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Water and fertilizer productivity as related to potassium fertilizer applied to cultivated desert soil

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Abstract

Field experiment was conducted in sandy soil at a cultivated desert between Karbala and Najaf Governorates to investigate different sources and rates of potassium fertilizers application on water and fertilizer productivity of maize. The experiment was a randomized complete blocks design with three replicates. Treatments included two sources of potassium fertilizers (potassium sulfate and potassium chloride) and four levels of each fertilizer (0, 75,150 and 300 kg K ha^{-1}). The applied amounts were divided into six segments added through fertigation. Maize (Corn) "*Zea mays* L." was planted in summer 2005 and was irrigated through drip irrigation. Results of the experiment indicated that levels of applied K increased plant K content especially with 150 kg K ha^{-1}. The highest values of potassium use efficiency (KUE) were obtained with 150 kg K ha^{-1}. Grain yield increased with potassium application with 150 kg ha^{-1} giving the highest yield 4.90 Mg ha^{-1} at 150 kg ha^{-1} with an increment of 56% compared to controlled treatment but with no significant differences than 75 kg K ha^{-1}. The highest value of fertilizer productivity was obtained with 75 kg K ha^{-1}. Potassium levels applied increased Water productivity giving a value of 0.54 kg m^{-3} at 150 kg K ha^{-1}compared to 0.349 kg m^{-3} at controlled treatment. Therefore, it can be concluded that 75-150 kg K ha^{-1} can give good results under such conditions.

Key words: Water productivity, fertilizer use efficiency, maize, desert soil, potassium fertilizers.

INTRODUCTION

The best management practices can be considered as the main reason for high crop productivity in developed countries. The proper management of soil, water and soil fertility in particular, can increase incomes and sustain soils for the future .The extensive and intensive use of lands can cope with nation demand for food and clothes. In Iraq good efforts being made for reclaiming deserted land especially salt affected and desert lands.

Water is considered as the most vital item in the world due to reduction of water resources in most regions, especially when we realized that the most water consumption belongs to agriculture and irrigation (Valipour, 2014). Drip irrigation, also known as trickle irrigation, is an irrigation method that saves water and fertilizer by allowing water to drip slowly to the roots of plants, either into the soil surface or directly into the root zone, through a network of valves, pipes, tubing, and emitters. It is done through narrow tubes that deliver water directly to the base of the plant (Wikipedia, the free encyclopedia). Drip irrigation offers improved yields, requires less water, decreases the cost of tillage and reduces the amount of fertilizer and other chemicals to be applied to the crop. Drip irrigation makes all these possible through placing water precisely where it is needed and application of water with high degree of uniformity. However, this system needs to be designed and managed carefully to insure high efficiency

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Table 1: Some chemical and physical soil properties

Property	Units	Depth (cm) 0-30	Depth (cm) 30-60
EC	dSm^{-1}	5.37	4.52
pH	-	7.62	7.76
CEC	C mol $_+$ Kg $^{-1}$Soil	10.80	10.69
SOM	g Kg^{-1}Soil	5.36	1.53
Carbonate Minerals		310.62	361.25
Ca^{2+}	m mol L^{-1}	12.5	12.0
Mg^{2+}		4.8	3.5
K^{+}		2.2	1.2
Na^{+}		15.1	12.4
SO_4^{2-}		17.8	16.4
Cl^{-}		9.5	7.2
HCO_3^{-}		2.2	1.4
CO_3^{2-}		-	-
N	mg Kg-1	33.41	11.18
P		5.98	2.12
K	Cm$_+$ Kg $^{-1}$ Soil	0.38	0.31
PSD			
Sand	g Kg^{-1}Soil	924.36	892.95
Silt		20.04	26.85
Clay		55.60	80.20
Texture		S	S
Bulk Density	Mg m^{-3}	1.55	-
Moisture at 10 Kpa	%	17.75	-

(Hanson, *et* al., 2006). Accurate computing of amount of pressure loss is very important in trickle irrigation system design . Pressure loss should be adjusted carefully in trickle irrigation for appropriate performance of and there are many attempts to solve this (Valipour, 2012).

