EFFECT OF RICE STRAW COMPOST ENRICHED WITH POTASSIUM RICH MATERIALS ON DRY MATTER AND WATER CONSUMPTION OF BARLEY UNDER DROUGHT CONDITIONS

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ABSTRACT

The main objective of this research was to study the effect of rice straw compost as a source of potassium on the barley dry matter under drought conditions using three ratios of the value of water consumption (100%, 80% and 60%). A pot experiment was conducted using loamy and sandy soils in the greenhouse of Soil Sci. Dept., Fac. of Agric., Ain Shams University. The suggested treatments can be summarized as control (without compost addition), (rice straw compost), (1% rice straw + 1% banana compost), (1% rice straw + 1% vegetables compost) and (1% rice straw + potassium dissolving bacteria (PDB)). The obtained results show the value of time growth for barley under control,1% rice straw compost (RSC), 1% RSC+ 1% banana residues compost (BRC), (1% RSC+ 1% vegetables residues compost (VRC) and 1% RSC+ potassium dissolving bacteria (PDB), respectively. The maximum potassium availability of the loamy soil were 2.96, 3.58, 3.38, 3.2 and 3.35 meq/l at 475, 494, 508, 457 and 350 hour, respectively. The corresponding figures for the sandy soil were 475, 375, 550, 575 and 425 hour producing the maximum potassium of 0.41, 0.58, 1.71, 1.08 and 1.06 meq/l at different time growth under rice straw compost treatments. The effect both water consumption and its potassium content on barley dry matter was significant and clear effect noticeable by using the treatment of rice straw compost (RSC)+bananas residues compost (BRC) on water consumption under 100 and 60%.

Key words: Drought stress, Water consumption, Potassium rich materials and Organic wastes

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INTRODUCTION

The supplies of water and nitrogen to a plant during its critical growth stages are the main factors that define crop yield. A crop experiences irregular water deficits during its life cycle in rain fed agriculture. An effective anti-stress-oriented approach therefore ought to focus on increasing the units of water productivity. Yield increases resulting from K application mostly appeared under conditions of mild water deficit. As described for sugar beet, finding the critical period of crop K sensitivity is a decisive step in understanding its impact on water-use efficiency. It has been shown that an insufficient supply of K during crucial stages in the yield formation of cereals (wheat, spring triticale), maize, and sugar beet coincides with a depressed development in the yield components. The application of K fertilizer to plants is a simple agronomic practice used to increase crop tolerance to a temporary water shortage. It may be that the improvement of a plant's access to K during mild water-deficiency stress will increase water uptake by the root cells, which in turn increases their osmotic potential and thereby allows extension growth. This growth in turn promotes access to other mineral elements (including nitrogen) and water, which favor plant growth and yield **(Grzebisz *et al.*, 2013).** In modern agriculture, the economically and environmentally sound practice of production requires some insight into processes that increase productivity per water unit. The depletion of soil nutrient reserves is a logical consequence of soil mining–oriented agriculture, which results in soil-fertility decline. **Wood *et al.* (2000)** and **Grzebisz and Diatta (2012)** reported that the main reason for low yields is not only the water supply but also the limited supply of nutrients, mainly potassium. The majority of arable lands worldwide are cropped with cereals **(FAO STAT, 2012)**. Plants treated with two regimes of irrigation water, 100% of evapotranspiration (ET_c) (control) and 60% of ET_c and three levels of (PDB) solution (0.0 (control), 20 and 40 mg l^{-1}). In comparison to water-stressed plants without PBZ treatment, water-stressed plants treated with PBZ (40 mg l^{-1}) had significant higher grain yield and WUE **(Mostafa *et al*, 2012).**

The highly potassium content in such wastes, besides the limitation of K resources and the higher price of potash on the local and international markets has reduced the demand of potassium, as most farmers are unwilling to put more potash into the soil.

The objective of this study was to maximize the utilization of the composted rice straw alone or mixed with potassium rich materials (banana or vegetables residues composts) as well as biofertilizer to reduce water consumption values and increase barley dry matter yield under drought conditions.

