EFFECT OF TILLAGE, CROP ROTATION AND PREVIOUS CROP RESIDUES ON CLOVER, MAIZE AND MUNG BEAN PRODUCTIVITY

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ABSTRACT

Two field experiments were conducted to evaluate the effect of tillage, crop residues and crop rotation on productivity of clover, maize and mung bean, at the experimental research station of the College of Agricultural Engineering Sciences - University of Baghdad in Aljadriya, Baghdad – Iraq during two seasons of 2021-2022. 1st trail was with two factors: residues (0%R and 100%R) and tillage (minimum (MT) and conventional (CT)) with four replicates. Results indicated the best values of height and dry matter yield were (70.25 cm and 5.558 Mg ha^{-1}) for (100%R+MT) compared with (65.5 cm and 4.985 Mg ha^{-1}) for (0%R+CT) respectively. The 2nd trail was with three factors: the same tillage and residues coupled with crop rotations (clover-maize) and (clover-mung bean). Results (representing the accumulated effect of both trials) indicated the best values of height, dry matter yield and grains and seeds yield were (236.25 and 111.5) cm, (4.560 and 14.745) Mg ha^{-1}, (6.840 and 3.754) Mg ha^{-1} for (100%R+MT) treatment compared to (210.0 and 101.25) cm, (4.048 and 11.337) Mg ha^{-1}, (5.685 and 2.829) Mg ha^{-1} with (0%R+CT) for maize and mung bean respectively and under crop rotations (clover-maize) for maize and (clover- mung bean) for mung bean.

Keywords: (*Vigna radiata* L.), (*Zea mays* L.), grains yield, dry matter yield, crop sequence .
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تأثير الحراثة و التعاقب المحصولي وبقايا المحصول السابق في إنتاجية البرسيم والذرة الصفراء والماش

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المستخلص

نفذت تجربتان حقليتان لمعرفة تأثير الحراثة وبقايا المحصول والتعاقب المحصولي في إنتاجية البرسيم والذرة الصفراء والماش, في المحطة البحثية التابعة لكلية علوم الهندسة الزراعية – جامعة بغداد في الجادرية، بغداد – العراق للموسمين الزراعيين لعام 2021 – 2022. كانت التجربة الأولى بعاملين هما: البقايا (0% بقايا و100% بقايا) والحراثة (دنيا و تقليدية) بأربعة مكررات. أظهرت نتائج التجربة الأولى ان افضل القيم لصفات ارتفاع النبات وحاصل المادة الجافة للبرسيم (70.25 سم و 4.985 ميكا غرام هـ$^{-1}$) للمعاملة (100% بقايا+ حراثة دنيا) بالقياس إلى (65.5 سم و 4.985 ميكا غرام هـ$^{-1}$) للمعاملة (0% بقايا+ حراثة تقليدية) على الترتيب. كانت التجربة الثانية بثلاث عوامل: العاملين السابقين الحراثة والبقايا مصحوبة بعامل ثالث هو تعاقب المحاصيل (برسيم–ذرة صفراء) و (برسيم– ماش). نتائج التجربة الثانية (تمثلت بالتأثير التراكمي لكلا التجربتين) وكانت افضل النتائج لارتفاع النبات و حاصل المادة الجافة و حاصل الحبوب والبذور (236.25 و111.5) سم و (4.560 و 14.745) ميكا غرام هـ$^{-1}$ و (6.840 و 3.754) ميكا غرام هـ$^{-1}$ للمعاملة (100% بقايا+ حراثة دنيا) بالمقارنة مع (210.0 و 101.25) سم و (4.048 و 11.337) ميكا غرام هـ$^{-1}$ و (5.685 و 2.829) ميكا غرام هـ$^{-1}$ للمعاملة (0% بقايا+ حراثة تقليدية) للذرة الصفراء والماش على الترتيب وضمن تعاقب المحاصيل (برسيم– ذرة صفراء) للذرة الصفراء و (برسيم – ماش) للماش.

الكلمات المفتاحية: (*Vigna radiata* L.)، (*Zea mays* L.)، حاصل الحبوب, حاصل المادة الجافة, الدورة الزراعية .