Issa, (2011) in a study for comparing different irrigation systems and measuring water consumptive use for cabbage crop (grown in silty loam soil) indicated that the highest % of distribution uniformity efficiency was 99% with drip irrigation. Drip irrigation saved amount of water applied around 62% and had the highest water use efficiency (water productivity) compared to other irrigation systems.

The scientific use of balanced chemical fertilizers together with organic and biofertilizer can produce high sustainable yield. Potassium one of the essential plant nutrients which can be considered as the master of cations in plants for its ability to regulate plant enzymes and water through the control on stomata opening (Mengle & Kirkby, 2001; Havlin *et* al, 2005 and Amberger, 2006), water use efficiency (water productivity) (Ali & Mohammed, 2003; Al-saadi,2007, Aoda and Mahmood, 2014) help plants to withstand different stresses (Krass, 2003; Popp, 2007). Aoda and Mahmood (2014) indicated that application of K fertilizers minimize the influence of water stress on wheat grain yield and Eta parameters.

The response of crop yield and quality to potassium application depends on soil, crop and fertilizer itself (source and rate applied) (Ali, 2012; Ali *et* al., 2014). Most Iraqi soils classified as low to moderate in its content of K and very low in its rate of release (AlZubaidy, 2003). A number of crops (field and vegetable crops) responded to K fertilizers application even where soil test indicated medium-high content (Al-saadi, 2007, Ali *et* al., 2009). Bashoor and Al-Saaigh, 2007 indicated that soil content of the range of 175-300 mg K kg^{-1} soil can be quite enough in most arid soil**s.** Therefore, the undergoing investigation was conducted to study the effect of potassium fertilizer application (source and rate) applied through fertigation (with drip irrigation) on productivities of maize crop, water and fertilizer.

MATERIALS AND METHODS

Field experiment was conducted in one of the Desert farm situated between Karbala and Najaf governorates to study the response of corn crop to different levels of potassium fertilizer and the role of different sources and levels of potassium fertilizer applied on water and fertilizer productivity.

Soil samples from A horizon (0-30 cm) were taken from the site, dried, grounded to pass 2 mm sieve and analyzed for some physical and chemical soil properties according to methods outlined in Black (1965), Page *et* al. (1982) and Bashoor and Al-Saaigh, (2007). Results of the analyses listed in Table 1.

