore, cowpea can be valued as a nutritional supplement to cereals especially in the semi-arid region where cereals are the staple food and there is the menace of nutritional disorders and food insecurity (El-Bably and El-Waraky, 2006). The new cowpea cultivar, Kafr El-Sheikh-1 has a short growth period, an erect and determinate growth habit and resistance to loading (Knany *et al.*, 2002; Masoud, 2002 and Waraky, 2007).

Irrigation is a significant factor affecting cowpea yield and its quality. The irrigation number, amount and uniformity water application are used mainly to determine the efficiency of irrigation scheduling. Excessive doses of infrequently applied water will lead to high percolation losses. So, a large amount of applied water will take their way to drains, also, increasing availability of nutrients in the soil. So, it is easy for these nutrients to find their way to drains; consequently, increase amount of water will be polluted by these nutrients, in addition to that bad effects for increasing amounts of applied water on soil properties and hence, affects badly plant growth. The water saved by reducing drainage losses can be used to obtained higher yields by giving additional application to irrigate other farmlands or to store it as an insurance against the more severe periods of drought. While, real time irrigation schedules can be used to maximize the yield for a specific growing season, they are less useful for planning and management as simulation models (Adekalu, 2006 and Uarrato, 2010).

El-Bably and El-Waraky (2006) and Lemma *et al.* (2009) reported that the highest irrigation rate 1.2 of ETc gave the highest values of plant height, number of leaves/plant, number of pods/plant, number of seeds/plant, 100-seed weight as well as the largest seed yield/plant, seed yield/fed. and protein content in percent, compared to irrigation at 1.0 and 0.8 of ETc. Because of limitation of irrigation water resources in Egypt, there is a strict competition on water by the agriculture which uses about 85% from Egypt's water allocation, domestic and industrial users during the dry season, hence, making rationalization for using water in agriculture is becoming a must this plays an important for saving a large amount of water, it can be used in watering other crops or adding new areas which so-called horizontall expansion. Adekalu and Okunade (2006) and Kayombo *et al.* (2002) indicated that the crop water use efficiency has been shown to depend on irrigation amount and frequency, also, the type of irrigation system and tillage practice can influence the water use efficiency for a given irrigation frequency. Byan *et al.* (2002) indicated that water consumptive use (WCU) of cowpea amounted to 0.426, 0.532 and 0.639 m^3m^{-2} when irrigated by 80, 100, 120% of water calculated by class A Pan method, respectively. Cowpea doesn't withstand water logged or flooded conditions. Cowpea grows under a wide extreme of moisture conditions and once established it is fairly drought tolerant. It is often grown in rainfed agriculture receiving at least 24 inches (600 mm) annual rainfall or less if some minimal irrigation is available.

Nitrogen fertilization, application of microbial inoculants and following irrigation regime are important factors have a great effect on cowpea yield as well as its quality. Application of nitrogen fertilizers increased vegetative growth characters as well as yield and its components of cowpea (Hussaini *et al.*, 2004 and El-Bably and El-Waraky, 2006). and Varughese (2001), and El-Waraky and Kasem (2007) indicated that cowpea plants fertilized with 30 kg N/fed. produced the greatest pods/yield, also, increasing nitrogen fertilization level up to 40 kg N/fed. gradually increased cowpea plant growth, yield and its components. Even though, cowpea, a leguminous crops has the ability to fix atmosphereic nitrogen, it requires a starter dose of nitrogen for early growth and establishment. Hussaini *et al.* (2004) reported that small doses of applied nitrogen (from 30 to 40 kg N/fed.) may be synergistic and stimulate nodulation and symbiotic fixation in cowpea and even improve seed yield.

Application of microbial inoculants also considers one of the most important factors affecting cowpea yield and quality, where it plays an important role for increasing nodules number on roots (Blorowi and Focht, 1981). So, increasing plant ability to make fixation for atmospheric nitrogen, therefore, decreasing amount of mineral nitrogen applied and hence decreasing fertilization costs this is from one point and also increasing productivity and quality. Application of this kind of fertilizers has also a good benefit to reduce the bad effects for applying mineral fertilizers which make pollution for the soil and water and this makes a big problem for reusing of drainage water because it contaminates by a lot of pollutants.

For the abovementioned facts about irrigation, application biofertilizers and nitrogen. The main targets for this present study were to:

- investigate water behavior of cowpea under the studied area.
- study the effects of irrigation treatments on yield, its components, quality and some water relationships.
- study the effects of mineral and biofertilizers on yield, its components, quality and some water relationships and
- rationalize mineral fertilizers by using biofertilizers

MATERIALS AND METHODS

Two field experiments were conducted at the Experimental Farm at Sakha Agricultural Research Station during the two successive summer growing *seasons 2012 and 2013 to investigate* the effect of water stress, biofertilizers application and nitrogen rates on cowpea yield, its components, nitrogen concentration, protein content and some water relations. The station is situated at 31°05` N latitude, 30°57`E longitude. It has elevation of about 6 metres above mean sea level (MSL). It represents the conditions of circumstances of the Northern Part of the Nile Delta region. Soil samples for different depths at the experimental site were collected at each (15 cm soil depth) up to 60 cm and analyzed for some physical characteristics (Table 1). Other soil samples were taken from the same experimental site which were collected at each (15 cm soil depth) up to 60 cm and analyzed for some chemical characteristics (Table 2).

Physical and chemical characteristics for the studied experimental site:

Physical characteristics of the studied site such as soil field capacity (FC) was determined at the site. permanent wilting point (PWP) and available water were determined according to James (1988) and soil bulk density were determined according to (Klute, 1986). To study the soil texture, the particle size distribution was determined according to the international method (Klute, 1986),. The obtained results indicated that the soil texture is clayey.

Table (1):The mean values for some physical characteristics of the studied experimental site.

Soil depth	Particle size distribution			Texture class	F.C. W%	PWP W%	bd kg/m^3	A.W	
	Sand %	Silt %	Clay %					W%	mm
0-15	15.28	18.80	65.92	Clayey	47.20	25.65	1.14	21.55	36.80
15-30	19.90	13.80	66.30	Clayey	40.50	22.01	1.15	18.45	31.80
30-45	16.59	16.92	66.49	Clayey	37.00	20.10	1.24	16.91	31.40
45-60	17.65	15.24	67.12	Clayey	34.50	18.79	1.26	15.71	29.60
Mean	17.36	16.19	66.46	Clayey	39.80	21.64	1.20	18.16	32.40

Where:

F.C. = Soil field capacity
PWP% = Permanent wilting point
bd kg/m^3 = Soil bulk density
AW% = Available water

Table (2):The mean values for some chemical characters of the studied experimental site

Soil depth, cm	EC dS/m	pH (1:2.5 soil water suspension)	SAR	Soluble cations meq/L				Soluble anions meq/L			
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
0-15	0.98	7.87	0.39	0.16	0.05	0.27	0.19	0.0	0.33	0.20	0.14
15-30	1.02	8.01	1.24	0.09	0.07	0.46	0.09	0.0	0.42	0.21	0.20
30-45	1.25	8.14	2.11	0.10	0.12	0.74	0.10	0.0	0.31	0.21	0.56
45-60	1.62	8.18	3.39	0.13	0.03	0.79	0.13	0.0	0.30	0.26	0.57
Mean	1.22	8.05	1.78	0.12	0.26	0.57	0.12	0.0	0.34	0.22	0.50

Chemical characteristics of the studied site such as total soluble salts (soil EC), soil reaction (pH), both soluble cations and anions were determined according to the methods described by Jackson (1973)

Experimental layout:

Cowpea as a summer crop was planted on 30th May and 3rd June. On the other hand, harvesting process was happened on 2nd and 6th September in 2012 and 2013, respectively. All farming practices were the same as recommended for the crop in the studied area except the studied parameters (irrigation treatment), biofertilizers and mineral nitrogen application rates. The experimental plots were arranged in a split- split plot design with four replicates in both growing seasons. The main plots were randomly assigned by irrigation treatments which were:

A. Main treatments (Irrigation)

I_1 = Control treatment without any water stress through the whole growing season (like local farmers practice in the studied area).

