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Humic Acid Fertigation of Drip Irrigated Cowpea under Sandy Soil Conditions

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Abstract: To estimate the effect of fertilization technology through irrigation water on soil fertility, yield and its components and nutritional status of cowpea plants grown on sandy soil conditions, a fertigation trial was carried out at a private farm, El-Nubaria district, Egypt during April-June of summer season, 2010. The experiment was set up in split plot design with three replicates, main treatments were assigned fertilizer types, i.e. single (N,P and K) and combined (19N:19P:19K) fertilizers, while sub treatments were contained 4 treatments as follow, 100% (recommended chemical N, P and K fertilizer), 100% NPK fertilizer + humic acid, 125% NPK and 125% NPK fertilizer + humic acid were injected through drip irrigation system. Data revealed that fertigation of combined (19N:19P:19K) fertilizer was more efficient than single N, P and K fertilizers on improving seed, straw and biomass yields and nutritional status of cowpea plants, as well as soil fertility after harvesting. Additional rates of fertigation significantly increased the yield and its components, NPK nutrients uptake by cowpea organs and fertilizer use efficiency (kg yield kg^{-1}NPK fertilizer). Moreover, humic acid injected with NPK ferrtigation treatments resulted in higher available soil-N, P and K nutrients. Also, the seed yield was increased significantly with addition of humic acid comparing to the recommended rate solely. The most considered treatments for enhancing seed, straw and biomass yields, nutritional status of cowpea and soil fertility compared to the recommended dose of N, P and K (100%) was addition humic acid with 125% fertigation followed by100% fertigation of combined NPK fertilizer. Generally, all nutrients were increased due to apllication of humic acid plus 125 % combined NPK fertilizer as compared to the other treatments.

Key words: Humic acid · Fertigation · Single and Combined NPK fertilizer · Soil fertility · Cowpea · Sandy soil.

INTRODUCTION

Fertigation has been described as the application of plant nutrients in irrigation water to accomplish fertilization. It is becoming widely accepted in the industry due to the fact that a properly designed system will perform accurately, is now economical, easy to install, saves time, labor and most importantly, will save you money. A proper system will eliminate waste, sludge and residues. It allows one to "fine tune" fertility levels and will monitor the rates of fertilizer being applied. A good system will also address the reduction of fertigation water runoff which will soon be environmentally required [1, 2]. Many researchers indicated to the beneficial effect of fertigation increasing the efficiency of nutrients utilization under drip irrigation system [3-8].

In sandy loam soil, Hebbar *et al.* [9] revealed that the total dry mater production, fruit yield, NPK uptake and K to deeper layer of the soil were significantly high in water soluble fertilizer fertigation by respectively compared to furrow irrigation. Humic substances are mixture of naturally occurring organic materials that arise from the decay of plant and animal residues that are broken down by soil organism. Humus is a generic term describing humic substances, which are comprised of three distinct groups, namely: humic acid, fulvic acid and humin [10]. Relations of humic acid and plant growth have been critically reviewed by Bryan and Jeff [11] and Yusuff *et al.* [12], they described growth promoting effects in cereals such as wheat, barley and corn and stimulation of root growth and enhancement of root initiation have been found.

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Cowpea (*Vigna unguiculata, L.*) is a warm-season adapted grain legume; however, moderately high night temperatures reduce pod set of most cultivars. Breeding for heat resistance, i.e. enhanced grain production under hot field conditions, has been achieved by selecting for reproductive-stage heat tolerance [13]. The main purpose of our study is to humic acid additives could be effective in improving cowpea seed, straw and biomass yields and its nutrients uptake by cowpea tissues as well as nutrients remained in soil after harvesting under fertigation treatments in sandy soil to be included in the drip fertigation system.

MATERIALS AND METHODS

Location of the Experiment and its Layout: Field experiment in randomized complete block with split plot design was done at a private farm, El-Nubaria district, Egypt during April-June of summer season, 2010 to estimate soil fertility after harvesting, yield and its components and N, P and K nutrients uptake by cowpea tissues following applications of single and combined N, P and K fertilizers integrated with humic acid injected through drip irrigation system under sandy soil conditions.

