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Cowpea Growth and Yield Components as Affected by Drought and Pk Soil Fertilization

Hussein, M.M.[1]; Al-Ashry, S.M.[2]; Camilia, Y. El-Dewiny[3]

[1]Water Relations & Irrigation Department, National Research Center, Tahrir st., Dokki, Cairo, Egypt

[2]Soil & Water Use Department, National Research Center, Tahrir st., Dokki, Cairo, Egypt

Abstract: ***Pot experiment was conducted in the greenhouse of the National Research Centre, Shalakan, Kalubia Governorate, during the summer seasons to evaluate the effect of PK fertilizers on growth and yield of cowpea (Vigna unguiculata L.) plants growth under drought through two stage of growth compared to plants irrigated regularly. Subjected cowpea plants to shortage of water by withholding of water at 35 days from sowing pronouncedly decreased plant height, number of leaves and fresh weight of stem, leaves and whole plants. Delaying drought to 70 days after sowing affected those mentioned characters but with lesser degrees. All fertilizing treatments increased the measured growth parameters in comparison with that irrigated regularly. Generally, the highest values of plant height, no of leaves no of cops and fresh weight of stem, leaves and whole plant. Addition of K_1 in corporation with P_1 increased plant height but when doses increased to P_2K_2 did not exert any effects. The reverse was true for fresh weight of leaves. Meanwhile, the no of leaves and cops and fresh weight of shoots as well as whole plant show positive response and synergistic effects with the increase in P and K doses. P_1K_1 increased the above mentioned criteria by 40.57, 48.23, 33.40, 42.36 and 37.87 % and P_2K_2 increased it by 50.29, 78.68, 59.99, 62.93 and 61.46 % respectively, compared to that of unfertilized plants. The increment in stem, leaves and whole plants can be illustrated as a result of: $P_1K_1<P_1K_2< P_2K_1<P_2K_2$ under the different irrigation treatments. The positive effects of P and K fertilizers were more under normal irrigation than stress treatments in plant height, number of leaves and stem, leaves and whole plants followed by that under D_2. The lowest were by D_1 except number of leaves which the lower were under D_2.***

Keywords: Cowpea *(Vigna unguiculata (L.) Walp*) - Drought- Growth stages- Potassium and Phosphorus Fertilizers, Yield components.

1. Introduction

Cowpea is one from the main legume crop in Egypt which characterized by its drought resistance more than the higher nutritional value of its shoots as forage and also considered as one from the important legume crop in new cultivated lands. Nevertheless, its higher productivity limited mainly by the shortage of water and poor soil fertility.

Cowpea is often one of the few crops that produces anything at all in drought-stricken areas with barren soil. In addition, the plant improves the soil's fertility because of its excellent nitrogen-fixing abilities. Poor harvests have a dramatic effect on over 200 million Africans who eat the legumes and feed the tops to their cattle. Therefore, highly drought-resistant cowpea has an increasingly difficult time surviving and to be suitable for regions characterizes by climate change has resulted in shorter and less frequent rainy seasons, **(Wageningen Univ., 2009).**Therefore, the problems caused from drought and its effect on growth, yield and nutritional values were under taken in many studies: **Sangakkara, *et al.* (2001a and b); Henry and Mather (2003) and Anitha, *et al.* (2004**).

Fertilization of cowpea was studied intensively by many authors among of them: **Bationo, and Natare (2001**) pointed out that dry matter yield increased with increasing phosphate rate, while calcium super phosphate increased at the higher rate. **Okeleye and Okolana (1997**) found that dry matter nodulation and grain yield gave its higher values by 30 kg P/ha in some varieties and by 60 kg P/ ha in others. Also, **Brj–Lal, *et al.* (1998)** revealed that the highest dry matter yield of forage obtained by addition of NPK fertilizers in the rate of 20-40-20. They added that K uptake in cowpea correlated with non-exchangeable K in surface soil.

The interaction effect of soil moisture and fertilization were investigated by many authors, among of them **Sangakkara, *et al*. (2001a)** who found that K promoted growth of cowpea subjected to sub optimal soil moisture, and **Sangakkara, *et al.* (2001b)** found that stress of moisture affected pronouncedly on the rate of photosynthesis rate and water potential**. Palta, *et al.* (2005**) reported that N application increased yield, yield attributes and protein concentration in grains. Drought resulted in a decrease in photosynthesis and urea application induced greater seed survival under terminal drought. Also, **Hussein, *et al.* (2011**) on millet, revealed that a continuous increase in growth traits as a results of the increase in the rate of N,P and K fertilizers up to $N_2P_2K_2$. The leaves area / plant markedly increased by addition of $N_3P_3K_3$, Moreover, regardless the PK effects, this parameter increased slightly by drought treatments. However, PK application induced gradual increase in this phenomenon as the level of these fertilizers increased, and addition of PK improved the WUE under different water regimes. Therefore the current study aimed to investigate the effect of PK fertilizers and drought by omitting of irrigation in some growth stages on growth, yield components and water use efficiency of millet plants.