I_2 = Withholding one irrigation at the vegetative growth stage,

I_3 = Withholding one irrigation at the flowering growth stage and

I_4 = Withholding one irrigation at the pod formation growth stage.

b. Sub treatments(Mineral nitrogen application rates, N)

N_1 = Without nitrogen fertilization (control treatment),

N_2 = Application of 15 kg N/fed.

N_3 = Application of 30 kg N/fed. (this is the recommended dose for cowpea)

C. Sub -Sub treatments (biofertilizers, Rhizobium bacteria)

b_1 = Without application of biofertilizers

b_2 = Application of biofertilizers (for the soil after emergence).

The irrigation plot area is 70 m^2 (7 m x 10 m), the irrigation plots were isolated by ditches of 1.5 m in width to avoid lateral movement of water. The area of biofertilizers treatment is 35 m^2 (10 m x 3.5 m), while the area of mineral nitrogen application rates treatment is 3.5 m^2 (1 m x 3.5 m). Phosphorus fertilization was used during seedbed preparation in the form of calcium superphosphate (15.5% P_2O_5) at rate of 100 kg/fed. Cowpea seeds of Kafr El-Sheikh cultivar were inoculated by rhizobium bacteria just before planting. Planting process was performed in hills at 20 cm apart on two sides of rows. Plants were thinned to two plants per hill after three weeks from planting. At harvesting, ten plants were randomly chosen from the fourth inner ridges to determine yield and yield components. Seed yield was determined from central area to avoid the border effect. Seed yield of cowpea was adjusted at 12% moisture content.

Soil moisture content was determined gravimetrically on oven dry basis before each irrigation and also after irrigation with 48 hours and as well as at harvesting times. Four soil samples were taken with a soil auger from four consecutive layers, every 15 cm depth to total depth of 60 cm.

Data collection:

1. Irrigation water applied (Wa):

Submerged flow orifice with fixed dimension was used to convey and measure the irrigation water applied, as the following equation (Michael, 1978).

$$Q = CA\sqrt{2gh}$$

Where

Q = Discharge through orifice, ($cm^3\ sec^{-1}$).

C = *Coefficient of discharges (0.61).*

A = Cross sectional area of orifice, cm^2.

g = Acceleration due to gravity, cm/sec^2 (980cm/sec).
h = Pressure head, over the orifice center, cm.

Total number of irrigation were events 10, 7 and 5 for treatment I_1, I_2 and I_3, respectively including sowing irrigation.

2. consumptive use (CU):

Water consumptive use was calculated using the following equation (Hansen *et al.*, 1979).

$$Cu = \sum_{i=1}^{I=4} D_I \times D_{bI} \times \frac{PW_2 - PW_1}{100}$$

CU = Water consumptive use (cm) in the effective root zone (60 cm).
D_1 = Soil layer depth (15 cm each).
D_{b1} = Soil bulk density, (g/cm^3) for this depth.
PW_1 = Soil moisture percentage before irrigation (on mass basis, %).
PW_2 = Soil moisture percentage, 48 hours after irrigation (on mass basis, %).

I = Number of soil layers each (15 cm) depth

3. Water productivity (WP):

It was calculated according to (Ali *et al.*, 2007).
WP = GY/ET.
Where WP (kg/m^3), GY is grain yield (kg/fed).
and ET total water consumption of the growing season (m^3/fed.)

4. Productivity of applied irrigation water (PIW)

was calculated as (Ali *et al.*, 2007)
PIW= GY/I
Where I is irrigation water applied (m^3/fed.).

To make determination for nitrogen and phosphorus uptake, the dried plant samples were grind and then wet digested according to the method described by Chapman and Pratte (1961). Total nitrogen percent in the digested was determined by using the modified Kjeldahl method (Cottenie *et al.*, 1982). Total phosphorus was determined using the calorimetric method (Jackson, 1973). The protein content in cowpea grains was calculated by multiplying nitrogen percent by 6.25.

Yield and yield components:

1. Seed yield (ardab/fed)
2. Plant height (cm)
3. Number of branches/plant
4. Number of leaves/plant
5. Number of pods/plant
6. Weight of 100-seed (g)

Statistical analysis:

All data were statistically analyzed according to the technique of analysis of variance (ANOVA) as published by Gomez and Gomez (1984). Means of the treatments were compared b the least significant difference (LSD) at 5% level of significance which developed by Waller and Duncan (1969).

RESULTS AND DISCUSSION

1.Amount of seasonal water applied:

Data presented in Table (3) clearly showed that the values of cowpea seasonal water applied were affected by irrigation treatments in the two growing seasons. The highest mean values through the two growing seasons were recorded under irrigation treatment I_1 (traditional irrigation) comparing with other irrigation treatments (I_2, I_3 and I_4) which exposed to water stress through growth stages during the two growing seasons and the values are 2950 m^3/fed (70.20 cm) and 2980 m^3/fed. (70.95 cm) in the first and second growing seasons, respectively. On the other hand, the lowest values for cowpea seasonal water applied were recorded under irrigation treatment I_4 (which suffered from skipping one irrigation at pod formation growth stage) in the two growing seasons and the values are 2400 m^3/fed. (57.1 cm) and 2420 m^3/fed. (57.6 cm) in the first and second growing seasons, respectively. Generally, the values of seasonal water applied through the two growing seasons can be descended in order $I_1>I_2>I_3>I_4$. Increasing the values of seasonal water applied in the two growing seasons under irrigation treatment (I_1, control treatment) comparing with other irrigation treatments which exposed to water stress through the two growing seasons (I_2, I_3 and I_4) might be due to increasing number of irrigations under irrigation treatment (I_1) in comparison with (I_2, I_3 and I_4). These results are in a great harmony with those obtained by Ali et al. (2007), Abou Kheira (2009), Uarrota (2010), El-Atawy and Kasem (2011) and Ardel and Stephen (2012).

