

## IRRIGATION WATER DEPTHS AND NITROGEN FERTILIZER LEVELS FOR RICE PRODUCTION UNDER TWO WATER TABLE LEVELS

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### ABSTRACT

Field experiment was conducted at El-Serw Agricultural Research Station (North of Delta, Egypt) during the 2004 and 2005 summer season. The study is concerned with the effect of water table levels (40 to 50 cm and 70 to 80 cm), irrigation water depths (4.5, 9 and 12 cm) and nitrogen fertilizer levels 30, 60 and 90 kg N fed.<sup>-1</sup>) on rice yield, yield components, amount of applied water, actual evapotranspiration (ET<sub>a</sub>), seepage, percolation losses, and water use efficiency. The early maturing rice cultivar Giza 178 was used in this experiment. A split-split-plot design with four replicates was used. The results indicated that the highest value of water use efficiency (WUE) is 0.76 kg grain/ m<sup>3</sup> for deep water table (70-80 cm), irrigation water depth 9 cm with nitrogen fertilizer 60 kg fed.<sup>-1</sup>.

### INTRODUCTION

Rice is the main cereal summer crop. It is a semi-aquatic plant and needs large quantity of water compared to the other field crops. It needs careful water and nitrogen fertilization management in order to obtain the high efficiency use of water and nitrogen. Percolation losses are a function of the local soil and topographic conditions. Irrigation water entering a soil becomes greater than its water-holding capacity, loss by the downward movement of free water will occur. Seepage normally flows onto the soil surface or into streams, rivers, or drainage waterways, while percolation flow usually moves to the water table, because it occurs simultaneously and are difficult to separate in the field, seepage and percolation are usually considered together, De Datta (1981).

Awad *et al.* (1995) concluded that the irrigation depth of 9 cm with the nitrogen fertilizer level of 60 kg N fed.<sup>-1</sup> could be recommended to obtain the best results from rice crop grown under El-Serw area conditions.

Anbumozhi *et al.* (1998) indicated that high values of water productivity were found at 9 cm ponding water depth under different water regimes and fertilization levels. Zeng *et al.* (2003) found that plants performed better with respect to seeding establishment and grain yield in shallow water (i.e. <10cm) than in deep water (i.e.>10cm). Under salt stress, the effect of water depth was significant for panicle number but not significant for panicle weight. El-Kholy *et al.* (1999) indicated that the application of nitrogen fertilization at the rate of 60 kg N fed.<sup>-1</sup> produced the highest yield. De Datta (1981) concluded that a percolation rate of 10-15 mm / day was favorable for supply of dissolved oxygen. The removal of harmful substances, and the maintenance of root activity. In fact, with some situations, the loss of plant nutrients may be serious if the percolation rate is high.

The object of this work is studying the effect of irrigation water depth, nitrogen levels and water table levels on Rice yield, yield components, amount of applied irrigation water and water use efficiency under the North of Delta conditions.

## MATERIALS AND METHODS

Field experiment was conducted at EL-Serw Agricultural Research Station Farm (North of Delta, Egypt) during the 2004 and 2005 summer seasons. Soil texture of the experimental site is classified as clayey soil and mainly characterized by pH= 8.05, CaCO<sub>3</sub> content 2.5%, organic matter content= 0.87% exchangeable sodium percentage (E.S.P.) = 8.3 and the average electrical conductivity value of soil extract (E.C.) = 4.6 dSm<sup>-1</sup>. Rice, variety Giza 178, was planted in this experiment. Dates of the main cultural practices during the two growing seasons are presented in Table 1. Nitrogen fertilizer in the form of urea (46%N) was applied in two equal doses the first was applied 14 days after transplanting and the second was added at panicle initiation. A split-split plot experimental design with four replications was used to conduct this experiment. The main plots were assigned for two water table levels. The sub plots were assigned for irrigation water depth treatments, while the sub-sub plots were assigned for the nitrogen level treatments.

**Table 1: Date of the main cultural practices for rice during the 2004 and 2005 growing seasons.**

| Cultural practice    | Season 2004                | Season 2005                |
|----------------------|----------------------------|----------------------------|
| Sowing               | May 3 <sup>rd</sup>        | May 1 <sup>st</sup>        |
| Transplanting        | June 13 <sup>th</sup>      | June 11 <sup>th</sup>      |
| N-application        |                            |                            |
| 1 <sup>st</sup> dose | June 27 <sup>th</sup>      | June 25 <sup>th</sup>      |
| 2 <sup>nd</sup> dose | July 17 <sup>th</sup>      | July 15 <sup>th</sup>      |
| Harvesting           | September 17 <sup>th</sup> | September 15 <sup>th</sup> |

The experimental area was 42 m<sup>2</sup> the tested variables were;

### Water table levels:

1. Shallow water table (S) (average 40 to 50 cm)
2. Deep water table (D) (average 70 to 80 cm)

These values were measured before growing seasons.

