Organic Fertilizers Improved Growth and Productivity of Cowpea (*Vigna unguiculata* (L.) Walp) under Water Stress Condition in El-Arish Region

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Abstract: The effect of three organic fertilizers; viz, chicken manure (ChM, 20 and 40 m^3 $fed.^{-1}$), pressed olive cake (POC, 20 and 40 m^3 $fed.^{-1}$) and cow manure (CwM, 30 and 60 m^3 $fed.^{-1}$) on growth and productivity of cowpea under water stress condition was investigated. A field experiment was carried out at The Experimental Farm, Fac. Environ. Agric. Sci., Arish Univ., El-Arish, Egypt in summer seasons of 2013 and 2014 in a sandy soil. Irrigation water requirements (IWR) were 50% (1050 m^3 $fed.^{-1}$) and 100% (2100 m^3 $fed.^{-1}$) of the estimated crop evapotranspiration. Results showed that20 m^3 $fed.^{-1}$of both ChM and POC were more effective for most vegetative growth parameters and yield components in well irrigated-cowpea in both seasons. Water stressed-cowpeas fertilized by 60 m^3 $fed.^{-1}$ of CwM showed the lowest reduction in yield (34.07 and 29.86%) in both seasons, respectively, followed by POC fertilizer at 40 m^3 $fed.^{-1}$. Water stressed cowpeas fertilized by 40 m^3 $fed.^{-1}$ of POC gave the highest values of water use efficiency (0.86 and 0.87 kg m^{-3}). The lowest total consumed water was recorded with 20 and 40 m^3 $fed.^{-1}$ of ChM–fertilized plants under normal and drought conditions. The content of biochemical compounds and macro-elements as well as measurements of some important tissues in leaflet of 3rd leaf related to drought and organic fertilizers were also studied. It was concluded that application of 20 $m^3 fed.^{-1}$ of ChM gave the highest yield in well irrigated-cowpea. Doubled amount of organic fertilizers reduced the deleterious effect of drought especially POC and CwM by saving irrigation water.

Keywords: Cowpea, leaflet histology, biochemical, drought, growth, yield.

INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp) is an important nutritional legume vegetable, consumed as dry or canned form in Egypt. Seed of cowpea had a 20–34% protein, 1.3% oil, 3.9% cellulose and 50–67% carbohydrates (Rochfort and Panozzo, 2007). Cultivated area reached to 4920 fed. in Egypt with a production rate of 7100 ton (FAO-STAT, 2014). Cowpea is widely cultivated in semiarid and tropical regions, but production is limited by the great variation in the amount and distribution of rainfall (Pandey *et al*., 1984). Although cowpea is relatively drought tolerant legumes but extend of drought period especially at the reproductive stage had a deleterious effect (Ogbonnaya *et al*., 2003). Estimation of seed yield of cowpea showed that it is drought resistant more than other grain legumes (Pandey *et al*., 1984). In addition, the effect of drought will be more injurious on plant growth and productivity as in soybean if the irrigated water was saline (Raper and Kramer, 1987).

Drought is a major abiotic stress which negatively affects plant growth, so limiting crop production world-wide (Shangguan *et al*., 2000). Water stress decreases plant growth by reducing cell division and root enlargement; leads to lowering ion adsorption on the root surface. Also, deficit of water had adversely affect on different physiological process such as photosynthesis, translocation of sugars and phytohormones, ion uptake transport and assimilation, nitrogen fixation, cell turgidity and dark respiration, consequently, yield of different crops was injured. (Fageria *et al*., 2006). So economic yield of cowpea was reduced by about 35-69% under drought stress according to timing and length of the drought period (Shouse *et al*., 1981).

Several physiological mechanisms were done to avoid water stress injury as lowering the transpiration rate by stomatal closure or leaf rolling; osmotic adjustments by accumulation of osmolytes as sugars and proline; reduction and consequently decrease in cellular expansion and alterations of various essential physiological and biochemical processes that can affect growth, yield and quality (Farouk and Amany, 2012).

To overcome the yield reduction of cowpea during water deficit, various tools were used such as selection of new cultivars (Addo-Quaye *et al*., 2011), agricultural practices as application of organic fertilizers (El-Bassiouny and Shukry, 2001), plant hormones as abscisic acid (Iuchi *et al*., 2000), had been done. Organic fertilizers were added to improve soil fertility and its physico-chemical properties due to increase soil microbial biomass and activity of soil enzymes (Sun *et al*., 2003). In addition, organic fertilizers were effective more than chemicals for soil and human health. Moreover, nutrients are less mobile mainly in dry soil because pores are filled with air and pathways for nutrient flux from soil to root surface are less direct. Such conditions in soil limit ion flux to root surface by diffusion and mass flow (Barber, 1995). So, application of organic fertilizers may diminish the deleterious effect of drought on cowpea.

Therefore the present study aimed to investigate the effect of application of recommended (20, 20 and 30 m^3 fed^{-1}) and doubled amount (40, 40 and 60 m^3 fed^{-1}) of different three organic fertilizers; viz, chicken manure, pressed olive cake and cow manure, respectively on growth and productivity of cowpea under normal and water stress conditions.

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MATERIALS AND METHODS

Experimental site and conditions

Two field experiments were carried out during summer seasons of 2013 and 2014 at The Experimental Farm of the Faculty of Environmental Agriculture Sciences, North Sinai, Arish University, Egypt (31º08′ N latitude, 33º49′ E longitude and 13 m above sea level) to study the effect of sources and rates of organic fertilizers as well as water stress on growth and seed yield of cowpea *cv.*" *Kafr-El Sheikh*" grown in sandy soil using drip irrigation system.

Seeds were sown on 20th April in the 1stand 2nd season. Planting was done in rows 15 cm between hills (two plants hill^{-1}) on the external sides of double lines, 25 cm between double lines on the same row and 120 cm between each two double dripper lines. Experimental unit area was 12 m^2 (10 m length and 1.2 m width). The seeds of cowpea were inoculated with N-fixer (*Rhizobium japonica*) as recommended using Arabic Gum as an adhesive material. Rhizobia obtained from General Organization for Agriculture Equalization Fund, Ministry of Agriculture and Land Reclamation. The mean monthly climatic data at El-Arish region during the growing seasons of cowpea are presented in Table (1). Some physico-chemical properties of the experimental soil site are shown in Table (2). Soil moisture constants for the experimental soil site were illustrated in Table (3). Chemical analysis of irrigation water is shown in Table (4).

Soil parameters determined before conducting the experiments were particles size distribution (Piper, 1950), total carbonate (Jackson, 1967) and soil pH value was determined in 1:2.5 soil water suspension. The soil water extract for the 1:5 soil water ratio was chemically analyzed for electrical conductivity (EC) according to Richard (1954) and Jackson (1967).

