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# EFFECT OF SOIL PUDDLING AND PREVIOUS CROP ON SOME SOIL PROPERTIES AND RICE PRODUCTIVITY IN CLAY SOILS

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## ABSTRACT

A field experiment was conducted at the experimental farm of the faculty of agriculture, Kafrelsheikh University, Kafr El-Sheikh, Egypt, in 2007 summer season. The experiment was conducted to study the effect of soil puddling (with puddling or without), previous crop (wheat or clover) and interaction between them on some soil properties and productivity of rice crop. Combined design with three replicates was used. It was found that, values of soil salinity under puddling soils were higher than that without puddling. Soil bulk density was significantly affected by puddling, previous crop and interaction between them in the two layers of soil except, puddling in surface layer (0-30 cm) was insignificant. Values of soil bulk density were higher under wheat-rice than those under clover-rice and it were higher under puddling soil than those without puddling. Infiltration rate was significantly affected by puddling and non significantly by previous crop. Infiltration rate values were higher under clover-rice than those under wheat-rice. Hydraulic conductivity of soil was insignificant affected by puddling and interaction between puddling and previous crop. It was significantly affected by previous crop. All parameters of aggregates were significantly affected by previous crop and its values were higher under clover-rice than those under wheat-rice. Values of rice yield without puddling were higher than those under puddling. The highest value of rice yield was found under clover-rice without puddling. Generally, it was recommended to cultivate rice after clover or wheat without puddling to increase the yield and save the cost of operation puddling.

**Keywords**: Clover- rice, hydraulic conductivity, rice yield, soil aggregates and wheat-rice

## INTRODUCTION

Rice is the most important cereal crop after wheat in Egypt. It occupies a pivotal position in the food security system of Egypt. Rice production can be increased through several factors, cultural practices viz land preparation and planting methods are inter-related factors which affect rice production and grain quality. Improved seedbed preparation is one of the promising recent advances in crop production into farmer's fields in order to increase rice yield, (RRTC, 2007). Elias (1969) showed that puddling operation now is one of the most tedious and expensive agricultural practices. Where puddling destroys soil aggregates from (1.7 to 0.36 mm) and thus changes other soil physical (bulk density, soil structure and soil strength). So, puddling process reduces root growth and distribution. Puddling does not benefit rice growth and yield on naturally dispersed soil, such as Vertisols and poorly drained. Sharma (1985) concluded that puddling does not significantly increase yield on clay soils. Also, Saffan (1975) reported that wet-leveling operation, increased soil bulk density in the upper

20 cm compared to without puddling and the grain yield of wet-leveling soil (puddling) was reduced by 8.12% as compared with control and reported that puddling soils gave poor distribution and penetration of rice roots than the untreated soil. Alva and Petersen (1979) reported that the better root development of rice in un-puddling soils than puddling soils. Ebada (1992) and Gorgy (1995) noticed that grain yields were higher in dry leveling than puddling or other treatments of land preparation. The objective of this study was to evaluate the puddling process on rice crop grown on heavy clay soil and its effects on soil properties and rice yield.

## MATERIALS AND METHODS

The current study was performed at the faculty of agriculture's farm, Kafr El-Sheikh University at summer season 2007. Kafr El-Sheikh is located at 31º 07¯ lat. and 30º 52¯ long. and it has elevation about 6 meters above sea level. Farm was irrigated with fresh water (EC < 0.5 $dSm^{-1}$) and had tile drainage. Combined design with three replicates was used. Four fields were chosen and prepared to cultivate rice crop, variety Giza 177, two of them were cultivated with wheat and others with clover as the preceding crop. In each location, chosen area was divided into two equals parts, one was puddled (wet leveling by wooden board drown by one horse) and other without puddling as well as automatic transplanting. All treatments were managed by the same practices at all season growth of rice. Soil samples were taken before experiment as described in Table (1) and after harvesting from (0-30) and (30-60cm) layers. Collected soil samples (disturbed) were air dried, gently ground, sieved through 2mm sieve and kept for analysis.

Total soluble salts and soil reaction (pH) were determined according to page *et al*., (1982). Soil bulk density was determined by soil cylinder according to Vomocil (1957). Particle size distribution was determined according to Gee and Bauder (1986). Aggregate stability parameters were determined by wet sieving technique according to Baver *et al.,* (1972).

