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EFFECT OF TILLAGE SYSTEMS AND SOIL MICROBES ON CONCENTRATION OF SOME AVAILABLE SOIL HEAVY METALS AND CROP YIELD

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ABSTRACT

The main object of this study is to investigate the influence of adding different soil microorganisms under different tillage systems on concentration of some heavy metals and productivity of crop yield. The experiments were carried out in clay soil during four successive seasons in private farm at Abo-Dawood village, Dakahlia governorate. The experimental field located far from contamination sources such as roads, factories or large cities.

The obtained results indicated that the conservation tillage system increased the crop yield about 50%, 37.5% in second season and 44.4%, 39.3% in fourth season in comparison with conventional and intensive tillage systems respectively. addition of Bucills megaterium led to an increase in the wheat crop yield in all tillage treatments with an increase by 20.4%, 18.6% and 19.8% as well as adding Cyan bacteria led to an increase in the productivity of the wheat crop with an increase by 12.3%, 10.9% and 7.8% in conventional, intensive and conservation tillage treatment respectively.

INTRODUCTION

Tillage techniques affect incorporation of plant residues with soil, consequently, decomposition rate, organic matter and PH. This gives rise to change in bioavailability of several elements in root biomass distribution.
Davis *et al*, 1995, found that no-tillage resulted increase in P at the 0-5 cm depth relative to P at the 5-10 cm depth, and at 0-5 cm P was 35% greater under no-tillage than under tillage.

Lavado *et al*, 1999, reported that the conventional tillage reduced the organic mater in soil in comparison with no tillage. The effect of the conventional tillage and zero tillage on concentration and stratification of trace elements demonstrated that copper and nickel didn't show significant differences related to tillage systems. Meanwhile copper (max value 1.46 mg/kg) and nickel (max. value 0.65 mg/kg) were higher under conventional tillage, while zinc (max. value 2.03mg/kg) and lead (max. value 0.94 mg/kg) showed higher concentration under zero tillage on top soil. Also zinc showed higher concentration under zero tillage on the top soil (0-5cm) but from 5 to 25 cm depth the concentration was significantly higher under conventional tillage. Green, *et al* 2007, reported that the no-tillage system resulted in greater biological activity than disk harrow and disk plow in the 0–5 cm depth due to crop residues accumulation on the soil surface under no tillage.

Santiago, *et al* 2008, found that no tillage and minimum tillage systems led to heavy metals accumulation in the surface layer of soil. DTPA extractable Cu and Zn, were higher under no tillage (2 mg/kg, 0.5 mg/kg) than under conventional tillage (1.5 mg/kg, 0.1 mg/kg) and minimum tillage (1.7 mg/kg, 0.2 mg/kg) respectively. Soil microorganisms affect soil quality and productivity through degradation plants and animals residues, participation in biogeochemical nutrients cycle including addition some nutrient elements to be available for plants in the soil or remediation heavy metals and other pollutants from soil environment. They added that the reduced tillage practices had a better effect on biological soil properties, as microbial activity (which was estimated by ß-glucosidase method) of the soil surface (0–5-cm layer) was found to be significantly higher under no-tillage (47 µg Para Nitro Phenol g-1h^{-1}) than under conventional tillage (23 µg Para Nitro Phenol $g^{-1}h^{-1}$) or minimum tillage (36 µg Para Nitro Phenol $g^{-1}h^{-1}$).

Khider, 2010, reported that the conservation tillage system (Chisel plow once followed by rotary tiller) increasing the wheat crop yield about 10.1% and 5.1% in comparison with the conventional tillage system (Chisel plow twice followed by hydraulic leveler) and intensive tillage system (Moldboard plow once followed by rotary tiller).

MATERIALS AND METHODS

The experiments were carried out in clay soil (54.5% clay, 29.2% silt and 16.3% sand) during four successive seasons (from May 2009 to April 2011) in private farm at Abo Dawood village, Dakahlia governorate. The experimental field located far from contamination sources such as roads, factories or large cities. The experimental area was about 0.5 feddan. According to seed bed preparation systems, the experimental area divided into three parts, each part have about 700 m^2 (14×48 m). (1- Conventional tillage (Ch_2+L): Two passes chiseling followed by wooden land leveler. 2- Intensive tillage (Ch_2+R): Two passes chiseling followed by rotary tiller. 3-Conservation tillage(Ch+R):One pass chiseling followed by rotary tiller).