MATERIALS AND METHODS

A pot experiment was conducted in the greenhouse of Soil Sci. Dept., Fac. of Agric., Ain Shams University using two types of soil, loamy from Shalaqan farm and sandy soil from Khatatba. Rice straw, Banana and vegetables residues were composted by adding 5 kg potassium sulphate / 100 kg of such residues. The suggested treatments could be summarized as following:

1. Control (containing on 90 mg K_2O/pot with N and P fertilizers being added at the recommended rates),
2. 1% rice straw compost (RSC),
3. 1% RSC+ 1% banana residues compost (BRC),
4. 1% RSC + 1% vegetable residues compost (VRC)
5. 1% RSC+bio-fertilizer (potassium dissolving bacteria, PDB) added at the rate of 20 ml/pot containing 4 kg soil. Each 1 ml of the used bio-fertilizer was containing 10^8 bacterium cells.

Physical and chemical analysis of the used soil and compost materials were determined according to **Jackson (1973)** while the available and total macronutrients were determined according to **Page *et al.* (1982).**

After good homogeneity of soil, compost and bio fertilizer, 15 barley grains (*Hordeum vulgare*, variety Giza 123) were cultivated, and thinned to 10 seedlings after complete germination, in pots containing 4 kg soil samples and taken into account under greenhouse conditions. The values of crop coefficient (**Doorenbos *et al.*, 1977 and Allen *et al.*, 1998)** presented in Table 1.

Table 1: Values for crop coefficient (Doorenbos et al., 1977 and Allen *et al.*, 1998) for barley crop at different stages of growth

Stage	Growth stage	Month	Crop coefficient	Length (days)
1	Establishment (initial)	November	0.3	15
2	Vegetative (development)	December	0.7	15

Soil and climate:

Soil and compost properties in the pots under study are given in Table 2 (a, b, c and d).

Table 2a: Some initial physical properties of the studied soils

Particle size distribution (%)				FC	WP	Bd	WHC	Texture
C. sand	F. sand	Silt	Clay	(%)	(%)	(g/cm^3)	(mm/m)	class
4.58	27.39	40.73	27.28	24.8	8.4	1.32	21.6	loam
50.00	43.5	5.0	1.5	12.2	5.5	1.60	10.7	Sandy

FC= field capacity; WP= welting point, FC and WP were determined as percentage in weight; Bd= bulk density; WHC= water holding capacity

Table 2b: Effect of applied treatments on some physical properties

Soil	Treatments	FC (%)	WP (%)	Bd (g/cm^3)	WHC (mm/m)
Loamy	1% RSC	19.4	9.3	1.3	13.1
	1% RSC+1% BRC	58.3	27.9	1.3	39.5
	1% RSC+1% VRC	22.5	7.5	1.3	19.5
	1% RSC+ Bio.	35. 2	11.7	1.3	30.6
Sandy	1% RSC	31.4	17.2	1.6	22.7
	1% RSC+1% BRC	39	11.8	1.6	43.5
	1% RSC+1% VRC	52.2	21.1	1.6	49.8
	1% RSC+ Bio.	54	15.1	1.6	62.2

Table 2c: Initial chemical properties in soil paste extract of the studied soils

Soil	ECe (dS/m)	pH	Soluble ions in saturated soil extract (meq/l)							
			K^+	Na^+	Ca^{+2}	Mg^{+2}	Cl^-	HCO_3^-	$CO_3^=$	$SO_4^=$
Loamy	1.17	7.34	0.78	2.94	4.00	4.00	5.10	3.30	0.00	3.32
Sandy	0.51	7.5	0.50	0.88	2.40	1.33	1.03	2.90	0.00	1.18

Table 2d: Chemical analysis of the used composts

Compost	pH 1:10 (susp.)	EC d S/m 1:10 extract	OM %	C/N ratio	Total nutrients, %			Available nutrients ppm		
					N	P	K	N	P	K
RSC	7.61	1.88	55.0	24.5	1.30	0.21	2.31	289	173	466
BRC	7.50	1.69	54.0	18.5	1.64	0.30	3.85	323	211	589
VRC	7.33	1.74	41.7	16.3	2.69	0.36	1.25	432	246	490

Data from the agricultural climatologic profiles (2013) is shown in Table 3.

Table 3: Climatologic data during months of evaluation (Agricultural climatologic profiles, 2013 and http://www.wunderground.com).