**Table (1): Some chemical and physical properties of soil samples before experiment.**

| Variables | After wheat | | | After clover | | |
|---|---|---|---|---|---|---|
| | 0-30 | 30-60 | Mean | 0-30 | 30-60 | Mean |
| EC, $dSm^{-1}$ (1:5 soil water extract) | 0.412 | 0.593 | **0.503** | 0.532 | 0.659 | **0.596** |
| pH (1:2.5 soil water suspension) | 8.37 | 8.48 | **-** | 8.12 | 8.26 | **-** |
| bulk density $\rho_a$, $Mg/m^3$ | 1.127 | 1.260 | **1.194** | 1.107 | 1.142 | **1.125** |
| particle size distribution, % | | | | | | |
| Sand | 22.6 | 20.5 | **21.5** | 22.4 | 20.9 | **21.7** |
| Silt | 27.7 | 25.9 | **26.8** | 26.2 | 25.4 | **25.8** |
| Clay | 49.7 | 53.6 | **51.7** | 51.4 | 53.7 | **52.5** |
| Texture class | Clay | Clay | **Clay** | Clay | Clay | **Clay** |
| Mean weight diameter, mm | 0.541 | 0.416 | **0.479** | 0.753 | 0.582 | **0.668** |

At harvesting time, rice plants were collected from $1m^2$ and dried to calculate the yield and yield components for each treatment with 3 replicates. Obtained data were subjected to analysis of variance according to Gomez and Gomez (1984). Treatment means were compared by Duncan's Multiple Range Test (Duncan, 1955). All statistical analysis was performed using analysis of variance technique by means of "MSTATC" computer software package.

## RESULTS AND DISCUSSION

Soil salinity ($EC_e$) and soil pH as affected by soil puddling, previous crop and interaction between them are shown in Table 2.

Soil salinity ($EC_e$) was increased by soil depth increasing. $EC_e$ was affected significantly by puddling in surface layer (0-30 cm) of soil and insignificantly affected by previous crop of rice and interaction between puddling and previous crop. $EC_e$ in subsurface layer (30-60 cm) was significantly affected by previous crop and insignificantly by puddling and interaction between puddling and previous crop. Values of soil salinity under puddling soils were higher than that without puddling. Soil pH follows the same trend of soil salinity.

**Table (2): Effect of previous crop, puddling and the interaction between them on soil salinity and pH under rice crop.**

| 0-30 cm | | | | 30-60 cm | | | |
|---|---|---|---|---|---|---|---|
| Previous crop | Puddling | | Mean | Previous crop | Puddling | | Mean |
| | with | without | | | with | without | |
| EC, dS/m | | | | | | | |
| wheat | 0.482 a | 0.407 a | 0.444 A | wheat | 0.529 a | 0.509 a | 0.519 B |
| clover | 0.572 a | 0.467 a | 0.519 A | clover | 0.747 a | 0.474 a | 0.610 A |
| Mean | 0.527 A | 0.437 B | | Mean | 0.638 A | 0.492 A | |
| PH | | | | | | | |
| wheat | 7.55 b | 7.74 a | 7.75 A | wheat | 7.70 a | 7.82 a | 7.76 B |
| clover | 7.72 a | 7.74 a | 7.73 B | clover | 7.88 a | 7.90 a | 7.89 A |
| Mean | 7.64 B | 7.74 A | | Mean | 7.79 A | 7.86 A | |

**In each column and the row of Mean, means followed by a common letter are not significantly different at 5% level according to DMRT**

Soil bulk density ($\rho_a$), infiltration rate (IR) and saturated hydraulic conductivity ($K_s$) as affected by soil puddling, previous crop and interaction between them are shown in Table 3.

$\rho_a$ was significantly affected by puddling, previous crop and interaction between them in the two layers of soil except, puddling in surface layer(0-30 cm) was not significant. Values of $\rho_a$ were higher under wheat-rice than that under clover-rice and it was higher under puddling soil than that without puddling. Values of soil bulk density were not change after rice without puddling and changed under puddling compared with those before experiment. Values of $\rho_a$ were increased by increasing soil depth. Gorgy (2010) showed that increasing puddling intensity increased soil bulk density compared with dry leveling and flooding. Infiltration rate (IR) was significantly affected by puddling and insignificantly affected by previous crop. IR values were higher under clover-rice than that under wheat-rice. The increasing in IR values without puddling than that puddling may be due to destroying of soil structure and aggregates. Hydraulic conductivity of soil was insignificantly affect by puddling and interaction between puddling and previous crop. It was significantly affect by previous crop that due to the effect of root crop as appear in soil profile and puddling effect appear in surface layer of soil. $K_s$ values were higher under without puddling and clover than that under puddling and wheat, respectively.