Soil Sampling and Chemical Analysis: Representative soil samples at 0-30cm was collected and analyzed for some physical and chemical properties e.g. particle size distribution, total carbonate, pH, EC, the amounts of water-soluble cations (Ca^{+2}, Mg^{+2}, Na^{+} and K^{+}) and anions ($CO^{=3}$, HCO^{-3} and Cl^{-}) for soil as described by Dewis and Fertias [14]. Available soil-N was extracted using KCl (2.0 M) and determined by using macro-Kjeldahl method according to Hesse [15]. Available soil-P was extracted with $NaHCO^{-}_{3}$ (0.5 M) at pH 8.5 and determined calorimetrically after treating with ammonium molybdate and stannous chloride at a wavelength of 660 nm, according to Olsen and Sommers [16]. Finally, Available soil-K was determined by extracting soil with ammonium acetate (1.0 M) at pH 7.0 using flame photometer as described by Hesse [15].

Soil of the experimental site was sandy in texture (*Typic torripsamments*) which comprising 87.34% sand, 9.44% silt and 3.22% clay. Non calcareous 4.5% $CaCO^{-3}$. It is very poor in fertility, 0.85% OM with alkaline $KMnO_4$-N status of 28, Olsen's P of 2.8 and NH_4OA_c-K of 98 mg kg^{-1} soil, respectively and the value of pH is 8.3 and ECe is 2.63 dSm^{-1}, there are no salinity and alkalinity problems.

Irrigation Set Up: The drip irrigation lines were used GR (built-in) drippers spaced 0.50 cm apart with a flow capacity of 4 liters $hour^{-1}$ at 1.5 bar working pressure and the spacing between lateral lines was 0.5 m and irrigation water, originating from a local well, had a good quality, pH of 7.1, EC=0.4dSm^{-1} and sodium absorption ratio (SAR) is 2.7, classified as C_2S_1 [17].

Cultivation: Karim 7 seeds of cowpea plants had cultivated on 15th April during summer season, 2010 and these plants treated with two rates of fertigation, 100% and 125% according to recommendation of Agriculture Ministry, using combined and single fertilizers of N, P and K produced locally and humic acid was injected with these rates through drip irrigation system. The seeds of cowpea were coated with N-fixer okadeen (Rhizobia) for cowpea plant that was obtained from general organization for Agriculture Equalization Fund (GOAEF), Ministry of Agriculture, Egypt. For combined fertilizers, the fertilizer in the form of (19N-19P-19K) according to the treatments of 100%, 100% + humic acid, 125% and 125% of recommended NPK fertilizer + humic acid injected through drip irrigation system from the 2nd week until the 6th week of the plant growth stage until the end of fertigation programme. Meanwhile, the single N, P and K fertilizers supplied with drip fertigation system along the growing season, nitrogen was added in the form of ammonium nitrate (33.5%N) and phosphorus as phosphoric acid (60% P_2O_5), while potassium was added in the form of potassium sulfate (48% K_2O). The nitrogen fertilizer was injected at the rates (60, 60, 75 and 75 N Kg $acre^{-1}$), respectively divided into 7 portions weekly starting from the second week after planting. Meanwhile, the phosphorus was injected at rates 30, 30, 37.5 and 37.5 P_2O_5 Kg $acre^{-1}$ of phosphoric acid divided into 5 portions weekly starting from the planting. After three weeks from planting, the rest of the total potassium requirement (30, 30, 37.5 and 37.5 K_2O Kg $acre^{-1}$) of potassium sulfate, respectively were injected in 5 doses during 7 weeks. Humic acid was produced from Egyptian Fertilizer Development Centre, El-Mansoura. Humic acid had characteristics of pH 7.83, EC 0.94 and OM 68%. N, P and K were 3.40, 0.15 & 3.42%, respectively. Zn, Fe, Mn were 258, 415 and 214 mg kg DW^{-1}, respectively. Humic acid was applied with 50 kg $acre^{-1}$ and divided into 3 equal doses and added through drip irrigation system at the same time of N, P and K fertigation.

