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ROLE OF WHEAT CROP RESIDUE AND TILLAGE SYSTEMS ON MAIZE GROWTH UNDER WATER STRESS AND WEED COMPETITION

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Abstract

To determine role of wheat straw and tillage system on growth of maize at water stress, a field experiment was carried out during autumn season of 2016 in Wasit governorate, south of Baghdad, in silt loan soil. Field experiment was carried out by randomized complete block design (RCBD) with split plot arrangement with three replicate. Wheat straw and tillage systems treatment as four whole plots (tillage without straw as control treatment , straw incorporated soil, without tillage and straw as cover crops and without tillage without straw treatment). Water stress treatments represent as main plots (50% as control, 60% and 75% decrease from available water). The result showed that the presence of wheat residues as a cover on the soil surface was reduced of weeds density to lowest number of weeds (9.78 plant/m^2) in the field compared with others treatments, while the treatment of tillage without residues of recorded the highest density of weeds (17.00 plants/m^2). The presence of wheat residues as cover crops on soil record a significant parameter above on others treatment (the most growth characteristics of the plant as total leaf area and the high ear). Also, water stress (at the level of 75% water depletion) caused significant decrease by the most of growth characteristics to maize , but using of cover crop have shown high efficiency on reducing the impact of water stress on vegetation through conserving of soil moisture content. Corporate residue with soil improved from plant growth under stress conditions, but it was less efficient than the use of residues as a cover. We can concluded the possibility of reducing the impact of water stress on the maize crop when the residues of wheat are used in the form of soil cover.

Key words : Crop residue, cover crop, water stress, maize, tillage system.

Introduction

The maize crop, like other crops, is exposed to many of biotic and abiotic stresses, including water stress that makes the plant incapable of exploiting its full physiological and genetic potential to the highest level (Jaleel *et al*., 2009; Joshi *et al*., 2005). Several studies indicated that water stress causes a lot of phenotypic and physiologic changes in the plant. It reduces plant height and surface area, as well as reducing the content of chlorophyll and its relative content, which caused a reduction in photosynthesis and dry matter accumulation (Ahmed and Abdulameer, 2014). As a result of these challenges, researchers have sought to find ways to reduce the negative effects of water stress, including the production of new varieties with high ability to withstand drought (Alalosi, 2005), or adding growth regulators , fertilizers or extracts of some plants, to maintain water or reduce the rate of transpiration and increase of water cells potential (Levitt, 1980, Garrity and O'Tool, 1994 and Rathinasabapathi, 2000 and Blume, 2005 and Lahmod *et al*., 2016). Some agricultural processes such as tillage, plant depth and plant intensities can increase the soil's ability to retain water or increase the ability of the root total to obtain the moisture required for plant (Al-Saad *et al*., 1985; Elmuttalibi, 1990).

Crop plant residues on soil surface can be used to reduce water scarcity by improving and maintaining soil moisture, regulating soil temperature, reducing soil salinity and increasing organic matter, as well as reducing pollution (Chalker-Scott, 2007). Because the direct evaporation of water from the soil surface is often a major loss of

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available water due to the non-contribution of this water to produce organic mass, so reducing the evaporation of the surface helps to save soil moisture and provide in irrigation water and reduce the accumulation of salts in the surface layer of soil. Roberts *et al*. (1994) and Mao (1998) have shown that the use of organic plant as soil mulch may increase plant growth compared to non mulch soil under saline conditions. Cadavid *et al*. (1998) noted that soil mulch is one of the most important agricultural practices to conserve moisture, cool soil surface, adjust its physical environment, prevent harmful weed growth and balance soil temperature. It also add organic matter to the soil if the mulching material is organic in nature and reduces soil erosion in the declivity. Biological mulching (crop residues) are one of the agricultural processes to improve plant growth and increase their production by increasing the bio-physics activities of the soil and the plant local environment (Al Masoum *et al.*, 1993), as well as reducing weed control , irrigation number, and fertilizer loss from soil, especially nitrogen (Romic *et al*., 2003). In addition to the allelopathic role of waste in reducing weeds and reducing its effect in competition of the crop (Al-Bahadli *et al*., 2016).