Month	T_{max} (^{0}c)	T_{min} (^{0}c)	RH_{mean} (%)	U (km/h)	n (hour)
November	25.5	17	*59.0	10.4	8.4
December	18.9	10.8	*56.0	10.2	7.1

(T_{max})= maximum temperature; (T_{min})= minimum temperature; *(RH_{mean}) = calculate (RH_{min}+ RH_{min})/2; (RH_{mean})= given mean relative humidity; (RH_{max})= maximum relative humidity; (RH_{min})= minimum relative humidity; (U)= wind speed and (n)= daily sunshine.

Equations used to estimate K-availability and irrigation management parameters:

a. Representative soil samples were taken out at 7, 15 and 30 days from the experiment start. Each treatment was replicated 6 times; two out of them were taken to represent a plant and soil samples at 3 and 6 weeks, respectively, after cultivation. In each plant samples, shoots and roots were separated, dried at 65-70 °C then their dry weights were recorded and K content was determined in wet digests as described by **Page *et al.*, 1982**. Each soil sample was subjected to the determination of several parameters expressing K availability, where (NH_4OAC-K) was determined according to **Jackson (1973)**. The obtained data were statistically subjected to analysis of variance, regression and correlation analysis according to the procedures outlined by **Snedecor and Cochran (1982)**.

Estimating reference evapotranspiration: Evapotranspiration from meteorological data was estimated using the following equation **(Allen *et al.*, 1998)** comprising a number of climatological and physical variables:

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34 u_2)} \qquad (1)$$

where:

ET_o = reference evapotranspiration (mm/day);

Δ = slope of vapor pressure curve at air temperature (kPa $^oc^{-1}$);

R_n = net radiation at the crop surface (M J $m^{-2}day^{-1}$);

G = soil heat flux density, (M J $m^{-2}day^{-1}$);

γ = psychrometric constant (kPa $^oc^{-1}$);

T = air temperature at 2 m height (^oC);

u = wind speed at 2 m above ground surface (m s^{-1});

e_a = actual vapor pressure (kPa); and

e_s = saturation vapor pressure (kPa).

Estimating crop evapotranspiration. The following equation was used **(Doorenbos *et al.*, 1977)**.

$$ET_c = ET_o \times K_c \qquad (2)$$

where:

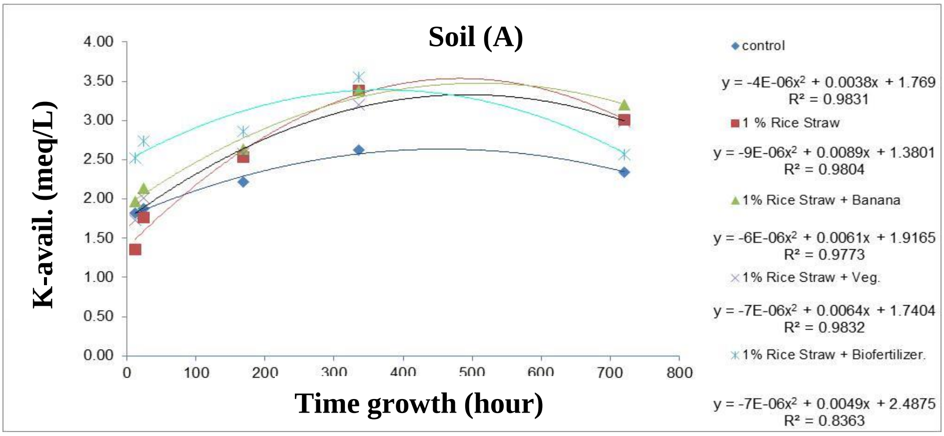
ET_c = crop evapotranspiration (mm/day);

ET_o = reference evapotranspiration (mm/day); and

K_c = crop coefficient

RESULTS AND DISCUSSION

Data in Table 4 and Fig (1) show that the applied treatments, in general, significantly increased the mean value of available-K at the different time growth compared to control. The highest effect in increasing available K was generally obtained from rice straw compost + banana residues compost, rice straw compost + vegetables residues compost and rice straw compost + bio fertilizer treatments. Meanwhile, rice straw compost alone treatment caused the lowest effect. To obtain the maximum potassium availability, the first derivative of the time growth function equations is set equal zero and solving it. Results presented in Table (4) show the maximum potassium in loamy soil reached to 2.96, 3.58, 3.38, 3.2 and 3.35 meq/l at 475, 508, 457,494 and 350 hour, respectively. The corresponding figures for sandy soil achieved 475, 375, 550, 575 and 425 hour producing the maximum potassium of 0.41, 0.58, 1.71, 1.08 and 1.06 meq/l at different time growth under the rice straw compost treatments. Based on the course of K accumulation during the growth season, three main characteristics of K uptake by a particular crop can be determined. They are as follows: (i) maximum K, (ii) the absolute rate of K accumulation, and (iii) the relative rate of K accumulation, which is useful in determining the earliest to a particular nutrient supply.



