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EFFECT OF TILLAGE PRACTICES AND MULCHING ON GROWTH AND YIELD OF SQUASH (*Cucurbita pepo*) GROWN UNDER RAIN-FED CONDITIONS IN SEMI-ARID REGION

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ABSTRACT

A field experiment was carried out during 2009-2010 growing season, at the Agricultural Research Station, Mu'tah University, Jordan; to study the effects of mulching and tillage on growth, yield, and quality of squash (*Cucurbita pepo, var. melopepo*) under rain-fed conditions of Jordan. The trial was laid out in split plot arrangement with a randomized complete block design with 3 replicates. Tillage treatments were assigned in the main plots and mulch treatments in the sub-plots. The field was divided into three blocks assigned to tillage times (T1, T2 and T3). T1: tillage was done only once during early spring; T2: tillage was done twice and T3: tillage was done three times. Soil cover treatments (black plastic mulch or no mulch) were distributed randomly according to split plot arrangement with a randomized complete block design.

Squash yields (early, mid and late) were higher when the soil was tilled three times (T3) and covered with BP mulch compared with other treatment combinations. Covering the soil surface with plastic mulch had pronounced positive effect on yield of squash compared with bare soil. Fruit number and average fruit weight had the same trends as fruit yield. Fresh weight of squash plants at the end of the growing season tended to be higher when the soil was tilled three times and covered with BP mulch. Plots covered with BP mulch produced higher fresh and dry weights.

In general, soil moisture contents after one month after planting were higher when the soil plowed three times (T3) compared with (T2 and T1). Non-mulched plots had the lower SMC than black plastic mulched plots.

It is concluded that using black plastic mulch as soil covering enhanced squash vegetative growth and yield. Also, tillage the soils three times and using black plastic mulch produced high squash yield under rain-fed conditions.

Key words: *Cucurbita pepo, plastic mulch, squash, tillage.*

1. INTRODUCTION

Jordan has a Mediterranean climate characterized by long, hot, dry summers and short, cool, rainy winters (Department of Metrology, 1997). Water is scarce and the demand is always increasing to meet the needs of modern irrigated agriculture. With rapidly growing population and expanding economy, optimal water management is a priority. Over 90% of Jordan area receives annual rainfall not exceeding 200 mm and only 4% of the area receives > 350 mm of annual rainfall, most of which evaporates back to atmosphere. The available volume of water in near future will not cover the total water need for domestic, industrial and agricultural use. In addition, the pattern of rainfall is characterized by uneven distribution and strong fluctuation from year to year in terms of quantity and timing. These prevailing conditions during the past 4 decades resulted in a dramatic reduction in planting summer vegetables such as cucurbits, okra and tomato under rain-fed conditions of Jordan. Therefore, low soil moisture content in the root zone usually limits productivity of rain-fed summer crops in Jordan.

Improving productivity of rain-fed summer crops in dry season can be enhanced by conserving moisture that has accumulated in the root zone during the previous rainy season. Soil management practices such as tillage practices and mulching have been suggested by several authors Hatami *et al*., 2012; Mamkagh, 2009; Mondal *et al*., 2008; (Anikwe *et al.*, 2007; Kouwenhoven *et al*., 2002; Mohler, and Callaway, 1995) Khatibu *et*

al., 1984; through improving water and nutrient uptake under drought conditions. Mulching is associated with yield increases for many vegetables (Berihun 2011; Hatami *et al*., 2012; Mamkagh, 2009) and improving soil moisture regime by reducing evaporation from the soil surface (Anikwe *et al*., 2007; Hatami *et al*. 2012; Mamkagh, 2009; Singh and Kamal, 2012), and water retention (Anikwe *et al*., 2007; Bhagat and Acharya, 1987; Jones, 2000; Jones and Sing, 2000). Mamkagh (2009) indicated that covering soil surface with plastic mulch reduced soil water evaporation and thus helps in retaining soil water. In Jordan, mulching has been practiced for several decades, but it has been done mostly in the production of vegetables under irrigation. This technique also might be introduced in the production of summer vegetables under rain-fed conditions.