This experiment included 12 treatments, which were the combinations of two levels of irrigation water requirements (IWR); *i.e.,* 50% (1050 m^{3}fed.$^{-1}$) and 100% (2100 m^3 fed.$^{-1}$) of IWR of the estimated crop evapotranspiration (ETc) and three types of organic fertilizer (chicken manure (ChM) at a rate of 20 and 40 m^3 fed.$^{-1}$; pressed olive cake (POC) at a rate of 20 and 40 m^3 fed.$^{-1}$ and cow manure (CwM) at a rate of 30 and 60 m^3 fed.$^{-1}$. The chemical analysis of each organic fertilizer is illustrated in Table (5).

Irrigation treatments were applied at the second true leaf stage. In the two growing seasons, the amount of water needed for each irrigation was calculated according to the crop coefficient (Kc) and the daily reference potential evapotranspiration (ETo).Treatments were randomly arranged in a spilt-split plot system in a complete randomized block design with three replicates. Organic fertilizers were allowed randomly to main plots, rates of organic fertilizers were assigned randomly in sub plots, while irrigation levels were distributed randomly in sub-sub plots. The normal agricultural practices were done as needed and similar to those used in commercial cowpea production in El-Arish region.

Data recorded

Water relationships

1. Consumptive use of water (CU): It was calculated using the equation given by Israelson and Hansen (1962) as follows:

$$CU = D \times AD \times [(ez - ei) \times 100]$$

Where:

CU = Consumptive use of water in cm,
D = Irrigated soil depth in cm,
AD = Bulk density, gm cm^{-3}, of the chosen irrigated soil depth,
ez = Soil moisture percent after irrigation, and
ei = Soil moisture percent before the next irrigation.

2. Water use efficiency (WUE): The consumed water by cowpea plant was calculated according to Yaron *et al.* (1973) as follows:

$$WUE = Y / ETa$$

Where:

Y = Crop yield (kg.fed^{-1}.), and
ETa = Evapotranspiration (m^3.fed^{-1}.)

The actual evapotranspiration, ETa, is assumed to be synonymous to the calculated consumptive use of water (C.U). Consequently, daily and monthly consumptive use of water was calculated for specified soil depths for all treatments.

3. The yield reduction and water saving were calculated from the following equations according to Ismail, 2010.

Reduction in yield =100 – [(Yield of 75 % of WR or 50% of WR/ Yield of 100 % of WR) x 100]

Water saving =100 – [(Water consumption of 75 % of WR or 50% of WR/ Water consumption of 100 % of WR) x 100]

Where:

WR = Water requirements

Table (1): The mean monthly climatic data at El-Arish Governorate during the growing periods of cowpea in 2013 and 2014 seasons

Months	Temperature ^{0}C						RH (%)						Wind speed (Kmh^{-1})			
	Max.		Min.		Avg.		Max.		Min.		Avg.		Max.		Avg.	
	13	14	13	14	13	14	13	14	13	14	13	14	13	14	13	14
April	25.1	25.9	12.0	12.7	18.7	19.3	93.2	98.0	27.0	36.9	62.5	75.2	20.7	16.8	8.2	5.2
May	29.2	28.6	15.8	16.7	22.5	22.5	96.2	91.1	30.9	34.9	67.6	68.4	18.0	16.7	6.8	5.2
June	30.8	30.9	18.9	18.9	24.9	24.9	95.5	92.8	33.9	33.4	66.9	69.1	21.9	16.9	6.7	5.1
July	30.7	31.8	21.4	21.3	26.1	26.5	93.7	94.8	41.6	43.4	70.3	73.6	18.8	15.0	7.1	5.1
August	32.3	32.5	21.3	22.3	26.9	27.6	96.1	94.6	41.7	43.9	72.7	73.3	16.2	15.8	5.9	5.0

Data collected from Agriculture Research Center Meteorological Station in El-Arish

Table (2): Initial soil physical and chemical analysis

Soil properties	Seasons					
	2013			2014		
	Depth (cm.)					
	0-15	15-30	30-45	0-15	15-30	30-45
Mechanical analysis						
Coarse sand %	68.00	69.22	62.70	68.56	69.92	65.41
Fine sand %	22.60	21.41	28.90	22.98	20.02	24.12
Silt %	3.50	3.12	2.95	3.21	3.52	4.60
Clay %	5.90	6.25	5.45	5.25	6.54	5.87
Soil texture	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy
Bulk density ($g.cm^{-3}$)	1.62	1.63	1.67	1.65	1.63	1.67
Chemical analysis (soluble ions in (1:5) extract)						
Ca^{++} ($meq.l^{-1}$)	2.48	3.12	2.08	3.06	3.61	2.66
Mg^{++} ($meq.l^{-1}$)	2.11	2.31	2.22	2.37	2.13	2.60
Na^{+} ($meq.l^{-1}$)	1.21	1.46	1.89	2.97	2.44	2.49
K^{+} ($meq.l^{-1}$)	0.30	0.31	0.21	0.40	0.22	0.35
HCO_3^{-} ($meq.l^{-1}$)	2.16	2.71	2.41	2.60	2.40	2.90
Cl^{-} ($meq.l^{-1}$)	1.25	1.80	1.36	1.88	2.61	2.64
SO_4^{--} ($meq.l^{-1}$)	2.69	2.69	2.63	4.32	3.39	2.56
Available N (ppm)	18.50	16.98	16.54	18.24	16.42	15.40
Available P (ppm)	45.55	46.22	44.52	46.21	44.01	41.61
Available K (ppm)	90.56	91.60	90.51	98.20	96.30	93.06
EC($dS\ m^{-1}$) in (1:5) extract)	0.61	0.72	0.64	0.88	0.84	0.81
pH in (1:2.5) extract)	8.23	8.21	8.20	8.02	8.04	8.10
$CaCO_3$ %	5.95	7.67	6.15	5.95	7.65	6.16

Table (3): Soil moisture constants for the experimental soil site

Depth (cm.)	Saturation percentage		Field capacity		Wilting point		Available water	
	$g.g^{-1}$ (%)	Soil moisture (mm/15cm)	$g.g^{-1}$ (%)	Soil moisture (mm/15cm)	$g.g^{-1}$ (%)	Soil moisture (mm/15cm)	$g.g^{-1}$ (%)	Soil moisture (mm/15cm)
0-15	28.92	66.37	7.50	17.21	3.21	7.37	4.29	9.85
15-30	28.29	64.50	7.71	17.58	3.13	7.14	4.58	10.44
30-45	30.04	70.29	7.32	17.13	3.14	7.35	4.18	9.78

Table (4): Chemical analysis of irrigation water

pH	*EC*		Soluble ions ($meq.l^{-1}$)						
	dSm^{-1}	ppm	Cations				Anions		
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	HCO_3^{-}	SO_4^{--}
First season									
7.04	6.41	4102.4	20.13	24.21	19.31	0.21	46.62	7.01	10.23
Second season									
7.23	6.29	4025.6	19.86	24.01	18.81	0.23	44.51	8.21	10.19

