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# EFFECT OF APPLICATION OF RICE STRAW COMPOST AND NPK FERTILIZERS UNDER SOME IRRIGATION REGIMES ON GRAIN YIELD AND WATER PRODUCTIVITY OF EHR1 HYBRID RICE CULTIVAR

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## ABSTRACT

Two field experiments were carried out at the Experimental Farm of Rice Research and Training Center (RRTC), Sakha-Kafr El-Sheikh, Egypt, during 2010 and 2011 summer seasons. The objective of this research was to investigate the effects of NPK fertilizers with rice straw compost on growth and grain yield, as well as water productivity (WP) and nitrogen use efficiency of Egyptian hybrid rice cultivar (EHR1) under different irrigation regimes. A split plot design, with four replicates, was used in all experiments. The main plots were devoted to three irrigation regimes; namely, continuous flooding (CF) and irrigation to 5 – 6 cm depth three (3-) and six (6-) days after disappearance of surface water (DADSW). The sub-plots were occupied by six fertilizer treatments; namely, zero fertilizer (T1), 100% of recommended NPK fertilizer (T2), application of two t/h rice straw compost + 25% NPK (T3), 50% NPK (T4), 75% NPK (T5) and 100% NPK (T6).

The main results indicated that CF and 3-DADSW treatments registered significant and higher values of growth attributes, grain yield and most of its attributes, as well as protein content and N-uptake, compared with 6-DADSW treatment, except for number of days to 50% heading and unfilled grain (%).

Dry matter, LAI, plant height and grain yield and most of its attributes, as well as protein content and N-uptake, were significantly enhanced by the application of 100% NPK, along with rice straw compost at two t/ha (T6), which was at per with T2 (100% NPK) and T5 (75 % NPK + 2 t/h rice straw compost). Under all irrigation regimes, application of NPK fertilizer, either alone or with rice straw compost, recorded higher grain yield and WP than the control treatment.

CF consumed the highest amount of irrigation water, while, application of 3- and 6-DADSW tended to decrease the amount of water used. Furthermore, 3-DADSW recorded the highest WP (0.84 and 0.86 kg/m$^3$) and the minimum grain yield reduction (4.59 and 6.41 %) with water saved about 11.55 and 11.12 % compared to CF in both seasons, respectively.

Generally, under the same experimental conditions, it was concluded to use 3-DADSW irrigation with adding 75% NPK, along with rice straw compost at two t/ha for reasonable grain yield and high WP, as well as it could decrease chemical fertilizer input by 25 % from the present recommended application without decreasing rice grain yield.

**Keywords:** Hybrid rice, irrigation regimes, NPK fertilizers, compost and water productivity.

## INTRODUCTION

The availability of water for agriculture, in particular for rice production, is threatened in many regions of the world, not only by limitations to water resources, but, also, by increases in urban and industrial demand (Wopereis *et al.,* 1994). Growing rice with less water, while, maintaining its high grain yields, is one of the major objectives in rice research to date. Rice, following wheat, is the major staple food for the large and growing population of the Egyptians, and the major using of water, with approximately 25.15 % of water requirements used in Egyptian agriculture, is used for rice production (Ainer *et al.*, 1999). The high water demand of irrigated lowland rice mainly arises from keeping a permanent layer of water on the field (Borrell *et al*., 1997). Therefore, new ways must be sought to produce more rice grain yield with less water (Guerra *et al*., 1998). There are different irrigation regimes for reduction of entering water to rice field, such as saturation of farm soil instead of a layer with deep 3-5cm water (Dong *et al.*, 2004), irrigation after some days of disappearance of water from farm level and increasing irrigation intervals (El-Refaee *et al*., 2008). One way for increasing water use efficiency, in rice growing, is alternating wet and dry irrigation (AWDI) method; viz., irrigation to submerge to a particular depth after disappearance of ponded water, in which rice fields are not kept continuously submerged, but, are allowed to dry, intermittently, during the rice growing stages. The beneficial effect of this irrigation practice was water saving and grain yield improvement in rice cultivars (Jayakumar and Krishnasamy, 2005). Intermittent irrigation regimes have been developed in some rice-production regions in attempts to reduce volumes of irrigation water and save water, where, Masian and Vijaykumar (1993) found that applying 5 cm of water at two days after disappearance of ponded water (DADPW) did not significantly reduce grain yield, but, it saved considerable water and had the highest water use efficiency, compared to continuous submergence. Peng *et al*., (1994) reported that intermittent application of irrigation water, 1–5 days after the disappearance of applied standing water, saved 25 – 50 % of the irrigation water, as compared to the continuous submergence of fields, without any adverse effects on rice grain yield.

In recent years, although chemical fertilizers have widely spread throughout the world, fertilizer cost and concern for sustainable soil productivity and ecological stability, in relation to chemical fertilizer use, has emerged as an important issue (Aulakh and Singh, 1997). However, it is now realized that, in fields under intensive monoculture, which receive heavy applications of chemical fertilizers alone, there is a slow decline in productivity. This decline occurs even in irrigated paddy fields (FFTC, 1998). Sustainability in crop yield and soil health could be achieved by the application of mineral fertilizers, along with organic fertilizers. Dobermann and Fairhurst (2002) reported that rice straw was the only organic material available in significant quantities to most rice farmers and about 40 % of the N, 30 to 35 % of the P, 80 to 85 % of the K and 40 to 50 % of the sulfur (S), taken up by rice, remained in vegetative plant parts at crop maturity. Therefore, use of rice straw compost in agricultural soils has been an increasing interest due to the possibility of recycling valuable components, such as organic matter, N, P and K. The application of organic materials, like farmyard manure, poultry manure and residual crops compost are fundamentally important in that they supply various kinds of plant nutrients, including micronutrients, improve soil physical and chemical properties and, hence, nutrient holding and buffering capacity, as well as, consequently, enhance microbial activities (Raikar, 2007). In addition, organic matter, continuously, releases N as plant needs it. N is the most limiting nutrient in irrigated rice systems, but, P and K deficiencies are, also, the constraints increasing grain yield for consecutive planting of rice. An advantage of farm application of organic materials is that they usually provide a number of nutritive elements to crops with little added cost. Experience in tropical Asian countries, generally, shows that organic farming alone does not supply enough nutrients and organic fertilizers need to be supplemented by a basal dressing of chemical fertilizer (Siavoshi *et al*., 2011). Prasad and Sinha (2000) found that the farmyard manure (FYM) or FYM + crop residues could substitute 50 % NPK for wheat production and their residual effect was equivalent to 50 % of the recommended dose of NPK, as a chemical fertilizer on grain yield of succeeding rice crop. To meet the current shortage of chemical fertilizers, caused by energy crisis and socioeconomic constraints, it has become desirable to conserve crop residues and organic manure and recycles them into the soil to increase the efficiency of soil nutrients.