Table (3):Effect of irrigation treatments on amount of seasonal water applied through the two growing seasons (2012 and 2013)

Irrigation treatments (I)	Seasonal water applied in m^3/fed and cm				Overall mean	
	1st growing season		2nd growing season			
	m^3/fed.	cm	m^3/fed.	cm	m^3/fed.	cm
I_1	2950	70.2	2980	70.95	2965	70.6
I_2	2470	58.8	2510	59.80	2490	59.3
I_3	2430	57.9	2410	57.40	2420	57.7
I_4	2400	57.1	2420	57.60	2410	57.4

2.The seasonal consumptive use (Cu) (m^3/fed.):

The values of seasonal consumptive use are presented in Table (4). These values showed that the consumptive use of cowpea was clearly affected by both irrigation treatments, biofertilizers and nitrogen application rates in the two growing seasons. Concerning with the effect of irrigation treatments, the highest values were recorded under irrigation treatments I_1 (traditional irrigation) comparing with other irrigation treatments (I_2, I_3 and I_4 which exposed to water stress during the whole growing season). The highest overall mean values are 1823.3 and 1846.7 m^3/fed. under irrigation treatment (I_1) in the first and second growing seasons, respectively. Generally, the mean values of seasonal consumptive use can be descended in order $I_1>I_2>I_3>I_4$ in the two growing seasons. Also, data in the same table showed that the lowest mean values were recorded under irrigation treatment (I_4) in the two growing seasons and the mean values are 1479.7 and 1448.3 m^3/fed. in the first and second growing seasons, respectively.

Table (4):Effect of irrigation treatments, biofertilizers application and nitrogen rates on cowpea consumptive use (m^3/fed) in the two growing seasons 2012 and 2013.

Irrigation treatments (I)	Nitrogen treatments	1st growing season			2nd growing season		
		Biofertilizers		I-mean	Biofertilizers		I-mean
		b_1	b_2		b_1	b_2	
I_1	N_1	1790	1820	1805	1820	1840	1830
	N_2	1800	1840	1820	1830	1860	1845
	N_3	1820	1870	1845	1850	1880	1865
Mean		1803.3	1843.3	1823.3	1833.3	1860	1846.7
I_2	N_1	1630	1660	1645	1620	1640	1630
	N_2	1690	1690	1690	1620	1660	1640
	N_3	1710	1720	1715	1700	1690	1695
Mean		1676.7	1690.0	1683.3	1646.7	1663.3	1655.0
I_3	N_1	1590	1620	1605	1560	1540	1550
	N_2	1610	1650	1630	1590	1570	1580
	N_3	1660	1670	1665	1610	1590	1600
Mean		1620.0	1646.7	1633.3	1586.7	1566.7	1576.7
I_4	N_1	1450	1470	1460	1410	1430	1420
	N_2	1460	1490	1475	1450	1450	1450
	N_3	1490	1518	1504	1460	1490	1475
Mean		1466.7	1492.7	1479.7	1440	1456.7	1448.3
B-mean		1641.7	1668.2	1654.9	1626.7	1636.7	1631.7

Increasing the mean values of cowpea consumptive use under traditional irrigation (I_1) comparing with other irrigation treatments (I_2, I_3 and I_4) which exposed to water stress at various growth stages, might be due to increasing amount of water applied under the conditions of this treatment as previously mentioned in water applied discussion, consequently, forming strong plants with a thick vegetative cover. So, increasing transpiration losses from plant surfaces, therefore, amount of Cu by plants will be increase to compensate these losses. Consequently, increasing the mean values of water consumptive use under the conditions of irrigation treatment (I_1) comparing with other irrigation treatments (I_2, I_3 and I_4) which exposed to water stress at different growth stages in the two growing seasons. Also, these results demonstrate that water consumptive use increased as soil moisture content was maintained high by increasing amount of water applied due to increasing number of irrigations. These findings are in a close harmony with those obtained by Byan et al. (2002), Anitha et al. (2004), El-Bably and El-Waraky (2006), Uarrota (2010), Faisal and Abdel Shakoor (2010), Aboamera (2010), El-Atawy and Kasem (2011) and Ardell and Stephen (2012).

3. Water productivity (WP, kg/m^3) and productivity of irrigation water (PIW, kg/m^3)

3.1. Water productivity (WP, kg/m^3)

Water productivity expressed in kg of seeds/m^3 of water consumed are presented in Table (5). As clearly shown in these table, the mean values of WP were affected by irrigation treatments, biofertilizers application and nitrogen rates. Concerning with the effect of irrigation treatments, the highest mean values were recorded under stressed treatments (I_2, I_3 and I_4) in the two growing seasons comparing with non-stressed one (control). As shown in Table (5), the lowest overall mean values were recorded under irrigation treatment (I_1) and the values are 0.566 and 0.584 kg/m^3 comparing with other irrigation treatments I_2, I_3 and I_4 which exposed to water stress at different growth stages and the mean values are 0.594, 0.573, 0.571 and 0.610, 0.630 and 0.623 kg/m^3 in the first and second growing seasons under I_2, I_3 and I_4, respectively. These results could be attributed to the great differences between seed yield of cowpea as well as differences between water consumed. These results are in a great line with those reported by Anyia and Heizog (2004), Adekalu and Okunade (2006), El-Bably and El-Waraky (2006), El-Atawy and Kasem (2011) and Ardell and Stephen (2012) who mentioned that the efficiency of water use decreased as the soil moisture was maintained high by frequent irrigation.

Table (5): Effect of irrigation treatments, biofertilizers application and nitrogen rates on cowpea water productivity (WP, kg/m^3) in the two growing seasons 2012 and 2013.

Irrigation treatments	Nitrogen treatments	1st growing season			2nd growing season		
		Biofertilizers		I-mean	Biofertilizers		I-mean
		b_1	b_2		b_1	b_2	
I_1	N_1	0.498	0.495	0.497	0.526	0.532	0.529
	N_2	0.585	0.606	0.596	0.605	0.608	0.607
	N_3	0.598	0.610	0.604	0.613	0.619	0.616
Mean		0.560	0.570	0.566	0.581	0.586	0.584
I_2	N_1	0.559	0.556	0.558	0.566	0.585	0.576
	N_2	0.603	0.612	0.608	0.608	0.627	0.618
	N_3	0.612	0.620	0.616	0.624	0.645	0.635
Mean		0.591	0.596	0.594	0.599	0.619	0.610
I_3	N_1	0.557	0.558	0.558	0.601	0.634	0.618
	N_2	0.581	0.575	0.578	0.613	0.640	0.627
	N_3	0.582	0.586	0.584	0.635	0.655	0.645
Mean		0.573	0.573	0.573	0.616	0.643	0.630
I_4	N_1	0.541	0.557	0.549	0.601	0.594	0.598
	N_2	0.568	0.568	0.568	0.619	0.640	0.630
	N_3	0.598	0.594	0.596	0.630	0.654	0.642
Mean		0.569	0.573	0.571	0.617	0.629	0.623
B-mean		0.573	0.578	0.576	0.603	0.619	0.612

3.2. Productivity of irrigation water (PIW, kg/m^3):

As clearly shown in Table (6), the mean values of productivity of irrigation water were affected by irrigation treatments, biofertilizers and nitrogen application rates in the two growing seasons. Concerning with the effect of irrigation treatments, the highest mean values for PIW were recorded under water stress conditions (I_2, I_3 an I_4) comparing with non-stressed plants which exposed to traditional irrigation (I_1) where the mean values are 0.350, 0.405, 0.385, 0.352 and 0.362, 0.402, 0.412 and 0.373 kg/m^3 under irrigation treatments I_1, I_2, I_3 and I_4 in the first and second growing seasons, respectively. Increasing the mean values of PIW under water stress conditions comparing with non-stressed ones might be due to decreasing amount of water applied under the conditions of these treatments. Also, these results could be attributed to the significant differences among cowpea seed yield, evapotranspiration and water applied values as previously shown. These findings are in a great harmony with those obtained by Byan et al. (2002), and El-Bably and El-Waraky (2006).