### Irrigation water depth:

- 1<sub>1</sub>: Ponding water depth 4.5 cm. all season.
- 1<sub>2</sub>: Ponding water depth 9 cm. all season.
- 1<sub>3</sub>: Ponding water depth 12 cm. all season.

### Nitrogen fertilizer levels:

- N<sub>1</sub>: Applying 30 kg Nfed.<sup>-1</sup>.
- N<sub>2</sub>: Applying 60 kg Nfed.<sup>-1</sup>.
- N<sub>3</sub>: Applying 90 kg Nfed.<sup>-1</sup>.

**Plant growth and yield determination:**

Just before harvest, ten guarded plants were selected from each plot to determine plant height, panicle length and 1000-grain weight. Number of panicles per square meter was also determined. At harvest time one square meter from each plot was harvested by hand for grain and straw yields determination.

**Water parameters:**

**Applied water:**

The amount of applied irrigation water delivered to each experimental plot was measured by using the cut-throat flume. The dimensions of the used flume were 20 x 90 cm.

**Seepage, percolation measurements and actual evapotranspiration (ET<sub>a</sub>):**

The seepage and percolation measurements were calculated from data obtained from sets of tanks installed in one plots of each irrigation water depth treatments and two water table levels. Each set consists of two tanks. The first an open tanks at the top and the bottom (95 cm in diameter and 100 cm long) which was used to determined the total amount of applied irrigation water needed to replenish losses through evapotranspiration, seepage and percolation. The second is a closed tank at the bottom only to determine the actual evapotranspiration (ET<sub>a</sub>) values. Rice plants were transplanted into the tanks and were treated similar to the plants grown in the open field.

**3- Water Utilization Efficiency (WUE).**

Water utilization efficiency values for the two growing seasons were calculated according to the following equation:

$$WUE = \frac{\text{Rice grain yield (kg)}}{\text{Amount of applied water (m}^3\text{)}}$$

**Statistical analysis:**

Data collected from each plot were analyzed using the Co-Hort Software (1986) statistical package. Average grain and straw yields from the four replicates of each treatment were interpreted using the analysis of variance (ANOVA). The Student – Newman – Keuls Test (SNK) was used for comparisons between the different sources of variation.

## **RESULTS AND DISCUSSION**

**Rice grain yield:**

The effects of water table, irrigation water depth and nitrogen fertilizer levels on rice grain yield (kg fed.<sup>-1</sup>) for the two growing seasons are shown in Table 2. Results indicate that, the grain yield obtained from deep water table, irrigation water depth I<sub>2</sub> (9 cm) and nitrogen fertilizer level N<sub>2</sub> (60 kg N fed.<sup>-1</sup>) was higher than the other treatments. These results are in agreement with those reported by Awad *et al.* (1995), Anbumozhi *et al.*

(1998), Zeng et al. (2003) and El-Kholy et al. (1999). The interaction between nitrogen levels, irrigation depths and water table levels is presented in Table 2. There were a significant effects in some cases W. D. and W.T.

Table 2: Effect of water table levels, irrigation water depth and nitrogen fertilizer levels on rice grain and straw yield (kg fed<sup>-1</sup>)