2. Materials and Methods

Two field experiments were conducted in the experimental farm of the National Research Center, Shalakan, Kalubia Governorate, during the 2006/2007 summer seasons to investigate the effect of fertilization and drought on growth and yield of cowpea plants. The treatments were as follows:

Drought : 1- Without, irrigated regularly.
2- Omitting of irrigation at 30 days.
3- Omitting of irrigation at 60 days.
Fertilization: 1- Without mineral fertilization
2- P_20_51+$k_20 1$ (calcium super phosphate and potassium sulfate)
3- P_20_51+K_202
4- P_20_52+K_201
5- P_20_52+K_202

The experiment included 15 treatments which were the combination between three drought treatments and 5 fertilizers treatments. The experimental design was split plot in sex replicates, two replicates for growth measurements and the rest for yield parameters. Drought treatments were in the main plots and the fertilization treatments were distributed randumizely in sub-plots. Seeds of cowpea *[Vigna unguiculata L.)* were sown in 20, July in both seasons. calcium supper phosphate (15.5 % P_2O_5) and Potassium sulfate (48.5 % K_2O) as treatments were broadcasted in to equal portions, the first before sowing and the 2nd was applied after 3 weeks from sowing. All other cultural practices were done as in the province. The soil characterized of the studied soil were determined according to **Black, *et al.* (1982)** in presents of table 1

Table 1: Analytical data of the experimental soil.

A . Soil mechanical Analysis

Sand		Silt 20-2 µ %	Clay < 2 µ %	Soil Texture
Course >200 µ %	Fine 200-20µ %			
9.20	14.0	28.0	48.8	Sandy loam

B. Soil chemical analysis

pH 1:2.5	EC dSm^{-1} 1:5	$CaCO_3$ %	OM %	Soluble cations and anions meq/L soil							
				Na^+	K^+	Ca^{2+}	Mg^{2+}	CO^{-3}	HCO^{-3}	Cl^{-1}	SO^{-2}
8.26	0.66	8.0	0.79	2.22	0.18	1.10	0.89	0.15	0.68	2.00	1.12
Total N ppm				Available -nutrients ppm							
				P					**K**		
130				20.1					222.4		

The collected Data of two season were subjected to the proper statistical analysis were done according to the methods described by **Senedcor and Cochran (1990).**

3. Results and Discussion

- **Growth**

Drought

It is clearly shown from Figure (1) Subjected cowpea plants to shortage of water by withholding water of the 3rd irrigation pronouncedly decreased plant height, number of leaves and fresh weight of stem, leaves and whole plants. Delaying drought by withholding 5th irrigation did not show the same effect on the mentioned characters by those of the drought by withholding the 3rd irrigation but with lesser degrees. This means that drought more effective at the time of third irrigation more than the time of fifth irrigation. The effect of drought on growth of different plants were reported by **Mehana, *et al.* (2013)** on maize**; Hussein, *et al.* (2013) on barley, Hussein, *et al.* (2013) on jojoba, Choudhurg, *et al.* (2000)** reported that the effect of drought in growth and yield of cowpea. **Benjamin and Nielsen (2004)** found that water deficit resulted in a greater proportion of chickpea and field pea roots to grow deeper in the soil. Under irrigated conditions, about 80 % of the chickpea and pea roots were in the surface 0.23m. Under dry condition, about 66% of the total chickpea roots to grow deeper in the soil. The adverse effect of drought in cowpea was found by: **Anitha, *et al.* (2004);) and Henry and Mather (2003).** This may be due to the increase in water saturation deficit (**Shinde, *et al.* 2001**). **Matsui and Singh (2003)** related that the effect of moisture stress in root penetration and top to root ratio, while **Sangakkara, *et al.* (2001b)** demonstrated that the negative effect of water stress on cowpea may be owing to its influences in photosynthetic process**.**

