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*Original Research Article*

# Influence of Perl Humus Levels on Growth and Yield of Irrigated Lowland Rice (*Oryza sativa*) Varieties

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**Abstract**

**A field experiment was carried out in two successive seasons of 2016 and 2017 in Meshkab region, Najaf province, Iraq to study the effect of different fertilizer treatments on the performance of two rice varieties. Rice varieties included Anber-33 and Yassmin, while fertilizer treatments included: 800 kg Perl humus ha$^{-1}$($T_1$); 100 kg Perl humus ha$^{-1}$ ($T_2$); 1200 kg Perl humus ha$^{-1}$ ($T_3$) and recommended chemical fertilizers ($T_4$). All the growth and yield parameters differed significantly due to variety. Anber-33 produced the longer plant height, maximum number of tiller, maximum straw yield, and maximum grains per panicle. However, Yassmin gave the longer panicle, maximum grain yield, and have 1000-grain weight. Data also showed that the application of different levels of Perl humus increased soil fertility indices (organic C, available N, and available P) and rice growth and yield, as compared to chemical fertilization treatment. Increasing Perl humus level, increased growth and yield parameters. Maximum grain yield (7.21 and 6.54 t ha$^{-1}$) at the two seasons, were obtained from 1200kg Perl humus ha$^{-1}$, but it was statistically at par with 1000 kg Perl humus ha$^{-1}$. The combination of varieties and fertilization treatments indicated that the variety Yassmin was more responsive to Perl humus to produce better yield (8.02 and 7.26 t ha$^{-1}$) for the two seasons, as well as reduced fertilizer cost. In view of the results obtained in this study, it might be suggested that rice of both varieties can be grown organically under conditions of the study area.**

**Keywords:** Available nutrients, Grain yield, Humic acid, Rice varieties, Straw yield

## INTRODUCTION

Rice (*Oryza sativa* L.) is one of the major crops grown in Iraq. It is mostly grown in middle Euphrates lowlands under full irrigated conditions. The yield of rice in Iraq reaches 3.95t ha$^{-1}$ with total cultivated area of 27600 ha in 2015 (OAR, 2016) which is almost less than the average yield of the world. The rice-wheat production system of such area is similar to the most cropping system in the world. This cropping system has been implemented in Iraq for the last 25 years. However, this system has shown signs of fatigue and evidences suggest that natural resources may be reducing productivity in this system (Singh *et al.*, 2007). Furthermore, the present system of rice production associated with the use of chemical fertilizers at heavy doses, especially to develop of high yielding varieties. The continuous use of higher doses of chemical fertilizer with insufficient use of organics could cause nutrient in balance in soil (Doran *et al.*, 1996), the destruction of useful microorganisms and insects, air and water pollution, increasing crop susceptibility to disease (Jien, 2012), the soils are showing signs of degradation resulted in decline the yield of rice as well as a lower response to applied chemical fertilizers (Yadav *et al.*, 1998). In contrast, organic fertilizers improve soil health and nutrient uptake by plant, hence develop growth and yield.

**Table 1.** Some initial physical and chemical characteristics of the soil

| Characteristics | Value |
|---|---|
| pH (1:1) in water | 8.5 |
| EC ($dSm^{-1}$) soil paste | 3.6 |
| Organic matter ($g\ kg^{-1}$) | 18.00 |
| Total N ($g\ kg^{-1}$) | 0.87 |
| Available N ($mg\ kg^{-1}$) in KCl | 80.66 |
| Available P ($mg\ kg^{-1}$) in $NaHCO_3$ | 16.31 |
| Soluble K ($mg\ kg^{-1}$) in $NH_4OAC$ | 12.70 |
| Sand (%) | 18.00 |
| Silt (%) | 37.20 |
| Clay (%) | 44.80 |
| Texture class | Silty clay |