Table (6):Effect of irrigation treatments, biofertilizers and nitrogen application rates on productivity of irrigation water (PIW) kg/m^3 in the two growing seasons 2012 and 2013.

Irrigation treatments	Nitrogen treatments	1st growing season			2nd growing season		
		Biofertilizers		I-mean	Biofertilizers		I-mean
		b_1	b_2		b_1	b_2	
I_1	N_1	0.302	0.306	0.304	0.321	0.329	0.325
	N_2	0.357	0.378	0.368	0.371	0.379	0.375
	N_3	0.369	0.378	0.387	0.381	0.390	0.386
Mean		0.343	0.357	0.350	0.358	0.366	0.362
I_2	N_1	0.369	0.373	0.371	0.365	0.382	0.374
	N_2	0.412	0.419	0.416	0.392	0.415	0.404
	N_3	0.423	0.432	0.428	0.423	0.434	0.429
Mean		0.401	0.408	0.405	0.393	0.410	0.402
I_3	N_1	0.364	0.372	0.368	0.389	0.405	0.397
	N_2	0.385	0.391	0.386	0.404	0.417	0.411
	N_3	0.399	0.403	0.401	0.424	0.432	0.428
Mean		0.383	0.389	0.385	0.406	0.418	0.412
I_4	N_1	0.327	0.341	0.334	0.350	0.351	0.351
	N_2	0.345	0.353	0.349	0.371	0.383	0.377
	N_3	0.371	0.376	0.374	0.380	0.403	0.391
Mean		0.348	0.357	0.352	0.367	0.379	0.373
B-mean		0.369	0.378	0.373	0.381	0.393	0.387

Concerning the effect of biofertilizers and nitrogen application, the mean values of PIW were also affected by these treatments where the highest mean values were recorded under the highest application rates of biofertilizers and nitrogen. The effect of biofertilizers can be shown by these values which are 0.369 and 0.381 and 0.378 and 0.387 kg/m^3 under biofertilizers application b_1 and b_2, respectively. Also, data in the same table showed that the highest mean value for PIW is 0.429 kg/m^3 in the two growing seasons, which was recorded under the highest level of nitrogen application (N_3). Increasing the mean values of PIW under the highest level of biofertilizers (b_2) and nitrogen (N_3) due to increasing seed yield with increasing these fertilizers application. These results are in a great harmony with those reported by Anitha et al. (2004), El-Bably and El-Waraky (2006) and Uarrota (2010) and El-Atawy and Kasem (2011).

4. Effect of irrigation treatments, biofertilizers application and nitrogen rates on cowpea yield and yield components:

4.1. Effect of irrigation treatments:

Presented data in Tables (7 - 12) clearly showed that the mean values of yield and yield components of cowpea (seed yield kg/fed, weight of 100 seed (g), plant height (cm), number of leaves/plant, number of branches/plant and number of pods/plant were affected by irrigation treatments in the two growing seasons.

Table (7): Effect of irrigation treatments, biofertilizers application and nitrogen rates on cowpea seed yield (kg/fed.) in the two growing seasons (2012 and 2013).

Irrigation treat.	Nitrogen treat.	1st growing season			2nd growing season		
		Biofertilizers		I-mean	Biofertilizers		I-mean
		b_1	b_2		b_1	b_2	
I_1	N_1	890.80	901.60	896.20	956.70	979.20	967.95
	N_2	1053.00	1115.10	1084.05	1107.00	1131.30	1119.15
	N_3	1088.77	1140.30	1114.53	1134.00	1162.80	1148.40
Mean		1010.86	1052.33	1031.60	1065.9	1091.1	1078.5
I_2	N_1	910.80	922.50	916.65	916.20	959.40	937.80
	N_2	1018.80	1034.07	1026.43	984.60	1040.40	1012.50
	N_3	1045.80	1066.50	1056.15	1061.10	1089.90	1075.50
Mean		991.8	1007.69	999.74	987.3	1029.90	1008.60
I_3	N_1	885.60	904.50	895.05	937.80	975.60	956.70
	N_2	935.10	949.50	942.30	974.70	1004.40	989.55
	N_3	968.40	978.30	973.35	1022.60	1042.20	1022.40
Mean		929.70	944.1	936.9	978.37	1007.4	989.55
I_4	N_1	784.80	818.10	801.45	847.00	850.50	848.75
	N_2	828.90	946.00	837.45	897.30	927.90	912.60
	N_3	891.00	901.80	896.40	919.80	974.70	947.25
Mean		834.90	855.30	845.1	888.03	917.7	902.87
B-mean		941.82	964.86	953.3	979.9	1011.53	944.88

In a column, under each N, means followed by a common letter are not significantly different at the 5% level by DMRT

Comparison	SED	LSD (0.05)	LSD (0.01)
2.B means at each IN	13.52	28.50	39.22
2. I means at each BN	14.61	31.74	44.66
2.N means at each IB	14.21	28.94	38.91

The highest mean values for the abovementioned studied parameters were recorded under irrigation treatment (I_1) (traditional irrigation, without any water stress at any growth stage like practice by local farmers in the studied area) comparing with other irrigation treatments (I_2, I_3 and I_4) where plants exposed to water stress at various growth stages in the two growing seasons. Generally, the mean values of the abovementioned studied parameters can be descended in order $I_1>I_2>I_3>I_4$ in the two growing seasons. Increasing the mean values of yield and yield components under irrigation treatment (I_1) comparing with other irrigation treatments (I_2, I_3 and I_4) in the two growing seasons might be due to increasing number of irrigations and so amount of irrigation water applied in the two growing seasons. Therefore, increasing availability of soil nutrients and hence, increasing amount of nutrients uptake. So, plants find an easy way to take their nutritional requirements. Consequently, form strong plants with good characters from different aspects comparing with other water stress conditions, where plants find a difficult way to uptake their nutritional needs. These results are in a great agreement with those obtained by Lemma et al. (2009), Uarrota

(2010), El-Atawy and Kasem (2011) and Ardell and Stephen (2012). Another explanation for reduction of seed yield under stress conditions comparing with traditional ones, this associate with reductions in number of harvested pods per plant, number of seeds per pod, seed size and weight (Faisal and Abdel-Shakoor, 2010). attributed the reduction in seed yield under drought to the secondary detrimental effects of drought avoidance on CO_2 assimilation. Songsri et al. (2008) surveyed groundnut in full irrigation conditions in water stress. They found that in full irrigation amount of biological yield is more than it in water stress (Abou Kheira, 2009) showed that water stress conditions in peanut plant significantly reduced pod yield. The same trend was observed for the interaction between different irrigation management and nitrogen fertilizer treatments.

Table (8):Effect of irrigation treatments, biofertilizers application and nitrogen rates on cowpea plant height (cm) in the two growing seasons (2012 and 2013).