Table (5): Chemical analysis of organic fertilizers under study

Organic fertilizer contents	Organic fertilizer		
	Cow manure	**Chicken manure**	**Pressed Olive Cake**
	First season		
Total N%	2.7	3.2	2.3
Total P%	0.4	0.2	0.3
Total K%	2.1	2.0	2.1
	Second season		
Total N%	2.8	3.3	2.4
Total P%	0.3	0.3	0.4
Total K%	1.8	2.1	1.9

Growth and yield parameters

At 70 days after sowing (at 50% of flowering) all vegetative and physiological parameters were estimated. Stem length (cm), number of both branches and leaves plant^{-1} were recorded. Fresh and dry weight plant^{-1} (g) was determined after drying at 70°C up to constant weight. Plant water content (%) was calculated as follow: (Fresh weight - dry weight)/(fresh weight) × 100. Leaf blade area (cm^2) was determined by scanning the terminal leaflet of 3rdleaf with a leaf area meter (AM 300). At harvest (after 120 days of sowing), seed yield (kg fed^{-1}), 100 seed weight (g), pod length (cm) and number of seedspod^{-1} were determined. Net yield (%) was estimated as seed yield / pods yield.

Chemical constituents

Chlorophyll assay

According to Arnon (1949), 0.5 g of the terminal leaflets of 3rdleaf was ground with 10 ml acetone 85% and filtered. Optical density was measured at 440.5, 644 and 662 nm using a Beckman DK-2 Spectrophotometer (T80, UV/VIS spectrometer, PG instrument Ltd, USA) to determine the concentration of chlorophyll a, b and carotenoids as mg 100 g^{-1} FW, respectively.

Reducing sugars, free phenolics and amino acids

Ethanol extract (96% EOH) of the terminal leaflets of 3rdleaf was prepared according to Abdel-Rahman *et al.* (1975). Reducing sugars were determined spectrophotometricaly at 540 nm according to Moore (1974). Free phenolics were determined spectrophotometricaly at 650 nm according to William *et al.* (1965). Free amino acids were estimated spectrophotometricaly at 570 nm using the method of Rosen (1957). Free proline was assayed in fresh flag leaf according to Bates *et al.* (1973), L-proline was used as a standard.

Soluble Protein

Soluble protein content (mg g^{-1} FW) was determined using bovine serum albumin (BSA) as a standard, according to the method of Bradford (1976), using 1 ml Bradford solution and 100 µl leaf extract.

Nitrogen, phosphorus, sodium and potassium leaves content

Random sample of the terminal leaflets of 3rdleaf from each experimental unit was dried at 70 C until the constant weight. Then 0.5 g of powdered material was digested using a mixture of sulfuric acid (H_2SO_4) and hydrogen peroxide (H_2O_2) and then brought to a final volume of 50 mL with distilled water. The content of N, P, Na and K was determined by flame photometer model III (Carl Zeiss Jena, Germany) according to Brown and Lilleland (1946).

Histological investigations

Terminal leaflets of 3rd leaf specimens from second season plants were fixed in F.A.A., dehydrated in ethyl alcohol series, embedded in Paraffin wax, sectioned to thickness of 15 µm, double stained with Safranin and Light green, cleared in Xylene and mounted in Canada balsam according to Willey (1971). All measurements were calculated by eyepiece micrometer.

Statistical analysis

All statistical analyses were performed with SPSS version 13.0 (SPSS Inc., Chicago, IL, USA). Data at each time point were analyzed by one-way ANOVA, and mean separations were performed by L.S.D test. Differences at $P < 0.05$ were considered significant.

RESULTS

Effect of organic fertilizers

Growth parameters

Application of 20 m^{3}fed.$^{-1}$ of ChM was more effective on stem length and leaf area of terminal leaflet of 3rdleaf in normal irrigated-cowpea plants than other fertilizers as shown in Table (6). Application of 20m^3 fed.$^{-1}$ of POC was valuable for enhancing number of branches and leaves plant^{-1}, FW, DW and percent of water content than ChM and CwM in well irrigated-cowpeas. In most cases, the higher dosages of all organic fertilizers enhanced the most investigated growth parameters in well watered-plants. The maximum significant values of stem length and number of branches plant^{-1} was recorded with 40m^3 fed.$^{-1}$ of POC-fertilized plants cultivated under normal irrigated conditions. Plants fertilized with 60 m^{3}fed.$^{-1}$ of ChM gave the highest values of FW and DW plant^{-1}. Reduction of irrigated water negatively affected the most investigated growth parameters and the lowest values of reduction were observed in ChM-fertilized plants. The higher amount of all three examined organic fertilizers overcome the reduction of most growth

Table (6): Effect of organic fertilizers on growth parameters of cowpea cv. *'Kafr-Elsheikh'* cultivated under different water regimes in 2013 and 2014 seasons

Organic Fertilizers		IWR	Stem length (cm)		N. of branches plant^{-1}		N. of leaves plant^{-1}		FW plant^{-1} (g)		DW plant^{-1} (g)		Water content (%)		Leaflet area of 3rd leaf (cm^2)	
Source	**Rates (m^{-3} fed^{-1})**		**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**
ChM	**20**	W_1	46.0 a	44.0 abc	2.0 b	2.0 b	11.0 c	10.0 c	97.5 abc	91.7 abc	26.7 bc	26.0 bcd	73.2 ab	71.9	63.4 a	57.0 a
		W 0.5	32.3 bc	29.7 cd	4.7 ab	3.7 ab	14.3 bc	13.3 bc	74.9 bc	68.7 c	25.5 bc	23.0 bcd	64.9 ab	65.6	43.4 ab	38.7 ab
	40	W_1	48.0 ab	47.7 ab	4.7 ab	4.0 ab	23.7 b	22.0 b	165.6 a	154.0 a	43.0 a	39.3 a	69.2 ab	69.3	47.9 a	41.0 ab
		W 0.5	44.0 ab	42.7 abc	3.3 ab	2.7 b	14.7 bc	13.3 bc	80.6 bc	73.3 bc	29.5 bc	25.3bcd	62.7 ab	65.0	45.1 ab	42.3 ab
POC	**20**	W_1	22.3 c	23.7 d	4.0 ab	3.0 ab	39.3 a	38.3 a	154.9 ab	146.7 ab	36.7 abc	33.0 abcd	75.4 a	76.0	26.1 b	24.0 b
		W 0.5	47.3 ab	44.3 abc	3.3 ab	3.0 ab	11.0 c	10.7 c	64.1 c	60.0 c	24.5 c	22.3 cd	61.6 ab	62.7	46.3 ab	43.0 ab
	40	W_1	59.7 a	53.0 a	6.0 a	5.3 a	17.3 bc	16.7 bc	129.8 abc	123.0abc	38.7 ab	35.7abc	66.2 ab	64.9	43.3 ab	39.7 ab
		W 0.5	43.0 ab	41.3 abc	3.7 ab	2.7 b	11.7 bc	11.7 c	69.3 c	68.7 c	27.5 bc	22.7 bcd	59.6 b	65.7	46.9 ab	40.3 ab
CwM	**30**	W_1	37.3 bc	34.0 bcd	1.7 b	1.7 b	15.3 bc	13.7 bc	107.1 abc	97.7 abc	30.0 abc	26.0 bcd	70.3 ab	72.9	56.8 a	53.0 a
		W 0.5	34.0 bc	33.0 bcd	3.3 ab	2.7 b	12.7 bc	11.0 c	67.9 c	63.3 c	23.3 c	21.3 d	64.2 ab	65.1	47.8 a	43.7 ab
	60	W_1	42.0 ab	39.7 abc	3.0 ab	2.7 b	18.3 bc	19.3 bc	148.1 abc	136.7 abc	36.9 abc	36.0 ab	74.4 a	73.9	50.6 a	47.7 a
		W 0.5	37.3 bc	35.7 bcd	2.7 b	2.7 b	12.0 bc	10.7 c	79.1 bc	79.7 abc	26.4 bc	24.0 bcd	65.6 ab	69.4	54.4 a	47.0 a
LSD at 5%			16.7	13.9	2.65	2.32	10.78	8.74	72.68	67.6	12.1	11.6	12.35	14.6 ns	18.8	17.7