Where water is more limiting than land, it has been argued that water productivity becomes more important than yield or 'land productivity' (Tuong and Bouman, 2003). Substantial yield and water productivity gains are possible with the application of appropriate nutrients in combination with optimum water management adapted to the target environments.

Thus, the objective of the present research was to evaluate the effect of NPK rates with rice straw compost addition, on growth and grain yield of EHR1 hybrid rice cultivar under different irrigation regimes, as well as to determine water productivity and nitrogen use efficiencies.

## MATERIALS AND METHODS

Two field experiments were conducted during 2010 and 2011 summer seasons at the Experimental Farm of Rice Research and Training Center (RRTC), Sakha-Kafr El-Sheikh, Egypt. The research was aimed to study the effect of NPK fertilizers with rice straw compost on growth and grain yield as well as water productivity and nitrogen use efficiency of HER1 Egyptian rice hybrid cultivar under some irrigation regimes. The average meteorological data (from May to September) of the experimental sites were 32.5 and 31.9 °C for maximum temperature, 18.8 and 17.3 °C for minimum temperature, 63.2 and 64.4 % for relative humidity and 6.78 and 6.98 mm/day for pan evaporation in the two successive seasons. A split-plot design, with four replicates, was used in all experiments. The main plots were devoted to three irrigation regimes; namely, continuous flooding (CF) and irrigation to 5–6 cm depth three days (3-) and six (6-) days after disappearance of surface water (DADSW). The sub-plots were occupied by six fertilizer treatments, as follows:

T1- Zero fertilizer (control).
T2- 100 % of the recommended NPK fertilizers.
T3- 25 % of the recommended NPK fertilizers + rice straw compost (2 t/ha).

T4- 50 % of the recommended NPK fertilizers + rice straw compost (2 t/ha).
T5- 75 % of the recommended NPK fertilizers + rice straw compost (2 t/ha).
T6- 100% of the recommended NPK fertilizers + rice straw compost (2 t/ha).

The recommended doses of NPK fertilizer were 165 kg N/ha (in the form of Urea, 46.5 % N) for nitrogen, 35.5 kg $P_2O_5$/ha for phosphorus and 57 kg $K_2O$/ha for potassium. According to treatments, the total P and K fertilizers were applied as a basal dose and incorporated into dry soil of the plots. The dose of N fertilizer was applied in three equal splits (as basal, top dressing at panicle initiation and late booting).

All experiments were preceded by barley (*Hordeum vulgare L.*). The experimental soil was clay and the chemical analysis is shown in Table 1. Compost was prepared at the Gemaza Agricultural Research Station, using organic materials, rice straw, as a main component, and, subsequently applied and incorporated into dry soil of the experimental plots, according to treatments. The chemical composition of composted rice straw is presented, also, in Table 1.

**Table 1: Chemical properties of the experimental sites before planting and chemical composition of rice straw compost.**

| Soil | | | | Composted rice straw | | | |
|---|---|---|---|---|---|---|---|
| **Properties** | **2010** | **2011** | **Average** | **Properties** | **2010** | **2011** | **Average** |
| PH | 8.1 | 8.3 | 8.2 | C (%) | 28.8 | 30.0 | 29.4 |
| Organic matter (%) | 1.55 | 1.65 | 1.60 | N (%) | 1.7 | 1.8 | 1.75 |
| Available N (ppm) | 495 | 510 | 503 | C/N ratio | 16.94 | 16.67 | 16.80 |
| Available P (ppm) | 14.0 | 12.0 | 13.0 | P (%) | 1.5 | 1.4 | 1.45 |
| Available K (ppm) | 300 | 330 | 315 | K (%) | 1.8 | 1.8 | 1.8 |
| | | | | Zn (ppm) | 51 | 50 | 50.5 |

Seeds of EHR1 rice cultivar, at a rate of 24 kg/ha, were soaked in sufficient water for 24 hours and, then, incubated for another 48 hours to enhance germination. Pre-germinated seeds were broadcasted, in the presence of water, after puddling the nursery. The experiments were sown on 13$^{th}$ and 8$^{th}$ of May in the two successive seasons. Zinc (Zn $So_4$) as well as all other cultural practices, were applied as recommended for the nursery. All plots, with an area of 30 $m^2$ (5 x 6 m) each, were transplanted with two to three, thirty days old, seedlings at 20 cm distance among hills and rows.

To avoid lateral irrigation water movement and more water control, each main plot was separated by two-meter wide ditches. Water pump, provided with a calibrated water meter, was used for all water measurements. Water productivity (WP) was calculated as the weight of grains per unit of water used (kg grains/$m^3$ water).

Number of days to 50 % heading was recorded in each sub-plot. Plant samples were randomly collected, from all treatments, at heading stage to estimate dry matter production and leaf area index (LAI). At harvest, plant height was estimated and total number of panicles, of ten random hills, were counted and, then, conformed to numbers/$m^2$. Ten random panicles were collected from each sub-plot to estimate panicle length, number of total grains/panicle, unfilled grain percentage, panicle weight, 1000-grain weight and sink capacity (grains number per field unit area). Panicle density was estimated as the number of grains per panicle divided by panicle length (Futuhara *et al*., 1979). Grain and straw yields were randomly measured from an area of 12 $m^2$ (3 x 4 m) and adjusted to 14 % moisture content. Improved Kjeldahl methods of A.O.A.C. (1970) was used to determine the nitrogen content in grains, and, then, multiplied by the factor of 5.95 to estimate the crude protein in rough grains (Black *et al*., 1965). Nitrogen use efficiency was calculated by using the following formulae (Ladha *et al.,* 2005).

1- Apparent nutrient recovery (ANR) of added N:

$$ANR = \frac{\text{(N uptake (kg N/ha) treatment - N uptake (kg N /ha) control)}}{\text{Applied N (kg/ha) treatment}}$$

2- Agronomic efficiency (AE) of added N:

$$\text{AE (kg grain / kg N applied)} = \frac{\text{(Grain yield (kg/ha) treatment - Grain yield (kg/ha) control)}}{\text{Applied N (kg/ha) treatment}}$$

The analysis of variance was carried out, according to Gomez and Gomez (1984), using GENSTAT 5$^{th}$ Edition Computer Program. Means were compared, using the least significant difference (LSD) at 5% probability level.