Irrigation treatments	Nitrogen treatments	1st growing season			2nd growing season		
		Biofertilizers		I-mean	Biofertilizers		I-mean
		b_1	b_2		b_1	b_2	
I_1	N_1	88.97	88.30	88.63	87.13	89.03	88.08
	N_2	91.80	92.60	92.20	91.30	93.17	92.23
	N_3	92.90	94.00	93.45	93.00	94.00	93.50
Mean		91.22	91.63	91.43	90.48	92.07	91.27
I_2	N_1	78.67	80.13	79.40	76.00	80.67	78.33
	N_2	80.20	82.10	81.15	79.53	82.93	81.23
	N_3	82.03	82.87	82.45	81.43	83.90	82.67
Mean		80.30	81.70	81.00	78.99	82.50	80.74
I_3	N_1	85.20	85.67	85.43	84.80	85.40	85.10
	N_2	85.97	87.53	86.75	85.97	88.40	87.18
	N_3	88.93	89.93	89.43	89.60	91.33	90.47
Mean		86.70	87.71	87.20	86.79	88.38	87.58
I_4	N_1	86.57	88.50	87.53	86.27	86.60	86.43
	N_2	87.93	89.53	88.73	89.53	91.37	90.45
	N_3	89.93	90.77	90.35	90.57	91.57	91.07
Mean		88.14	89.60	88.87	88.79	89.85	89.32
B-mean		86.59	87.66	87.13	86.26	88.20	87.23

In a column, under each N, means followed by a common letter are not significantly different at the 5% level by DMRT

Comparison	1st growing season			2nd growing season		
	SED	LSD (0.05)	LSD (0.01)	SED	LSD (0.05)	LSD (0.01)
2.B means at each IN	0.52	1.11	1.54	0.76	1.61	2.22
2. I means at each BN	0.67	1.52	2.21	0.73	1.55	2.15
2.N means at each IB	0.49	0.99	1.34	0.76	1.56	2.09
2- B means	0.16	0.38	0.55			

4.2. Effect of biofertilizers application and nitrogen rates:

Data in the same abovementioned tables illustrated that the mean values of both yield and yield components were increased under application of biofertilizers comparing with non-application treatment. Increasing the mean values of yield and yield components under application of biofertilizers might be attributed to under the conditions of biofertilizers application encourage plants to grow well and become strong and health. So, plants will be able to endure unsuitable conditions which have bad effects on yield and yield components. These results are in a great harmony with those obtained by Zablotowicz and Focht (1981), Hamdi (1999), Faisal and. Abdel Shakoor. (2000)and Sarker (2001) .

Table (9):Effect of irrigation treatments, biofertilizers application and nitrogen rates on cowpea number of branches/plant in the two growing seasons (2012 and 2013).

Irrigation treat.	Nitrogen treat.	1st growing season			2nd growing season		
		Biofertilizers		I-mean	Biofertilizers		I-mean
		b_1	b_2		b_1	b_2	
I_1	N_1	2.43	2.80	2.62	2.50	2.60	2.55
	N_2	2.83	3.23	3.03	2.70	2.90	2.80
	N_3	3.60	3.60	3.60	3.70	3.90	3.80
Mean		2.95	3.21	3.08	2.97	3.13	3.05
I_2	N_1	1.90	2.07	1.98	1.90	2.03	1.97
	N_2	2.10	2.20	2.15	2.10	2.27	2.18
	N_3	2.33	2.47	2.40	2.57	2.67	2.62
Mean		2.11	2.25	2.18	2.19	2.32	2.26
I_3	N_1	2.03	2.20	2.12	2.17	2.27	2.22
	N_2	2.20	2.50	2.35	2.43	2.53	2.48
	N_3	2.40	2.63	2.52	2.90	3.10	3.00
Mean		2.21	2.44	2.33	2.50	2.63	2.57
I_4	N_1	2.20	2.43	2.32	2.37	2.40	2.38
	N_2	2.50	2.80	2.65	2.60	2.67	2.63
	N_3	2.90	3.00	2.95	3.37	3.63	3.50
Mean		2.53	2.74	2.64	2.78	2.90	2.84
B-mean		2.45	2.66	2.56	2.61	3.66	2.68

In a column, under each N, means followed by a common letter are not significantly different at the 5% level by DMRT

Comparison	1st growing season			2nd growing season		
	SED	LSD (0.05)	LSD (0.01)	SED	LSD (0.05)	LSD (0.01)
2.B means at each IN	0.10	0.22	0.30	0.09	0.19	0.26
2. I means at each BN	0.11	0.23	0.33	0.11	0.24	0.33
2.N means at each IB	0.10	0.20	0.27	0.11	0.23	0.31
2- B means	0.03	0.07	0.10	0.01	0.02	0.02

Regarding the effect of mineral nitrogen rates, data in the same tables declared that the mean values of yield and yield components were clearly affected by nitrogen rates in the two growing seasons. The highest mean values for yield and yield components were recorded under nitrogen treatments N_3 (application of 30 kg N/fed.) comparing with other nitrogen rates N_1 (control, without any addition of nitrogen) and N_2 (application of 15 kg N/fed.).

Under the conditions of this experiment, application of 30 kg N/fed. was enough a starter dose for health host plants and rhizobium complete the plant nitrogen need by symbiotic N-fixation. The obtained increasing in the seed yield as a result of increasing nitrogen rate of application might be directly attributed to the increase in pod number/plant, number of seeds/pod and 100 seed weight. These results seemed to be in accordance with those reported by Bin Ishag (2003), Ardell and Stephen (2012) and Shahi (2012). They found that the soil application of N at the rate of 40 or 60 kg N/fed. gave the highest *mean values of* pea dry seed *yield. The latter reported that* the increase in seed yield was related to the increments on number of pods/plant rather than that to increase in weight of seeds/ pod. Similar discussion was reported by Hussaini et al. (2004) who explained the increase in seed yield as a result of nitrogen fertilization on the basis that the pollen produced by plants with high nitrogen treatment sired significantly more seeds than pollen produced from low nitrogen dose. Similar results on cowpea were recorded by Knany et al. (2002), El-Bably and El-Waraky (2006), El-Waraky (2007), El-Waraky and Kasem (2007), El-Atawy and Kassem (2011) and Shahi (2012).

Table (10): Effect of irrigation treatments, biofertilizers application and nitrogen rates on cowpea number of leaves/plant in the two growing seasons (2012 and 2013).

Irrigation treat.	Nitrogen treat.	1st growing season			2nd growing season		
		Biofertilizers application		I-mean	Biofertilizers application		I-mean
		b_1	b_2		b_1	b_2	
I_1	N_1	38.70	39.33	39.02	39.33	40.27	39.80
	N_2	39.80	41.50	40.65	41.07	42.63	41.85
	N_3	42.90	44.07	43.48	42.73	44.17	43.45
Mean		40.47	41.63	41.05	41.04	42.36	41.70
I_2	N_1	36.53	37.23	36.88	37.23	38.40	37.82
	N_2	38.67	39.67	39.17	39.20	40.07	39.63
	N_3	39.80	41.43	40.62	41.17	42.20	41.68
Mean		38.33	39.44	38.89	39.20	40.22	39.71
I_3	N_1	37.43	38.80 a	38.12	38.73	38.93	38.83
	N_2	39.00	40.53 b	39.77	39.63	41.13	40.38
	N_3	40.43	41.53 c	40.98	41.27	42.33	41.80
Mean		38.95	40.29	39.62	39.88	40.80	40.34
I_4	N_1	37.50	37.97 bc	37.73	38.60	39.97	39.28
	N_2	39.77	40.50 b	40.13	40.00	40.57	40.28
	N_3	41.90	42.43 b	42.17	41.20	42.67	41.93
Mean		39.72	40.30	40.01	39.93	41.07	40.50
B-mean		39.37	40.42	39.89	40.01	41.11	40.56

In a column, under each N, means followed by a common letter are not significantly different at the 5% level by DMRT

Comparison	1st growing season			2nd growing season		
	SED	LSD (0.05)	LSD (0.01)	SED	LSD (0.05)	LSD (0.01)
2.B means at each IN	0.31	0.66	0.90	0.31	0.64	0.88
2. I means at each BN	0.38	0.85	1.22	0.37	0.82	1.16
2.N means at each IB	0.34	0.68	0.92	0.34	0.69	0.92
2- B means				0.07	0.16	0.23

Table (11): Effect of irrigation treatments, biofertilizers application and nitrogen rates on cowpea number of pods/plant in the two growing seasons (2012 and 2013).