| Treatment                          | Grain yield (kg fed <sup>-1</sup> ) |        | Straw yield (kg fed <sup>-1</sup> ) |        |
|------------------------------------|-------------------------------------|--------|-------------------------------------|--------|
|                                    | 2004                                | 2005   | 2004                                | 2005   |
| <b>Nitrogen fertilizer levels.</b> |                                     |        |                                     |        |
| N <sub>1</sub>                     | 2831 c                              | 2677 c | 3275 c                              | 3241 c |
| N <sub>2</sub>                     | 3290 a                              | 3143 a | 3732 b                              | 3520 b |
| N <sub>3</sub>                     | 3033 b                              | 2841 b | 3876 a                              | 3811 a |
| L.S.D. 0.05                        | 88.28                               | 162.89 | 8.26                                | 11.83  |
| <b>Irrigation water depth.</b>     |                                     |        |                                     |        |
| I <sub>1</sub>                     | 2979 b                              | 2815 b | 3544 c                              | 3396 c |
| I <sub>2</sub>                     | 3277 a                              | 3065 a | 3736 a                              | 3691 a |
| I <sub>3</sub>                     | 2899 b                              | 2780 b | 3603 b                              | 3486 b |
| L.S.D. 0.05                        | 97.04                               | 135.57 | 9.81                                | 12.66  |
| <b>Water table levels.</b>         |                                     |        |                                     |        |
| Shallow                            | 2725 b                              | 2541 b | 3587 b                              | 3474 b |
| Deep                               | 3378 a                              | 3232 a | 3669 a                              | 3574 a |
| L.S.D. 0.05                        | 274.33                              | 212.73 | 11.15                               | 10.34  |
| <b>Interactions</b>                |                                     |        |                                     |        |
| N. f.                              | ***                                 | ***    | ***                                 | ***    |
| W. d                               | ***                                 | **     | ***                                 | ***    |
| W. t.                              | **                                  | **     | ***                                 | **     |
| N. f. x W. d.                      | N.S                                 | N.S    | ***                                 | ***    |
| N. f. x W. t.                      | *                                   | N.S    | ***                                 | ***    |
| W. d. x W. t.                      | ***                                 | **     | **                                  | ***    |
| N. f. x W. d. x W. t.              | *                                   | N.S    | ***                                 | ***    |

**Rice straw yield:**

The effect of tested variables on rice straw yield for the two growing seasons is presented in Table 2. Results reveal that there was a significant effect of the N- fertilizer levels, irrigation water depth and water table levels. Results showed that, there was a significant increase in the straw yield with increase in N- fertilizer level from N<sub>1</sub> to N<sub>3</sub> (30 to 90 kg N fed.<sup>-1</sup>).but the highest straw yield obtained from I<sub>2</sub> ponding water depth 9 cm and deep water table are 70 to 80 cm. These results are in agreement with those reported by Anbumozhi et al. (1998) and Zeng et al. (2003).

**Yield components:**

The effect of water table, irrigation water depth and nitrogen fertilizer levels on the yield components are presented in Table 3. Shows that plant height (cm) increased significantly with increased N- fertilizer, water depth and water table level. Also the highest values for the panicle length (cm), average number of panicles/ m<sup>2</sup> and 1000 grain weight values were at N<sub>2</sub>. There was no a significant difference between ingestion water depths for average number of panicle /m<sup>2</sup> and 1000 grains weight (g).Also the Highest values for these parameters were obtained from deep water table level. The obtained results agree with the result of El-Kholy et al. (1999) and De Datta (1981).

**Applied water:**

The amount of applied water to each plot is presented in Table 4. The table result shows that, applied water was increased by the increasing irrigation depth. Irrigation water was increased by increasing the nitrogen fertilizer from N<sub>1</sub> to N<sub>3</sub>. Also irrigation water was increased by increasing water table levels from average 50 to average 80 cm under soil surface, this is depth increasing in the percolation losses. These results are in agreement with those obtained with De Datta (1981), Awad *et al.* (1995) and Zeng *et al.* (2003).

**Actual evapotranspiration (ETa) and average seepage and percolation measurements:**

An average values of actual evapotranspiration (ETa) and average seepage and percolation losses (cm) for treatments for two growing seasons. Results indicate that (ETa) values for N<sub>1</sub>, N<sub>2</sub> and N<sub>3</sub> treatments were 77.5, 79.2 and 83.5 cm respectively for I<sub>1</sub>, I<sub>2</sub> and I<sub>3</sub> treatments. Also results indicated that the average seepage and percolation losses for water table levels for two growing seasons were 14.1, 20.4 and 26.9 cm for 50 cm water table and 19.8, 37.2 and 54.6 cm for 80 cm water table for 4.5, 9 and 12 cm ponding water depth respectively.