**Table (3):Effect of previous crop, puddling and the interaction between them on soil bulk density, infiltration rate and hydraulic conductivity under rice crop.**

| $\rho_a$, $Mg/m^3$ | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0-30 cm | | | | 30-60 cm | | | |
| Previous crop | Puddling with | Puddling without | Mean | Previous crop | Puddling with | Puddling without | Mean |
| wheat | 1.286 a | 1.167 b | 1.227 A | wheat | 1.312 a | 1.258 b | 1.285 A |
| clover | 1.234 a | 1.112 b | 1.173 B | clover | 1.286 a | 1.183 b | 1.234 B |
| Mean | 1.260 A | 1.140 A | | Mean | 1.299 B | 1.221 A | |
| IR, cm/hr | | | | Ks, cm/day | | | |
| wheat | 2.0 a | 2.4 a | 2.2 A | wheat | 12.7 a | 13.9 a | 13.3 B |
| clover | 2.2 a | 2.8 a | 2.5 A | clover | 14.0 a | 15.0 a | 14.5 A |
| Mean | 2.1 B | 2.6 A | | Mean | 13.4 A | 14.5 A | |

**In each column and the row of Mean, means followed by a common letter are not significantly different at 5% level according to DMRT**

Data in Table (4) show the effect of puddling, previous crop and interaction between them on aggregation parameters such as total of water stable aggregates > 0.25 mm, optimum size of aggregates and mean weight diameter. All parameters of aggregates were significantly affected by previous crop and its values were higher under clover-rice than that under wheat-rice that is becuae organic residues were higher under clover than wheat and the role of it in aggregation formation. All values of aggregation parameters decreased as soil depth increasing and were lower under puddling than that without puddling.

**Table (4):Effect of previous crop, puddling and the interaction between them on some soil aggregation parameters under rice crop.**

| 0-30 cm | | | | 30-60 cm | | | |
|---|---|---|---|---|---|---|---|
| Previous crop | Puddling with | Puddling without | Mean | Previous crop | Puddling with | Puddling without | Mean |
| Total WSA > 0.25 mm,% | | | | | | | |
| wheat | 57.09 a | 53.81 a | 55.45 B | wheat | 50.88 a | 49.71 a | 50.30 B |
| clover | 60.31 a | 64.89 a | 62.60 A | clover | 53.96 a | 55.72 a | 54.84 A |
| Mean | 58.70 A | 59.35 A | | Mean | 52.42 A | 52.71 A | |
| Optimum size of aggregates, % | | | | | | | |
| wheat | 44.59 a | 47.42 a | 46.01 B | wheat | 33.61 a | 40.10 a | 36.85 B |
| clover | 49.89 a | 54.44 a | 52.17 A | clover | 42.31 a | 45.96 a | 44.14 A |
| Mean | 47.24 B | 50.93 A | | Mean | 37.96 A | 43.03 A | |
| Mean weight diameter, mm | | | | | | | |
| wheat | 0.53 b | 0.48 b | 0.51 B | wheat | 0.35 a | 0.42 a | 0.39 B |
| clover | 0.63 a | 0.72 a | 0.68 A | clover | 0.47 a | 0.53 a | 0.50 A |
| Mean | 0.58 A | 0.60 A | | Mean | 0.42 A | 0.47 A | |

**In each column and the row of Mean, means followed by a common letter are not significantly different at 5% level according to DMRT**

Soil physical changes from puddling is likely related to the site specific nature of soil puddling. The physical manipulation of saturated soil (i.e. puddling) disperses surface aggregates and compresses the subsoil. A portion of the clay fraction from the surface horizon is deposited as clay-skins along pore surfaces at the top fringe of the compacted layer (Grant, 1964; Hobbs et al., 1994). These processes reduce macro pore volume in the upper portion of the soil profile while increasing bulk density in the compacted, anthropogenic horizon that is alternately termed the plough sole or tillage pan (Adachi, 1990 and Aggarwal *et al*., 1995). Puddling typically lowers soil hydraulic conductivity and diminishes the water required to maintain flooding (DeDatta and Kerim, 1974 and Naklang *et al.*, 1996). Behera *et al.*, (2007) stated that bulk density of puddled soil was higher than unpuddled soil. They showed that after dispersion of soil particles by puddling, flocculation takes place and there is a stratified settlement of soil particles leading to destruction of macro pores, which creates a dense soil. Bulk density, soil moisture content and water percolation rate decreased faster in the puddled soil under field and laboratory conditions, (Mousavi *et al*., 2009).