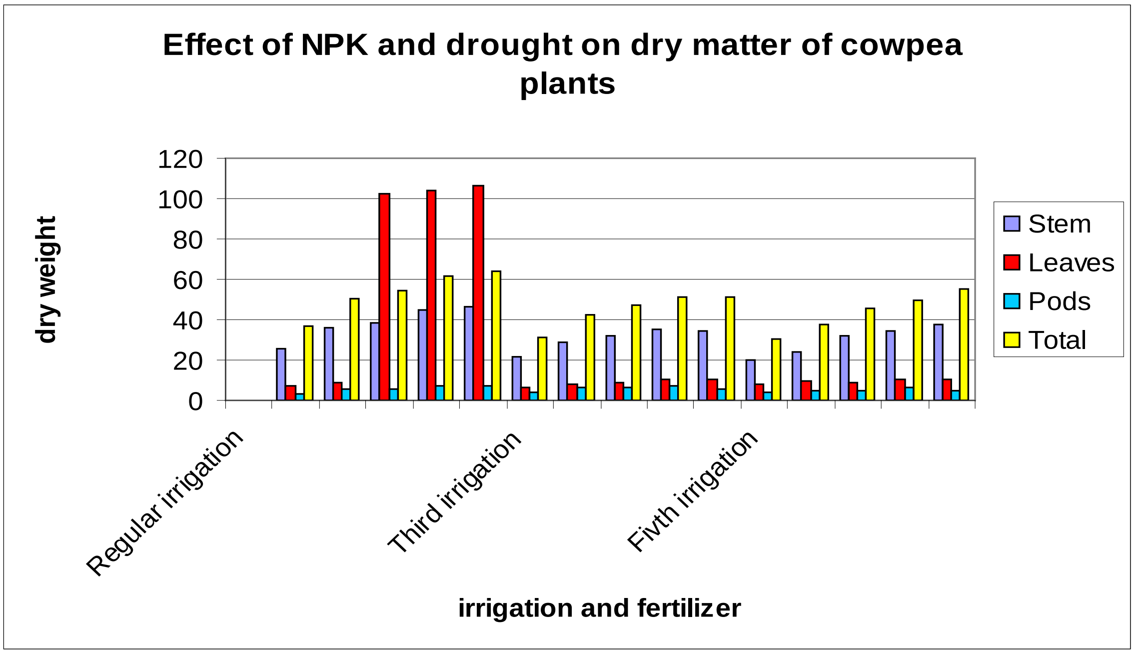


Figure 1: Effect of PK and drought on dry matter of cowpea plants.

PK fertilization

Data presented in Table (2) revealed that all fertilizing treatments increased the measured growth parameters in comparison with that irrigated regularly. Generally, the highest values of plant height, number of leaves number of cops and fresh weight of stem, leaves and whole plant. Addition of K_1 in corporation with P_1 increased plant height but when doses increased to P_2K_2 did not exert any effects. The reverse was true for fresh weight of leaves. Meanwhile, the number of leaves and pods and fresh weight of shoots as well as whole plant show positive response and synergistic effects with the increase in P and K doses. P_1K_1 treatment increased the above mentioned criteria by 40.57, 48.23, 33.40, 42.36 and 37.87 % and P_2K_2 increased it by 50.29, 78.68, 59.99, 62.93 and 61.46 %, respectively, compared to that of unfertilized plants. **Okeleye and Okelana (1997)** emphasized that nodulation, dry matter accumulation and yield of cowpea increased significantly with increase in P application from 0 – 30 kg in some varieties and to 60 kg /h in others. **Srvanan and Basker (1997)** indicated that yield of cowpea was higher when fertilizer were applied in mixture as fertigation and soil application than soil application only. **Blragwas, *et al.* (1997)** pointed out that P addition increased cowpea yield. Phosphorus as an important nutritional element plays its part in regulating many physiological criteria in the plant which in turn affect the resulted total yield. Phosphorus is implicated in carbohydrate metabolism. Although the rates of photosynthetic carbon fixation by plants may be reduced by phosphorus deficiency (**Plesniˇar, *et al*. 1994**). The presence of phosphorus in the soil encourages plant growth because the phosphorus is an essential nutrient. Practically, phosphorus is a major building block of DND molecules (**Pant and Reddy, 2003**). It evident that, addition phosphorus as chemical source, i.e. super-phosphate for onion plant gained the vigor plant growth if compared with the natural phosphate and/or the supplying half of the total needed phosphorus fertilizer as chemical mixed with other half of natural one (**Shaheen, *et al.* 2007**). Potassium also plays some important roles in plant metabolism. The role of K in photosynthesis is complex. The activation of enzymes by K and its involvement in adenosine tri-phosphate (ATP) production is probably more important in regulating the rate of photosynthesis than is the role of K in stomatal activity. Potassium also plays a major role in the transport of water and nutrients throughout the plant in the xylem **(Paul, 1990**). The combined fertilizer (NPK) increased growth, yield and water use efficiency of forage sorghum (**Hussein, *et al.* 2014**).