The use of plant crop residues had been associated with the term conservation agriculture, or so-called zero tillage, which means direct seed without moving the soil or raising it to protect it from degradation and erosion, and improve its composition, and natural biodiversity, with leaving enough residue on the surface soil (Bukhari, 2014). Tillage reduces the proportion of soil organic matter and the deterioration of its physical and chemical properties, which in turn increases the deterioration of soil construction. This process occurs rapidly in tropical climatic zones. Tillage increasing soil moisture loss, increasing the amount of irrigation water required and washing mineral elements away from the root zone (Lafond *et al*., 2006; Niari *et al*., 2012). Continuous tillage increases the soil retention of annual weed seeds and the spread of perennial rhizomes, which requires more efforts and costs to control and reduce their presence with the crop (Al-Eqaili *et al*., 2016). The use of more than one package to reduce the effect of drought or improve plant resistance to its damage may be caused a positive effect on crop growth and yield. Therefore, the use of wheat plant residue under tillage and no tillage systems may reduce the effect of water stress on maize crop and limit weed plant developing, as well as the possibility of providing irrigation water.

Materials and Methods

A field experiment was carried out during the autumn season of 2016 in Wasit governorate, Kut city, southwest of Baghdad, at latitudes 45-49 and 32.3 long, in silt loam soil. Factorial experiment was conducted within split plot arrangement in randomized complete block design (RCBD) and three replicates. The main plots consist of four wheat residue and tillage treatments (tillage without wheat residue as control, tillage with wheat residue, residue without tillage, and without residue without tillage). Sub plot consist of three moisture depletion coefficients of ready water (50% as control, 60% and 75% depletion of the ready-water).

An area of a field planted with wheat crop (Eba 99 variety) was selected for the winter season 2015-2016 in one of the agricultural fields on the side of the Tigris River north of Kut city (Umm Helail village). A homogeneous piece of waste was selected after wheat harvest at stems residue height of 30-35 cm. The amount of waste was calculated in the experimental units by dropping a wooden box ($1m^2$) in four random areas within the field before tillage. The waste was then collected and weighed and the amount of waste was estimated at 500 $kg.ha^{-1}$. The selected area was divided into three longitudinal sections with dimensions of 4 × 53 m per sector, and then each sector was divided into four treatments representing the waste and tillage treatments in the form of regular plates separated by a 50-70 cm deep and 1.5 m wide. The wheat residues from the waste-free treatments were removed completely and reciprocally between the sectors and were plowed with disk plow.

The main plats were divided into three secondary plates (4 × 3 m for each plate) representing moisture attenuation levels. The secondary and cross-sections were separated by a 50-70 cm depth and 1.5 m width to ensure that the water was not transferred between the treatments. Maize seeds (Euphrates hybrid var.) were seeded at 27/7/2016 in holes (25 cm apart) on lines (75 cm apart) by putting 3-4 seeds in each hole and then subsided into one plant per hole after one month of planting. DAP fertilizer at rate of 260 $kg.ha^{-1}$ was added with seeds, while urea fertilizer was added at a rate of 400 $kg.ha^{-1}$ in two batches: the first rate of 200 kg after one month of seeding and the second before the stage of male blossoms.