Plant Sampling and Analysis: Three plants from each plot per treatment were randomly chosen at 35, 70 days after planting and at harvest to determine N, P and K concentrations in tissues of cowpea, after then these samples dried at 70°C and grounded using stainless steel equipments. From each sample 0.2 g was digested using 5 cm^3 from the mixture of sulfuric (H_2SO_4) and perchloric ($HClO_4$) acids (1:1) as described by Cottenie *et al.* [18].Total nitrogen was determined by micro-Kjeldahl method, whereas total phosphorus was determined calorimetrically at wavelength 660 nm using spectrophotometer (Spekol) and total potassium was determined by using Gallen Kamp flame photometer as mentioned by Cottenie *et al.* [18].Total crude protein % in seeds was calculated by multiplying % total nitrogen by 6.25 [19].After cowpea harvesting, soil sample was taken by soil auger relative to the drip line study N, P and K nutrients in soil under investigated treatments as mentioned by Hesse [15]. Fertilizer-use efficiency was worked out as a factor of biomass yield by quantity of fertilizer applied and expressed as a ratio.

All data were statistically analyzed according to the technique of analysis of variance (ANOVA) published by Gomez and Gomez [20].

RESULTS AND DISCUSSION

Nutrients Status in the Soil After harvesing: No doubt that the agricultural potential of sandy soils depends on the availability of sufficient water for crop cultivation and the provision of nutrients. So, Table 1 reveals that additional rates of fertigation treatments had a significant effect on N, P and K nutrients remained at the investigated soil. Injection of NPK fertilizer as a combined form increased available soil-N, P and K more than a single form.

Addition of humic acid jointly with N, P and K either single or combined fertilizer form improving the soil fertility status. Highest available N, P and K were 65.23, 10.00 and 119.94 mg kg $soil^{-1}$ occurred with the addition of humic acid to 125% combined NPK fertilizer through drip fertigation system, respectively. While, the lowest available N, P and K in soil was 42.20, 8.66 and 104.55mg kg $soil^{-1}$ occurred with 100% single NPK fertigation, respectively. It is well established that when humic acid applied to sandy soils, it adds essential organic material necessary for water retention thus improving root growth and enhancing the sandy soil's ability to retain and not leach out vital plant nutrients [12 ,21].

Table 1: Means of available soil-N, P and K (mg kg^{-1} soil) as affected by fertilizer types and humic acid under fertigation system during summer season, 2010

		Available nutrients (mg kg^{-1} soil)		
Treatments		N	P	K
Fertilizer types				
Single		51.52	8.97	107.25
Combined		55.59	9.26	113.02
F test		*	*	*
Fertigation treatments plus humic acid				
100% NPK		44.59d	8.74c	104.90c
100%NPK + Humic acid (HA)		51.81c	8.90b	109.69b
125%NPK		55.96b	9.23ab	111.45ab
125% NPK+ Humic acid(HA)		61.87a	9.60a	114.51a
Fertilizer types x fertigation treatments plus humic acid				
Single	100% NPK	42.20d	8.66 f	104.55 d
	100%NPK + Humic acid(HA)	50.03bc	8.87e	107.14c
	125%NPK	55.34bc	9.16b	108.24bc
	125% NPK+ Humic acid(HA)	58.50ab	9.20b	109.08bc
Combined	100% NPK	46.98c	8.82e	105.24d
	100%NPK + Humic acid(HA)	53.58bc	8.92d	112.23b
	125%NPK	56.58b	9.30b	114.66ab
	125% NPK+ Humic acid(HA)	65.23a	10.00a	119.94a

[1]Means within a column followed by the same letters are not significantly different ($P < 0.05$).

Table 2: Means of yield (Mg**acre^{-1}) and its components of cowpea crop as affected by humic acid and fertigation treatments during summer 2010 season.