Drought x PK fertilization

Data presented in Table (2) shows the interaction effect of drought and PK fertilization on growth parameters. Examination of these data reported that all growth criteria increased with further fertilizers treatments used. Increased the rate of K and P as $K_1P_1$and K_1P_2 led to increases in plant height but the increment from P_2K_1 more than that from P_1K_1. Raised the rate of P to P_2 did not induced any effect under normal irrigation and D_1 treatments, however, under D_2 plant height tended to decrease but still more than the other treatments. Data also showed that the increment in stem, leaves and whole plants can be illustrated as a result of: P_1K_1<P_1K_2< P_2K_1<P_2K_2 under the different irrigation treatments. The positive effects of P and K fertilizers were more unde

Table 2: Growth of cowpea plants responses to PK fertilizers and omitting of irrigation (average of two seasons).

Omitting of irrigation	Fertilizer	Plant height cm	No of Leaves /plant	No of pods	Fresh weight (g): Stem	Leaves	Pods	Total	Dry weight (g): Stem	Leaves	Pods	Total
Regular irrigation	O	42.5	16.4	8.3	147	136	19.7	302.7	25.9	7.23	3.40	36.53
	P1K1	52.3	21.6	8.0	186	166	29.3	381.3	36.1	8.60	5.87	50.57
	P1K2	64.0	23.3	18.0	193	207	38.3	438.3	38.5	102.3	5.79	54.52
	P2K1	71.0	24.8	18.5	2.8	231	363	475.7	44.5	103.7	7.08	61.95
	P2K2	71.0	25.1	19.7	230	243	41.0	414.0	46.1	106.8	6.84	63.62
Mean		**60.16**	**22.24**	**14.64**	**192.8**	**196.6**	**33.0**	**422.4**	**38.2**	**9.42**	**5.80**	**53.42**
Third irrigation	O	45.0	13.9	11.3	144	146	22.3	312.3	21.4	6.57	3.63	31.60
	P1K1	51.0	20.2	11.3	165	162	23.0	350.0	28.5	7.93	6.12	42.11
	P1K2	57.0	21.0	11.7	185	200	27.3	412.3	31.9	8.80	6.05	46.82
	P2K1	60.3	20.2	12.3	199	183	28.3	410.3	35.1	10.10	6.89	51.25
	P2K2	61.3	21.8	15.3	227	235	27.0	489.0	34.2	10.38	5.67	51.47
Mean		**54.92**	**19.43**	**12.38**	**184.0**	**185.2**	**25.78**	**395.0**	**30.2**	**8.76**	**2.59**	**44.63**
Fifth irrigation	O	50.7	15.7	9.7	149	160	23.7	322.7	20.2	7.70	4.20	30.49
	P1K1	61.0	20.2	11.7	175	215	303	420.3	23.8	9.22	4.49	37.22
	P1K2	62.0	20.3	15.3	209	222	33.3	464.3	32.0	9.20	4.60	45.69
	P2K1	66.0	20.7	18.7	232	219	33.7	484.7	34.8	10.36	6.63	49.76
	P2K2	64.0	20.8	20.0	247	242	41.0	530.0	38.0	10.38	4.50	55.01
Mean		**60.74**	**19.53**	**14.48**	**202.4**	**211.6**	**32.40**	**446.4**	**29.8**	**9.38**	**3.21**	**43.67**
Mean values of fertilizer	O	46.07	46.00	8.77	146.7	147.3	21.90	312.0	22.5	7.17	5.25	32.88
	P1K1	54.77	62.03	10.33	175.3	181.0	27.53	383.9	29.5	8.58	5.17	43.33
	P1K2	61.00	64.66	13.00	195.7	209.7	32.97	438.3	34.1	9.41	6.79	48.98
	P2K1	65.77	65.67	14.00	213.0	211.0	32.90	456.9	38.1	10.48	6.79	54.29
	P2K2	65.43	67.63	15.67	234.7	240.0	36.33	511.0	39.4	10.48	1.34	56.64
LSD at 5 %	Irrig.	N.S	N.S	0.70	N.S	N.S	4.83	N.S	N.S	N.S	2.45	9.10
	Fert.	0.88	2.04	2.13	15.95	9.35	12.95	187	5.95	0.65	2.45	17.36
	I X F	N.S	N.S	3.76	N.S	N.S	22.67	N.S	N.S	N.S	N.S	30.38