**Table 3: Effect of water table levels, irrigation water depth and nitrogen fertilizer levels on yield components.**

| Treatments.                        | Plant height (cm) |        | Panicle length (cm) |        | Average Number of panicles/ m <sup>2</sup> |         | 1000 grain weight (g) |        |
|------------------------------------|-------------------|--------|---------------------|--------|--|---------|-----------------------|--------|
|                                    | 2004              | 2005   | 2004                | 2005   | 2004                                       | 2005    | 2004                  | 2005   |
| <b>Nitrogen fertilizer levels.</b> |                   |        |                     |        |  |         |                       |        |
| N <sub>1</sub>                     | 69.3 c            | 68.1 c | 17.7 c              | 17.0 b | 432.3 b                                    | 429.3 b | 19.8 c                | 19.3 c |
| N <sub>2</sub>                     | 74.9 b            | 73.3 b | 20.5 a              | 19.8 a | 592.8 a                                    | 627.5 a | 22.2 a                | 22.0 a |
| N <sub>3</sub>                     | 81.3 a            | 77.9 a | 19.7 b              | 19.5 a | 596.2 a                                    | 610.6 a | 20.5 b                | 20.0 b |
| L.S.D. 0.05                        | 0.87              | 1.1    | 0.31                | 0.45   | 29.7                                       | 41.37   | 0.17                  | 0.11   |
| <b>Irrigation depth.</b>           |                   |        |                     |        |  |         |                       |        |
| I <sub>1</sub>                     | 74.26 b           | 70.8 c | 19.2 b              | 19.2 a | 521.6 b                                    | 543.0 a | 20.7 b                | 20.5 a |
| I <sub>2</sub>                     | 75.8 a            | 73.1 b | 20.1 a              | 19.3 a | 570.0 a                                    | 576.4 a | 21.0 a                | 20.5 a |
| I <sub>3</sub>                     | 75.5 a            | 75.3 a | 19.0 b              | 17.8 b | 529.7 b                                    | 547.9 a | 20.8 a                | 20.4 a |
| L.S.D. 0.05                        | 0.77              | 1.41   | 0.32                | 0.62   | 29.21                                      | 41.37   | 0.17                  | 0.11   |
| <b>Water table levels.</b>         |                   |        |                     |        |  |         |                       |        |
| Shallow                            | 74.3 b            | 72.4 b | 19.0 b              | 16.7 a | 521.6 b                                    | 535.8 b | 20.6 b                | 20.3 b |
| Deep                               | 76.0 a            | 73.8 a | 19.7 a              | 18.7 a | 559.3 a                                    | 575.7 a | 21.1 a                | 20.6 a |
| L.S.D. 0.05                        | 0.94              | 0.42   | 0.65                | 0.46   | 23.85                                      | 33.7    | 0.15                  | 0.11   |
| <b>Interactions</b>                |                   |        |                     |        |  |         |                       |        |
| N. f.                              | ***               | ***    | ***                 | ***    | ***  | ***     | ***                   | ***    |
| W. d                               | **                | ***    | ***                 | ***    | *  | N.S     | *                     | N.S    |
| W. t.                              | .                 | **     | .                   | N.S    | N.S  | N.S     | **                    | **     |
| N. f. x W. d.                      | .                 | **     | N.S                 | *      | ***  | ***     | ***                   | ***    |
| N. f. x W. t.                      | ***               | ***    | N.S                 | **     | N.S  | N.S     | ***                   | ***    |
| W. d. x W. t.                      | ***               | **     | *                   | N.S    | N.S  | N.S     | *                     | ***    |
| N. f. x W. d. x W. t.              | ***               | .      | ***                 | ***    | ***  | N.S     | ***                   | ***    |

**Table 4: The amount of applied irrigation water (m<sup>3</sup> fed.<sup>-1</sup>) as the effect of water table levels, irrigation water depth and nitrogen fertilizer levels.**

| Treatment   |                     | I <sub>1</sub> | I <sub>2</sub> | I <sub>3</sub> | Ave. |      |
|-------------|---------------------|----------------|----------------|----------------|------|------|
| Season 2004 | Shallow water table | N <sub>1</sub> | 3864           | 4116           | 4410 | 4130 |
|             |                     | N <sub>2</sub> | 3927           | 4221           | 4464 | 4204 |
|             |                     | N <sub>3</sub> | 4158           | 4368           | 4662 | 4396 |
|             |                     | Ave.           | 3983           | 4235           | 4512 |      |
|             | Deep water table    | N <sub>1</sub> | 4074           | 4830           | 5566 | 4830 |
|             |                     | N <sub>2</sub> | 4242           | 4914           | 5628 | 4928 |
|             |                     | N <sub>3</sub> | 4368           | 5082           | 5817 | 5089 |
|             |                     | Ave.           | 4228           | 4942           | 5677 |      |
| Season 2005 | Shallow water table | N <sub>1</sub> | 3822           | 4095           | 4368 | 4095 |
|             |                     | N <sub>2</sub> | 3893           | 4166           | 4439 | 4166 |
|             |                     | N <sub>3</sub> | 4074           | 4347           | 4620 | 4347 |
|             |                     | Ave.           | 3929           | 4202           | 4475 |      |
|             | Deep water table    | N <sub>1</sub> | 4053           | 4809           | 5544 | 4802 |
|             |                     | N <sub>2</sub> | 4116           | 4880           | 5615 | 4870 |
|             |                     | N <sub>3</sub> | 4305           | 5061           | 5796 | 5054 |
|             |                     | Ave.           | 4158           | 4916           | 5651 |      |

Those values were measure after transplanting and up to harvesting process.