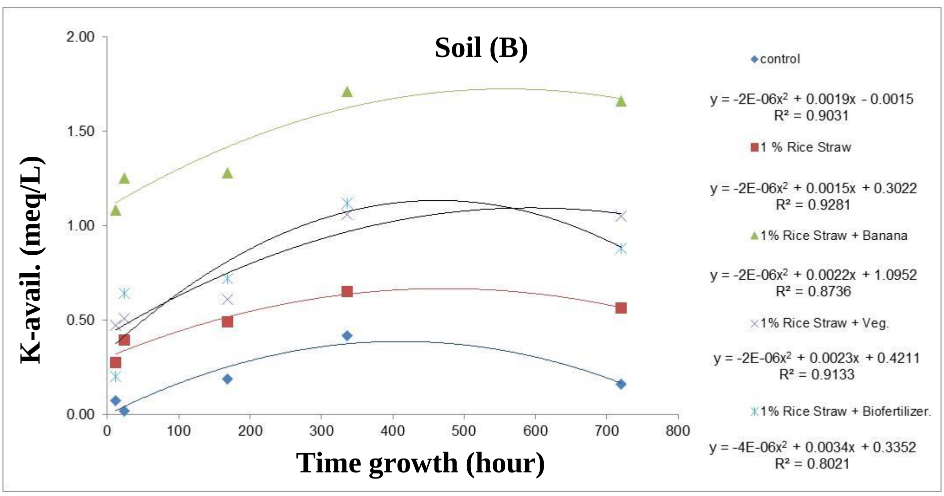


Fig (1): Relationship between K- availability and time growth in soil study

In the present case, the RRAK reached a maximum around the 7th week after plant emergence (***Malnou et al.*, 2006).**

Table 4: Maximum potassium availability and time applied for barley crop under different treatments

Treatments	Max. potassium (meq/l)	Time growth (hour)	Time as the ratio of potassium (%)
i) loamy soil			
Control	2.96	475	70
RSC	3.2	494	68
RSC+BRC	3.58	508	66
RSC+VRC	3.38	457	73
RSC+Bio	3.35	350	96
ii) sandy soil			
Control	0.41	475	70
RSC	0.58	375	89
RSC+BRC	1.71	550	61
RSC+VRC	1.08	575	58
RSC+Bio	1.06	425	79

Applied water

Data presented in Table (5) show the mean values of applied water amount under drought condition (100, 80, 60% from ET_c).

Table 5: Water amount of evapotranspiration crop under barley crop at different stages of growth

Growth stage	Month	Crop coeff.	ET_0 mm/day	Length (days)	100% ET_c		80% ET_c		60% ET_c	
					mm/day	mm/stage	mm/day	mm/stage	mm/day	mm/stage
Initial	Nov.	0.3	1.97	15	0.59	8.9	0.47	7.0	0.35	5.31
Develop.	Dec.	0.7	1.25	15	0.88	13.1	0.7	10.6	0.53	7.92
Sum						**22**		**17.6**		**13.2**

Data presented in Tables (5 and 6) show the effect of the water consumption values (100, 80 and 60 %) on barley dry matter and potassium content, which has been added to RSC 1% or mixed with BRC, VRC and biofertilizer as a source of nutrient plant potassium. There is a significant and clear effect by using RSC+BRC on water consumption under 100 and 60% referring to the effect of potassium nutrition. The physiological roles of K in plants have been extensively described in recent reviews **(Marschner, 2012). Shao *et al*. (2009)** characterize the physiological functions of water at three levels: (i) cellular (as a component and medium for biochemical reactions), (ii) tissue (as a link to adjacent cells) and (iii) whole plant (as a means of mineral nutrient and hormone transport. In agronomy, a fourth operational level of water's effect on a crop plant has been developed that summarizes all basic processes at the canopy level. This index is known as the water-use-efficiency (WUE) index, and in a broad sense it describes the quantity of biomass produced by a particular crop plant in relation to the volume of water that is evaporated and transpired during its life cycle.