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INTRODUCTION

The main aim of all agricultural management practices is to increase crop yield and conserve the soil from degradation (5, 6, 9, 14, 19 and 20). The ultimate aim for soil ecological management is to create an appropriate place under the soil surface (i.e. Rhizosphere) characterized by good stable soil structure, good content of soil organic carbon, good biodiversity, and good nutrients reserve for high and good quality crops to ensure human food security and keep the environment clean. This can be achieved through reducing tillage as possible, avoiding soil crusting and compaction, adopting good crop rotation, using intercropping and applying of amendments (8, 9, 16, 17, 19, 22 and 23). Leaving crop residues on the soil surface increased dry matter yield and grain yield of maize by 109.57% and 54.0% respectively (1). Using crop residues of the last crop and minimum tillage application improved the soil's physical, chemical, and biological properties reflecting on its productivity as a result of improving soil properties (10, 25 and 28). Using crop residues and zero tillage with crop rotation increased the yield of the wheat - mung bean - rice cropping system (3). Using crop residues improved soil structure and increased soil organic carbon and crop yield (15). Planting legume plants in the crop rotation and using their residues increased the availability of nutrients in the soil, especially nitrogen **(**24). Jeghata and Muhawish indicated that using conservative tillage and residues improved some soil properties which were reflected in good crop productivity in a gypsiferous soil (18). Using good soil amendments (i.e. organic fertilization) had a good effect on soil properties (chemical & physical) led to an increased in yield of plants by 30% (2, 5, 6 and 27). The main aim of the ongoing study was to evaluated the effects of some soil management practices on clover, maize and mung bean productivity**.**

MATERIALS AND METHODS

Two field experiments were conducted at the experimental research station of the College of Agricultural Engineering Sciences, University of Baghdad in Aljadriya, Baghdad, Iraq. (33̊ 16̍ 02̎ N . 44̊ 22̍ 33̎ E) during two seasons “fall and spring of 2021-2022”. The two trials were conducted in a randomized complete block design with four replicates to investigate the effect of tillage, crop residues and crop rotation management practices on clover, maize, and mung bean productivities. In the 1st experiment, two factors were used: the first was the residues of the previous crop alfalfa (*Medicago sativa* L.), 100% residues (100%R) and 0% residues (0%R) the 2nd factor was tillage minimum tillage (MT) and conventional tillage (CT) in split-plot arrangement planted with clover (*Trifolium repens* L.) (the experiment started in 20th of November 2021 and finished in 1st of March 2022). Soil samples were collected before trial to test the soil's chemical, physical, and biological properties. Results of soil analysis show in Table 1 for soil before land cultivation. The 2nd experiment followed the 1st one in the spring season using tillage, crop residues, and crop rotation clover – maize (*Zea mays* L.) and clover - mung bean (*Vigna radiata* L.) productivities. Both crops were sown at the same plots of the previous clover crop (the experiment started in 22th of March 2022 and finished in 1st of August 2022) in a split plot arrangement. Three plants were fertilized in the two trails according to Ali (7). Growth, yield, and grains yield increments were measured for the three crops at the termination of each trial.

Table 1. Chemical , physical , biological and fertility properties of the soil before planting*

property		Value	Unit
Hydrogen potential (pH) (1:1)		8.25	-
Electrical conductivity (EC) (1:1)		1.85	dS m^{-1}
Available nitrogen		28.00	
Available phosphorus		13.25	
Available potassium		174.01	mg kg^{-1} soil
Available iron		5.65	
Available zinc		3.75	
Carbonate minerals		345.0	
Soil organic matter		16.13	g kg^{-1} soil
Soil organic carbon		9.35	
Active carbon		128.44	mg kg^{-1} soil
Cations	Ca^{2+}	8.95	
	Mg^{2+}	4.55	
	K^{1+}	2.35	
	Na^{1+}	3.47	m mol L^{-1}
Anions	SO_4^{2-}	5.1	
	Cl^{1-}	21.5	
	HCO_3^{1-}	2.95	
	CO_3^{2-}	Nill	
CEC		19.45	C mol_+ kg^{-1}soil
Soil aggregate stability		26.45	%
Saturated hydraulic conductivity		1.96	cm h^{-1}
Sand		353.0	g kg^{-1}
Silt		519.0	
Clay		128.0	g kg^{-1}
Soil texture class		Silty loam	
water content			
at 33 kPa		23.4	
at 1500 kPa		12.0	%
Available water		11.4	
Biological properties			
Total bacteria count		$4.5 * 10^9$	CFU g^{-1} soil
Total fungi count		$3 * 10^3$	
Alkaline phosphatase enzyme activity		108.49	Microgram p-nitro phenol g^{-1}dry soil h^{-1}

*Measurements done according to methods mentioned (11, 12 and 26).