Mean values followed by the same letter in each bar show non-significantly different at the $P < 0.05$ probability level
IWR: Irrigation water requirements W0: Well watered (2100 m-3 fad.)W 0.5: Water stressed (1050 m-3 fad.) ChM: Chicken manure POC: Pressed Olive Cake CwM: Cow manure

parameters of water stressed-plants, especially in ChM fertilized-ones. In this respect, the higher amount of ChM compensates the reduction of stem length by 36.2 and 43.7% in both seasons compared to water stress cowpeas. FW and leaf area were enhanced by 16.5 and 25.9%, 13.8 and 7.5% in CwM-fertilized plants in the first and second seasons, respectively. DW enhanced by 15.6% in the first season in ChM-fertilized plants and by 12.6% in CwM-fertilized ones in the second season.

Yield components

In general, low amount of both ChM and POC fertilizers was more effective on most investigated yield parameters in well watered plants than that of CwM as shown in Table (7). Higher amount of all three organic fertilizers enhanced the most yield parameters in non-stressed water plants. The maximum value of seed yield (kg fed.$^{-1}$) was recorded with ChM and POC-fertilized plants under normal irrigated conditions. The most yield parameters were differed according to cultivated season. Decreasing amount of irrigation water reduced the most investigated yield parameters in all three different fertilized cowpeas. The lowest reduction in yield was recorded in POC-fertilized plants. Higher amount of ChM and CwM improved the yield of cowpeas under water stress. However, ChM-fertilized plants showed about 9.4 and 10.3%; 4.9 and 12.2% increment of both net weight and weight of 100 seed compared to water stressed ones in the first and second seasons, respectively.

Plant water-relations

Water consumptive use (CU)

Values of water consumptive use (CU) were more influenced by irrigation water levels than by the sources and rates of organic fertilizer (Table 8). Generally, sufficient irrigation water increased CU under any source and rate of organic fertilizers. The highest value of CU (1812.12 and 1842.31 m^{3}fed.$^{-1}$) was recorded with application of 60 m^{3}fed.$^{-1}$ of CwM under normal irrigation conditions in the first and second season, respectively. The lowest CU value (616.51 and 621.54 m^{3}fed.$^{-1}$) was recorded with application of 20 m^{3}fed.$^{-1}$ of ChM under 50% of IWR in both seasons. Doubled amount of all three organic fertilizers under study soil conditions increased the CU with 100 and 50% of IWR.

Yield reduction and water saving

Increasing all investigated organic fertilizers rates with lowering the irrigation water amount led to water saving more than 60% and lowering the reduction of seed yield (Table 8). Although, seed yield of cowpea decreased by more than half under 50% of IWR with ChM or POC fertilizers, but CwM-fertilized plants lost only 36.13 and 33.59% of seed yield in first and second season, respectively. Doubled fertilized-cowpea with CwM had only 34.07 and 29.86% of yield reduction under 50% of IWR compared to 59.32 and 58.20; 43.69 and 42.42% under ChM and POC in first and second season, respectively.

Water Use Efficiency (WUE)

In all cases, doubled amount of all organic fertilizers increased the WUE of both well and stressed water plants (Table 8). The highest value of WUE (0.87 and 0.86 kg m^{-3}) was obtained with application of doubled amount POC under 50% of IWR treatment than ChM and CwM.

Photosynthetic pigments

Under normal irrigated conditions CwM-fertilized plants had high amount of Ch.a, b and carotenoids than POC and ChM fertilizers (Table 9). Well-watered plants fertilized with high amount of POC had the highest content of Ch.a, b and a+b. The maximum significant value of carotenoids was observed in non-water stressed plants fertilized with low amount of CwM. Lowering water irrigated amount reduced the content of Ch.b and carotenoids of POC and CwM-fertilized plants. Higher dose of organic fertilizers lowered the reduction of pigments as a result of water stress, especially CwM. CwM-fertilized plants which were lowered by about 65.2% for Chl. b and 34.2% for Chl. a+b. ChM enhanced the amount of Chl.a by 20.2% compared to water stressed plants.

Organic and non-organic chemical compounds

Recommend amount of POC under normal irrigation conditions resulted in plants with high content of reducing sugars, free phenolics, soluble protein and potassium than other organic fertilizers (Table 10). Addition of low amount of CwM resulted in high value of proline and P. ChM in low amount resulted in the high amount of nitrogen and Na. Under high amount of ChM, plants had the highest content of reducing sugars, free phenols, soluble protein and phosphorus under normal water conditions. Proline content was higher in plants fertilized with high amount of CwM than other fertilizers under non-water stress. Most of estimated chemical compounds were decreased with reduction of water irrigation in low POC-fertilized plants, but addition of ChM and CwM increased the amount of reducing sugars, free phenolics, soluble protein, proline and Na content. Higher amount of POC and CwM improved the content of reducing sugars, free phenolics and K under water stress conditions. POC increased the content of reducing sugars by 14.5% and P by 53.7%. CwM increased the content of phenolics by 13.9% and K by 61.6. ChM increased the protein content by 25.9% compared to water stressed plants.