The experiment consisted of three irrigation parameters: the normal irrigation treatment (control) when depleting 50% of the prepared water and two treatments for wet depletion of ready water (60 and 75%). Irrigation was carried out by a flexible 2-inch plastic pipe connected to a water-fed pump whose drainage is calibrated before irrigation to control the addition of calculated water based on depletion of the water content in control treatment (tillage without residue). The depth of irrigation water is based on the wet attenuation at depth of 0-30 cm to the beginning of the flowering stage, and then the depth of the irrigation water was increased based on the wet attenuation of the depth 0-40 cm for physiological maturity to reach moisture content approaching field capacity. In order to determine the irrigation dates and their quantities, moisture was measured by the weight method of the above depths before each irrigation to determine the specific irrigation time for each treatment. The prepared water was determined by the difference between the humidity at the field capacity and the wilt point of the field soil, according to the depth of water to be added to compensate moisture depletion for field capacity using the following formula:

$d = [\theta f.c - \theta bi]D$ (Kovda *et al.*, 1973)

As:

d = depth of water added (mm)

$\theta f.c$ = volumetric humidity at field capacity

θbi = volumetric humidity before irrigation

D = Soil depth at the desired root mass (cm)

The depth of irrigation water added to the subsequent irrigations was calculated according to the following equations:

$d = D \times \Delta\theta$

$= D \times (\varnothing fc - \varnothing d)$

$\varnothing d = \varnothing fc$- depletion rate × available water

Where, d = depth of irrigation water added (cm)

$\varnothing d$ = water content in which the percentage of depletion $\varnothing d\%$.

The amount of water needed for each plate was calculated according to the following equation:

$V = d \times A$

V = the volume amount of water needed to add it

A = the area of the plot (m^2)

When the ears reached the physiological maturation stage, weed density (plant.m^2) was calculated at 1 m^2 by a 1 × 1 m wooden box randomly received in the middle of the plot and recording the weed number and types. The vegetative traits were measured from five plants randomly taken from the middle lines, and the rate of each characteristic was estimated, including plant height, stem diameter, plant leaves number, plant leaf area and leaves chlorophyll content. The data were statistically analyzed according to Genstat program and the means were compared according to the least significant differences (LSD) and 0.05.

Results and Discussion

Types of weed growing during the season

When weed species were identified and diagnosed in the field during the seasons of maize cultivation, it was observed that there was a prevalence of some annual and perennial weed (*Pbragmites communis* L., *Convolvulus arvensis* L., *Cyperus rotaundus* L., *Cynodon dactylon* L.) and some annual plantations such as *Plantago* spp, *Echinochloa colonum* L. and a few winter weed such as Raphanus raphanistrum and Malva parviflora, which began to appear at the end of the season and were not important in the crop competition. The reeds accounted for the largest percentage (30%), the sheep (20%) and the convolvulus (16%) of the growing weed species in the field, while the other species accounted for the rest. It was observed by counting and recording the weed species in the various treatments that the wild cane reed, which is a perennial weed, was less affected than the rest of the species in the treatment of the presence of waste. It was observed that its apical buds were penetrated the waste cover and exited . This may be due to the susceptibility of perennial plants to the extension of their rhizomes and their supplies away from the mother plant and their penetration to the surface of the soil or plant coverings (Al-Jubouri *et al*., 1985). This allows them to receive light and continue growth over the waste, unlike the annual weed that grow from the seeds.

Weed density (plant.m^{-2})

Table 1 shows that the treatments of the presence of wheat residues on the surface of the soil or its plow recorded the lowest density of the weed in the field (9.78 and 10.11 plants, m^{-2}, respectively) compared with the rest of the treatments. The weed reached 17.00 plants. This is an indication of the role of waste in preventing or reducing the germination and growth of weed, which was agreed to Bhattaryya *et al*. (2006), Antar and Albder (2012). The presence of a quantity of crop residues on the surface of the soil prevents the access of light to the seedlings growing from weed seeds, which prevents their development and thus their death (Hobbs *et al*., 2008), as well as the release of some allilopathic compounds from those wastes to the soil and discouraging the growth of the weed (AL-Bahadli *et al*., 2016). Sowing the waste in the soil caused an increases in releasing some of allilopathic compounds from those wastes known in their inhibitory effect against many small weed seeds during the early stages of agriculture. This may give the crop plants an opportunity to grow without competition during the first period (Lahmod, 2012). These results agreed with the results obtained by Lahmod *et al*. (2014) in the

Table 1 : Effect of wheat residues, tillage systems and water stress in weed density with maize.