**Water Use Efficiency:**

Data in table 5: Show that the highest value of water use efficiency for treatments is 0.76 kg grain/ m<sup>3</sup> for deep water table, irrigation water depth 9 cm and nitrogen fertilizer 60 kg N fed.<sup>-1</sup> It could be concluded that ponding water depth 9 cm, nitrogen fertilizer 60 kg N fed.<sup>-1</sup> and 70 to 80 cm water table proved to be the best practices for rice production under North of Delta conditions.

**Table 5: Average water use efficiency (WUE) values as affected by water table levels, irrigation water depth and nitrogen fertilizer levels.**

| Treatment   |                     | I <sub>1</sub> | I <sub>2</sub> | I <sub>3</sub> | Ave. |      |
|-------------|---------------------|----------------|----------------|----------------|------|------|
| Season 2004 | Shallow water table | N <sub>1</sub> | 0.55           | 0.72           | 0.56 | 0.61 |
|             |                     | N <sub>2</sub> | 0.65           | 0.73           | 0.63 | 0.67 |
|             |                     | N <sub>3</sub> | 0.59           | 0.70           | 0.54 | 0.61 |
|             |                     | Ave.           | 0.59           | 0.71           | 0.57 |      |
|             | Deep water table    | N <sub>1</sub> | 0.66           | 0.68           | 0.59 | 0.64 |
|             |                     | N <sub>2</sub> | 0.72           | 0.67           | 0.57 | 0.68 |
|             |                     | N <sub>3</sub> | 0.66           | 0.64           | 0.56 | 0.62 |
|             |                     | Ave.           | 0.68           | 0.69           | 0.56 |      |
| Season 2005 | Shallow water table | N <sub>1</sub> | 0.52           | 0.69           | 0.51 | 0.57 |
|             |                     | N <sub>2</sub> | 0.64           | 0.72           | 0.59 | 0.65 |
|             |                     | N <sub>3</sub> | 0.57           | 0.68           | 0.51 | 0.58 |
|             |                     | Ave.           | 0.57           | 0.69           | 0.53 |      |
|             | Deep water table    | N <sub>1</sub> | 0.65           | 0.67           | 0.50 | 0.60 |
|             |                     | N <sub>2</sub> | 0.70           | 0.76           | 0.56 | 0.67 |
|             |                     | N <sub>3</sub> | 0.64           | 0.65           | 0.57 | 0.62 |
|             |                     | Ave.           | 0.66           | 0.69           | 0.54 |      |

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### أعماق ماء الري ومستويات التسميد النيتروجيني لإنتاج الأرز تحت مستويين مختلفين من الماء الأرضي

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بالسرو

أقيمت تجربتين حقليتين في مزرعة محطة البحوث الزراعية بالسرو شمال الدلتا بمصر خلال صيف ٢٠٠٤ و ٢٠٠٥ وذلك لدراسة تأثير مستويين للماء الأرضي من ٤٠ إلى ٥٠ سم ومن ٧٠ إلى ٨٠ سم وثلاث أعماق من ماء الري ٤,٥، ٩، ١٢ سم وثلاثة مستويات من التسميد النيتروجيني ٣٠، ٦٠، ٩٠ كيلو جرام نيتروجين للفدان علي محصول الأرز ومكوناته وكمية الماء المضاف للري والاستهلاك المائي والتسبييل والرشح والكفاءة الإستعمالية للماء ولقد استخدم الصنف جيزة ١٧٨ واستخدمت تصميم القطع المنشقة مرتين للتجربة وأربع مكررات وكانت النتائج المتحصل عليها كالتالي:

كانت أعلى كفاءة لاستعمال الماء هي ٠,٧٦ كيلو جرام أرز لكل متر مكعب ماء ري وذلك للمعاملة ذات الماء الأرضي العميق من ٧٠ إلى ٨٠ سم عمق ماء ري ٩ سم وتسميد ٦٠ كيلو جرام للفدان.