Anatomical characters of terminal leaflet of 3rd leaf

Under normal irrigation conditions, plants fertilized with low amount of ChM gave higher values of thickness of spongy tissue, intercellular space, number of xylem arms bundles^{-1}, number of vessels bundles^{-1}, Phloem in the main vascular bundle, xylem thickness, number of vessels bundles^{-1} in the second vascular bundle than other fertilizers (Table 11 and Fig. 1). Plants fertilized with low amount of POC had the higher values of thickness of mesophyll and epidermis, palisade tissue, number of arms bundles^{-1} and phloem in the secondary vascular bundle. Higher amount of the three different organic fertilizers increased the number of arms bundle^{-1}, number of vessels bundle^{-1} in main vascular bundle and number of arms bundle^{-1} in the secondary vascular bundle. With reducing irrigated water, the most histological characters of leaf were decreased under ChM and POC fertilization, but these characters were increased in CwM-fertilized plants.

Leaflets of ChM-fertilized plants showed increment by 29% for the thickness of palisade tissue, 47.6% for xylem thickness, 28.9% for number of arms $bundles^{-1}$, 66.6% for number of vessels $bundles^{-1}$ and 22.8% for phloem thickness in the main vascular bundle and 6.2% for phloem thickness in the secondary vascular bundle. POC-fertilized plants showed increment of the intercellular spaces by 105.9%, xylem thickness by 26.6% and number of arms $bundle^{-1}$ by 30.3% in the secondary vascular bundle.

Table (7): Effect of organic fertilizers on yield parameters of cowpea cv. *'Kafr-Elsheikh'* cultivated under different water regimes in 2013 and 2014 seasons

Organic Fertilizers		IWR	Net weight (%)		Seed yield (kg fed^{-1})		Weight of 100 seed (g)		Pod length (cm)		Number of seeds pod^{-1}	
Source	**Rates (m^{-3} $fed.^{-1}$)**		**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**
ChM	20	W_1	80.7c	73.6ab	1100b	1120b	15.2a	19.8bcd	20.3a	18.8ab	13.4a	11.9abc
		W 0.5	80.2c	65.2c	420g	460 i	14.2bc	18.8def	19.6bc	16.4d	12.7b	9.8d
	40	W_1	80.1c	69.5bc	1180a	1220a	14.7ab	20.4ab	18.7de	18.9a	11.8c	12.1abc
		W 0.5	87.8ab	71.9ab	480f	510h	14.9ab	21.1a	20.2ab	16.8cd	13.4a	11.9cd
POC	20	W_1	78.7c	72.6ab	1000d	990d	15.2a	19.8bc	19.7abc	18.8a	13.7a	12.4ab
		W 0.5	80.9c	71.6ab	420h	430i	13.5c	18.9cde	19.2cd	17.5c	13.5a	11.7abc
	40	W_1	80.3c	76.5a	1030c	1040c	13.3c	19.5bcd	19.8abc	17.7bc	13.9a	11.8abc
		W 0.5	89.2a	75.0ab	580e	600e	14.7ab	19.8bcd	18.2ef	17.4cd	13.5a	11.7abc
CwM	30	W_1	83.0bc	70.4bc	500f	510g	15.3a	17.9fg	18.2ef	17.4cd	11.5c	11.5bc
		W 0.5	90.1a	57.9d	320j	340k	14.0bc	18.5efg	18.5e	18.7ab	12.4b	12.9a
	60	W_1	78.5c	75.3ab	550g	460f	14.5ab	17.8g	18.9de	17.8abc	12.5b	11.8abc
		W 0.5	83.7bc	71.5ab	360i	390j	14.7ab	20.2ab	17.7f	17.0cd	11.6c	11.3bc
LSD at 5%			5.39	5.8	7.04	2.11	0.918	0.976	0.604	1.00	0.528	1.087

Mean values followed by the same letter in each bar show non-significantly different at the $P < 0.05$ probability level
IWR: Irrigation water requirements W0: Well watered (2100 m-3 fad.) W 0.5: Water stressed (1050 m-3 fad.) ChM: Chicken manure
POC: Pressed Olive Cake CwM: Cow manure

Table (8): Effect of organic fertilizers and irrigation water levels on total consumed water, reduction of yield, water saving and water use efficiency of cowpea during 2013 and 2014 seasons

Organic Fertilizers		IWR	Total consumed water (m^3 fed^{-1})	Reduction in yield %	Water saving %	Water use efficiency (kgm^{-3})	Total consumed water (m^3fed^{-1})	Reduction in yield %	Water saving %	Water use efficiency (kgm^{-3})
Source	**Rates (m^{-3} $fed.^{-1}$)**		**2013**				**2014**			
ChM	20	W_1	1689.32	-	-	0.65	1719.02	-	-	0.65
		W 0.5	616.51	61.82	63.51	0.68	621.54	58.93	63.84	0.74
	40	W_1	1732.03	-	-	0.68	1743.20	-	-	0.70
		W 0.5	634.12	59.32	63.39	0.76	685.21	58.20	60.69	0.74
POC	20	W_1	1745.56	-	-	0.57	1764.48	-	-	0.56
		W 0.5	663.63	57.82	61.98	0.63	671.88	56.42	61.91	0.64
	40	W_1	1772.64	-	-	0.58	1792.31	-	-	0.58
		W 0.5	664.56	43.69	62.50	0.87	700.66	42.42	60.92	0.86
CwM	30	W_1	1801.52	-	-	0.28	1809.22	-	-	0.28
		W 0.5	693.14	36.13	61.52	0.46	716.11	33.59	60.42	0.47
	60	W_1	1812.15	-	-	0.30	1842.31	-	-	0.30
		W 0.5	712.61	34.07	60.68	0.51	722.21	29.86	60.80	0.54

IWR: Irrigation water requirements W0: Well watered (2100 m-3 fad.) W 0.5: Water stressed (1050 m-3 fad.) ChM: Chicken manure
POC: Pressed Olive Cake CwM: Cow manure

Table (9): Effect of organic fertilizers on photosynthetic pigments contained of the terminal leaflet of 3rd leaf of cowpea cv. '*Kafr-Elsheikh*' cultivated under different water regimes

Organic Fertilizers: Source	Rates (m^{-3} $fed.^{-1}$)	IWR	Ch.a	Ch.b	Carotenoids	Ch.a +b	Ch.a/b
			mg/100 g FW				
ChM	20	W_1	42.1 h	26.2 h	27.0 g	68.3 f	1.6 a
		W 0.5	19.3 j	34.0 e	34.2 c	53.3 g	0.57 f
	40	W_1	65.3 b	42.2 d	34.1 c	107.4 b	1.5 b
		W 0.5	23.2 i	42.2 d	31.2 ef	65.5 f	0.57 f
POC	20	W_1	51.3 f	30.1 f	32.1 de	81.4 d	1.7 a
		W 0.5	55.0 e	47.2 c	30.1 f	102.3 c	1.2 d
	40	W_1	73.1 a	62.0 a	37.3 b	135.0 a	1.2 d
		W 0.5	55.2 e	49.1 b	33.2 cd	104.3 bc	1.1 e
CwM	30	W_1	58.5 cd	47.0 c	40.3 a	105.5 bc	1.3 d
		W 0.5	48.1 g	28.2 g	30.2 f	76.4 e	1.7 a
	60	W_1	59.2 c	43.0 d	34.1 c	102.2 c	1.4 c
		W 0.5	56.0 de	46.6 c	30.1 f	102.6 c	1.2 d
LSD at 5%			2.8	1.68	1.75	3.54	0.079