Tillage and residue treat.	(available- water depletion)			Average
	50%	60%	75%	
Tillage with residue	12.67	5.00	12.67	10.11
Residue without tillage	10.67	10.67	8.00	9.78
Tillage without residue	28.33	12.33	10.33	17.00
Without tillage without residue	13.00	14.67	11.67	13.11
Water stress means	16.17	10.67	10.67	
$LSD_{0.05}$	Water stress=2.23 interaction=4.43			3.1

Table 2 : Effect of wheat residues, tillage systems and water stress on maize plant height (cm).

Tillage and residue treat.	(available- water depletion)			Average
	50%	60%	75%	
Tillage with residue	146.9	143.9	142.5	144.4
Residue without tillage	148.0	143.6	142.2	144.6
Tillage without residue	146.1	143.3	136.4	141.9
Without tillage without residue	139.7	138.9	134.1	137.6
Water stress means	145.2	142.4	138.8	
$LSD_{0.05}$	Water stress=4.1 interaction=n.s			5.2

effect of sorghum residues on the weed associated with wheat.

It is noticed that the density of the bushes decreased with the increasing of moisture depletion from ready water. The stress treatments (75% and 60%) gave a density of 10.67 plants.m-2 compared to the normal irrigation treatment (50%), which reached 16.17 plants.m^{-2}. This decline in weed germination may be due to the lack of available moisture to the seeds, which prevents their germination. Some weed seeds are characterized by their dormancy and need high moisture for germination and growth (Al-Jubouri *et al*., 1985). The presence of waste on soil surface without plowing or plowing with the soil, caused a homogeneous density of weed which did not differ significantly compared to almost all water stress treatments, while weed density increased significantly in the normal irrigation treatment (50% depletion). This Indicated that tillage with good soil moisture helped to grow many weed seeds compared to the rest of treatments (Chauhan *et al*., 2006; Blackshaw *et al*., 2007), which may be affecting crop productivity during the growing season.

Plant height (cm)

Table 2 indicates that wheat residues and plowing caused a significant effect on plant height. Wheat residues without plowing (soil covering) gave the highest average of 144.6 cm, while the treatment without a residue without plowing gave less average of 137.6 cm. This was related to the effect of wheat straw in providing moisture reservoirs in the soil, which helped the plant to obtain its water needs and to complete its growth and development. This was agreed with the results of Ndawi (1998), who explained that soil cover was used to promote moisture content, nutrient readiness, microbial activity and soil temperature, which have a significant impact on the growth of the root system and its development and thus increase growth. Irrigation treatments caused a significant effects and the level of water depletion to 75% caused a significant decrease in plant height to 138.8 cm, while control irrigation treatment (50% of water depletion) gave the highest mean of 145.2 cm. This reduction in plant height may be due to the fact that water stress during the vegetative stage caused lack elongation and expansion of stem cells due to low water potential of plant cells associated with lack of soil water availability, as well as auxin photo-oxidation due to the reduction of vegetation (Hsiao *et al*., 1976; Falih and Salih, 2012). This indicated that plant height may be associated with hormonal factors rather than other environmental factors (Al-mutrafy *et al*., 2014). This finding is consistent with Cakir (2004) who said that water stress during the vegetative stages led to a decrease plant height by its effect on cell elongation and division. The interaction had no significant effect.

Diameter of stem (cm)

Table 3 indicates that wheat residues and tillage systems caused a significant effect on the stem diameter. Wheat residue as cover caused high stem diameter of 3.17 cm significantly compared to the other treatments, while tillage with or without residue gave 2.73 cm and the control (without tillage and no residue gave (2.66 cm)). The irrigation treatments had significantly effect on stem diameter. It was reduced to 2.66 cm and 2.79 cm at high and medium stress level (75% and 60% depletion) compared to normal irrigation which was 3.01 cm. This confirms the decline in cell growth rate and expansion, or perhaps due to the lack in number of vascular bundles or size or both due to lack of water and the inability of the plant to absorb and to benefit from nutrients (Ahmad, 2012).