## RESULTS AND DISCUSSION

**1- Growth attributes:**

The results, in Table 2, revealed that the growth attributes; viz., number of days to 50 % heading, dry matter production (DM), leaf area index (LAI) and plant height were significantly influenced by irrigation regimes. The irrigation regimes caused a significant difference in the number of days to 50 % heading (Table 2). It was less at CF (99.8 and 100.5 days), as compared to 3-DADSW (100.1 and 101.6 days) and 6-DADSW (101.3 and 102.3 days) in both seasons, respectively. Sikuku *et al*., (2010) found that the rice plants, watered daily, took the least days to attain 50 % flowering, while plants watered after every six days, which were the most stressed plants, took the longest duration to attain 50 % flowering. Dry matter production (1191 and 1294 g/$m^2$), LAI (6.38 and 6.57) and plant height (104.9 and 104.2 cm) showed the highest values at continuous irrigation (CF), followed by irrigation to 5-6 cm depth three days after disappearance of surface water (3-DADSW), in the two successive seasons. However, the lowest values were observed at 6-DADSW (irrigation to 5-6 cm depth six days after disappearance of surface water). Meanwhile, the differences in LAI between CF and 3-DADSW treatments were statistically insignificant in both seasons. The reduction in DM and LAI might be attributed to the reduction in plant height, number of tiller, total leaf area, death of the lower leaves and plant growth, in general, as affected by less available water. However, the increased plant height might be attributed to the significant effect of water in encouraging the cell division and elongation. Also, it might be due to favorable root growth and higher mobility of N in soil solution and its absorption by plant roots and, consequently, resulting in higher vegetative growth. Kato *et al*., (2006) reported that total dry matter (TDM) increased with increasing water supply.

These results are in agreement with the findings of Chandrasekaran (1996) and Jayakumar and Krishnasamy (2005).

**Table 2: Number of days to 50 % heading, LAI, dry matter production and plant height of EHR1 rice cultivar as affected by irrigation regimes and NPK fertilizers during 2010 and 2011 seasons.**

| Character / Treatment | Number of days to 50 % heading | | LAI | | Dry matter production (g/m$^2$) | | Plant height (cm) | |
|---|---|---|---|---|---|---|---|---|
| | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 |
| **Irrigation regimes (I):** | | | | | | | | |
| CF | 99.8 | 100.5 | 6.38 | 6.57 | 1191 | 1294 | 104.9 | 104.2 |
| 3-DADSW | 100.1 | 101.6 | 6.23 | 6.50 | 1134 | 1239 | 100.9 | 101.8 |
| 6-DADSW | 101.3 | 102.3 | 5.50 | 5.42 | 930 | 955 | 88.5 | 90.6 |
| LSD (5 %) | 1.1 | 0.8 | 0.27 | 0.25 | 34 | 28 | 2.8 | 2.2 |
| **NPK fertilizers (T):** | | | | | | | | |
| T1 | 99.8 | 100.5 | 4.90 | 4.96 | 849 | 915 | 87.4 | 87.7 |
| T2 | 101.0 | 102.6 | 6.50 | 6.67 | 1234 | 1295 | 103.6 | 103.6 |
| T3 | 99.8 | 100.7 | 5.59 | 5.53 | 922 | 989 | 94.3 | 93.1 |
| T4 | 100.3 | 101.3 | 6.15 | 6.40 | 1013 | 1080 | 97.7 | 99.5 |
| T5 | 100.5 | 101.6 | 6.43 | 6.61 | 1216 | 1308 | 101.8 | 103.9 |
| T6 | 101.2 | 102.2 | 6.66 | 6.82 | 1278 | 1383 | 104.0 | 105.3 |
| LSD (5 %) | 1.0 | 0.9 | 0.37 | 0.46 | 54 | 58 | 2.5 | 2.8 |
| Interaction (I x T) | NS | NS | NS | NS | NS | * | NS | NS |

**CF = Continuous flooding, DADSW = Days after disappearance of surface water. T1 = Control, T2 = 100% NPK, T3 = 25 % NPK + 2 t/h compost, T4 = 50 % NPK + 2 t/h compost, T5 = 75 % NPK + 2 t/h compost and T6 = 100 % NPK + 2 t/h compost. * = Significant at 0.05 level. NS = Not significant.**

Data in Table 2, also, revealed that growth attributes (number of days to 50 % heading, DM production, LAI and plant height) were significantly affected by combination between composted rice straw and NPK rates. Maximum values of all studied traits were noted in plants treated with 100 % NPK + 2 t/ha of compost (T6), followed by adding two t/ha of compost in combination with 75 % NPK (T5) and 100 % NPK alone (T2), without significant differences among each other. While, the minimum values of such traits were obtained by the control treatment (T1). The increase in plant height, in response to application of organic compost with chemical NPK fertilizers, was probably due to enhanced availability of major nutrients. The available nutrients might have helped in enhancing leaf area, which, thereby, resulted in higher photo-assimilates and more dry matter accumulation. These results are supported by the findings of Swarup and Yaduvanshi (2000), Yadana *et al*., (2009) and Siavoshi *et al*., (2011).

The interaction between irrigation regimes and NPK fertilizers significantly produced the highest DM production (1483 g/m$^2$) in the combination of CF, with applied 75% NPK + 2 t/ha compost (T5), but, the lowest value (701 g/m$^2$) was produced in 6-DADSW with control treatment (T1), in 2011 season (Table 3).

**Table 3: Dry matter production ($g/m^2$) of EHR1rice cultivar as affected by the interaction between irrigation regimes and NPK fertilizers in 2011.**

| Irrigation regime | NPK fertilizers | | | | | |
|---|---|---|---|---|---|---|
| | T1 | T2 | T3 | T4 | T5 | T6 |
| CF | 1048 | 1466 | 1101 | 1197 | 1483 | 1470 |
| 3-DADSW | 995 | 1397 | 1066 | 1127 | 1421 | 1432 |
| 6-DADSW | 701 | 1020 | 799 | 917 | 1022 | 1269 |
| L.S.D (5%) | 94 | | | | | |

**CF = Continuous flooding, DADSW = Days after disappearance of surface water. T1 = Control, T2 = 100% NPK, T3 = 25 % NPK + 2 t/h compost, T4 = 50 % NPK + 2 t/h compost, T5 = 75 % NPK + 2 t/h compost and T6 = 100 % NPK + 2 t/h compost.**