normal irrigation more than stress treatments in plant height, number of leaves and stem, leaves and whole plants followed by that under D_2. The lowest were by D_1 except number of leaves which the lower were under D_2. Interaction effects of soil moisture and fertilization was studied by **Sangakkara, *et al.* (2001a**) who emphasized that K promoted growth of both species when subjected to suboptimal soil moisture. Also, the application of K fertilizer can be considered a significant factor in overcoming soil moisture stress in these legumes commonly grow in tropical cropping systems. **Meroena and Sreekhmar (1997**) concluded that cultivars of cowpea with high harvest index, high leaf are index in the vegetative period and long seed filling period will produce the yield under drought condition. In addition, **Shinde, *et al*. (2001)** concluded that water saturation deficit (WSD) was maximum under stress, addition of K or PGR decreased the WSD and increase the relative water content and water absorption coefficient in five legumes included cowpea. However, **Sangakkara, *et al.* (2001b**) attributed the adverse effect of moisture deficit to its effect on the rate of photosynthesis, shoot water potential and carbon movement. They added that the rate of photosynthesis was higher at reduced water stress when K + was applied.

- **Yield**

Drought

After examination of Data in Table (3) it could be mentioned that the dry yield of the 2nd season only significantly responded. The more effect the withholding of the fifth irrigation compared to that withholding of third irrigation or irrigated regularly. This agree with the finding that cowpea relatively drought tolerant plants.

Previously, **Mwanamwenge, *et al.* (1999)** found that the early pod ding stage of development was the most sensitive to water deficit in faba bean, causing a reduction in harvest indices and seed yields of at least 50% in all three genotypes. In contrast, genotypes showed a better ability to recover from stress at floral initiation and first flower stages than at early pod ding. As water deficits developed, leaf water potential decreased, leaves lost turgor and leaf area was reduced dramatically due to wilting. However, **Thomas, *et al.* (2004)** showed that the contribution of the second flush to final yield is highly variable (1–56%) and can be considerable, especially where mid-season stress is relieved at early pod filling. The capacity to produce a second flush of pods did not compensate fully for yield reduction due to water stress. Relief from mid-season stress also resulted in continued leaf production, N_2 fixation and vegetative biomass accumulation during pod filling. Despite the wide variation in the degree of change in vegetative biomass and N during pod filling, there were strong relationships between grain yield and net-above-ground biomass at maturity, and grain N and above-ground N at maturity. **Anyia and Herzog (2004**) induced water deficit by withholding irrigation until the soil water potential was −75 k Pa, which was then maintained for 10 days, Water deficit treatment reduced mean water use by 21%. This caused between 11 and more than 40% reduction of biomass across the genotypes. Reductions in biomass were due to decline in leaf gas exchange and leaf area during water deficit. **Blum (2009)** concluded that since biomass production is tightly linked to transpiration, breeding for maximized soil moisture capture for transpiration is the most important target for improvement under stress. In addition, **Mohamed and Abd El-Haddy (2009**) showed that irrigation treatments (Intervals) significantly affected fresh yield in both seasons. The highest values of these characters were obtained with irrigation at 30 days intervals. They added that these increases could be explained in the light of increments in yield parameters i.e. number of pods, seeds/pod, length of pods and number of seeds/pod as found by **Salem, *et al.* (1990). Sanada and Maina (2013**) noticed that in all the parameters measured, which include fodder yield, days to 50% flowering, 95% maturity ratio, and grain yield, and sowing dates, had some significant effect, and it therefore, assumed that drought and terminal stress does not only affect the grain yield, but also the fodder production in all the cultivars tested.

The highest seed yield (1.12 ten./fed.) was observed with fully irrigation, while the lowest (0.67 ten./fed.) was with 60% of field capacity. This lowest value of seed yield was associated with low number of pods/plant (14.6 pods /plant) and small increase in number of seeds per pod (11.00 seeds/pod) and average seed weight (20 g/plant).Increasing the deficit percent of water application resulted in progressively lower water use efficiency. At 80 % of field capacity, water use efficiency was 0.68 kg/m3 while, it decreased to 0.59 kg/m3 as the deficit percent increased from 80% to 60% of soil moisture content at field capacity (**Aboameria, 2010**). While, **Benvindo, *et al*. (2014)** found that The maximum yield was of 1,319 kg/ ha achieved with 168 kg/ha of P_2O_5. Generally, rates of phosphorus increases the rendering of cowpea grains.