Data in Table (5) show the effect of puddling, previous crop and the interaction between them on plant height, number of grain at pinnacle, 1000 grain weight and rice yield. All parameters in Table (5) were insignificantly affected by puddling, previous crop and the interaction between them. Values of rice yield without puddling were higher than that under puddling. The highest value of rice yield was found under clover-rice without puddling. These results were in agreements with those obtain by Gorgy (2010). Lal (1983) reported that for soils with relatively high clay content, there is no obvious advantage in rice yield by puddling over no-till method of seedbed preparation. But in medium textured soils, puddling increases grain yield over no-till method (Mambani *et al.*, 1989).

**Table (5): Effect of Previous crop, puddling and the interaction between them on yield and yield components of rice crop.**

| Previous crop | Puddling | | Mean | Previous crop | Puddling | | Mean |
|---|---|---|---|---|---|---|---|
| | with | without | | | with | without | |
| **Plant height, cm** | | | | **No. of grain at pinnacle** | | | |
| wheat | 68.4 a | 73.0 a | 70.7 A | wheat | 87.1 a | 90.7 a | 88.9 A |
| clover | 67.5 a | 76.6 a | 72.1 A | clover | 94.1 a | 96.6 a | 95.3 A |
| Mean | 68.0 A | 74.8 A | | Mean | 90.6 A | 93.7 A | |
| **1000 grain weight, gm** | | | | **Yield, Mg/ha.** | | | |
| wheat | 21.34 a | 21.32 a | 21.33 A | wheat | 4.793 a | 4.850 a | 4.821 A |
| clover | 21.30 a | 21.29 a | 21.29 A | clover | 4.905 a | 4.929 a | 4.917 A |
| Mean | 21.32 A | 21.30 A | | Mean | 4.850 A | 4.888 A | |

**In each column and the row of Mean, means followed by a common letter are not significantly different at 5% level according to DMRT.**

Generally, it is recommended to cultivate rice after clover or wheat without puddling, this will lead to increase the yield and save some cost of operation puddling which cost about 250 L.E /ha.

## REFERENCES

Adachi K. (1990): Effects of rice–soil puddling on water percolation. In: Proceeding of the Transactions of the 14th International Congress of Soil Science, Kyoto, Japan, pp. 146–151.

Aggarwal G.C., Sidhu A.S., Sekhon N.K., Sandhu K.S., Sur H.S. (1995): Puddling and N management effects on crop response in a rice–wheat cropping system. Soil Till Res. 36 (3/4), 129–139.

Alva A.K. and Ptersen L. (1979): Soil Physical properties in relation to rice yield and water consumption under flood and unflood condition. Plant and Soil, 52: 353-363.

Baver L.D., Gardner W.H. and Gardner W.R. (1972): Soil Physics. John Wiley & Sons. Inc. New York, $4^{th}$ edition.

Behera B.K., Varshney B.P., Swain S. (2007): Effect of puddling on physical properties of soil and rice yield. Agric Mech Asia Afr Lat Am 38(1):23–28.

DeDatta, S.K., Kerim M.A. (1974): Water and nitrogen economy of rainfed rice as affected by puddling. Soil Sci. Soc. Am. Proc. 38, 515–518.

Duncan B.D. (1955): Multiple range and multiple F. Tests. Biometrics, 11: 1-42.

Ebada R.H. (1992): Study of some physical properties in some soils of middle Delta. M. Sc. Thesis, Faculty of Agric. Tanta University.

Elias R.S. (1969): Rice production and minimum tillage. Out look on Agriculture, 6(2): 67-70.

Gee G.W. and Bauder J.W. (1986): Particle size analysis, in methods of soil analysis. C. f. Klute, A. (ed.) Part I. Agron. 9, 15: 383-409, Amer. Soc. Agron. Madison, Wisconsin, USA.

Gomez K.A. and Gomez A.A. (1984): Statistical Procedures for Agricultural Research 2nd Ed. John Wiley and Sons, New York.

Gorgy R.N. (1995): Effect of some agricultural treatments on rice yield and quality. Ph. D. Thesis, Fac. Agric., Kafr El-Sheikh, Tanta Univ., Egypt.

Gorgy R.N. (2010): Effect of different land preparation treatments and planting methods on growth, yield and yield components of three cultivars. J. Agric. Res. Kafer El-Sheikh Univ., 36(3): 259-277

Grant C.J. (1964): Soil characteristics associated with the wet cultivation of rice. In: The Mineral Nutrition of the Rice Plant, Johns Hopkins Press, Baltimore, pp. 15–28.

Hobbs P.R., Woodhead T., Meisner C. (1994): Soil physical factors limiting the productivity of the rice–wheat rotation and ways to reduce their impact through management. In: Proceedings of the International Conferences on Wheat in Heat-stressed Environments: Irrigated, Dry Areas and Rice–Wheat Farming Systems, Wad Medani, Sudan, February 1–4, 1993, and Dinajpur, Bangladesh, February 13–15, 1993, CIMMYT – International Maize and Wheat Improvement Center, pp. 276–289.