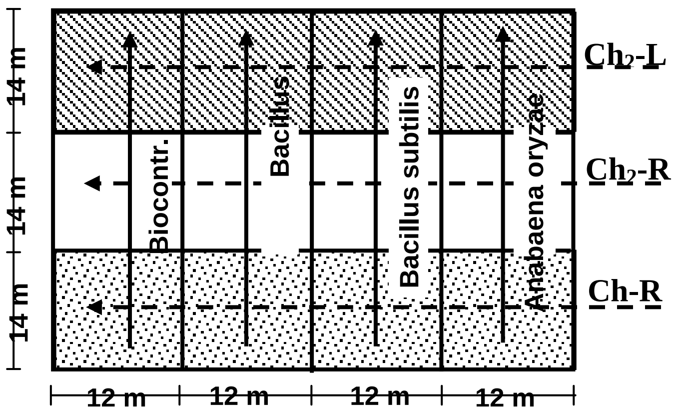

Fig. 1: Experimental field layout.

In the fourth season, each part was divided into four subplots, in according with adding of microorganisms (fig. 1), which are:

1- Biocontrol Treatment: Without adding any Microorganisms. (Biocontr.)
2- Bacillus megatherium var. phosphaticum (B. meg.)
3- Bacillus subtilis (B. subt.)   4- Anabaena oryzae 231 (Cyan B.)

The concentration of available heavy metals Lead, Nickel, Zinc and Copper were determined in both surface (0-10 cm) and bottom (10-20 cm) layers. The available heavy metals was extracted by Ethylenediaminetetra-acetic acid (EDTA), according to Cottenie *et al*, 1982,. Analyses were carried out in Soil Sci. Dept. Fac. of Agric., Kafer El-Sheikh Univ.

Plate count technique was used to determine total bacterial count using soil extract agar media (Allen, 1959). Total count of bacterial was carried out in Microbiology Dept., Fac. of Agric., Mansoura Univ.

The crop yield was evaluated by taking five randomly selected samples of one square meter area for each plot. The yield was expressed as dry matter weights. The samples were collected using a wooden frame (1 m^2), which was placed on the field carefully with a randomize way in each plot. Five samples were taken and shelled by hand and weighed and used to extrapolate the crop yield in related to the feddan.

RESULTS AND DISCUSSION

Effect of tillage systems on concentration of available heavy elements:

The results indicated that all the seedbed preparation systems, which used in this study, reduced the concentration of tested available elements.

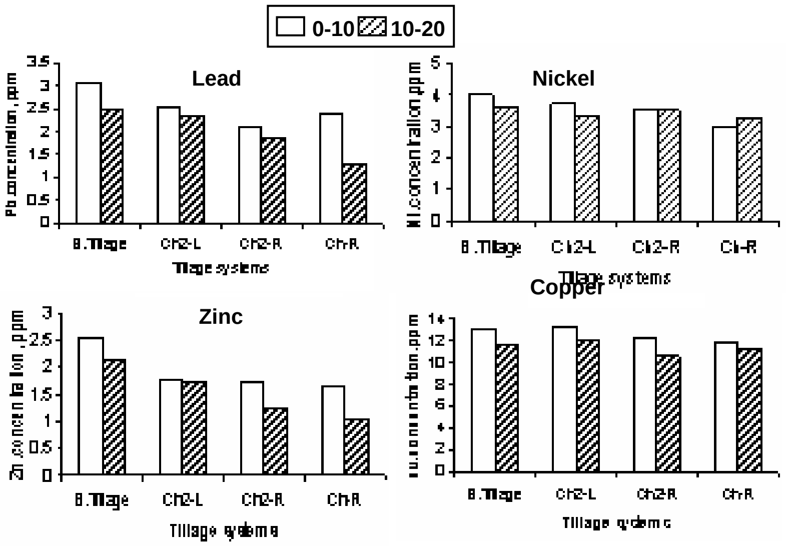

Fig. 2: Effect of tillage systems on available heavy metals concentration.

Fig. 2 show that the concentration of available heavy metals (lead, Nickel, Zinc and Copper) before tillage treatments in surface layer (0-10cm) are higher than in bottom layer (10-20cm) about 24.77%, 10.57%, 19.72% and 12.91% respectively. Using conservation tillage system (Ch-R) decreased the concentration of available lead, Nickel, Zinc and Copper elements about 21.7% and 47%, 25.2% and 9.7%, 35.3% and 50.8%, 9.3% and 4% in surface

(0-10 cm) and bottom layer (10-20 cm) in comparison with before tillage respectively. The results indicated that the conservation tillage system has a clear impact in reducing the proportion of elements in the soil compared to other tillage systems. The results showed a significant decrease of the various elements in all depths, except for the lead in the surface layer, which achieved the highest decrease of available element concentration in the surface layer after using intensive tillage system for other systems.