The results showed that the highest value of WUE (3.59 kg fresh pod yield/m^3 water) was obtained when irrigation was applied at 30 days followed by the values of 3.06 and 2.27 kg fresh pods yield /m^3 water which was recorded as irrigation was given at 40 and 20 days, respectively, in the 1st season. Similar results were obtained in the 2nd season, where, it was found that WUE values decreased gradually from 3.52 to 3.14 and 2.27 kg fresh pods yield /m^3 water when pea .The reduction in WUE in the values of 20 and 40 days could be attributed to the increase in water consumptive use recorded by applying the 1st and 2nd irrigation regimes, respectively. These results were in agreement with that obtained by **Abd El–Atti, *et al.* (2000**). **Wu and Wang (2000)** mentioned that water deficit reduced plant shoot dry weight, bean yield, and water use efficiency (WUE) by over 40, 30, and 15%, respectively. **Anyia and Herzog (2004**) concluded that water deficit improved the WUE of two genotypes (IFH27-8 and Lobia) by approximately 20 %. **Sezen, *et al.* (2008**) noticed that with the longer irrigation interval (I_4), lower yields were obtained with all K_{cp1} coefficients. Water use efficiency (WUE) and irrigation water use efficiency (IWUE) values were significantly influenced by the irrigation intervals and plant–pan coefficients.

PK fertilization:-

Data in Table (3) indicated that raised the rate of potassium and phosphorus levels increased the fresh and dry yield of cowpea plants particularly with the P_2K_2 level. This means that fresh or dry matter yields increased gradually by the increase in P or K fertilizer rates or the increase of rate of both. **Ali, *et al.* (2006)** revealed that Different potassium levels significantly affected the seed yield and protein contents. Maximum seed yield (1458.46 kg/ha) with 25.31 percent protein contents was obtained with 100 kg K per hectare. Genotype NM-98 produced higher seed yield than NM-92. **Carsky (2003)** stated that at Adingnigon, P application had a large relative effect (30–200%) but a small absolute effect (less than 100 kg/ha) on cowpea and soybean yield. **Abayomi, *et al.* (2008)** sawed that yield components and grain yield were significantly enhanced by the application of fertilizer at 150kha^{-1} (i.e., 30 kg N, 15 P_2O_5 and 15 K_2O ha^{-1})

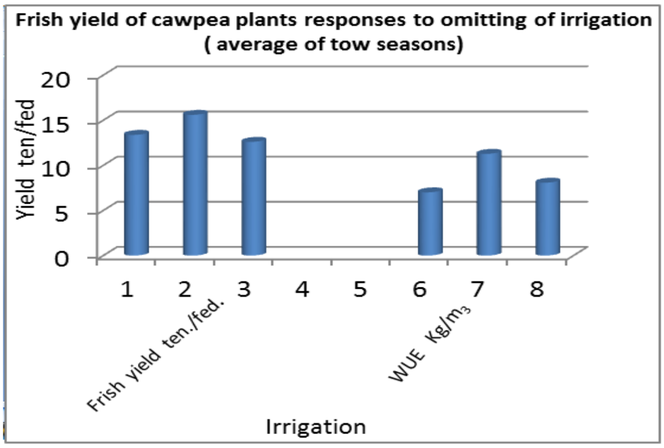
A gradual increase in WUE were detected with increase in rates of potassium and phosphorus fertilizers up to the highest levels used. Regarding, potassium effect on WUE, it was found by **Mohamed and Abd El-Haddy (2009)** that increasing K rate to pea cultivars from 0-40 kg/fed caused a gradual increase in the values in 1st and 2nd season. These results were in agreement with that obtained **by Abd El-Atti, *et al.* (2000)** showed that NPK fertilizer at the rate of 200kg/ha improved pod production, weight of 100seeds, pod weight and final grain yield per hectare.

Table 3: Yield of cowpea plants responses to PK fertilizers and omitting of irrigation (average of two seasons).