Tillage practices are critical components of soil management systems (Mosaddeghi *et al.*, 2009). The selection of an appropriate tillage practice for the production of crops is very important for optimum growth and yield (Aikins and Afuakwa, 2010). The yield increase was correlated with an increase in water contents in the soil due to reduced evaporation (Hatami *et al*., 2012; Khurshid *et al.*, 2006; Mamkagh, 2009; Singh and Kamal, 2012). Among the crop production factors, tillage contributes up to 20% (Khurshid *et al.*, 2006). Tillage plays a vital role in conservation of soil moisture at different depths in rain fed cultivation. It also improves soil conditions by altering the mechanical impedance to root penetration, hydraulic conductivity and holding capacity, which in turn affects plant growth (De Costa *et al*., 1997; Gupta and Gupta, 1986; Pilbeam *et al*., 1991; Thompson and Taylor, 1982; Varco *et al*., 1989). However, effects of tillage practices on vegetable crops have not been studied extensively. A few existing tillage studies indicated that most tillage benefits are directly related to soil moisture conservation and available moisture during the growing season (Abu-Hammad and Battikhi, 1995; Jones, 2000; Jones and Sing, 2000).

The present investigation was planned to determine the effect of different tillage practices in combination with mulching on growth and yield of summer squash under rain-fed conditions of Jordan highland.

2. MATERIALS AND METHODS

Experimental site:The experiment was conducted at the Research Station, Faculty of Agriculture, Mutah University, Jordan during 2009/2010 summer growing season. The region has a Mediterranean climate (semi-arid, with cold rainy winters and hot dry summers) with annual mean rainfall of 350 mm, most of rain fall occurs from December to February. During 2009/2010 season, the rainfall was 320 mm. The soil of the experimental site is sand clay loam. Some soil physical and chemical properties of the experimental site are given in Table (1).

Soil sampling and analysis: Representative soil samples were taken from the experimental site to determine soil physical and chemical properties (Table 1). Between sowing and harvesting, the moisture levels in the soil were measured 3 times. The soil moisture was measured at 30, 60 and 90 days up to 30 cm depth by gravimetric method (Black, 1965). The soil from 0-30 cm depth was sampled by manual coring and gravimetric moisture content (g/g) of the soil samples was calculated on oven dry weight basis and converted into volumetric moisture content (cm^3/cm^3) and then expressed as profile water content in 0–30 cm soil depth.

Experimental design and treatments: The trial was laid out in split plot arrangement with a randomized complete block design with 3 replicates. Tillage treatments were placed in the main plots and mulch treatments in the sub-plots. The field was divided into three blocks which were assigned to tillage treatments (T1, T2 and T3) by using the traditional plow (disc plow). Tillage treatments were done from the end of the previous crop (wheat).

T1: spring tillage was done only during early spring before seed planting (25/3/2010).

T2: tillage was done two times; winter tillage (10/12/2009) and spring tillage (early spring before seed planting 1/4/2010).

T3: tillage was done three times; summer tillage (after harvesting of the previous crop 1/8/2009), winter tillage (10/12/2009) and spring tillage (early spring before seed planting 1/4/2010).

All tillage treatments were followed by disking with a disc harrow to a depth of approximately 8 cm during spring to prepare seedbed.

Soil covering treatments: black plastic mulch (BP Mulch) or bare soil (No Mulch) were distributed randomly in sub-plots. Each sub plot consisted of 4 rows 2.40 m length. Inter- and intra- row spacing were 1.00m x 0.40m.

The experiment beds were prepared manually with traditional hoes. Black plastic-film (100 cm wide and 125 micron thick) were used to cover the appropriate plots before planting (mid April) and

two sides of the film were held down with soil. The squash (*Cucurbita pepo*) seeds were used. Seeds of squash (Anita hybrid cultivar) were planted on April 15, 2010.

Data collection: For fresh and dry weight, 4 plants were randomly selected, tagged and sampled. Fruits of each crop were harvested at the immature stage, counted and weighed. Fruit yield was separated into: early, mid, late and the total yield as well as fruit number were recorded. Squash was harvested from May, 31 to July, 19, 2010. Early yield started from May, 31 to June, 15; mid yield from June, 16 to June, 30 and late yield from July, 1 to the end of experiment.

MSTAT-C statistical package was used to analyze the data obtained from this experiment. Duncan's Multiple Ranges Test (DMRT) was used to determine the mean separations. The level of significance was calculated with an error probability of 0.05 (Steel and Torrie, 1980).