Irrigation treat.	Nitrogen treat.	1st growing season			2nd growing season		
		Biofertilizers application		I-mean	Biofertilizers application		I-mean
		b_1	b_2		b_1	b_2	
I_1	N_1	17.97	19.23	18.60	18.47	19.47	18.97
	N_2	19.07	20.70	19.88	20.00	21.20	20.60
	N_3	20.60	22.03	21.32	20.90	22.23	21.57
Mean		19.21	20.65	19.93	19.79	20.97	20.38
I_2	N_1	17.27	17.33	17.30	1730	17.83	17.57
	N_2	18.63	19.37	19.00	19.10	19.83	19.47
	N_3	19.93	20.77	20.35	21.30	21.83	21.57
Mean		18.61	19.16	18.88	19.23	19.83	19.57
I_3	N_1	16.57	17.77	16.87	17.00	17.40	17.20
	N_2	17.33	17.87	17.60	17.80	18.13	17.97
	N_3	18.33	18.90	18.62	19.43	20.63	20.03
Mean		17.41	18.18	17.70	18.08	18.72	18.40
I_4	N_1	16.23	16.83	16.53	16.23	17.23	16.73
	N_2	17.23	17.43	17.33	17.43	17.80	17.62
	N_3	17.97	18.47	18.22	19.43	20.33	19.88
Mean		17.14	17.58	17.36	17.70	18.45	18.08
B-mean		18.09	18.89	18.47	18.70	19.49	19.10

In a column, under each N, means followed by a common letter are not significantly different at the 5% level by DMRT

Comparison	1st growing season			2nd growing season		
	SED	LSD (0.05)	LSD (0.01)	SED	LSD (0.05)	LSD (0.01)
2.B means at each IN	0.24	0.53	0.74	0.32	0.67	0.93
2. I means at each BN	0.22	0.47	0.66	0.32	0.70	0.98
2.N means at each IB	0.21	0.43	0.58	0.33	0.67	0.89
2- B means				0.09	0.20	0.29

5. Effect of irrigation treatments, biofertilizers application and nitrogen rates on nitrogen uptake and protein content in cowpea plant:

Presented data in Table (13 and 14) clearly showed that the mean values of nitrogen percentage and protein content were affected by both irrigation treatments, biofertilizers application and nitrogen rates in the two growing seasons.

Concerning with, the effect of irrigation treatments, the highest mean values for nitrogen percentage and protein content were recorded under irrigation treatment I_1 (traditional irrigation, like practice by local farmers in the studied area) comparing with other irrigation treatments I_2, I_3 and i4 (which exposed to water stress at various growth stages and the highest mean values are 3.336 and 3.277% for nitrogen and 20.85 and 20.48% for protein in the first and second seasons, respectively.

On the contrary, the lowest mean values were recorded under irrigation treatment I_4 (skipping one irrigation at pod formation) and the mean values are 3.191 and 2.942% for nitrogen and 19.94 and 18.39% for protein in the first and second growing seasons, respectively. Increasing the mean values of nitrogen percentage and protein content under irrigation treatment (I_1) in comparison with stressed treatments I_2, I_3 and I_4 might be attributed to *increasing amount of water applied* which leads to increasing availability of nutrients such as nitrogen. Consequently, increasing amount of nitrogen percentage and hence increasing nitrogen content in plant organs. Therefore, increasing protein content. Increasing nitrogen percentage and protein content under traditional irrigation (I_1) comparing with other stressed irrigation treatemtns (I_2, I_3 and I_4) are in a great harmony with those obtained by and Kuruvilla (2001), Aboamera (2010), Sehetha (2010), El-Atawy and Kasem (2011) and Ardell and Stephen (2012).

Table (12): Effect of irrigation treatments, biofertilizers application and nitrogen rates on cowpea 100 seed weight (g) in the two growing seasons (2012 and 2013).

Irrigation treat.	Nitrogen treat.	1st growing season			2nd growing season		
		Biofertilizers application		I-mean	Biofertilizers application		I-mean
		b_1	b_2		b_1	b_2	
I_1	N_1	15.47	15.53	15.50	15.50	16.10	15.80
	N_2	15.90	16.17	16.03	16.07	16.30	16.18
	N_3	16.07	16.80	16.43	16.33	17.03	16.68
Mean		15.81	16.17	15.99	15.97	16.48	16.22
I_2	N_1	15.23	15.30	15.27	15.33	15.00	15.17
	N_2	15.67	15.87	15.77	15.43	15.93	15.68
	N_3	15.37	16.13	15.75	15.73	16.17	15.95
Mean		15.42	15.77	15.60	15.50	15.70	15.60
I_3	N_1	14.40	14.67	14.53	14.67	14.67	14.67
	N_2	14.87	15.17	15.02	14.77	15.30	15.03
	N_3	15.27	15.70	15.48	15.40	15.73	15.57
Mean		14.85	15.18	15.01	14.95	15.23	15.09
I_4	N_1	13.80	14.37	14.08	14.33	14.50	14.42
	N_2	14.43	15.00	14.72	14.37	15.07	14.72
	N_3	15.03	15.27	15.15	15.13	15.47	15.30
Mean		14.42	14.88	14.65	14.61	15.01	14.81
B-mean		15.13	15.50	15.31	15.26	15.61	15.43

In a column, under each N, means followed by a common letter are not significantly different at the 5% level by DMRT

Comparison	1st growing season			2nd growing season		
	SED	LSD (0.05)	LSD (0.01)	SED	LSD (0.05)	LSD (0.01)
2.B means at each IN	0.25	0.55	0.77	0.22	0.48	0.68
2. I means at each BN	0.23	0.48	0.67	0.20	0.42	0.58
2.N means at each IB	0.23	0.46	0.62	0.20	0.40	0.54
2- B means	0.09	0.20	0.29			

Also, increasing the mean values of the abovementioned two studied parameters under traditional irrigation (I_1) comparing with irrigation treatment (I_2, I_3 and I_4) which exposed to water stress under different growth stages because of forming plants with thick vegetative cover by increasing amount of applied water, this encourages plants to grow well under easy obtaining their water needs and hence, increasing amount of nitrogen uptake and protein content in plants.

Table (13): Effect of irrigation treatments, biofertilizers application and nitrogen rates on nitrogen uptake by cowpea plants in the two growing seasons (2012 and 2013).