Irrigation Omitting	Fertilizer	Fresh yield t/fed			Dry yield t/fed			Water use efficiency kg/m3					
								Fresh yield			Dry yield		
		1st s	2nd s	M	1st s	2nd s	M	1st s	2nd s	M	1st s	2nd s	M
Regular Irrigation	O	12.92	9.60	11.26	1.74	1.30	1.52	5.33	7.18	6.26	0.72	1.00	0.86
	P1K1	13.76	10.27	12.02	1.94	1.45	1.70	5.69	5.69	5.69	0.80	1.08	0.94
	P1K2	16.36	12.28	14.32	2.23	1.66	1.95	6.76	6.76	6.76	0.92	1.24	1.08
	P2K1	16.60	12.35	14.48	2.43	1.81	2.12	6.86	9.22	8.04	1.00	1.35	1,18
	P2K2	17.08	12.71	14.90	2.54	1.89	2.22	7.06	9.49	8.28	1.05	1.41	1.23
Mean		**15.34**	**11.41**	**13.38**	**2.18**	**1.62**	**1.90**	**6.34**	**7.67**	**7.01**	**0.90**	**1.21**	**1.06**
Third Irrigation	O	10.52	7.84	9.18	1.24	0.92	1.08	5.22	7.01	6.12	0.61	0.82	0.72
	P1K1	12.68	7.84	10.26	1.90	1.41	1.66	6.29	8.45	7.37	0.94	1.26	1.10
	P1K2	13.80	9.43	11.62	2.00	1.48	1.74	6.84	9.20	8.02	0.99	1.33	1.16
	P2K1	16.16	10.26	13.21	2.37	1.76	2.07	8.01	10.77	9.39	1.17	1.58	1.38
	P2K2	16.28	12.02	14.15	2.33	1.74	2.05	11.65	10.91	11.28	1.18	1.56	1.37
Mean		**13.88**	**17.48**	**15.60**	**1.96**	**1.46**	**1.71**	**7.60**	**9.26**	**8.43**	**0.98**	**1.31**	**1.15**
Five Irrigation	O	12.32	11.40	11.86	1.34	1.00	1.17	6.10	8.21	7.16	0.66	0.89	0.78
	P1K1	13.32	9.16	11.24	1.90	1.41	1.66	6.61	8.88	7.75	0.94	1.27	1.11
	P1K2	14.72	9.91	12.32	2.06	1.53	1.80	7.03	9.81	8.42	1.02	1.37	1.20
	P2K1	16.04	10.55	13.30	2.38	1.78	2.08	7.95	10.70	9.33	1.18	1.58	1.38
	P2K2	16.57	12.10	14.34	2.45	1.82	2.14	8.94	6.52	7.73	1.15	1.54	1.35
		14.60	**10.62**	**12.61**	**2.03**	**1.51**	**1.77**	**7.33**	**8.82**	**8.08**	**0.99**	**0.90**	**0.95**
LSD at 5 %	Irrigation	N.S	N.S	….	0.54	N.S	….	……	….	….	…..	…..	…
	Fertilizer	3.59	N.S	…..	0.60	0.09	….	…..	….	…..	….	…	…
	I X F	N.S	3.61	….	1.10	N.S	….	…..	…..	….	…..	…..	…

Drought x PK fertilization:-

It is clear from Data in Table (3) and Figure (2) that addition of potassium and phosphorus fertilizer improved the fresh as well as dry yield under the omitting of irrigation or that plants irrigated regularly. Addition of P_1K_2 increased the dry weight by: 28.16, 61.29 and 53.73 % in the 1st year and by 22.69, 60.82 and 53.00 %in the 2nd year. However, addition of P_2 K_2 increased dry weight by: 45.98, 87.90 and 82.84 % in the 1st year and in the 2nd year by: 45.37, 89.13 and 82.00 %, compare to that without mineral fertilizer, respectively.