Mean values followed by the same letter in each bar show non-significantly different at the P < 0.05 probability level
IWR: Irrigation water requirements W0: Well watered (2100 m-3 fad.) W 0.5: Water stressed (1050 m-3 fad.) ChM: Chicken manure
POC: Pressed Olive Cake CwM: Cow manure

Table (10): Effect of organic fertilizers on content of organic and non-organic substances in leaflet of 3rd leaf of cowpea cv. '*Kafr-Elsheikh*' cultivated under different water regimes

Organic Fertilizers: Source	Rates (m^{-3} $fed.^{-1}$)	IWR	Biomolecules: Reducing sugars	Free phenolics	Proline	protein	Elements: N	P	Na	K
			mg $10g^{-1}$ FW	mg $100g^{-1}$ FW		mg g^{-1} FW	%			
ChM	20	W_1	85.1e	71.3e	24.2e	15.3f	1.20a	.085de	8.5b	0.717abc
		W 0.5	115.2b	74.2d	32.9b	15.8f	1.00bc	.087cd	8.7a	0.467e
	40	W_1	119.2a	115.2a	30.3cd	31.1a	0.917bcd	0.121a	6.1f	0.81ab
		W 0.5	109.1c	72.3e	22.0f	19.9de	0.84d	0.088cd	8.5b	0.677bc
POC	20	W_1	110.3c	91.1b	24.2e	22.1c	1.03b	0.105b	6.4cd	0.85a
		W 0.5	84.1e	59.1g	31.1c	19.3de	0.90cd	0.082de	6.37cde	0.367e
	40	W_1	97.1d	91.8b	29.3d	29.7b	0.89cd	0.101bc	6.2ef	0.627cd
		W 0.5	96.3d	66.2f	19.7g	20.5d	0.70e	0.126a	6.27def	0.373e
CwM	30	W_1	70.0h	53.2h	31.0c	18.7e	0.92bcd	0.119a	6.4cd	0.71abc
		W 0.5	80.0g	71.2e	31.0c	20.5d	0.80de	0.071ef	6.50c	0.497de
	60	W_1	66.1i	51.0i	39.1a	19.9de	0.89cd	0.089cd	4.33g	0.633cd
		W 0.5	82.1f	81.1c	31.1c	15.2f	0.81de	0.062f	6.20ef	0.803ab
LSD at 5%			1.74	1.86	1.54	1.32	0.113	0.014	0.161	0.149

Mean values followed by the same letter in each bar show non-significantly different at the P < 0.05 probability level
IWR: Irrigation water requirements W0: Well watered (2100 m-3 fad.) W 0.5: Water stressed (1050 m-3 fad.) ChM: Chicken manure
POC: Pressed Olive Cake CwM: Cow manure

Table (11): Effect of organic fertilizers on anatomical parameters of 3rd leaf of cowpea cv. *'Kafr-Elsheikh'* cultivated under different water regimes

Organic Fertilizers		IWR	Blade				Midrib							
			Thickness (µm) of				Main vascular bundle				Second vascular bundle			
							xylem			Phloem	xylem			Phloem
Source	Rates (m^3 fed.$^{-1}$)		Mesophyll and epidermis	Palisade tissue	Spongy tissue	intercellular space	Thickness (µm)	N. of arms bundle^{-1}	N. of vessels bundle^{-1}	Thickness (µm)	Thickness (µm)	N. of arms bundle^{-1}	N. of vessels bundle^{-1}	Thickness (µm)
ChM	20	W_1	510.0 a	210.0 b	239.3 a	41.7 d	241.0 c	12.3 b	50.3 a	272.0 a	205.0 a	4.3 bc	25.3 a	139.3 c
		W 0.5	466.7 b	133.3 d	239.3 a	31.7 ef	210.0 d	8.3 d	21.0 f	139.3 e	139.0 c	5.3 ab	13.3 cd	96.7 e
	40	W_1	372.0 d	131.7 d	170.3 c	75.0 a	307.7 a	14.3 a	50.0 a	170.3 d	139.3 c	4.3 bc	15.0 c	110.0 d
		W 0.5	416.7 c	172.0 c	139.3 d	36.7 de	310.0 a	10.7 c	35.0 bc	171.7 d	170.3 b	5.0 b	12.7 cd	102.7 de
POC	20	W_1	520.0 a	240.0 a	210.0 b	63.3 b	210.0 d	10.3 c	37.7 b	209.7 c	139.3 c	6.3 a	23.0 b	172.0 b
		W 0.5	372.0 d	210.0 b	139.3 d	26.7 f	236.7 c	9.7 c	30.0 de	270.3 a	110.0 d	3.3 c	11.0 de	172.0 b
	40	W_1	272.0 f	172.0 c	110.0 e	31.7 ef	234.3 c	14.3 a	47.3 a	211.7 c	139.0 c	6.3 a	14.0 c	172.0 b
		W 0.5	372.0 d	172.0 c	139.3 d	55.0 c	233.3 c	10.0 c	35.3 bc	210.0 c	139.3 c	4.3 bc	11.0 de	72.0 f
CwM	30	W_1	416.7 c	206.7 b	135.0d	50.0 c	310.0 a	11.0 c	32.7 cd	210.0 c	170.3 b	3.3 c	9.0 e	139.3 c
		W 0.5	472.0 b	231.0 a	172.0 c	51.7 c	239.3 c	8.3 d	25.7 e	237.0 b	170.3 b	4.3 bc	15.0 c	139.3 c
	60	W_1	310.0 e	170.3 c	110.0 e	65.0 b	268.7 b	13.3 ab	51.7 a	172.0 d	210.0a	5.3 ab	15.0 c	210.0 a
		W 0.5	410.0 c	172.0 c	172.0 c	51.7 c	238.3 c	10.3 c	34.7 bc	210.0 c	139.3 c	4.7 b	11.0 de	139.3 c
LSD at 5%			18.59	13.38	12.2	6.28	12.86	1.22	4.37	13.2	11.3	0.93	2.2	12.2

Mean values followed by the same letter in each bar show non-significantly different at the $P < 0.05$ probability level
IWR: Irrigation water requirements W0: Well watered (2100 m-3 fad.)W 0.5: Water stressed (1050 m-3 fad.) ChM: Chicken manure POC: Pressed Olive Cake CwM: Cow manure