RESULTS AND DISSCUSION

First experiment

Plant height: Results of the 1st trial indicated that height of clover was affected by both residues and tillage factors giving the best result with (100% R + MT) which was 70.25 cm with increment percent 16.12% compared with 65.50 cm for (0%R + MC). Using crop residues (100%R) increased significantly of plant height which was 69.12 cm with increment percent 4.92% compared with 65.88 cm for (0%R) treatment. Minimum tillage (MT) increased significantly plant height which value was 68.25 cm with increment percent 2.25% compared with 66.75 cm for (CT) treatment (Table 2)

Table 2. Effect of crop residues and tillage on clover height (cm)

Residues %	Tillage		Mean of residues
	Conventional tillage (CT)	Minimum tillage (MT)	
0	65.50	66.25	65.88
100	68.00	70.25	69.12
LSD 0.05	0.95		0.77
Mean of tillage	66.75	68.25	
LSD 0.05	0.83		

Dry matter yield

The dry matter yield of clover was affected by treatments (Table 3). The best dry matter yield was with 100%R + MT treatment giving 5.558 Mg ha^{-1} with an 11.5% increment compared to that of 0%R + CT with 4.985 Mg ha^{-1}. Using crop residues (100%R) increased dry matter weight of clover significantly to 5.421 Mg ha^{-1} with 7.71% increment compared to 5.033 Mg ha^{-1} with (0%R). Using MT increased dry matter weight of clover significantly 5.319 Mg ha^{-1} with 3.58% increment compared to 5.135

Mg ha^{-1} for CT treatment. From tables 2 and 3 it can be indicated that residues of previous crop (alfalfa) and minimum tillage had a very clear effect on clover height and dry matter yield. This can be due to the role of these two factors in improving soil properties (4). These results are in agreement with some researchers (13 and 21).

Table 3. Effect of crop residues and tillage on clover dry matter yield (Mg ha^{-1})

Crop residues %	Tillage		Mean of residues
	Conventional tillage (CT)	Minimum tillage (MT)	
0	4.985	5.080	5.033
100	5.284	5.558	5.421
LSD 0.05	0.194		0.208
Mean of tillage	5.135	5.319	
LSD 0.05	0.079		

Second experiment

Plants height: Table 4 shows the effect of crop residues and tillage under crop rotation on the height of maize and mung bean. Crop residues using (100%R) showed a significant increase in the height of maize under crop rotation (clover–maize) with a value of 233.75 cm with an increment of 10% compared with (0%R) giving 212.50 cm. Using crop residues (100%R) appeared to have a significant effect on the height of mung bean under crop rotation (clover–mung bean) with a 109.00 cm value with a 6.99% increment compared to 101.88 cm of (0%R). The interaction treatment (100%R+MT) was the best treatment under both clover-maize and clover–mung bean rotations.

Table 4. Effect of crop residues and tillage under crop rotation on plant height of maize and mung bean (cm)

Crop residues	Maize			Mung bean		
	Tillage system		Residues mean	Tillage system		Residues mean
	CT	MT		CT	MT	
0% R	210.00	215.00	212.50	101.25	102.50	101.88
100% R	231.25	236.25	233.75	106.50	111.50	109.00
LSD 0.05	16.57		17.64	6.19		6.41
Tillage mean	220.63	225.63		103.88	107.00	
LSD 0.05	NS*			NS		

*** NS: Non significant**

Dry matter yield of plants

Table 5 shows the effect of crop residues and tillage on maize and mung bean dry matter yield. Single factors and the interactions among them were affected positively and significantly by the treatments used. Using (100%R) increased of dry matter weight for maize and mung bean which were 4.407 Mg ha^{-1} and 14.525 Mg ha^{-1} with increments percent 7.44% and 15.24% compared with 4.156 Mg ha^{-1} and 12.604 Mg ha^{-1} to (0%R) treatments for maize and mung bean respectively. Minimum tillage (MT) increased dry matter weight of maize and mung bean significantly which values were 4.358 Mg ha^{-1} and 14.308 Mg ha^{-1} with an increments percent (4.99% and 11.6%) compared to 4.151 Mg ha^{-1} and 12.821 Mg ha^{-1} for CT treatment for maize and mung bean respectively. The interaction (100%R+ MT) gave the best values 4.560 Mg ha^{-1} and 14.745 Mg ha^{-1} with an increments percent 12.65% and 30.06% compared to 4.048 Mg ha^{-1} and 11.337 Mg ha^{-1} with (0%R+CT) treatment for maize and mung bean respectively. Planting maize and mung bean after clover gives the best results with the treatment (100%R+MT).