### 2- Grain yield and its attributes:

Grain yield and its attributes (number of panicles/$m^2$, panicle length, total number of grains/panicle, sink capacity, panicle density, panicle weight, 1000-grain weight and straw yield) were significantly higher under CF over the irrigation at 6-DADSW (Table 4). However, the grain yield and most of its attributes, with 3-DADPW, was at par with CF. On the other hand, unfilled grain percentage increased with increasing number of days after disappearance of surface water up to six days. These results are in accordance with those reported by Pirmoradian *et al*., (2004) who indicated that water stress caused an increase in percentage of unfilled grains. The highest values of grain yield were recorded by CF (11.33 and 11.53 t/ha), followed by 3-DADSW (10.81 and 10.82 t/ha), without significant differences in aforementioned characters. However, the lowest values (8.13 and 8.56 t/ha) were obtained by 6-DADSW. The increased grain yield, with CF, could be ascribed to increased grain yield attributes (Table 4). Also, such results might be interpreted by the fact that available water enhanced the production and transportation of the dry matter content to panicles, resulting in more grain filling and weight, as well as higher grain yield. However, increased grain yield with 3-DADSW might be due to better aeration and root system associated with higher mobility and absorption of inorganic N in soil solution, which increased the uptake of nutrients and contributed to favorable growth attributes, which, in turn, had resulted in higher grain yield attributes. On the other side, the results indicated that, exposing rice plants to less available water with 6-DADSW, caused significant reduction in grain yield. This holds true since all grain yield attributes were affected by such conditions. These results are in agreement with those obtained by Masian and Vijaykumar (1993), Peng *et al*., (1994), El-Refaee (2002) and Jayakumar and Krishnasamy (2005).

The effect of application of NPK fertilizers and composted rice straw, on grain yield and its attributes of EHR1 rice cultivar, was presented in Table 4. Grain yield and its attributes were significantly higher in organic and mineral fertilizer application than control treatment.

The maximum values of number of panicles/m$^2$, panicle length, total number of grains/panicle, sink capacity, panicle density, panicle weight, 1000-grain weight and straw yield were noted in plants treated with 100 % NPK + 2 t/ha rice straw compost (T6), followed by 75 % NPK + 2 t/ha rice straw compost (T5) and the recommended dose of NPK fertilizers (T2), with no significant differences among each other in grain yield and most of its attributes. However, the minimum values of all such traits were obtained by control treatment (T1) in both seasons. The lowest significant unfilled grains percentage was obtained during both seasons from T2, T5 and T6 treatments. This might be due to a decrease in number of abortive kernels per panicle, as a result of integrated use of nutrients (Jilani, 1988). The maximum grain yield, in 2010, was observed in T6 (11.60 and 11.81 t/ha), followed by T2 (11.16 and 11.39 t/ha) and T5 (11.11 and 11.27 t/ha). Whereas, the minimum grain yield (7.17 and 7.05 t/ha) was obtained by the control treatment (T1) in both seasons, respectively. Such result supported the finding, in a long-term experiment, by Man *et al.,* (2003) who found that rice grain yield, in treatment of rice straw after decomposition (6 t/ha), combined with 50 % recommended rate of chemical fertilizer (NPK), was not significantly different from treatment of 100% recommended rate of chemical fertilizer application. The grain yield of rice in the treatment of 75 % NPK + 2 t/ha rice straw compost (T5) was statistically the same with that of 100% NPK alone (T2), indicating that rice straw compost could substitute 25 % of recommended dose of NPK in rice production. It could be attributed to enhancing the availability of plant nutrients and improvement in soil physical properties by rice straw compost incorporation. The beneficial effect of organic fertilizer, also, could be attributed to continuous mineralization and release of nutrients from the organic manure, compared to the application of NPK alone. These results are in line with the findings of Mondal *et al.,* (1990) and Usman *et al.,* (2003).

The effect of the interaction, between irrigation regimes and NPK fertilizers, was significant with respect to panicle length only in 2010 season, as well as grain yield, but was highly significant in the and yield in 2010 season (Table 4). Panicle length recorded its maximum value (25.00 cm) with CF and T5 (75 % NPK + 2 t/ha rice straw compost). While, the lowest value (19.35 cm) was obtained from the combination between 6-DADSW and T1 (Table 5). The results showed that application of organic and chemical fertilizers had a significant effect on panicle length under all irrigation regimes. These observations were apparently due to the availability of more nutrients to the rice plant following the fertilizer application, relative to the control treatment.

Under CF, T6 produced the maximum grain yield (12.66 t/ha), followed by T2 (12.59 t/ha) and T5 (12.16 t/ha), without significant differences in aforementioned characters. The same trend was found under 3-DADSW treatment, where, T6 was followed by T2 and T5 and produced the maximum grain yields (Table 5). However, 6-DADSW treatment, under zero fertilizer, gave the lowest grain yield (5.57 t/ha). In fact, nutrients fertilizer was much needed to compensate the unavailable water effect under increasing days after disappearance of surface water up to six days. The best combination, to produce the maximum straw yield (13.40 t/ha), was CF and T2 (Table 5). However, zero fertilizer under 6-DADSW treatment, gave the lowest straw yield (9.16 t/ha).

**Table 5: Panicle length, grain yield and straw yield of EHR1hybrid rice cultivar as affected by the interaction between irrigation regimes and NPK fertilizers in 2010 season.**

| NPK fertilizer | Panicle length (cm) | | | Grain yield (t/ha) | | | Straw yield (t/ha) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Irrigation regimes | | | | | | | | |
| | CF | 3-DADSW | 6-DADSW | CF | 3-DADSW | 6-DADSW | CF | 3-DADSW | 6-DADSW |
| T1 | 22.25 | 21.63 | 19.35 | 8.23 | 7.72 | 5.57 | 12.16 | 10.39 | 9.16 |
| T2 | 24.80 | 24.90 | 21.03 | 12.59 | 11.92 | 8.96 | 13.40 | 12.92 | 10.54 |
| T3 | 23.35 | 21.38 | 20.33 | 10.71 | 10.09 | 6.17 | 12.50 | 11.09 | 10.25 |
| T4 | 23.90 | 23.25 | 20.90 | 11.63 | 11.17 | 8.76 | 12.57 | 11.80 | 10.58 |
| T5 | 25.00 | 24.93 | 20.98 | 12.16 | 11.72 | 9.45 | 12.78 | 12.65 | 11.14 |
| T6 | 24.90 | 24.85 | 21.65 | 12.66 | 12.27 | 9.86 | 12.99 | 13.02 | 11.22 |
| LSD (5%) | 1.13 | | | 0.90 | | | 0.69 | | |