3. RESULTS

The soil moisture content (SMC) varied due to the experimental treatments. At 30 and 60 days after planting, there was a significant interaction between tillage practices and mulching for SMC at 30 cm depth (Table 2). Non-mulched plots had lower SMC than black plastic mulched (BP mulch) plots. The highest SMC (25.94) was observed at 30 days after planting in the plots tilled three times (T 3) and covered with BP mulch followed by plots tilled two times (T 2) and covered with BP mulch (23.27). At 60 days after planting, SMC was significantly the highest when plots covered with BP mulch regardless of tillage practices. In general, soil moisture content at 90 days after planting was not affected by different treatment combinations.

Date of squash seed germination was not significantly affected by tillage treatments and mulching treatments (Table 3). However, the earliest seed germination (about 11 days after seed planting) was achieved when the soil was covered with BP mulch. It appears that covering the soil with BP mulch had more pronounced effects on seed germination compared with tillage treatments. Also, the time of flowering was affected mainly by using BP mulch. Squash plants reached 50% flowering about 2 days earlier compared with non-mulched plots.

Fresh weight of squash plants at the end of the growing season tended to be higher when the soil tilled three times and covered with BP mulch compared with other treatment combinations (Table 3). On the other hand, the lowest fresh weight was produced when the soil was tilled once in spring without using BP mulch. In general, plots covered with BP mulch produced higher fresh weight compared with uncovered plots. In general, covering the soil surface with BP mulch significantly increased the dry weight of squash compared with bare soil under different tillage treatments. While the highest dry weight of squash plants was obtained when the soil tilled twice (T_2) and using BP mulch, the lowest fresh weight was obtained when the soil tilled only was once in the spring and non-mulched.

The data of effect of tillage practices and BP mulch on squash yield and its distribution (early, mid, late and total yield) are presented in Table (4). Early, mid and late squash yields were significantly higher when the soil was tilled three times (T3) and covered with BP mulch compared with other treatment combinations. Regardless of tillage practices, mulched plots significantly increased early, mid, late and the total yield of squash compared with bare plots. The present results indicated that plots tilled three times (T3) had the highest early, mid, late and total yield of squash, followed by tilled two times (T2) and followed by tilled one time (T1). While the highest total squash yield (27.9 ton^{-ha}) was produced when the soil tilled three times (T 3) and covered with BP mulch; the lowest total yield (7.6 ton^{-ha}) was produced when the soil was tilled once (T1) and no mulch. The same trends were also observed for early, mid and late yield.

The number of squash fruits (1000 $fruit^{-ha}$) is presented in Table (5). Soil tilled three times (T3) produced the highest number of squash fruits (early, med, late and total) compared with other tillage treatments. Also, covering the soils with plastic-film mulch significantly increased early, med, late and total fruit number compared with bare soil. It appears that plowing the soil three times (T 3) and covering with BP mulch produced the highest fruit numbers compared with other treatment combinations.

Average fruit weight of early yield was not significantly affected by different tillage time and soil covering treatment combinations (Table 6), however, significantly the lowest average of fruit weight (92.8gm) was produced when the soil was tilled one time during spring season (T 1) without using the BP mulch. In general, average fruit of med, early and total yield were higher when the soil tilled 3 times and covered with BP mulch compared with other treatment combinations.

Table (1): Some physical and chemical soil characteristics of the experimental site.

Texture	pH	EC (dS m-1)	CaCo3 (%)	Organic matter (%)	Total N (%)	NaHCO3 -P (ppm)
Sand Clay Loam	7.91	1.58	30	1.69	0.0621	22

Table (2): Effects of tillage and mulching on soil moisture content of squash grown under rain-fed conditions.

Tillage time	Mulch	Soil Moisture content (SMC)		
		(30 days)	(60 days)	(90 days)
T 1	BP Mulch	23.0 bc*	18.1 a	13.0 ab
	No mulch	20.9 c	15.5 bc	12.4 ab
T 2	BP Mulch	23.9 b	16.8 ab	12.8 ab
	No mulch	21.7 c	14.3 c	12.6 ab
T 3	BP Mulch	26.5 a	17.0 a	13.5 a
	No mulch	21.2 c	15.0 c	11.8 b

*** Means having different letters within each column are significantly different at 5% level of probability according to DMRT**

Table (3): Effects of tillage and mulching on vegetative growth, germination and flowering times of squash grown under rain-fed conditions.