One of the organic fertilizers widely used in recent times is humic acid (HA) which is an organically charged bio-stimulant. However, Saruhan *et al.*(2011) considered HA as organic-mineral fertilizers. Erangelou *et al.* (2002) defined HA as a component of organic material that has active functional groups i.e carboxyl (-COOH), amine (-$NH_2$), hydroxyl (-OH) and phenol (Ar-OH) and has a negative charge in weakly acidic to basic media because of deprotonation. Using of HA can improve soil structure, increase soil water holding capacity and CEC, and enhance nutrient availability by formation of organo-metal complex compounds or chelate (Tan, 2003).Improvement of physical and chemical soil properties after addition of HA provide a higher concentration of nutrients in the soil solution and act as a source and sink for nutrients such as N, P and K (Vaughan *et al.,* 1985). Humic substances have been reported to affect the plant growth directly and indirectly. Directly by various biochemical effects either at cell, membrane level or in the cytoplasm, including increase photosynthesis and respiration rates in plants, enhanced protein synthesis and plant hormone like activity (Chen and Aviad, 1990). The indirect effects of humic compounds on soil fertility include: increase in soil microbial population, improved soil structure and increase in cation exchange capacity and the pH buffering capacity of the soil (Saruhan *et al.*, 2011).Vaughan and Malcom (1985) also reported that the direct effect of HA on plant growth may be related to the improvement of the overall plant biomass, particularly, the increase of root growth.

Several research workers pointed out the positive benefits of HA or HA-based fertilizers on rice yield (Chen *et al.*, 2010; Herviyanti *et al.*, 2012; Saha *et al.*, 2013). Enhancement of nutrient uptake by rice plants as a result of HA application also established (Sathiyabama, 2009). Furthermore, improving soil fertility and chemical properties after addition of HA also observed (El-Etr *et al.*, 2011; Sarwar *et al.*, 2014). With such background, a field experiment was conducted to examine the impact of Perl humus fertilizer, as an organic system on growth and yield of two rice varieties and some soil fertility indices.

## MATERIALS AND METHODS

The experiment was conducted in a farm (31° 45' N lat., 44° 28' long., about 23m above the sea level) at Meshkab region, Najaf province, Iraq during two growing seasons of 2016 and 2017. The climate of the area is arid. Cropping pattern common in the area is rice-wheat. A soil sample (0-30 cm) of the experimental site was collected and analyzed for physical and chemical properties according to the standard methods outlined by Black (1965) and Page *et al.* (1982) and presented in Table 1.

The experiment was laid out in split-plot design with three replicates. The main plots were rice varieties (Anber-33 and Yassmin), while the subplots were fertilizer treatments [$T_1$:800 kg $ha^{-1}$of Perl humus, $T_2$:1000 kg $ha^{-1}$of Perl humus,$T_3$:1200kg $ha^{-1}$ of Perl humus, and $T_4$: conventional treatment consists of 400 kg NPK $ha^{-1}$as formula 18-18-0+128 kg $Nha^{-1}$as urea (46%N)]. Perl humus is a granular formulation of humic acid derived from leonardite obtained by the German company "Humintech" and its characteristics are given in Table 2. The humus was incorporated into field one day before transplanting. Urea and NPK fertilizers were applied in two equal split doses at transplanting and at 30 days after transplanting.

Field was ploughed twice, leveled with ladder, flooded with water and puddling. Individual plots (4 × 3 m) were prepared. All fertilizers were incorporated at 15 cm depth of each plot. Rice seedlings (20 days old) of each variety were transplanting manually at spacing of 30 × 20 cm with 3 seedlings per hill on 16 June and on 18 June for 2016 and 2017 seasons, respectively. The level of water was maintained at 10-15 cm all over the season. The agricultural operations were done as commonly practiced by farmers in rice fields in Middle Euphrates Region until a harvest time.

At maturity stage, $3m^2$ of each plot were selected randomly, and data on straw yield and grain yield were measured. Subsamples of plants were selected randomly to determine the number of tillers per hill, plant height, panicle length, number of filled grains per panicle and 1000-grain weight. At the harvest stage of the 2017

**Table 2.** Composition and properties of perl humus fertilizer

| Characteristics | Value |
|---|---|
| Humic acids (%) | 60-75 |
| Organic matter (%) | 89 |
| Water holding capacity | ~20 times |
| pH | 5.5-6.7 |
| Conductivity in KCl (%) | 0.41 |
| CEC (meq/100g) | 400-600 |
| Nitrogen (urea N %) | 1 |
| Available phosphoric acid (%$P_2O_5$) | 0.2 |
| Soluble potassium (% $K_2O$) | 0.3 |
| Color | black |
| Product type | granulates 4mm |
| Rich in micro-elements in form of humic acid complexes | |

season, soil samples (0-30cm) were collected from each plot to determine organic C, available N and available P. Organic C was assay according to Walkly-Black method presented in Page *et al*. (1982). Available N was assay by extracting with 2*M* KCl solution according to Bremner and Keeney (1966), then available N was determined by the micro Kjeldahl method according to Bremner and Edwards (1965). For available P, soil samples were extracted with 0.5*M* $NaHCO_3$ solution, then determined spectrophotometrically according to Murphy and Riley (1962). Economic benefit based on marginal analysis described by Hossain *et al*. (2005) was used to compare using of perl humus fertilizer over recommended chemical fertilizers for variety Yassmin that produced higher grain yield and which has relatively stable price.