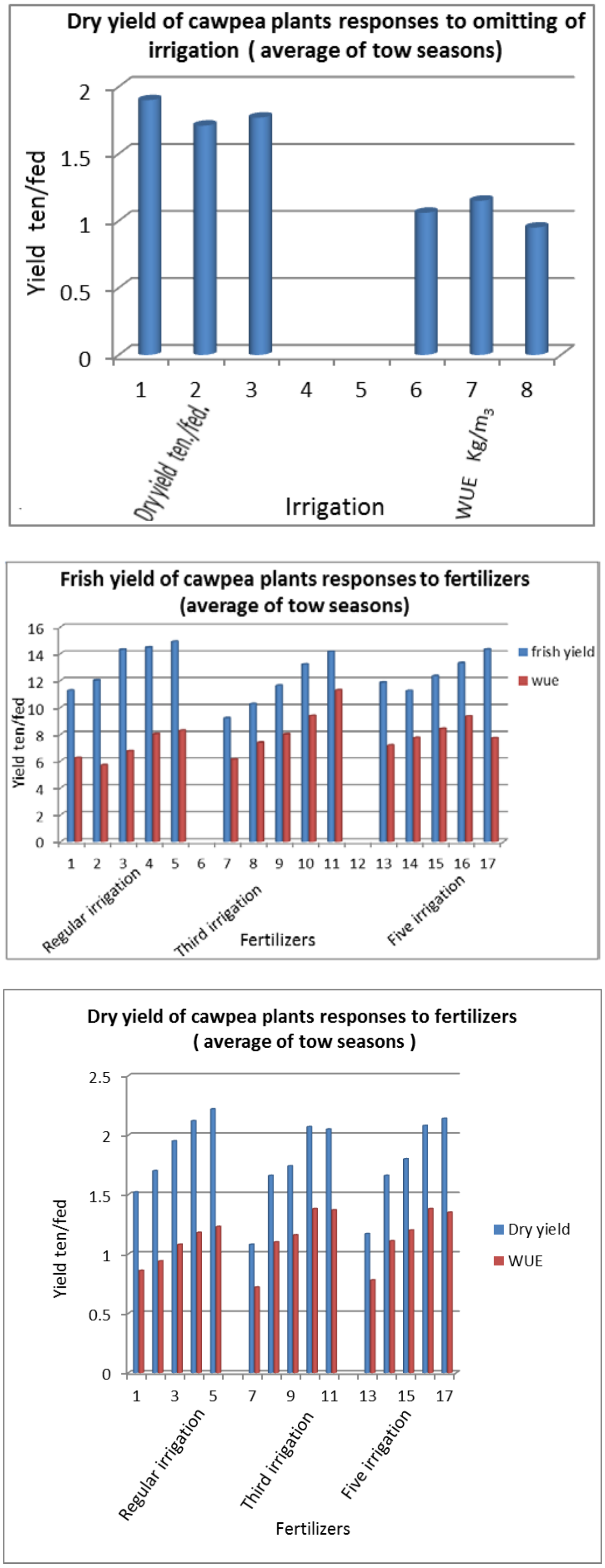


Figure 2: Yield of cowpea plants responses to PK fertilizers and omitting of irrigation (average of two seasons).

Fapohunda and Adekalu (1995) found that yields increased with increasing fertilizer and applied water, but became depressed at 240 kg/ha of fertilizer application. Multiple regression showed that the optimum combination of fertilizer and water for the maximum cowpea seed yield of 1.58 t/ha was found to be 120 kg/ha and 340 mm; respectively. The highest dry matter yield of 6.12 t/ha was produced with 235 kg/ha of fertilizer and 205 mm of water. Substantial reductions of fertilizer input from the optimum to minimum requirements did not appreciably decrease cowpea yields. However, only minor reductions of applied water could be made without adversely affecting yields. **Li, *et al.* (2004**) emphasized that fertilizer improved yield and water use efficiency of maize grown and subjected to dry-period, also reported that missing of irrigation decreased the fresh or dry mass of millet. The depression with missing the 4th irrigation exceeded those obtained by missing the 2nd irrigation. It can be seen from this data a continuous increase in growth traits as a results of the increase in the rate of N, P and K fertilizers up to $N_2P_2K_2$. The leaves area/plant markedly increased by addition of $N_3P_3K_3$, however, the all other characters did not show any significant differences with the higher fertilizer treatment used. Slight increases were shown in Water Use Efficiency (WUE) with drought treatment as omitting of the 2nd or 4th irrigation compare to the treatment irrigated regularly as a control. Also, there is a positive relationship between fertilizer treatment and WUE. Moreover, regardless the NPK effects, this parameter increased slightly by drought treatments. However, NPK application induced gradual increase in this phenomenon as the level of these fertilizers increased, and addition of NPK improved the WUE under different water regimes (**Hussein, *et al.* 2008, 2011 & 2014**). In addition, **Hussein, *et al.* (2013)** concluded that foliar fertilizer act positively to ameliorate drought negative effects. This phenomenon was very clear when irrigation omitted at heading stage. Furthermore, the enhancement of foliar fertilizer lowered when plant subjected to drought at dough stage to be less than the control plants (Regular irrigation). This effect may be related to the disturbance in nutrient stations (**Hussein, *et al.* 2006** on barley) and/or in photosynthesis (**Hussein, *et al.* 2013**) on jatropha

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