Table 5. Effect of crop residues and tillage under crop rotation on dry matter yield of maize and mung bean (Mg ha^{-1})

Crop residues	Maize			Mung bean		
	Tillage system		Residues mean	Tillage system		Residues mean
	CT	MT		CT	MT	
0% R	4.048	4.156	4.102	11.337	13.871	12.604
100% R	4.254	4.560	4.407	14.304	14.745	14.525
LSD 0.05	0.088		0.077	0.138		0.138
Tillage mean	4.151	4.358		12.821	14.308	
LSD 0.05	0.075			0.099		

Weight of 1000 grains and seeds

Results in Table (6) show that treatments did not have any significant differences between treatment means of factors and their interaction on weight of 1000 grains of maize and seeds of mung bean.

Table 6. Effect of crop residues and tillage under crop rotation on the weight of 1000 grains of maize and mung bean seeds (g)

Crop residues	Maize Tillage system CT	Maize Tillage system MT	Maize Residues mean	Mung bean Tillage system CT	Mung bean Tillage system MT	Mung bean Residues mean
0% R	281.0	283.0	282.0	33.43	34.73	34.08
100% R	290.5	307.2	298.9	35.28	35.85	35.56
LSD 0.05	NS		NS	NS		NS
Tillage mean	285.8	295.1		34.35	35.29	
LSD 0.05	NS			NS		

Grains and seeds yield (Mg ha^{-1})

The grains yield of maize and seeds yield of mung bean as affected by treatments is shown in Table 7. Using crop residues (100%R) increased significantly in grains yield of maize and seeds of mung bean which were 6.660 Mg ha^{-1} and 3.433 Mg ha^{-1} with an increments percent 14.22% and 18.54% compared to 5.831 Mg ha^{-1} and 2.896 Mg ha^{-1} for (0%R) treatment for maize and mung bean respectively. Using MT increased in grains yield of maize and seeds of mung bean which were 6.409 Mg ha^{-1} and 3.358 Mg ha^{-1} with an increments percent 5.38% and 13.03% compared with CT treatment which were 6.082 Mg ha^{-1} and 2.971 Mg ha^{-1} for maize and mung bean respectively. Interaction treatment (100%R+MT) gave the best values (6.840 Mg ha^{-1} and 3.754 Mg ha^{-1} with an increments percent 20.32% and 32.70% compared to 5.685 Mg ha^{-1} and 2.829 Mg ha^{-1} for (0%R+CT) for maize and mung bean respectively. As the grains yield of maize and seeds of mung bean can be considered as the sink for other growth and yield components it can be seen the best yield was with (100%R+MT) treatment under both crop rotations.

Table 7. Effect of crop residues and tillage under crop rotation on grains yield weight of maize and mung bean seeds (Mg ha^{-1})

Crop residues	Maize Tillage system CT	Maize Tillage system MT	Maize Residues mean	Mung bean Tillage system CT	Mung bean Tillage system MT	Mung bean Residues mean
0% R	5.685	5.977	5.831	2.829	2.962	2.896
100% R	6.479	6.840	6.660	3.112	3.754	3.433
LSD 0.05	0.106		0.114	0.087		0.085
Tillage mean	6.082	6.409		2.971	3.358	
LSD 0.05	0.039			0.065		

Grains and seeds yield increments

From Table 8, it can be seen that the increment in grains yield of maize was around 20% and seeds yield of mung bean was 33% due to the adoption of these management practices.

Table 8. Grains yield increments* for maize and mung bean seeds (%)

Crop residues	Maize Tillage system CT	Maize Tillage system MT	Mung bean Tillage system CT	Mung bean Tillage system MT
0% R	-	5.14	-	4.70
100% R	13.97	20.32	10.00	32.70

*** %yield increment ={(treatment yield – control yield) / (control yield)}*100**

Results in (Tables 2, 3, 4, 5, 7) show the good yield and growth properties of plants and that return to the role of crop residues and minimum tillage in improving soil properties of tested soil and this will be reflected in microorganisms activity which play the main role in decomposing of organic matter (crop residues) and on soil fertility as well through increasing nutrients availability and uptake (4). Minimum tillage also plays a very important role in conserving organic carbon and microorganisms colonies from degradation compared with conventional tillage. Improvements in soil properties were reflected in maize and mung bean crops' growth and yield. planting maize after clover (legume) and alfalfa (legume) in a crops rotation improved maize yield. Planting mung bean after clover and alfalfa (all legumes) gave the best results with mung bean. Legume plants included in such rotations should improve soil supply with more nutrients especially nitrogen through fixation (9). In addition, planting cover crops (clover) improves soil moisture and soil organic matter (5, 6, 19 and 20).

CONCLUSION

Using integrated management practices: crops rotation, residues of previous crop and minimum tillage can have a very clear impact on soil properties so using such practices can be recommend.

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