Treatments		No. of seeds pod^{-1}	100 seed weight (g)	Yield (Mg acre^{-1}) Seed	Straw	Biomass yield (Mg acre^{-1})	Total crude protein (%)
Fertilizer types							
Single		11.00	20.75	0.835	0.886	1.722	25.35
Combined		9.00	25.79	0.908	0.968	1.876	26.07
F test		*	*	*	*	*	*
Fertigation treatments plus humic acid							
100%NPK		8.00	20.42b	0.750b	0.802c	1.552c	25.46b
100%NPK + Humic acid (HA)		9.00	21.34b	0.848ab	0.917b	1.765b	25.66b
125%NPK		11.00	23.43b	0.885ab	0.965ab	1.850ab	25.63b
125% NPK+ Humic acid(HA)		11.00	27.89a	1.004a	1.025a	2.029a	26.10a
Fertilizer types X fertigation treatments plus humic acid							
Single	100% NPK	8.00	18.25c	0.679d	0.775d	1.454e	25.23d
	100%NPK + Humic acid(HA)	9.00	18.69c	0.829bc	0.892c	1.721c	25.30c
	125%NPK	10.00	20.28b	0.871ab	0.908b	1.779c	25.26c
	125% NPK+ Humic acid(HA)	10.00	25.78ab	0.963ab	0.971ab	1.933b	25.60bc
Combined	100% NPK	9.00	22.58b	0.821bc	0.829c	1.650d	25.68bc
	100%NPK + Humic acid(HA)	10.00	23.98b	0.867b	0.942ab	1.808bc	26.02b
	125%NPK	12.00	26.58ab	0.900b	1.021a	1.921b	26.00b
	125% NPK+ Humic acid(HA)	12.00	30.00a	1.046a	1.079a	2.125a	26.59a

[1]Means within a column followed by the same letters are not significantly different ($P < 0.05$), ** Mg, Miga = ton

Table 3: Means of nutrients uptake (kg acre^{-1}) by cowpea organs as affected by humic acid and fertigation treatments during summer 2010 season.

Treatments		Seeds N	P	K	Straw N	P	K
Fertilizer types							
Single		61.61	2.76	10.86	8.05	0.87	7.89
Combined		73.85	3.35	12.52	10.41	1.07	9.59
F test		*	NS	*	*	NS	*
Fertigation treatments plus humic acid							
100%NPK		21.28b	1.83c	9.49c	7.28c	0.63	6.70b
100%NPK + Humic acid (HA)		28.30b	2.93b	6.06b	6.06c	0.98	8.52ab
125%NPK		29.07b	3.34b	10.00b	10.00b	1.05	9.60ab
125% NPK+ Humic acid (HA)		34.89a	4.11a	13.59a	13.59a	1.24	10.14a
Fertilizer types X fertigation treatments plus humic acid							
Single	100% NPK	18.27d	1.58e	8.35d	9.01c	0.60	6.35e
	100%NPK + Humic acid (HA)	26.78c	2.65c	10.67c	5.55e	0.86	7.31d
	125%NPK	27.00c	3.16b	11.44b	7.76b	0.97	8.48c
	125% NPK+ Humic acid(HA)	31.18b	3.63b	12.96a	9.89b	1.07	9.42b
Combined	100% NPK	24.30d	2.08d	10.62c	5.55e	0.66	7.05d
	100%NPK + Humic acid (HA)	29.81b	3.21b	11.67b	6.57d	1.10	9.73b
	125%NPK	31.14b	3.51b	12.57a	12.23b	1.13	10.72a
	125% NPK+ Humic acid(HA)	38.59a	4.60a	15.20a	17.28a	1.40	10.86a

[1]Means within a column followed by the same letters are not significantly different ($P < 0.05$).

Yield and its Components: Data of the Table 2 reveal that, that fertigation of single or a combined NPK fertilizer had a significant effect on yield and its components, i.e. number of seeds pod^{-1}, 100 seed weight (g), seed, straw and biomass yields (Mg acre^{-1}) and total crude total protein (%) of cowpea grown on sandy soil conditions. Moreover, additional rates of NPK fertigation had significantly increased the aforementioned attributes except for number of seeds pod^{-1}.

Injection of humic acid to the NPK fertilizer tended to increase100 seed weight (g), seed, straw and biomass yields and total crude protein (%) at both 100% and 125%

single or combined NPK fertilizer followed by the injection of these fertilizers solely. The highest means of biomass yield of cowpea was 2.125 Mg acre^{-1} produced from the addition of humic acid to 125% combined NPK fertigation. While, the lowest mean of this attribute was 1.454 Mg acre^{-1} obtained from the addition of the recommended rate of single NPK fertigation. These results could be attributed to the improvement of the moisture retention and nutrient supply potentials of sandy soils after humic substances application [6, 7, 8, 22].