Effect of adding soil microbes on concentration of available heavy metals:

The obtained results in fig. 3 showed the effect of addition soil microbes on concentration of available heavy metals in soil. Fig 3-A showed that addition Bacillus megatherium has achieved a reduction in the proportion of available lead element in the conventional tillage treatment by 54%, 18% at the depths of 0-10 and 10-20 cm and about 47.9% at soil depth 0-10 cm in conservation tillage treatment, whereas addition Bacillus subtilis reduced the concentration of available lead element about 24.4% at soil depth 0-10 cm in intensive tillage treatment and 41.5%, 29.9% in conservation tillage treatment at the depths of 0-10 and10-20 cm respectively.

Fig 3-B showed that addition Bacillus megatherium decreased the concentration of available nickel element about by 16%, 23% in the conventional tillage treatment at the depths of 0-10 and10-20 cm. respectively. Whereas addition Bacillus subtilis reduced the concentration of available nickel element about 17%, 14% and 16.7%, 16% at soil depth 0-10 and 10-20 cm in intensive tillage and conservation tillage treatments respectively. Fig 3-C showed that addition Bacillus megatherium decreased the concentration of available zinc element about by 17.2%, 20% in the conventional tillage treatment at the depths of 0-10 and10-20 cm. respectively. Whereas addition Bacillus subtilis reduced the concentration of available zinc element about 23.6%, 24% at soil depth 0-10 and 10-20 cm in intensive tillage treatment respectively. While conservation tillage treatment was affected with addition of Bacillus megatherium and Bacillus subtilis, whereas the concentration of available zinc element decreased about 32.7%, 25.9% and 36.7% and 33.3% at soil depth 0-10 and 10-20 cm respectively. Fig 3-D showed that addition B. meg decreased the concentration of available copper element about 22% in the conventional tillage treatment at the depths of 0-10 cm. Whereas addition Bacillus subtilis reduced the concentration of available copper element about 22.5%, 20.8% at soil depth 0-10 and 10-20 cm in intensive tillage treatment respectively. While conservation tillage treatment was affected with addition of Bacillus megatherium and Bacillus subtilis, whereas the concentration of available copper element decreased about 24%, 29% and 25.9% and 27.7% at soil depth 0-10 and 10-20 cm respectively.

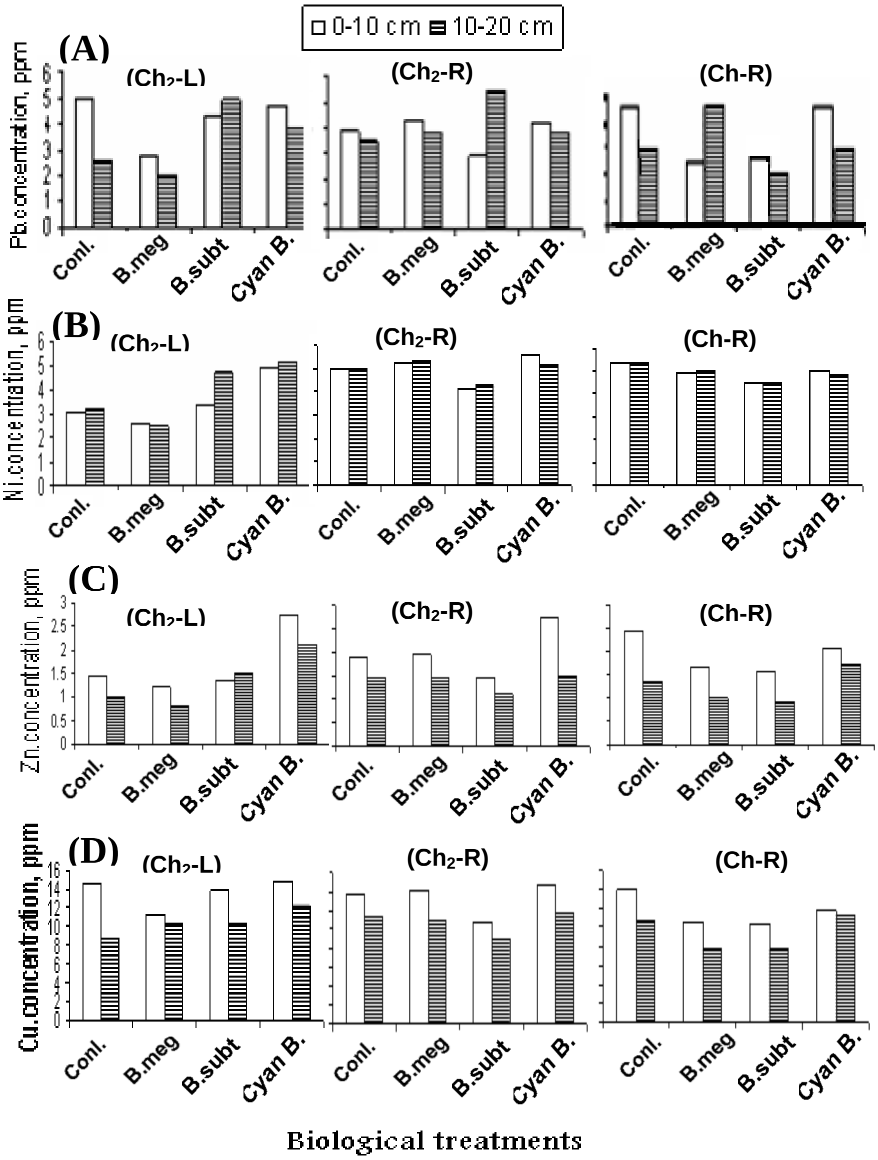

Fig. 3: Effect of adding soil microbes on concentration of available heavy metals under different tillage system.