The interaction between the treatments had no

Table 3 : Effect of wheat residues, tillage systems and water stress on maize stem diameter (cm).

Tillage and residue treat.	(available- water depletion)			Average
	50%	60%	75%	
Tillage with residue	2.83	2.80	2.57	2.73
Residue without tillage	3.23	3.10	3.13	3.16
Tillage without residue	3.13	2.67	2.40	2.73
Without tillage without residue	2.83	2.60	2.53	2.66
Water stress means	3.01	2.79	2.66	
$LSD_{0.05}$	Water stress=0.18 interaction=n.s			0.34

Table 4 : Effect of wheat residues, tillage systems and water stress on maize leaves number.

Tillage and residue treat.	(available- water depletion)			Average
	50%	60%	75%	
Tillage with residue	13.8	13.5	13.3	13.56
Residue without tillage	14.4	13.4	13.9	13.9
Tillage without residue	13.9	13.5	13.0	13.49
Without tillage without residue	13.9	13.6	12.6	13.38
Water stress means	14.0	13.5	14.0	
$LSD_{0.05}$	Water stress=0.4 interaction=n.s			n.s

significant effect, but stem diameter tends to increase at wheat residue treatment under water stress. This confirms the efficiency of soil covering in maintaining soil moisture and reducing the stress effect on the plant. This was previously referred by many researchers (FAO, 2001; Hobbs, 2008 and Moyo, 2013). The stem diameter had an important role in the plant seed yield by increasing the vascular bundles which resulting from the increase of the thickness of wood and phylum layers, which leads to increase utilization of the nutrients absorbed by the root through the expansion of the source and increase the sink (grain) (ELsahookie, 1994).

Leaves number per plant

The leaf is the main part that the plant depends on it in photosynthesis and metabolism in general, and if plant leaf area was increased to optimize, the system capacity constant (SCC) in the plant was increases (Subedi and Ma, 2005). Some weather factors control the growth of leaves. As the conditions were favorable, leaves growth were greater, and the plant leaf area was increased. Water stress reduces green leaf area and accelerates aging, thereby reducing the efficiency of photosynthesis (Richards *et al*., 1997).

Table 4 shows that wheat residue treatment had no significant effect on plant leaves number, while irrigation treatments had significant effect and the 75% depletion gave less leaves number (13.2), compared to 50% depletion treatment which gave 14 leaves. The interaction had no significant effect. Thus, it was clear that the number of leaves was moving in the same direction as plant height. The effect of water stress on the number of leaves may be due to the negative effect of shortage water available on the vegetation in the elongation of internodes and thus the low rate of leaf emergence (Faleh, 2011), or perhaps also due to the apparent decrease in plant height, causing the reduction of leaves. This results were agreed with the findings of Cavero *et al*. (2000), Anand *et al*. (2012), Kuscu and Demir (2012), who found that water stress reduces the expanding and elongation of maize leaves.

Plant leaf area (cm^2)

If plant leaf area increases to an optimal limit, the system's compatibility constant (SCC) increases in the plant (Subedi and Ma, 2005) and this increase allows for rapid transformation from vegetative to reproductive phase and thus increase the rate of grain filling (Elsahooki, 2004). Table 5 indicates that there is a significant effect of the addition of residues, tillage and water stress factors on maize plant leaf area. Adding wheat residue without tillage recorded the highest leaf area of 8497.3 cm^2 compared to without residue without tillage which gave 7329.0 cm^2. This may be due to the use of residue as a cover that provided good environmental conditions for plant growth by maintaining soil moisture, reduce temperature, improve porosity and these factors combined increase the biological activity of microorganisms in the soil and encourages the production of hormones such as GA_3 and cytokinins (Ali, 2001). The use of crop residues as covering improves plant environment in soils by maintaining soil moisture, regulating its temperature, adding organic matter, reducing soil salinity and growth of weeds, as well as increasing nutrient availability.