Tillage practices	Mulch	Fresh wt (gm/plant)	Dry wt (gm/plant)	Germination time (days)	Flowering time (days)
T 3	BP Mulch	607.0 ab*	66.11 ab	11.00 c	38.00 c
	No mulch	487.0 b	37.67 b	13.22 b	40.22 b
T 2	BP Mulch	694.2 a	78.89 a	11.00 c	38.00 c
	No mulch	526.4 ab	40.56 b	14.33 a	41.33 a
T 1	BP Mulch	713.1 a	63.33 ab	11.00 c	38.00 c
	No mulch	645.3 ab	41.11 b	14.33 a	41.33 a

*** Means having different letters within each column are significantly different at 5% level of probability according to DMRT**

Table (4): Effect of tillage and mulching on yield of squash grown under rain-fed conditions.

Tillage practices	Mulch	Yield distribution (ton/ha)			
		Early	Mid	Late	Total
T 1	BP Mulch	6.54 bc*	6.93 bc	3.23 bc	16.60 b
	No mulch	3.63 d	2.91 d	1.09 d	7.63 c
T 2	BP Mulch	8.66 ab	9.03 ab	5.59 a	23.28 a
	No mulch	5.32 cd	4.48 cd	1.77 cd	11.57 bc
T 3	BP Mulch	10.34 a	11.55 a	6.06 a	27.95 a
	No mulch	6.08 c	6.84 bc	3.70 b	16.62 b

*** Means having different letters within each column are significantly different at 5% level of probability according to DMRT**

Table (5): Effects of tillage and mulching on fruit number of squash grown under rain-fed conditions.

Tillage practices	Mulch	Fruit number (1000 ha^{-1})			
		Early	Mid	Late	Total
T 1	BP Mulch	49.7 bc*	83.9 bc	42.4 bc	176.0 b
	No mulch	38.7 d	48.6 d	17.5 d	104.8 c
T 2	BP Mulch	62.3 ab	92.2 ab	56.8 a	211.3 a
	No mulch	41.3 cd	59.2 cd	25.0 cd	125.5 bc
T 3	BP Mulch	72.0 a	111.3 a	67.5 a	250.8 a
	No mulch	47.9 c	74.3 bc	45.3 b	167.5 b

*** Means having different letters within each column are significantly different at 5% level of probability according to DMRT**

Table (6): Effects of tillage and mulching on average fruit weight of squash grown under rain-fed conditions.

Tillage practices	Mulch	Average fruit weight (g)			
		Early	Mid	Late	Total
T 1	BP Mulch	131.6 a*	82.5 b	76.2 bc	94.3 c
	No mulch	93.7 b	59.8 d	62.3 c	72.8 d
T 2	BP Mulch	139.0 a	97.9 a	98.4 a	110.2 ab
	No mulch	128.8 a	75.6 c	70.8 c	92.2 c
T 3	BP Mulch	143.6 a	103.8 a	89.8 a	111.4 a
	No mulch	126.9 a	92.1 b	81.7 ab	99.2 bc

*** Means having different letters within each column are significantly different at 5% level of probability according to MRT**

4. DISCUSSION

Soil water content (SMC) was significantly higher in plots covered with black plastic mulch than non covered plots. It means that black plastic mulch reduced soil water evaporation and thus helps retain soil water. The combination of mulching with tillage in conserving soil moisture has been recognized by many researchers (Hatami *et al*., 2012; Singh and Kamal, 2012; Mamkagh, 2009; Anikwe *et al*., 2007; Grevers *et al*., 1986; Bhagat and Acharya, 1987; Sarkar and Singh, 2007).

Ramakrishna *et al*. (2006) reported that evaporation from the soil accounts for 25–50% of the total quantity of water used. Covering the soil with plastic mulch reduced soil water evaporation, and thus helps retain soil moisture (Mamkagh, 2009; Ogban *et al*., 2008; Ramakrishna *et al*., 2006). Data of soil moisture content 30 days after planting indicated that plastic mulch plots contained more water than the unmulched plots.