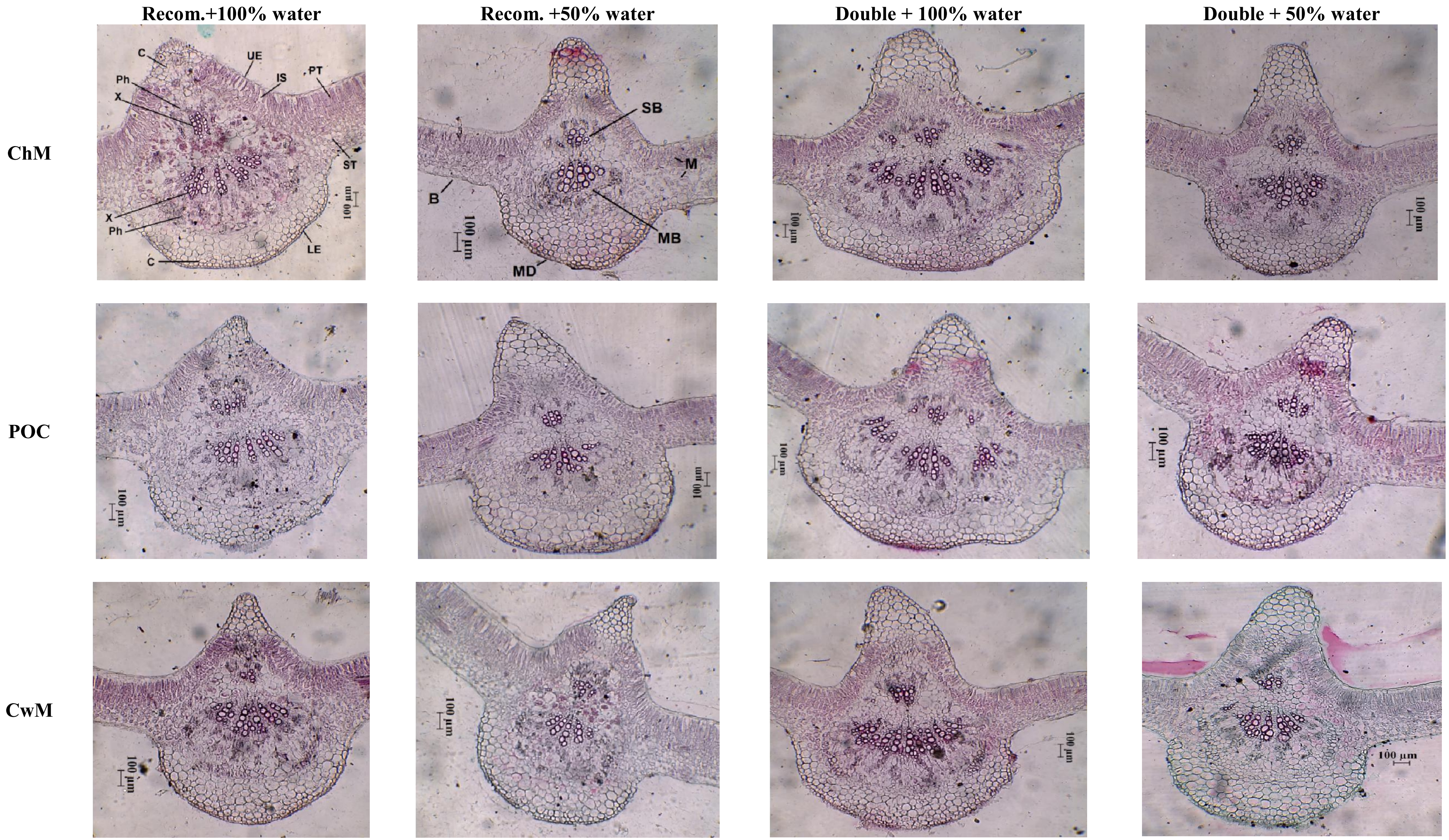

Fig. (1): Effect of organic fertilizers on anatomical characters of terminal leaflet of 3rd leaf of cowpea cultivated under different water regimes.

B, Blade; C, Collenchyma; IS, Intercellular space; LE, Lower epidermis; ; M, Mesophyll; MB, Main bundle; MD, Midrib ; Ph, Phloem; PT, Palisade tissue; SB, Second bundle ST, Spongy tissue, UE, Upper epidermis; X , xylem.

DISCUSSION

In present study, cowpeas cultivated in alkaline sandy soil as shown in Table (2) and irrigated with saline irrigation water as shown in Table (4), whereas EC of irrigated water was 4102.4 and 4025.6 ppm, in the first and second season, respectively. Application of organic fertilizers improved the physical and chemical properties of sandy soil and preserve water among soil particles especially when added in doubled amount (Sun *et al*., 2003). Application of recommended and doubled amount of three different organic fertilizers was investigated under 50 and 100% of IWR. Results showed that application of recommended amount (20 m^3 $fed.^{-1}$) of ChM to well watered-cowpeas was more efficient on stem length and leaf area due to its higher content of total nitrogen (3.1%) as shown in Table (5) and its high decomposition compared to other organic fertilizers (Azeez and Van Averbeke, 2012). Also the 3rd leaf of cowpea fertilized with 20 m^3 $fed.^{-1}$of ChM had high content of N and Na (Table 10) compared to other fertilizers. This remark coordinate with that fact, nitrogen participate in amino acids synthesis as tryptophan, which represent the precursor of auxins in plants that promote the vegetative organs of cowpeas (Taiz and Zeiger, 2002). The same treatment gave the highest thickness of spongy tissue, intercellular space, and vascular elements (xylem and phloem) in the main and second vascular bundles in the leaflet of the 3rd leaf (Table 11 and Fig. 1) which led to increase the content of reducing sugars, free phenolics, soluble protein and phosphorous as shown in Table (8), especially, under the double dose of ChM. These findings are agreed with the fact, presence of loosely mesophyll cells (palisade and spongy tissues) in leaf leads to a high assimilation efficiency of CO_2 and subsequently increased the photosynthetic rate (Esau, 2006). The low dose of all three organic fertilizers under study increased the thickness and numbers of vascular elements in both the main and secondary bundles in leaflet of 3rd leaf, led to high efficiency of organic and non-organic compounds transportation. Therefore, it improved all growth parameters (Table 6) especially, in ChM at the rate of 60 m^3 $fed.^{-1}$ for FW and DW and POC at the rate of 40 m^3 $fed.^{-1}$ for stem length and number of branches $plant^{-1}$.

Enhancement of previous growth parameters led to the highest seed yield (kg $fed.^{-1}$) under both recommended and doubled amount of ChM and POC fertilizers under 100% of IWR. CwM-fertilized and well irrigated cowpea gave lower amount of seed yield than ChM and POC. These findings coordinated with Ahmed and Elzaawely (2010) who found that chicken manure (45 m^3 $fed.^{-1}$) combined with cattle manure (21 m^3 $fed.^{-1}$) significantly increased plant height, number of leaves, number of branches, leaf area, number of pods, seed index, seeds total yield and contents of P and K in seeds and P in leaves of cowpea cv. *Kaha1*under normal irrigation conditions. The low amount of CwM increased the content of proline and phosphorous in 3rd leaf due to its high EC, about 2 – 3.5 ds m^{-1} (Azeez and Van Averbeke, 2012), therefore, decreased the growth parameters compared to other fertilizers.