The irrigation treatment of 75% gave the lowest leaf area (7343.5 cm^2), while control irrigation treatment (50%) gave the highest leaf area (8401.0 cm^2). The reduction in leaf area may be due to the impact of water stress in decrease leave growth and expansion which resulted in non-elongation of cells, which negatively affected the leaf area (Faleh, 2011). These results are consistent with Ghooshchi *et al*. (2008), Rong (2012) and Soltani *et al*. (2013) who found that water stress in

Table 5 : Effect of wheat residues, tillage systems and water stress on maize leaf area (cm^2).

Tillage and residue treat.	(available- water depletion)			Average
	50%	60%	75%	
Tillage with residue	8413	7839	7420	7890.7
Residue without tillage	9135	8262	8095	8497.3
Tillage without residue	8171	7463	7158	7597.3
Without tillage without residue	7885	7401	6701	7329.0
Water stress means	8401.0	7741.3	7343.5	
$LSD_{0.05}$	Water stress=327 interaction=n.s.			769.2

Table 6 : Effect of wheat residues, tillage systems and water stress on chlorophyll content (spad).

Tillage and residue treat.	(available- water depletion)			Average
	50%	60%	75%	
Tillage with residue	53.9	61.7	61.0	58.9
Residue without tillage	48.5	55.5	56.9	53.6
Tillage without residue	54.4	56.8	60.8	57.3
Without tillage without residue	55.2	59.2	58.8	57.7
Water stress means	53.0	58.3	59.4	
$LSD_{0.05}$	Water stress=3.8 interaction=n.s			3.6

vegetative phase leads to reduction of leaf area. The interaction between the factors was not significant.

Leaf chlorophyll content (Spad)

Leaf chlorophyll content is one of the traits that affected by the stresses, including water stress (Mahmoud *et al.*, 2005). Table 6 indicates that wheat residue treatments caused a significant effect leaf content of chlorophyll. Plowing wheat residue gave the highest (58.9 spad) chlorophyll content, while tillage without wheat residue gave the lowest value (57.3 spad). Control irrigation treatment (50%) gave the lowest mean of 53.0 spade, while the irrigation treatment of 75% gave the highest average of 59.4 spad. The interaction between the factors was not significant. The results showed that the increase of the irrigation process (50% depletion) caused the reduction of the plant chlorophyll rate in all tillage and the addition of wheat residue compared to the other treatments. This may be due to a lack of nutrients in the soil, especially nitrogen due to high soil porosity and water availability which caused washing of nutrients from the soil. The lack of water usually gives a dark color to the plant.

In general, plowing wheat residue in the soil caused an increase in the plant content of chlorophyll, while chlorophyll was decreased when wheat residue added on the soil surface (as cover). May be, there was an allelopathic effect of wheat residues that were plowed in the soil (in the early stages as field observation), as indicated by Roth *et al.* (2000), but this effect soon disappears after the degradation of these organic compounds in the soil by micro-organism and transformation into elements. This results was consistent with Roth *et al.* (2000) that leaving the sorghum residues on soil surface (as cover) had no significant effect on chlorophyll and the growth rate of the wheat crop. However, the effect emerged in later stages due to the release of the allelopathic compounds to the soil due to irrigation water and rain, while the reverse effect was obtained in the case of plowing sorghum residues in the soil, in which the effect on the crop appeared at the beginning of the season and soon thereafter. This was also obtained in the current study, that chlorophyll content was decreased at soil covering by wheat residue, especially with normal irrigation (50%) which gave the lowest chlorophyll content (48.5 spad) compared to other rest treatments, which ranged between 53.9 - 61.7 spad. This effect may be due to the release of some allelopathic compounds from wheat residue when used as a soil cover.

Conclusion

It can be concluded that adding wheat plant residues as soil cover can reduce the impact of water stress on maize crop and reduce the growth and competition of weeds.

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