Irrigation treat.	Nitrogen treat.	1st growing season Biofertilizers application		I-mean	2nd growing season Biofertilizers application		I-mean
		b_1	b_2		b_1	b_2	
I_1	N_1	3.297	3.310	3.304	3.190	3.270	3.230
	N_2	3.330	3.350	3.340	3.220	3.310	3.265
	N_3	3.350	3.380	3.365	3.330	3.340	3.335
Mean		3.326	3.347	3.336	3.247	3.307	3.277
I_2	N_1	3.157	3.260	3.209	3.140	3.150	3.145
	N_2	3.320	3.350	3.335	3.170	3.190	3.180
	N_3	3.340	3.390	3.365	3.230	3.290	3.260
Mean		3.272	3.333	3.302	3.180	3.210	3.195
I_3	N_1	3.100	3.243	3.172	3.960	3.110	3.035
	N_2	3.200	3.270	3.235	3.100	3.180	3.140
	N_3	3.290	3.360	3.325	3.170	3.250	3.210
Mean		3.197	3.291	3.244	3.077	3.180	3.129
I_4	N_1	2.960	3.120	3.040	2.890	2.920	2.905
	N_2	3.243	3..280	3.262	2.910	2.960	2.935
	N_3	3.240	3.300	3.270	2.980	2.990	2.985
Mean		3.148	3.233	3.191	2.927	2.957	2.942
B-mean		3.236	3.301	3.268	3.108	3.164	3.136

In a column, under each N, means followed by a common letter are not significantly different at the 5% level by DMRT

Comparison	SED	LSD (0.05)	LSD (0.01)
2.B means at each IN	0.150	0.033	0.046
2. I means at each BN	0.150	0.033	0.047
2.N means at each IB	0.140	0.029	0.039

Also, data in the same tables, illustrated that the mean values of nitrogen percentage and protein content in cowpea plants were clearly affected by adding bioferitlizers and increasing nitrogen rates. Concerning with the effect of biofertilizers application, the highest mean values for the abovementioned two studied parameters were recorded under application of biofertilizers (b_2) comparing with non-application (b_1) where the lowest mean values were recorded in the two growing seasons for nitrogen percentage and protein content. The mean values are 3.236, 3.108% and 3.301 and 3.164% for nitrogen percentage and 20.23, 19.43% and 20.63 and 19.78% under b_1, and b_2 in the first and second growing seasons, respectively. Increasing the mean values for the two studied parameters might be attributed to application of these kind of fertilizers increasing number of soil microbes and hence increasing anlaysis process for soil organic matter. So, improving soil physical and chemical characteristics. Therefore, increasing soil content from nutrients. Consequently, increasing amount of nitrogen uptake by plants and protein content. There results are in a great harmony with those obtained by Zablotowicz and Focht (1981), Hamdi (1999), Faisal and. Abdel Shakoor. (2000)and Sarker *et al.* (2001) .

Table (14): Effect of irrigation treatments, biofertilizers application and nitrogen rates on protein content in cowpea plants in the two growing seasons (2012 and 2013).

Irrigation treat.	Nitrogen treat.	1st growing season Biofertilizers application b1	b2	I-mean	2nd growing season Biofertilizers application b1	b2	I-mean
I1	N1	20.61	20.69	20.65	19.94	20.44	20.19
	N2	20.81	20.94	20.88	20.13	20.69	20.41
	N3	20.94	21.13	21.03	20.81	20.88	20.84
Mean		20.79	20.92	20.85	20.29	20.67	20.48
I2	N1	19.73	20.38	20.06	19.63	19.69	19.66
	N2	20.75	20.94	20.84	19.81	19.94	19.88
	N3	20.88	21.19	21.03	20.19	20.56	20.38
Mean		20.45	20.83	20.64	19.88	20.06	19.97
I3	N1	19.38	20.27	19.83	18.50	19.44	18.97
	N2	20.00	20.44	20.22	19.38	19.88	19.63
	N3	20.56	21.00	20.78	19.81	20.31	20.06
Mean		19.98	20.57	20.28	19.23	19.88	19.56
I4	N1	18.50	19.50	19.00	18.06	18.25	18.16
	N2	20.27	20.50	20.39	18.19	18.50	18.34
	N3	20.25	20.63	20.44	18.63	18.69	18.66
Mean		19.68	20.21	19.94	18.29	18.48	18.39
B-mean		20.23	20.63	20.43	19.43	19.78	19.60

In a column, under each N, means followed by a common letter are not significantly different at the 5% level by DMRT

Comparison	SED	LSD (0.05)	LSD (0.01)
2.B means at each IN	0.412	0.880	1.22
2. I means at each BN	0.399	0.856	1.19
2.N means at each IB	0.399	0.812	1.09

Concerning with the effect of nitrogen application rates, the highest mean values for the abovementioned two studied parameters (nitrogen percentage and protein content were recorded under the highest rate of nitrogen application N_3 (30 kg N/fed.) in the two growing seasons. The highest values are 3.39% for nitrogen and 21.19% for protein content. On the contrary, the lowest mean values were recorded under N_1 (control treatment, without nitrogen application) in the two growing seasons. Increasing the mean values of nitrogen percentage and protein content under the highest rate of nitrogen N_3 (application 30 kg N/fed.) comparing with N_1 and N_2 might be attributed to under the highest rate of nitrogen application encourages plants to grow well and form thick vegetative cover and plants also become healthy by increasing amount of nitrogen availability in the soil under the highest rate of application. So, increasing amount of nitrogen percentage and hence, increasing protein content in cowpea seeds. These results are in a great agreement with those obtained by Shahi et al. (2012).

Concerning with the effect of irrigation treatments (I_1, I_2, I_3 and I_4) on phosphorus percentage in cowpea seeds, the presented data in the same table declared that the highest mean values for phosphorus percentage were recorded under irrigation treatment (I_1). The overall mean values are 0.201 and 0.195% in the first and second growing seasons, respectively. The other irrigation treatments I_2, I_3 and I_4 which exposed to water stress at various growth stages recorded lower values in comparison with irrigation treatment (I_1). These results are in agreement with those obtained by Sehetha (2010) and Ardell and Stephen (2012).

Also, data in the same table clearly declared that the mean values of phosphorus percentage increased under application of biofertilizers (b_2) comparing with non-application (b_1) in the two growing seasons. Where the overall mean values are 1.85, 0.181 and 0.193 and 0.188% under (b_1) and (b_2) in the first and second growing seasons, respectively.

Data in the same table also indicated that the mean values of phosphorus percentage were increased under the highest rate of nitrogen application (30 kg N/fed.) in the two growing seasons. The mean values of phosphorus percentage can be descended in order N_3>N_2>N_1 in the two growing seasons. These findings are in a good agreement with those obtained by Shahi et al. (2012).

6.Effect of irrigation treatments, biofertilizers application and nitrogen rates on phosphorus percentage in cowpea seeds:

Presented data in Table (15) clearly illustrated that the mean values of phosphorus percentage in cowpea seeds were affected by both irrigation treatments, biofertilizers application and nitrogen rates in the two growing seasons.

Table (15):Effect of irrigation treatments, biofertilizers application and nitrogen rates on phosphorus uptake by cowpea plants in the two growing seasons (2012 and 2013).