Under water stress, the most estimated histological characters of leaflets of 3rd leaf were decreased. These findings were agreed with that, water stress increases root length and thickness than shoot components. Also drought increased the thickness of cell walls and amount of cutinization and lignifications. Srivalli *et al*. (2003) showed that, plant must equilibrate the shoot root ratio to survive under drought conditions. In addition, leaf area index was decreased in mungbean under water stress conditions (Naresh *et al*., 2013).

Values of WUE increased as water deficit and with application of organic fertilizers especially POC this may be due to water movement into seeds without effect on the translocation of dry matter into the seed and this effect resulted in an increase in mass production per unit of water (Shouse *et al*., 1981). Although drought-tolerant species maintain water-use efficiency by reducing the water loss, longevity of drought period reduced it (Anjum *et al*., 2009). Cowpea showed some characters of leaf anatomy similar to drought tolerant species to increase water use efficiency as presence of several layers of palisade tissue at the expense of spongy tissue to increase the path of water through intercellular spaces to reach stomata *i.e.* ratio of carbon dioxide fixed to water lost. Malty-serrate palisade tissue in leaf optimizes the light interception in the early morning and in late afternoon (Lewis 1972). Also, photosynthetic capacity increased with increment of mesophyll thickness due to increase the number of chloroplasts (Oguchi *et al*., 2005).

Under water deficit, CwM and POC fertilized-cowpeas showed the lowest reduction of growth parameters and the higher dose compensate this reduction, contributed with increase of reducing sugars, free phenolics, soluble protein, proline and Na as shown in Table (10). Increment of cowpea growth and productivity after application of organic fertilizers under normal water irrigation may be due to its effect on soil microorganisms which increased the ability of mobilizing the unavailable forms of nutrient element to available forms (El-Boraie *et al*., 2009).Similar results were reported by Raper and Kramer (1987) who found that low productivity of cowpea under water stress associated with decreasing of photosynthetic rates and decrease the amount of photosynthates allocated to floral organs, causing increased abortion or resulting in smaller seed size. Increment of reducing sugars, proline and Na is one of the main mechanisms for drought tolerance to maintenance cell turgidity through osmotic adjustment (Agbicodo *et al*., 2009). Rhodes and Samaras, 1994 reported that under drought cytosol of plant cells accumulate different types of organic as sugars and prolineas well as inorganic solutes as potassium ions to lower osmotic potential thereby maintaining cell turgor.

The low amount of POC resulted in high thickness of mesophyll and palisade tissues in 3rdleaf (Table 11 and Fig. 1) which may enhance the photosynthetic rate and as a result increased the content of reducing sugars, free phenolics, soluble protein and potassium (Table 10). In addition, higher dose of POC gave the highest Chl a, b and a+b (Table 9). Therefore, number of branches and leaves $plant^{-1}$, FW, DW and percent of water content where in their highest values compared to ChM and CwM in well irrigated-cowpeas. Both Chl. a and b is the major photosynthetic pigments for photosynthesis and their content has a positive relationship with photosynthetic rate and declined under water stress due to oxidative stress (Farooq *et al*., 2009).

CONCLUSION

Application of 20 m^3 fed^{-1} of either ChM or POC was benefit for enhancing the growth parameters and yield components in well irrigated-cowpeas compared to CwM. Application of organic fertilizers is a beneficial practice to increase the potential of cowpea to survive under water deficit with relative reduction of yield. Addition of 40 m^3 of POC or 60 m^3 of CwM in similar condition to El-Arish area, overcome the reduction of plant growth and productivity due to drought. POC resulted in the maximum water use efficiency value. Application of POC as a cheaper and available source in El-Arish was useful than other fertilizers. Lowering the deleterious effect of drought by application of organic fertilizers was associated with enhancement of biochemical compound and tissues of leaflets.

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تحسين نمو وإنتاجية اللوبيا بالتسميد العضوي تحت ظروف الإجهاد المائي بمنطقة العريش

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تم دراسة تأثير إضافة ٣ أنواع مختلفة من السماد العضوي هي: ١) سماد كتكوت بمعدل ٢٠ و ٤٠ م^{٣}/فدان، و ٢) مخلف الزيتون بمعدل ٢٠ و ٤٠م^{٣}/فدان، و ٣) سماد بقرى بمعدل ٣٠ و ٦٠ م^{٣}/فدان على نمو وإنتاجية محصول اللوبيا تحت ظروف نقص الماء. أجريت تجربة حقلية في المزرعة التجريبية لكلية العلوم الزراعية البيئية بالعريش خلال الموسمين الصيفيين ٢٠١٣-٢٠١٤م في تربة رملية واستخدام مستويين من مياه الري هما الاحتياج المائي لنبات اللوبيا وفقا لمعادلة النتح - بخر وهو ٢١٠٠ م^{٣}/فدان (١٠٠% من الاحتياج المائي) و ١٠٥٠م^{٣}/ فدان (٥٠% من الاحتياج المائي) للموسم. أوضحت النتائج أن إضافة ٢٠م^{٣}/فدان سماد كتكوت أو مخلف الزيتون أعطت أفضل القيم لقياسات نمو وإنتاجية اللوبيا تحت ظروف الري العادي (١٠٠%). سجل اقل انخفاض في المحصول (٣٤.٠٧ و ٢٩.٨٦%) عند التسميد بالسماد البقرى بمعدل ٦٠ م^{٣}/فدان تحت ظروف الإجهاد المائي (٥٠%) يليه مخلف الزيتون بمعدل ٤٠م^{٣}/فدان. كانت أعلى القيم لكفاءة استخدام المياه هي ٠.٨٦ و ٠.٨٧ كجم/م^{٣} في النباتات المسمدة بمخلف الزيتون بمعدل ٤٠ م^{٣}/فدان في الموسم الأول والثاني على التوالي تحت ظروف نقص الماء. اقل امتصاص مائي في النباتات المسمدة بسماد الكتكوت بكلا المعدلين تحت ظروف الري الطبيعي والإجهاد المائي. أظهرت النتائج وجود تغير في المركبات الكيميائية العضوية والغير عضوية وكذلك الصفات التشريحية للوريقة الطرفية للورقة الثالثة على النبات بسبب الإجهاد المائي.يمكن التوصية بإضافة ٢٠ م^{٣}/فدان من سماد الكتكوت للحصول على إنتاجية مرتفعة من محصول اللوبيا تحت معدلات الري الطبيعي. كما أن إضافة كمية مضاعفة من الأسمدة العضوية يؤدى للتغلب على الأضرار الناجمة من الجفاف على نبات اللوبيا خاصة مخلف الزيتون والسماد البقرى نتيجة توفيرها لمياه الري.