Effect of tillage systems and soil microbes on wheat crop yield:

The obtained results in figure (4) showed that the conservation tillage system recorded the highest crop yield in comparison with conventional and intensive tillage systems. Conservation tillage treatment recorded increase of wheat crop yield about 44.4%, 39.3% more than conventional and intensive tillage treatments.

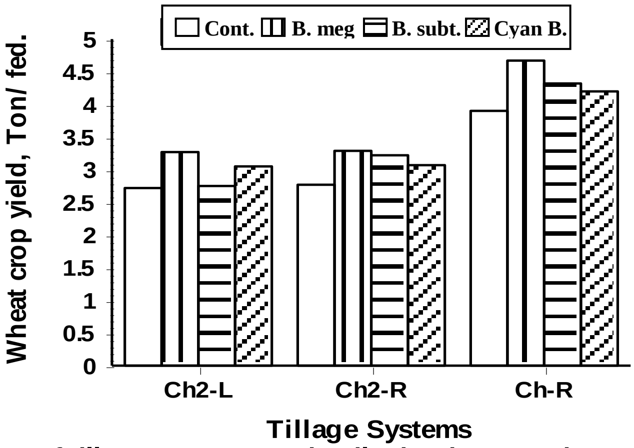

Fig. 4: Effect of tillage systems and soil microbes on wheat crop yield.

Addition of different types of bacteria led to increased crop productivity in all tillage treatments. Bucills megaterium recorded an increase in the wheat crop yield in all tillage treatments with an increase by 20.4%, 18.6% and 19.8% as well as adding Cyan bacteria led to an increase in the productivity of the wheat crop with an increase by 12.3%, 10.9% and 7.8% in conventional, intensive and conservation tillage treatment respectively. While the addition of Bucillus subtitlus recorded an increase in the wheat crop yield in intensive and conservation tillage treatments about 16.5% and 10.9% respectively. While adding Bucillus subtitlus have not significant effect on the productivity of the wheat crop yield in conventional tillage treatment.

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تأثير نظم الحرث وميكروبات التربة على تركيز بعض عناصر التربة الثقيلة وإنتاجية المحصول

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لا تقتصر العناصر الثقيلة على كونها أحد العوامل الهامة في تلوث البيئة ولكنها تشكل أهم المخاطر على صحة الإنسان. فارتفاع تركيز هذه العناصر بالتربة لا تؤدي فقط لتقليل النشاط الحيوي بالتربة وانخفاض إنتاجية المحصول ولكن تمثل تهديد خطير على صحة الإنسان من خلال الغذاء المحتوي غلى هذه العناصر. لذا أجريت هذه الدراسة بغرض تحديد تأثير بعض نظم الحرث وإضافة بعض ميكروبات التربة على تركيز بعض العناصر الثقيلة بالتربة.

تم التوصل لمجموعة من النتائج يمكن تلخيصها فيما يلي:

- استخدام نظام الحرث لحماية التربة (Ch-R) حقق انخفاض في تركيز العناصر الثقيلة محل الدراسة في طبقتي التربة (0- 10سم)، (10-20سم) بالمقارنة بنظم الحرث الأخرى.
- إضافة (.B.subt., B.meg) حقق انخفاض ملحوظ في تركيز جميع عناصر الدراسة في معاملات الحرث لحماية التربة (Ch-R)، في حين إضافة (.B.meg) حققت انخفاض في تركيز عناصر الرصاص، النيكل، الزنك في معاملات الحرث التقليدي (Ch_2-L)، بينما إضافة (.B.subt) حققت انخفاض في تركيز عنصر الزنك في معاملة الحرث الكثيف (Ch_2-R).
- حققت معاملة الحرث لحماية التربة (Ch-R) أعلى انتاجية للمحصول بالنسبة لمعاملات الحرث الآخري.
-إضافة ميكروبات التربة أدت لزيادة انتاجية المحصول مع جميع معاملات الحرث المختلفة. كما حققت معاملة الحرث لحماية التربة (Ch-R) وإضافة (.B.meg) أعلى انتاجية للمحصول بالنسبة للمعاملات المختلفة الآخرى.

قام بتحكيم البحث

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