Irrig-tion treat.	Nitrogen - treat.	1st growing se-son			2nd growing se-son		
		Biofertilizers -pplic-tion		I me-n	Biofertilizers -pplic-tion		I me-n
		b1	b2		b1	b2	
I1	N1	0.187	0.187	0.187	0.177	0.183	0.180
	N2	0.207	0.207	0.207	0.197	0.203	0.200
	N3	0.203	0.217	0.210	0.203	0.207	0.205
Me-n		0.199	0.204	0.201	0.192	0.198	0.195
I2	N1	0.180	0.183	0.182	0.167	0.173	0.170
	N2	0.200	0.203	0.202	0.177	0.187	0.182
	N3	0.203	0.190	0.197	0.183	0.188	0.186
Me-n		0.194	0.192	0.194	0.176	0.183	0.179
I3	N1	0.153	0.173	0.163	0.177	0.177	0.177
	N2	0.180	0.177	0.179	0.187	0.190	0.189
	N3	0.193	0.193	0.193	0.173	0.200	0.187
Me-n		0.175	0.181	0.178	0.179	0.189	0.184
I4	N1	0.150	0.180	0.165	0.157	0.167	0.162
	N2	0.180	0.200	0.190	0.177	0.173	0.175
	N3	0.190	0.203	0.197	0.197	0.200	0.199
Me-n		0.173	0.194	0.184	0.177	0.180	0.179
B-me-n		0.185	0.193	0.189	0.181	0.188	0.184

In a column, under each N, means followed by a common letter are not significantly different at the 5% level by DMRT

	1st growing season			2nd growing season		
Comparison	**SED**	**LSD (0.05)**	**LSD (0.01)**	**SED**	**LSD (0.05)**	**LSD (0.01)**
2.B means at each IN	**0.008**	**0.017**	**0.023**	**0.004**	**0.008**	**0.011**
2. I means at each BN	**0.008**	**0.017**	**0.023**	**0.004**	**0.008**	**0.011**
2.N means at each IB	**0.008**	**0.016**	**0.021**	**0.002**	**0.004**	**0.006**

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تأثير حرمان الرى وإضافة الأسمدة الحيوية ومعدلات النيتروجين على محصول اللوبيا وبعض العلاقات المائية فى منطقة شمال وسط دلتا النيل

السيد أبو الفتوح مرسى ، منال عادل عزيز ، محمود أبو الفتوح عياد ، رضا خالد درويش
معهد بحوث الأراضى والمياه والبيئية – مركز البحوث الزراعية – جيزة – مصر

أجريت تجربتان حقليتان فى مزرعة محطة البحوث الزراعية بسخا محافظة كفرالشيخ خلال موسمى النمو ٢٠١٢ ، ٢٠١٣ وذلك بهدف دراسة تأثير حرمان الرى خلال مراحل النمو المختلفة والأسمدة الحيوية ومعدلات التسميد النيتروجينى على محصول اللوبيا ومكوناته ، امتصاص النيتروجين والفوسفور وكذلك محتوى البروتين فى النبات وبعض العلاقات المائية فى منطقة شمال وسط الدلتا – التحليل الإحصائى المستخدم نظام القطع المنشقة مرتين فى ٤ مكررات – المعاملات الرئيسية هى معاملات الرى حيث كانت I_1 معاملة الرى العادية بدون حرمان ، I_2 حرمان رية فى مرحلة النمو الخضرى ، I_3 حرمان رية فى مرحلة التزهير ، I_4 حرمان رية فى مرحلة تكوين القرون – بينما المعاملات تحت الرئيسية هى إضافة التسميد الحيوى وكانت b_1 (بدون التسميد حيوى) ، b_2 (إضافة السماد الحيوى بعد الإنبات) ، والمعاملات تحت الرئيسية هى معدلات النيتروجين وكانت ٣ معدلات ، N_1 بدون تسميد ، N_2 إضافة ١٥كجم نيتروجين للفدان ، ثم N_3 إضافة ٣٠كجم نيتروجين للفدان وهى الجرعة الموصى بها.

أهم النتائج يمكن تلخيصها فى الآتى:

- كمية المياه الموسمية المضافة سجلت أعلى الكميات تحت معاملة الرى I_1 (رى عادى) وكانت القيم (٢٩٥٠ م٣/فدان ، ٧٠.٢سم) ، ٢٩٨٠م٣/فدان (٧٠.٩٥سم) فىالموسم الأول والثانى على الترتيب. بصفة عامة كميات المياه يمكن ترتيبها $I_1 > I_2 > I_3 > I_4$.
- بالنسبة لقيم الاستهلاكا لمائى سجلت أعلى القيم تحت المعاملة I_1 مقارنة I_2, I_3, I_4 وكانت القيم ١٨٢٣.٣ ، ١٨٤٦.٧م٣/فدان فى الموسم الأول والثانى على الترتيب. كذلك أعلى القيم سجلت تحت إضافة الأسمدة الحيوية b_2 والمعدلات المرتفعة من التسميد النيتروجينى N_3.

- بالنسبة الإنتاجية وحدة المياه المستهلكة (wp) ، إنتاجية وحدة المياه المضافة (piw) سجلت أعلى القيم تحت ظروف الحرمان مقارنة بالرى العادى حيث سجلت أقل القيم كذلك أعلى القيم سجلت تحت معاملة التسميد الحيوى b_2 والمعدلات المرتفعة من التسميد النيتروجينى N_3.
- بالنسبة للمحصول ومكوناته سجلت أعلى القيم تحت معاملة الرى I_1 (رى عادى) مقارنة بالمعاملات التى حدث لها حرمان I_2, I_3, I_4 كذلك سجلت أعلى القيم تحت إضافة الأسمدة الحيوية b_2 مقارنة بحالة عدم الإضافة b_1 ، كذلك سجلت أعلى القيم تحت المعاملة التسميد النيتروجينى N_3 مقارنة N_1, N_2.

بالنسبة لتأثير معاملات الرى وإضافة التسميد الحيوى ومعدلات النيتروجين على المحتوى من النيتروجين والفوسفور وكذلك البروتين سجلت أعلى القيم تحت معاملة الرى العادى I_1 مقارنة بالمعاملات التى حدث بها حرمان خلال مراحل النمو المختلفة I_2, I_3, I_4 فى كلا موسمين الدراسة وكانت أعلى القيم هى ٣.٣٣٦ ، ٣.٢٧٧% للنتيروجين ، ٢٠.٨٥ ، ٢٠.٤٨% للبروتين فى الموسم الأول والثانى على الترتيب وعلى العكس من ذلك سجلت أقل القيم تحت معاملة الرى I_4 (حرمان رية فى مرحلة تكوين القرون) فى كلا موسمى الدراسة وكانت القيم ٣.١٩١ ، ٢.٩٤٢% للنتيروجين ، ١٩.٩٤ ، ١٨.٣٩% للبروتين فى الموسم الأول والثانى على الترتيب بالنسبة لتأثير معاملات الرى على المحتوى من الفوسفور كذلك سجلت أعلى القيم تحت معاملة الرى I_1 وكانت القيم ٠.٢٠١ ، ٠.١٩٥% فى الموسم الأول والثانى على الترتيب. وأقلها سجلت تحت المعاملات آلتى حدث بها حرمان بالنسبة لتأثير إضافة الأسمدة الحيوية والنيتروجين أعلى القيم بالنسبة للنيتروجين والبروتين والفوسفور وسجلت تحت إضافة الأسمدة الحيوية b_2 وكذلك تحت معاملة النيتروجين N_3 فى كلا موسمى الدراسة.

قام بتحكيم البحث

أ.د / السيد محمود الحديدى	كلية الزراعة – جامعة المنصورة
أ.د / صبحى محمد اسماعيل عيد	مركز البحوث الزراعيه