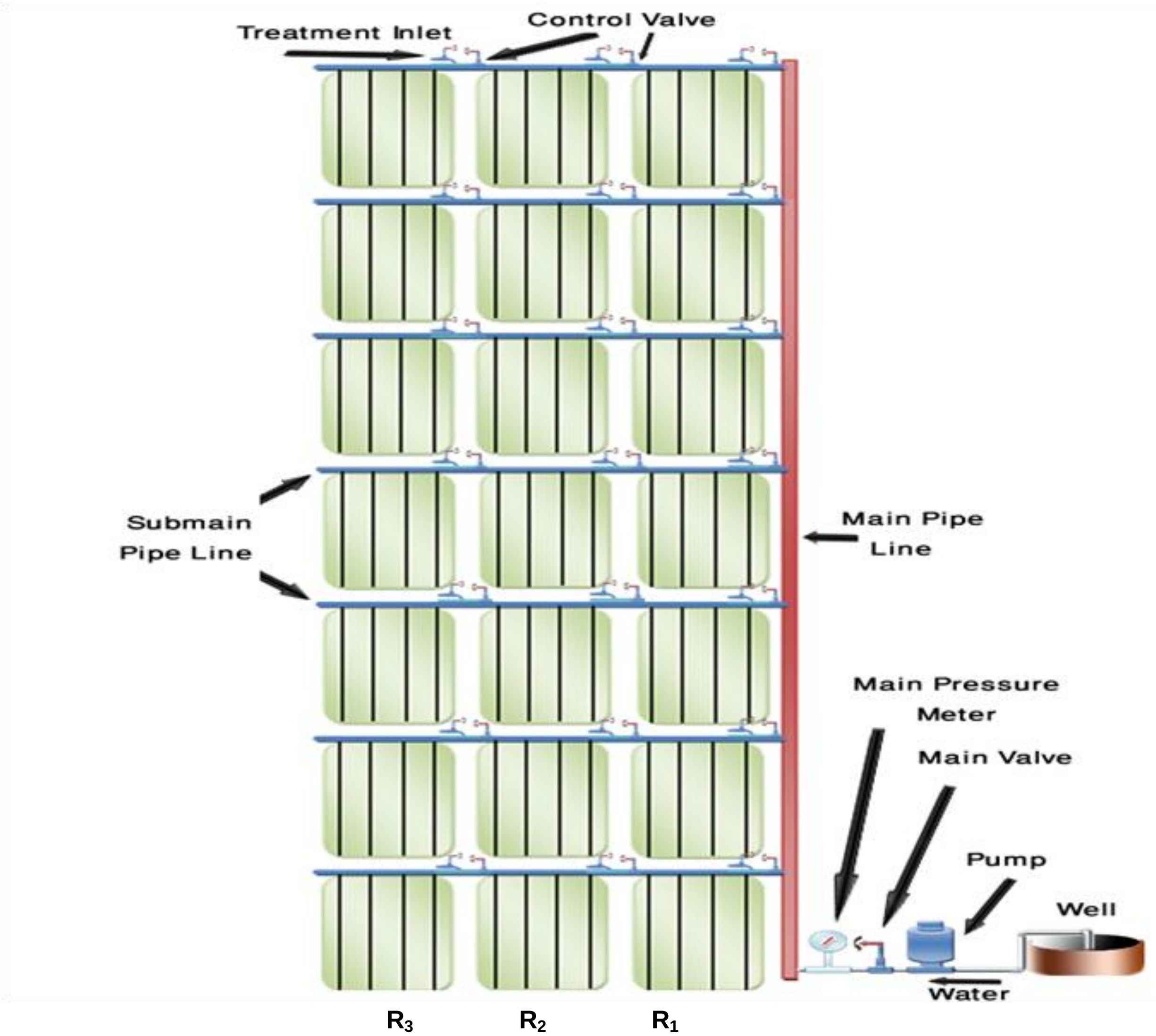

Figure 1: A schematic descriptions for the experiment

Treatments included 4 rates of potassium 0, 75, 150, and 300 kg K ha^{-1} using two potassium sources namely potassium chloride and potassium sulfate applied in 6 different splits through fertigation distributed according to corn growth stages (Ritchie *et* al., 1993 and Vyn, *et* al., 2002). Before planting, all experiment units received 320 kg DAP (18-46-0) ha^{-1} as source for P and some of N requirements. Urea fertilizer was applied later on in a rate of 200 Kg^{-1} N ha through fertigation in four different splits. All treatments were replicated 3 times in a Randomized Complete Block Design, "RCBD".

Corn "Maize" (*Zea mays* L) Al-Bohooth 106 cultivar seeds were seeded at 20th of July in lines 75 cm apart among lines and 20 cm among seeds holes with plant density of 66666 plant ha^{-1} (Al-Sahooki, 1980). The crop was irrigated through drip irrigation system using well water(EC:2.9 dSm^{-1} ,pH:7.82,TDS:2905 mg L^{-1}) with main pipe (7.5 cm) and sub pipes (2.5 cm) connected to feeding lines (outer dimater:17.6 mm, inner diameter :17.0 mm ,operating pressure :80 Kpa ,Maximum working pressure: 140 Kpa, distance between emitters: 200 mm, and normal flow rate :1.3 L h^{-1}) with distribution efficiency of 90.07% (Al- Semmak, (2009) as partly shown in the layout of the experiment (Figure 1). Water applied according to corn requirements (MOWR, 1982) using calibrated tensiometers to apply water) after depletion of 50% of available water). Besides, all required management practices were done at proper times and Dizenon 60% was applied after 3 weeks of germination and repeated 3 weeks later. At maturity stage whole plants from mid lines in each replicate were taken for determination of grain yield. Water productivity, Fertilizer productivity and potassium use efficiency were calculated according to equation recommended by Hillel, (2008) and Ali*, (*2012):