Nutritional Status of Cowpea Plants: As shown in Table 3, the differences in means of nutrients uptake by cowpea tissues with the fertigation of single or combined NPK fertilizers were significant except for P uptake (kg acre^{-1}) by seed and straw tissues ($P < 0.05$). The additional rates of NPK fertilizer significantly enhanced the nutrients uptake (kg acre^{-1}) by cowpea organs except for phosphorus uptake by straw of cowpea plants. Concerning the effect of addition of humic acid to fertigation treatments, the same Table shows that addition of humic acid to fertigation treatments positively increased nutrients uptake by cowpea seeds comparing with fertigation treatment of NPK fertilizers solely.

The highest values of N, P and K nutrients were 38.59, 4.60 and 15.20 kg acre^{-1} occurred with 125% combined NPK fertigation plus humic acid followed by 100% combined NPK fertigation plus humic acid, 125% fertigation alone and finally 100% NPK fertigation, respectively.

Similarly, higher N, P and K uptake by straw tissues with the addition of mineral fertilizer as a combined form, with further increases resulting from the addition of humic acid. The maximum values of N, P and K were 17.28, 1.4 and 10.86 kg acre^{-1} taken up by straw occurred with addition of humic acid to 125% fertigation of combined NPK fertilizer as compared to the others. Humic matter has been shown to increase the uptake of nitrogen by plants and to increase soil nitrogen utilization efficiency [12]. It can also enhance the uptake of potassium, calcium, magnesium and phosphorus [23, 24].

Fertilizer Use Efficiency (Kg Biomass Yield Kg^{-1} Npk Fertilizer): A glance of the following figures, it could noticed that fertilizer-use efficiency was significantly superior in all the treatments where either single or combined fertilizer injected through drip irrigated system (Fig. 1). This was due to better availability of moisture and nutrients throughout the growth stages in drip fertigation system leading to better uptake of nutrients and production by potato tubers [12].

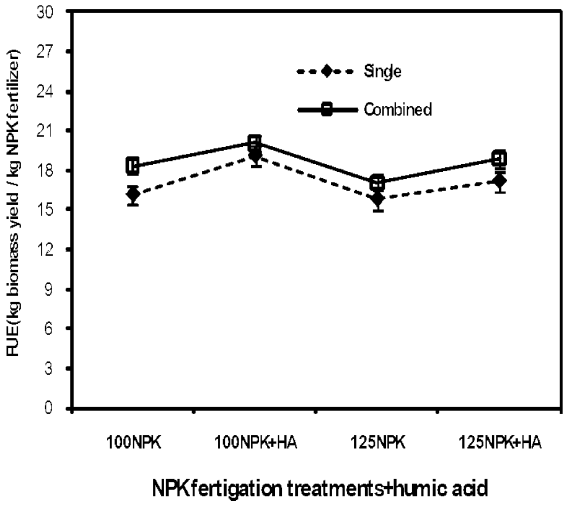

Fig. 1: FUE (kg biomass yield kg NPK^{-1} fertilizer) as affected as affected by humic acid and fertigation treatments during summer 2010 season.

FUE was significantly higher with addition of humic acid to NPK fertilizer compared to mineral NPK fertigation only. Highest mean value of fertilizer use efficiency was 20.9 kg biomass yield kg^{-1}NPK fertilizer occurred with injection of 100% combined NPK fertilizer jointly with humic acid fertigation. While, the lowest mean value of this attribute was 16.16 kg^{-1}NPK fertilizer obtained from fertigation of 100% single NPK fertilizer. Accordingly, humic acid should be used to decrease the chemical fertilizer negative effects on soil and plant growth.

CONCLUSION

This study has concluded that fertigation of NPK as a combined form increased available soil-N, P and K nutrients, seed, straw and biomass yields and nutrients uptake by cowpea organs as well as fertilizer use efficiency more than in single form. Addition of humic acid to NPK fertilizer through drip irrigation system resulted in higher available N, P and K to deeper layer of investigated soil. Generally, the most considered treatments for enhancing biomass yield, nutritional status of cowpea organs and soil fertility compared to recommended dose of NPK (control) was addition humic acid to 125% fertigation followed by 100% fertigation of combined NPK fertilizer. Meanwhile, higher fertilizer use efficiency was occurred with injection of 100% combined NPK fertilizer jointly with humic acid through drip fertigation system.

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