**CF = Continuous flooding, DADSW = Days after disappearance of surface water. T1 = Control, T2 = 100% NPK, T3 = 25 % NPK + 2 t/h compost, T4 = 50 % NPK + 2 t/h compost, T5 = 75 % NPK + 2 t/h compost and T6 = 100 % NPK + 2 t/h compost.**

### 3- Nitrogen uptake and N use efficiency:

Significant differences were observed in the N-uptake and protein content, in both seasons, as well as apparent nutrient recovery (ANR) and agronomic efficiency (AE) of nitrogen, in the second season, due to different irrigation regimes (Table 6). CF conditions recorded significantly higher protein content (6.40 and 6.41 %) and N-uptake (126.0 and 123.5 kg/ha), followed by 3-DADSW treatment. However, 6-DADSW treatment recorded the lowest values of N-uptake and protein content in both seasons, respectively. The ANR values were 54.8, 55.3 and 37.0 % and AE values were 37.25, 36.96 and 26.23 kg grains/kg N applied for CF and 3- and 6-DADSW, respectively. This might be due to increased grain yield and comparative increase in uptake of nitrogen. This, in turn, attributed to better availability of nutrients due to efficient water management. Similar findings were observed by Belder *et al*., (2005), Jayakumar and Krishnasamy (2005) and El-Refaee *et al*., (2008).

The data, concerning N-uptake and protein content, clearly indicated that both characters significantly increased in all chemical fertilizers treated plants as against untreated plants (control), as shown in Table 6. The maximum values of protein content (6.86 and 6.46 %) and N-uptake (137.5 and 128.3 kg N/ha) were observed in plants treated with 100% NPK + 2 t/ha compost (T6), followed by 75 % NPK + 2 t/ha compost (T5) and 100% NPK alone, with no significant difference between each other, in the two respective seasons. The other treatments decreased N-uptake and protein content and the maximum decrease was noted in the control treatment (T1), while, the minimum decrease was that for 2 t/ha compost fertilizer in combination with 25 % NPK (T3). N-uptake and protein content were higher with the application of NPK fertilizers, which might be due to the increased root dry weight that caused more nutrient uptake, especially N. Also, compost (as an organic fertilizer) increased the fertilizer use efficiency and improved the physical and chemical properties of soil, hence, making better utilization of nutrients and might, also, be a reason towards increased grain yield. ANR and AE, due to nitrogen fertilization, were presented in Table 6. In the first season, the efficiency of absorption of applied N evaluated, as ANR, was the highest (77.2 %) when rice straw compost, at 2 t/ha, was combined with added N at 25 % of recommended dose (T3). However, in the second season, the highest value of ANR (62.6 %) was recorded by application of 50% NPK + 2 t/ha compost (T4). On the other hand, it was lower (35.9 and 40.7 %) when 100% NPK was used alone in both seasons, respectively. This means that, in rice field, N applied to rice had a recovery of 35 – 77 %, while the remaining 23 – 65 % of applied N remained in the soil and rice straw compost. El-Refaee *et al*., (2008) reported that N applied to rice had a recovery of 20 – 50 %. Agronomic efficiency (calculated as kg dry grain per kg of N applied) varied from 26.28 to 77.21 kg grains per kg of N applied with T2 and T4, in the first season, and it varied from 24.15 to 44.02 kg grains per kg of N applied with T2 and T4, in the second season, respectively. The AE was improved by incorporation of rice straw compost at 2 t/ha with 25 and 50 % NPK fertilizer. The improved AE, with added compost at 2 t/ha combinations with 25 and 50 % NPK, reflected the greater RE, compared with 100% NPK alone or with 2 t/ha compost.

**Table 6: Protein content, N-uptake, apparent nutrient efficiency (ANR) of added N and agronomic efficiency (AE) of EHR1 rice cultivar as affected by irrigation regimes and NPK fertilizers during 2010 and 2011 seasons.**

| Character / Treatment | Protein content (%) | | N- uptake (kg/ha) | | ANR (%) | | AE (kg grains/kg N applied) | |
|---|---|---|---|---|---|---|---|---|
| | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 |
| **Irrigation regimes (I):** | | | | | | | | |
| CF | 6.40 | 6.41 | 126.0 | 123.5 | 58.7 | 54.8 | 38.50 | 37.25 |
| 3-DADSW | 6.14 | 6.05 | 113.4 | 111.9 | 56.8 | 55.3 | 39.76 | 36.96 |
| 6-DADSW | 5.43 | 5.09 | 79.8 | 70.7 | 52.1 | 37.0 | 38.64 | 26.23 |
| LSD (5 %) | 0.29 | 0.78 | 8.2 | 16.2 | NS | 10.1 | NS | 10.71 |
| **NPK fertilizers (T):** | | | | | | | | |
| T1 | 4.75 | 4.73 | 57.3 | 58.0 | - | - | - | - |
| T2 | 6.44 | 6.21 | 124.4 | 117.2 | 40.7 | 35.9 | 26.28 | 24.15 |
| T3 | 5.52 | 5.30 | 89.1 | 81.1 | 77.2 | 55.9 | 61.46 | 44.02 |
| T4 | 5.82 | 6.18 | 105.0 | 109.7 | 57.8 | 62.6 | 77.21 | 40.60 |
| T5 | 6.56 | 6.23 | 125.3 | 117.8 | 55.0 | 48.3 | 34.03 | 31.80 |
| T6 | 6.86 | 6.46 | 137.5 | 128.3 | 48.6 | 42.6 | 28.85 | 26.81 |
| LSD (5 %) | 0.23 | 0.82 | 6.4 | 14.6 | 6.7 | 13.3 | 5.61 | 5.65 |
| Interaction (I x T) | ** | NS | ** | NS | * | NS | NS | ** |

**CF = Continuous flooding, DADSW = Days after disappearance of surface water. T1 = Control, T2 = 100% NPK, T3 = 25 % NPK + 2 t/h compost, T4 = 50 % NPK + 2 t/h compost, T5 = 75 % NPK + 2 t/h compost and T6 = 100 % NPK + 2 t/h compost. **, * = Highly significant and significant at 0.01 and 0.05 levels, respectively. NS = Not significant.**

Incorporation of rice straw compost affected the loss of added N from the plant-soil system, indicating the importance of immobilization and re-mineralization of added N in the presence of the incorporated composts. Roberts (2008) reported that the highest nutrient use efficiency always occurred at the lower parts of the yield response curve, where fertilizer inputs were the lowest. These results are in line with the findings of Shahnawaz *et al*., (2009).