Lal R. (1983): No-till farming: soil and water conservation and management in the humid and subhumid tropics. Monograph No. 2, Ibadan, p 64.

Mambani B., DeDatta S.K., Redula A.C. (1989): Soil physical behaviour and crop responses to tillage in lowland rice soil of varying clay content. Plant Soil 126(2):227–235.

Mousavi S.F., Yousefi-Moghadam S., Mostafazadeh-Fard B., Hemmat A. and Yazdani M.R. (2009): Effect of puddling intensity on physical properties of a silty clay soil under laboratory and field conditions. Paddy water Environ (2009) 7:45–54.

Naklang K., Fukai S., Nathabut K. (1996): Growth of rice cultivars by direct seeding and transplanting under upland and lowland conditions. Field Crop Res. 48 (2/3), 115–123.

RRTC (2007): Rice Research and Training Center, Annual Report. Sakha, Kafr El-Sheikh, Egypt.

Saffan M.M. (1975): Effect of wet-levelling on some physical properties and root system development of rice in clay soils. M. Sc. Thesis, Faculty of Agric. Tanta University.

Sharma P.K. (1985): Physical edaphology research in low land rice-based cropping system. IRRI Saturday Seminar, June 22, 1985.

Page A.L., Miller R.H. and Keeney D.R. (1982): “Methods of Soil Analysis”. Part 2: Chemical and Microbiological Properties. 2nd edition. Amer. Soc. of Agron, Inc. Soil Sci. Soc. of Amer., Inc. Madison, Wisconsin, USA.

Vomocil J.A. (1957): Measurements of soil bulk density and penetrability. A Review of Methods Adv. Agron. 9: 159-176.

## أثر التلويط والمحصول السابق على بعض خواص التربة وإنتاجية الأرز فى الأراضى الطينية

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أجريت تجربة حقلية في مزرعة كلية الزراعة، جامعة كفر الشيخ في موسم صيف 2007. وذلك لدراسة تأثير التلويط والمحصول السابق (قمح -أرز أو برسيم- أرز) والتفاعل بينهما على بعض خواص التربة وإنتاجية محصول الأرز وقد تم استخدام التصميم الإحصائي Combined design مع ثلاث مكررات لإجراء الدراسة.

**وكانت أهم النتائج المتحصل عليها ما يلى:**

- كانت ملوحة التربة تحت التلويط أعلي منها بدون تلويط. وتأثرت كثافة التربة الظاهرية معنويا بكل من التلويط والمحصول السابق والتفاعل بينهما في طبقتي التربة 0-30سم، 30-60سم ما عدا التلويط في الطبقة السطحية لم يكن له تأثيرا معنويا علي كثافة التربة الظاهرية. وكانت قيم الكثافة الظاهرية للتربة تحت النظام المحصولي (قمح-أرز) أعلي منها في حالة (برسيم-أرز) وكانت قيمها اعلي تحت التلويط عنها بدون تلويط.
- تأثر معدل التشرب معنويا بعملية التلويط بينما لم يكن للمحصول السابق تأثيرا معنويا عليه. وكانت قيم معدل التشرب تحت النظام المحصولي (برسيم-أرز) أعلي منها تحت نظام (قمح-أرز).
- لم تتأثر قيم معامل التوصيل الهيدروليكي المشبع للتربة معنويا بكل من التلويط والتفاعل بين المحصول السابق والتلويط ولكنها تأثرت معنويا بالمحصول السابق. بينما تأثرت جميع أدلة التحبب المدروسة معنويا بالمحصول السابق وكانت قيمها تحت نظام (برسيم-أرز) أعلي منها

تحت نظام (قمح-أرز).

- كانت إنتاجية الأرز في التربة بدون تلويط اعلي منها تحت التلويط وكانت أعلي القيم المتحصل عليها في الأراضي المنزرعة بالنظام المحصولي (برسيم-أرز) وبدون إجراء عملية التلويط للتربة.

بصفة عامة يمكن أن نوصي بزراعة الأرز بعد محصول البرسيم أو القمح ولكن بدون إجراء عملية التلويط لان ذلك يؤدي إلي زيادة الإنتاجية وتوفير تكلفة إجراء عملية التلويط للتربة والتي لم يكن لها أي تأثير أو فروق معنوية علي الإنتاجية وخواص التربة بجانب ما لها من آثار سيئة علي خواص التربة.

**قام بتحكيم البحث**

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