Water productivity (Kg grain yield per m^3 of water applied)

$$= \frac{grain\ yield\ of\ fertilized\ - grain\ yield\ of\ control}{ammount\ \ of\ water\ applied\ \ (m3)}$$

Table 2 K content, KUE, Grain yield, Fertilizer productivity and Water productivity

Treatment	Rates of K applied (Kg K ha^{-1})	K content (Uptake) at Flowering stage (Kg ha^{-1})	KUE %	Grain yield (Mg ha^{-1})	Fertilizer Productivity (Agronomic Efficiency) Kg Grain Kg^{-1} fertilizer	Water productivity WUE (Kg m^{-3})
L0	0	67.6	-	3.14	-	0.35
K1L1	75	76.4	11.7	**4.66**	**20.3**	0.52
K1L2	150	**91.1**	**15.7**	5.03	12.6	**0.56**
K1L3	300	84.7	5.7	4.54	4.7	0.50
K2L1	75	77.1	12.7	4.47	**17.7**	0.50
K2L2	150	**93.3**	**17.1**	**4.76**	10.8	**0.53**
K2L3	300	94.2	8.9	4.31	3.9	0.47
LSD0.05		2.67		NS		NS

K1,K2 : Potassium Chloride , Potassium Sulfate ; L0,L1,L2,L3 : 0,75,150,300 Kg K ha^{-1} Respectively.

Fertilizer productivity (Kg grain Kg^{-1} K fertilizer applied) $= \frac{grain\ yield\ of\ fertilized\ - grain\ yield\ of\ control}{ammount\ \ of\ K\ fertilizer\ \ applied}$

Potassium Use Efficiency (%) $= \frac{K\ content\ \ in\ fertilized\ \ -K\ content\ \ of\ \ control}{ammount\ \ of\ K\ fertilizer\ \ applied}$

Where K content = K concentration in grain ×Grain yield

Data were analyzed using SAS (SAS, 2001) and differences among treatments tested according to LSD0.05 (Steel and Torri, 1980).

RESULTS AND DISCUSSION

Results of soil evaluation before planting indicated that the soil material had medium content of available potassium and low reserves according to the traditional method. The soil was classified as medium ability to supply potassium and low potassium buffering capacity according to thermodynamics parameters and that the soil had a low capacity and very low rate of potassium release according to kinetics means (Ali *et* al, 2010).

Potassium application significantly increased potassium uptake by corn plants (Table, 2). Potassium sulfate was better in this parameter with an increment of 8% compared to potassium chloride source and this can be attributed to presence of sulfate as companion ion. The best potassium use efficiency (KUE) for both sources was with 150 kg K ha^{-1} (Table 2) and higher with potassium sulfate compared to potassium chloride.

These results at the same trained to Al-Amiri, (2005) and Al-Shikali (2006) and confirmed Purdy (1999) results. Purdy, (1999) indicated that potassium sulfate was better source due to its low salt index especially in salt affected soils.

Results of Table 2 also indicated that source of potassium had no significant effect on grain yield. These results were in agreement with Yassen *et* al., (1997) results. However rates applied had significant effect on grain yield especially between control treatment (0 kg K ha^{-1}) and 75 - 150 kg K ha^{-1}. These results confirmed Tony, (2005) results. Results of fertilizer productivity indicated that the highest values were accompanied with 75 kg K $ha^{-1}$from both sources.

Water productivity was affected by level of potassium applied with 75 kg K ha^{-1} being the best level with no significant differences than 150 kg K ha^{-1} . The application of 75 kg K ha^{-1} increased WUE by 46% compared to control treatment. These results were in agreement with Ali and Mohammed, (2003) results.

Therefore, it can be concluded that 75 -150 kg K ha^{-1} can be consider as the best level in such soil under such conditions.

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