The interaction between irrigation regimes and NPK fertilizers had a highly significant effect on the protein content and N-uptake in 2010 (Table 6). The data, in Table 7, indicated that protein content and N-uptake were significantly increased due to each increase in NPK level up to 100 %NPK + compost (T6) under all irrigation regimes. The added 100 %NPK + compost, under CF, recorded the maximum value of protein content (7.35 %) and N-uptake (160.11 kg N/ha), however, 6-DADSW and control treatment (T1) gave the minimum value of protein content (4.06 %) and N-uptake (36.16 kg N/ha).

Data in the same table, also, indicated that ANR and AE of added N were significantly affected by the interaction between irrigation regimes and NPK fertilizers in 2010 and 2011 seasons, respectively. The maximum value of ANR (79.3 %) was obtained with added 25% NPK + compost under 6-DADSW. While, CF recorded the maximum value of AE (60.06 kg grain/ kg N) with the same NPK fertilizer treatment. On the other hand, the minimum value of ANR (34.1 %) and AE (14.54 kg grains/ kg N) were obtained by the combination between 6-DADSW with added 100% NPK alone and 25 % NPK+ compost, respectively.

**Table 7: Protein content, N-uptake, apparent nutrient efficiency (ANR) and agronomic efficiency (AE) of EHR1rice cultivar as affected by the interaction between irrigation regimes and NPK fertilizers.**

| NPK fertilizer | Protein content (2010) | | | N-uptake (kg N/ha) (2010) | | | ANR (%) 2010 | | | AE (kg grains/kg N) (2011) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Irrigation regimes | | | | | | | | | | | |
| | CF | 3-DADSW | 6-DADSW | CF | 3-DADSW | 6-DADSW | CF | 3-DADSW | 6-DADSW | CF | 3-DADSW | 6-DADSW |
| T1 | 5.20 | 4.99 | 4.06 | 72.59 | 63.04 | 36.16 | - | - | - | - | - | - |
| T2 | 7.22 | 6.31 | 5.79 | 155.10 | 125.71 | 92.48 | 50.0 | 38.0 | 34.1 | 26.42 | 25.47 | 20.56 |
| T3 | 5.65 | 5.49 | 5.42 | 103.68 | 94.75 | 68.89 | 75.4 | 76.9 | 79.3 | 60.06 | 57.46 | 14.54 |
| T4 | 5.95 | 5.92 | 5.59 | 118.22 | 109.97 | 86.65 | 55.3 | 56.9 | 61.2 | 41.18 | 41.91 | 38.73 |
| T5 | 7.05 | 6.89 | 5.74 | 146.44 | 135.07 | 94.33 | 59.7 | 58.2 | 47.0 | 31.72 | 32.36 | 31.33 |
| T6 | 7.35 | 7.26 | 5.97 | 160.11 | 152.08 | 100.39 | 53.0 | 54.0 | 38.9 | 26.85 | 27.59 | 25.98 |
| LSD (5%) | 0.44 | | | 12.24 | | | 12.8 | | | 13.54 | | |

**CF = Continuous flooding, DADSW = Days after disappearance of surface water. T1 = Control, T2 = 100% NPK, T3 = 25 % NPK + 2 t/h compost, T4 = 50 % NPK + 2 t/h compost, T5 = 75 % NPK + 2 t/h compost and T6 = 100 % NPK + 2 t/h compost.**

### 4-Water relations:

Data in Table 8 showed that the amounts of water input, before staring irrigation treatments, for land preparation of both nursery and permanent field, raising nursery for thirty days and through ten days after transplanting and before treatments application were 4170 and 3860 $m^3$/ha in 2010 and 2011 seasons, respectively. The previous period (forty days) was considered a blank for all treatments.

**Table 8: Amounts of water applied ($m^3$/ha) in rice field before starting irrigation treatments during 2010 and 2011 seasons.**

| Period | 2010 | 2011 |
|---|---|---|
| Land preparation of the nursery | 250 | 210 |
| Seedling raising (30 days) | 350 | 290 |
| Preparation of permanent field | 2300 | 2110 |
| Ten days before starting treatments | 1270 | 1250 |
| Total | 4170 | 3860 |

Comparing the different treatments of irrigation (Table 9), it was observed that CF received the highest amounts of water throughout the season (14550 and 14120 $m^3$/ha), as expected, while, the lowest amounts were received by irrigation as 6-DADSW (11395 and 11235 $m^3$/ha) in 2010 and 2011 seasons, respectively. There were no large variations in the amounts of irrigation water input due to the stable conditions; namely, temperature, relative humidity and evaporation rates in both seasons.

Water saved, due to increasing the intervals, compared to CF, ranged from 11.55 to 21.68 %, in the first season, and from 11.12 to 20.43 %, in the second season, for 3- and 6-DADSW, respectively (Table 9). Irrigation at 6-DADSW might, considerably, reduce irrigation water input, compared with continuous flooding. But, at the same time, grain yield was significantly decreased.

**Table 9: Total water used, water saved and grain yield reduction as affected by irrigation regimes during 2010 and 2011 seasons.**

| Irrigation regimes | Total water used ($m^3$/h) | | Water saved (%) | | Grain yield reduction (%) | |
|---|---|---|---|---|---|---|
| | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 |
| CF | 14550 | 14120 | - | - | - | - |
| 3-DADSW | 12870 | 12540 | 11.55 | 11.12 | 4.59 | 6.41 |
| 6-DADSW | 11395 | 11235 | 21.68 | 20.43 | 27.98 | 25.63 |
| Average | 12938 | 12632 | 16.62 | 15.78 | 16.29 | 16.02 |

**CF = Continuous flooding, DADSW = Days after disappearance of surface water. T1 = Control, T2 = 100% NPK, T3 = 25 % NPK + 2 t/h compost, T4 = 50 % NPK + 2 t/h compost, T5 = 75 % NPK + 2 t/h compost and T6 = 100 % NPK + 2 t/h compost.**

Among different tried irrigation schedules, the application of 5-6 cm irrigation water (3-DADSW) was considered the best water productivity (WP) (averaged 0.84 and 0.86 kg/$m^3$) in the first and second seasons, respectively (Table 10). The high values of WP, in 3-DADSW, were caused by the extremely high grain yield, which, statistically, was the same as that obtained from CF, and low water inputs in this treatment (Table 9). Masian and Vijaykumar (1993) found that maintaining 5 cm of water yielded the most rice grain yield in the experiment, but required the highest amounts of water.