Table (6) Effect of water requirements on dry matter and K content in different soil

Treatment	100% Ir. Req			80% Ir. Req			60% Ir. Req		
	dry matter	K-cont.		dry matter	K-cont.		dry matter	K-cont.	
Loamy soil									
Control	12.42	0.585	e	21.84	0.771	f	12.66	0.599	d
1%RSC	14.83	1.522	d	23.23	1.779	a	12.95	0.825	c
1% RSC +BRC	33.46	1.971	a	24.75	1.108	de	29.63	1.89	a
1% RSC+VRC	14.32	1.696	bc	17.55	1.1	e	15.74	1.016	b
1%RSC+Bio	14.58	1.681	ab	29.07	1.341	bc	14.52	1.246	a
Average	**17.922**	**1.491**	**A**	**23.288**	**1.220**	**B**	**17.100**	**1.115**	**A**
Sandy soil									
Control	5.59	1.142	d	6.20	1.142	d	9.10	0.195	d
1%RSC	27.40	1.501	b	26.33	1.501	b	16.17	0.667	c
1% RSC +BRC	19.46	1.616	ab	7.61	1.616	ab	29.95	1.166	a
1% RSC+VRC	20.50	1.276	cd	27.27	1.646	ab	22.64	1.105	a
1%RSC+Bio	12.36	1.646	ab	20.66	1.704	a	23.54	1.13	a
Average	**17.062**	**1.436**	**A**	**17.614**	**1.522**	**A**	**20.280**	**0.853**	**B**

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الملخص العربى

تاثير سماد قش الارز كمصدر للبوتاسيوم على المادة الجافة لنبات الشعير تحت ظروف الجفاف

منال مبارك ١ و خالد فران الباجورى٢

الهدف الرئيسي من هذا البحث دراسة تأثير سماد قش الأرز كمصدر للبوتاسيوم على أساس المادة الجافة الشعير تحت ظروف الجفاف باستخدام ثلاث نسب من قيمة استهلاك المياه (١٠٠ ٪، ٨٠ ٪ و ٦٠ ٪). أجريت التجربة باستخدام الأراضي الطميية والرملية في الصوبة الزراعية بقسم الاراضى، كلية الزراعة، جامعة عين شمس. يمكن تلخيص المعاملات المقترحة على النحو الاتى: معاملة المقارنة (دون إضافة السماد)، (الأرز السماد قش)، (١٪ قش الأرز + ١٪ الموز)، (١٪ قش الأرز + ١٪ الخضار) و (١٪ + قش الأرز تذويب البوتاسيوم البكتيريا (PDB)). أظهرت النتائج التي تم الحصول عليها من قيمة نمو وقت الشعير تحت السيطرة، ١٪ السماد قش الأرز ((RSC، ٪1 + RSC 1٪ مخلفات الموز السماد ((BRC، + RSC 1٪) 1٪ الخضار مخلفات السماد (VRC) و ١٪ RSC + البوتاسيوم حل البكتيريا (PDB)، على التوالي، وكانت أقصى توافر البوتاسيوم من التربة الطفيلية ٢,٩٦، ٣,٥٨، ٣,٣٨، ٣,٢ و ٣,٣٥ مل مكافئ / لتر في ٤٧٥، ٤٩٤، ٥٠٨، ٤٥٧ و ٣٥٠ ساعة، على التوالي. الأرقام المقابلة لل كانت التربة الرملية ٤٧٥، ٣٧٥، ٥٥٠، ٥٧٥ و ٤٢٥ ساعة إنتاج البوتاسيوم أقصاها ٠,٤١، ٠,٥٨، ١,٧١، ١,٠٨ و ١,٠٦ مل مكافئ / لتر في النمو زمنية مختلفة في ظل العلاجات السماد قش الأرز.تأثير كل من استهلاك المياه ومحتوى البوتاسيوم على المادة الجافة للشعير تأثيرا معنويا وواضحا باستخدام معاملة قش الأرز السماد (RSC) + مخلفات سماد الموز (BRC) عند استهلاك المياه لقيم ١٠٠ و ٦٠٪.

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