Nearly, similar trend was noticed at 60 and 90 days after planting while the difference in soil moisture storage was reduced. The amount of moisture stored in the profile to a soil depth of 30 cm was significantly higher under BP mulch over bare soil. Similar results were obtained by Mamkagh, (2009) and Ramakrishna *et al*. (2006) who reported that optimum soil moisture ensures good emergence and seedling growth during early and mid season. Also, higher soil moisture content increased root proliferation and thus enhanced availability of nutrients to crop roots (Mamkagh, 2009; Ogban *et al*., 2008; Sharma *et al*., 1990). These figures also imply that greater moisture availability to mulched crop during the growing season helped to cope better with drought in mid and late season drought. Douglas and Mckyes (1983) reported that the influence of tillage methods on crop growth and yields is manifested through changes in the soil structure and soil moisture depletion patterns during the growing season. Mulching the soil surface favorably influences the soil moisture regime by controlling evaporation from the soil surface (Mamkagh, 2009; Pawar *et al*., 2004), and facilitates condensation of soil water at night due to temperature reversals (Tisdall *et al*., 1991). Mulches also promote crop development and early harvest, and increase yields. Squash growth parameters showed a significant increase in mulched plots compared with non covered plots.

Khattak *et al*. (2006) indicated that inappropriate tillage and improper timing of field operations caused subsoil compaction, which reducesd 41% of the water and nutrient use efficiencies by crops. These might decrease soil productivity and crop yields. Also, Jones and

Sing, (2000) and Jones, (2000) reported that tillage benefits are directly related to soil moisture conservation and available moisture during the growing season. Also, certain tillage management practices could improve some soil physical properties and soil fertility and increase the conservation of soil moisture (Abu-Hammad and Battikhi, 1995).

From the results of the present study, it was concluded that soils tilled three times and covered with plastic mulch produced more vigorous plant and high yield compared with other treatments.

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دراسة تأثير الحراثه والملش البلاستيكي الأسود على نمو وإنتاجية محصول الكوسا تحت ظروف الزراعة البعلية في المناطق شبه الجافة

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ملخص

اجريت تجربة حقلية خلال الموسم الزراعي 2010/2009 في محطة البحوث الزراعية/كلية الزراعة /جامعة مؤتة لدراسة تأثير استخدام الملش وعمليات الحراثة على نمو وإنتاجية الكوسا تحت ظروف الزراعة البعلية. رتبت المعاملات في تجربة القطع المنشقة باستخدام تصميم القطاعات العشوائية الكاملة وبثلاث مكررات. حيث تم استخدام 3 معاملات للحراثه (معاملة 1: حراثة ربيعية فقط، معاملة 2: حراثة شتوية+حراثة ربيعية ومعاملة 3: حراثة صيفية+حراثة شتوية+ حراثة ربيعية) ومعاملتين لتغطية سطح التربة (الملش البلاستيكي الأسود وبدون تغطية).

دلت النتائج على إن الحراثه 3 مرات والتغطية بالغطاء البلاستيكي الأسود أدى إلى زيادة معنوية في إنتاجية محصول الكوسا (المبكر واالمتوسط والمتأخر والكلي) وكذلك بالنسبة لعدد الثمار ومعدل وزن الثمرة. وكان لاستخدام الغطاء البلاستيكي الأسود تأثير معنوي واضح على زيادة الإنتاجية وعدد الثمار ومعدل وزن الثمرة والوزن الطازج والجاف للمجموع الخضري لنباتات الكوسا بغض النظر عن معاملات الحراثة مقارنة بمعاملة بدون تغطية التربة.

بالنسبة لمحتوى التربة من الرطوبة كانت أعلى في المعاملات التي تمت حراثتها 3 مرات (صيفية+شتوية+ربيعية) وتغطيتها بالغطاء البلاستيكي الأسود والذي انعكس بصورة ايجابية على نمو وإنتاجية الكوسا. من خلال النتائج المتحصل عليها من هذه التجربة، يمكن الاستنتاج بأن حراثة التربة 3 مرات والتغطية بالغطاء البلاستيكي الأسود تعتبر الطريقة الأفضل لزراعة الكوسا تحت ظروف الزراعة البعلية في المناطق شبه الجافة والتي كان لها دور في تخزين الرطوبة في التربة والاحتفاظ بها خلال موسم نمو النبات.