Applying 5 cm of water at two days after disappearance of pounded water (DADPW) did not significantly reduce grain yield, but it saved considerable water. It, also, had the highest water use efficiency among treatments. Other treatments consumed less water than CF, but significantly yielded less. Wardana *et al.,* (2010) found that intermittent irrigation technique saved water up to 55% without affecting yields, resulting in a 2-3 times higher water productivity. Similar findings were reported by Cao *et al.,* (2002) with savings up to 36%, and Bindraban *et al.,* (2006), with water savings up to 50%, for a range of experimental conditions.

Regarding the effect of rice NPK fertilizer on WP, data observed that WP, over irrigation regimes, ranged from 0.56 to 0.55 kg/m$^3$ (with T1) and from 0.90 to 0.93 kg/m$^3$ (with T6) in both seasons, respectively (Table 10). Under all irrigation regimes, application of NPK fertilizers, either with rice straw compost or alone, recorded higher WP than the control treatment. High WP, with NPK application, was associated with high grain yield. The mean WP could be increased to reach its maximum values under 3-DADSW treatment with T6 (0.95 and 0.99 kg/m$^3$), followed by T2 (0.93 and 0.95 kg/m$^3$) and T5 (0.91 and 0.93 kg/m$^3$). However, the maximum values, under 6-DADSW, were recorded by T6 (0.86 and 0.89 kg/m$^3$), followed by T5 (0.83 and 0.87 kg/m$^3$). On the other hand, under CF, the maximum values were recorded when T2 (0.87 and 0.91) and T6 (0.87 and 0.91 kg/m$^3$) were used, in the two successive seasons.

**Table 10: Water productivity (kg/m$^3$) as influenced by irrigation regimes and NPK fertilizer during 2010 and 2011 seasons**

| NPK fertilizers | Irrigation regimes | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2010 | | | | 2011 | | | |
| | CF | 3-DADSW | 6-DADSW | Average | CF | 3-DADSW | 6-DADSW | Average |
| T1 | 0.57 | 0.60 | 0.51 | 0.56 | 0.59 | 0.60 | 0.47 | 0.55 |
| T2 | 0.86 | 0.93 | 0.79 | 0.86 | 0.91 | 0.95 | 0.85 | 0.90 |
| T3 | 0.74 | 0.78 | 0.54 | 0.69 | 0.77 | 0.82 | 0.67 | 0.76 |
| T4 | 0.80 | 0.87 | 0.77 | 0.81 | 0.84 | 0.88 | 0.82 | 0.85 |
| T5 | 0.84 | 0.91 | 0.83 | 0.86 | 0.88 | 0.93 | 0.87 | 0.89 |
| T6 | 0.87 | 0.95 | 0.86 | 0.90 | 0.92 | 0.99 | 0.89 | 0.93 |
| Average | 0.78 | 0.84 | 0.72 | 0.78 | 0.82 | 0.86 | 0.76 | 0.81 |

**CF = Continuous flooding, DADSW = Days after disappearance of surface water. T1 = Control, T2 = 100% NPK, T3 = 25 % NPK + 2 t/h compost, T4 = 50 % NPK + 2 t/h compost, T5 = 75 % NPK + 2 t/h compost and T6 = 100 % NPK + 2 t/h compost**

Generally, under the same experimental conditions, it could be concluded that using irrigation 3-DADSW, with added 75 % NPK, along with rice straw compost 2 t/ha might gave a reasonable grain yield and high WP, as well as it could decrease chemical fertilizer input by 25% from the present recommended application rate by using two tons of rice straw compost without decreasing grain yield.

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# تأثيرإضافة كمبوست قش الأرز و التسميد الآزوتى و الفوسفاتى و البوتاسى تحت بعض نظم الرى على محصول الحبوب و إنتاجية وحدة المياه فى صنف الأرز الهجين "هجين مصرى واحد"

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**مركز البحوث الزراعية– معهد بحوث المحاصيل الحقلية– مركز البحوث و التدريب في الأرز-سخا–كفر الشيخ- جمهورية مصر العربية**

أقيمت تجربتان حقليتان بالمزرعة البحثية لمركز البحوث و التدريب فى الأرز بسخا – كفر الشيخ ، جمهورية مصر العربية و ذلك فى موسمى صيف 2010 و 2011م بهدف دراسة تأثير إضافة كمبوست قش الأرز والتسميد الآزوتى و الفوسفاتى و البوتاسى على النمو و محصول الحبوب و إنتاجية وحدة المياه و كفاءة إستخدام النيتروجين لصنف الأرز هجين مصرى واحد و ذلك تحت بعض نظم الرى. إستُخدم تصميم القطع المنشقة مرة واحدة فى أربع مكررات حيث احتوت القطع الرئيسية على ثلاثة نظم للرى و هى: الغمر المستمر طوال الموسم و الرى لإرتفاع 5-6 سم بعد ثلاثة أيام و ستة أيام من إختفاء مياه الرى السطحية، فى حين إحتوت القطع الشقية على ست مُعاملات للتسميد وهى: المعاملة بدون تسميد (م1) و 100 % من معدل السماد الآزوتى و الفوسفاتى و البوتاسى الموصى به (م2) و2 طن /هـ كمبوست قش الأرز + 25 % (م3) و 50 % (م4) و 75 % (م5) و 100 % (م6) من معدل السماد الآزوتى و الفوسفاتى و البوتاسى الموصى به.

و تُشير أهم النتائج إلى أن مُعاملتى الغمر المستمر و الرى بعد ثلاثة أيام من اختفاء المياه السطحية قد سَجلت أعلى القيم لصفات النمو و محصول الحبوب و معظم مكوناتة بالإضافة الى محتوى البروتين فى الحبوب و كمية النيتروجين الممتص و ذلك بالمقارنة مع معاملة الرى بعد ستة أيام من اختفاء المياه السطحية، فيما عدا عدد الأيام حتى التزهير و نسبة الحبوب الفارغه.

زَادت صفات النمو ( الوزن الجاف و دليل مساحة الورقة و ارتفاع النباتات) و محصول الحبوب و معظم مكوناتة بالإضافة الى محتوى البروتين و كمية النيتروجين الممتص زيادةً معنوية بإضافة 100 % من معدل السماد الآزوتى و الفوسفاتى و البوتاسى الموصى به + 2 طن /هـ كمبوست قش الأرز (م 6) و التى جاءت على نفس درجة المعنوية مع المعاملة م2 (100 % من معدل السماد الآزوتى و الفوسفاتى و البوتاسى الموصى به) و المعاملة م5 (75 % من معدل السماد الآزوتى و الفوسفاتى و البوتاسى الموصى به + و 2 طن /هـ كمبوست قش الأرز).

تَحت جميع نظم الرى، سجلت معاملات إضافة السماد الآزوتى و الفوسفاتى و البوتاسى الموصى به منفردا أو مصحوبا مع الكمبوست أعلى القيم لمحصول الحبوب و إنتاجية وحدة المياه و ذلك بالمقارنة مع المعاملة بدون تسميد (المقارنة).

استهلكت معاملة الغمر المستمر طوال الموسم أكبر كميه لمياه الرى فى حين تقل كميات مياه الرى المستهلكة بزيادة الفترات إلى ثلاثة و ستة أيام من اختفاء المياه السطحية. علاوة على ذلك سَجلت معاملة الرى بعد ثلاثة أيام من اختفاء المياه السطحية أعلى القيم لإنتاجية وحدة المياه (0.84 و 0.86 كجم/م$^3$) و أقل نقص فى محصول الحبوب (4.59 و 6.41 %) و وفرت كمية من مياه الرى تعادل 11.55 و 11.12% و ذلك بالمقارنة بمعاملة الغمر المستمر و ذلك فى كلا الموسمين، على التوالى.

بصفة عامة، و تحت نفس الظروف المماثلة للتجربة، يمكن الاستنتاج بأنه بإستخدام معاملة الرى بعد ثلاثة أيام من اختفاء المياه السطحية، مع إضافة 75 % من معدل السماد الآزوتى و الفوسفاتى و البوتاسى الموصى به + 2 طن /هـ كمبوست قش الأرز يمكن الحصول على محصول حبوب مقبول لصنف الأرز "هجين مصرى واحد" و كذلك الحصول على أعلى إنتاجية لوحدة المياه بالإضافة إلى أنه يمكن توفير25 % من معد السماد الموصى به حاليا عند إضافة 2 طن /هـ كمبوست قش الأرز بدون أى نقص فى محصول الحبوب.

**قام بتحكيم البحث**

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**Table 4: Grain yield and its attributes of EHR1 hybrid rice cultivar as affected by irrigation regimes and NPK fertilizes during 2010 and 2011 seasons.**

| Character | Number of panicles/ $m^2$ | | Panicle length (cm) | | Total number of grains/ panicle | | Unfilled grains (%) | | Sink capacity (x1000) | | Panicle density | | Panicle weight (g) | | 1000-grain weight (g) | | Grain yield (t/ha) | | Straw yield (t/ha) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatment | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 |
| **Irrigation regimes (I):** | | | | | | | | | | | | | | | | | | | | |
| CF | 537.7 | 554.2 | 24.03 | 23.17 | 180.6 | 173.0 | 6.39 | 5.19 | 98.0 | 96.4 | 7.51 | 7.47 | 4.20 | 4.44 | 25.08 | 24.49 | 11.33 | 11.53 | 12.73 | 12.82 |
| 3-DADSW | 522.6 | 538.5 | 23.49 | 22.81 | 178.3 | 165.1 | 6.42 | 6.04 | 94.0 | 89.5 | 7.60 | 7.24 | 4.12 | 4.21 | 24.40 | 24.51 | 10.81 | 10.82 | 11.98 | 12.26 |
| 6-DADSW | 450.1 | 476.0 | 20.70 | 20.69 | 162.3 | 145.0 | 8.19 | 6.76 | 69.1 | 69.5 | 7.35 | 7.00 | 3.95 | 3.59 | 23.73 | 23.93 | 8.13 | 8.56 | 10.48 | 10.37 |
| LSD (5 %) | 27.1 | 48.3 | 0.54 | 0.46 | 5.6 | 5.6 | 1.57 | 0.80 | 4.4 | 8.8 | NS | 0.28 | 0.16 | 0.15 | 0.46 | 0.52 | 0.60 | 0.74 | 0.23 | 0.39 |
| **NPK fertilizers (T):** | | | | | | | | | | | | | | | | | | | | |
| T1 | 389.4 | 424.2 | 21.08 | 20.48 | 152.9 | 142.7 | 9.58 | 7.77 | 60.1 | 61.0 | 7.26 | 6.96 | 3.51 | 3.42 | 23.65 | 23.70 | 7.17 | 7.05 | 10.57 | 11.00 |
| T2 | 549.8 | 575.2 | 23.58 | 23.16 | 178.2 | 167.2 | 5.27 | 5.74 | 98.7 | 96.7 | 7.57 | 7.20 | 4.45 | 4.34 | 24.79 | 24.34 | 11.16 | 11.39 | 12.29 | 12.30 |
| T3 | 485.5 | 486.2 | 21.68 | 21.15 | 156.8 | 152.0 | 7.59 | 6.91 | 72.2 | 74.3 | 7.24 | 7.18 | 3.69 | 3.92 | 24.42 | 23.94 | 8.99 | 9.59 | 11.28 | 11.19 |
| T4 | 514.4 | 517.1 | 22.68 | 22.08 | 159.7 | 156.7 | 6.00 | 5.72 | 87.7 | 81.1 | 7.48 | 7.10 | 4.04 | 4.03 | 24.40 | 24.44 | 10.52 | 10.70 | 11.65 | 11.85 |
| T5 | 542.5 | 542.3 | 23.63 | 22.71 | 177.4 | 170.0 | 5.82 | 5.23 | 96.9 | 92.1 | 7.51 | 7.50 | 4.34 | 4.32 | 24.46 | 24.52 | 11.11 | 11.27 | 12.18 | 12.12 |
| T6 | 566.2 | 592.5 | 23.80 | 23.77 | 187.4 | 177.8 | 6.75 | 4.63 | 106.5 | 105.9 | 7.88 | 7.49 | 4.52 | 4.43 | 24.71 | 24.90 | 11.60 | 11.81 | 12.41 | 12.42 |
| LSD (5 %) | 37.1 | 26.2 | 0.66 | 0.71 | 6.0 | 14.0 | 1.70 | 0.95 | 7.3 | 7.2 | 0.36 | NS | 0.17 | 0.21 | 0.66 | 0.48 | 0.47 | 0.47 | 0.42 | 0.39 |
| Interaction (I x T) | NS | NS | * | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | * | NS | ** | NS |

**CF = Continuous flooding, DADSW = Days after disappearance of surface water. T1 = Control, T2 = 100% NPK, T3 = 25 % NPK + 2 t/h compost, T4 = 50 % NPK + 2 t/h compost, T5 = 75 % NPK + 2 t/h compost and T6 = 100 % NPK + 2 t/h compost. **, * = Highly significant and significant at 0.01 and 0.05 levels, respectively. NS = Not significant.**