All the obtained data of main effects and their interactions was subjected to analysis of variance (ANOVA) under CRD using GenStat Procedure Library Release PL15. The significant differences (Revised LSD ≤ 0.05) among the means were conducted for all studied parameters.

## RESULTS AND DISCUSSION

### Growth parameter

Results showed that plant height was significantly differed with different varieties at the two seasons (Table 3). Higher plant height was obtained from the variety Anber-33 as compared with lower plant height of variety Yassmin with an increasing percent of 58 and 49% at the seasons of 2016 and 2017, respectively. Hossain *et al*. (2008) observed variable plant height among four rice varieties. Significant differences were also obtained for panicle length and number of tillers (Table 3). Yassmin produced the higher panicle length and lower number of tillers at the two seasons, as compared with variety Anber-33. The less number of tillers might be attributed to genetic make-up and/or to the mortality of tillers during the vegetative stage.

Variation in growth parameters due to varieties might be attributed to the differences in genetic make-up and the rate of response to environmental conditions. The response of plant to environmental conditions varies depending on the physiological and morphological of a variety. For example, each variety has an active root system which is closely related to nutrients uptake. It was found that cultivars of the same crop differ in their efficiency of using nutrients due to their resistance to diseases and extreme circumstances (Tisdale and Nelson, 1975). Al-Abdulla (2015) stated that variations in plant height among wheat varieties might be related to the amount of auxin and gibberllin in tissues. Nungkat *et al*. (2015) suggested that selection of rice varieties grown in an area is determined by the potential of the crop, the condition of the ecosystem, as well as resistance to pests and diseases endemic and extreme conditions.

There were significant effects ($P \leq 0.05$) of different fertilizer treatments on growth parameter of rice at the two seasons except that of panicle length at the season of 2016 (Table 4). Increasing perl humus level increased plant height with maximum value at $T_3$ treatment which statistically differed from other treatments except that of $T_2$ treatment. As compared with conventional treatment ($T_4$), plant heights at all humus treatments were significantly increased by 15, 28 and 30% at season 2016 and 6, 9 and 15% at the season of 2017 for $T_1$, $T_2$ and $T_3$ treatments, respectively. Chan *et al*. (2010) reported an increase in plant height of rice due to humic acid application. Similar effects were also observed for panicle length and number of tillers (Table 4). Longest panicle (25.17 and 27.35 cm) and maximum number of tillers per hill (15.02 and 15.29) for 2016 and 2017 seasons, respectively, were found at $T_3$ treatment with significantly different from most of the other treatments. Saha *et al*. (2013) found that panicle length of rice significantly increased from 23.43 to 24.78 cm with increasing humic acid from 0 to 6 L $ha^{-1}$.

Humic acid plays a major role in improving the growth of root which was directly correlated with enhanced uptake of macronutrients (N, P and S) and micronutrients

**Table 3.** Rice growth parameters (mean ± SE) as affected by different varieties at the two seasons of 2016 and 2017

| Varieties | Plant height (cm) | | Panicle length (cm) | | No. of tiller hill$^{-1}$ | |
|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 |
| Anber-33 | 133.49±3.98a | 126.96±2.46a | 23.73±0.68a | 25.13±0.46b | 15.03±0.38a | 15.01±0.35a |
| Yassmin | 84.67±1.24b | 85.36±1.21b | 25.43±0.28a | 27.80±0.61a | 12.29±0.40b | 12.99±2.11b |

Means in columns followed by the same letter are not significantly different at P≤0.05

**Table 4.** Rice growth parameters (mean ± SE) as affected by different fertilizer treatment at the two seasons of 2016 and 2017

| Fertilizer treatment | Plant height (cm) | | Panicle length (cm) | | No. of tiller hill$^{-1}$ | |
|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 |
| T1 | 106.47±10.90b | 104.43±9.49b | 24.40±1.31 | 26.32±0.74a | 12.71±0.78c | 13.41±0.63b |
| T2 | 118.13±12.00a | 107.43±9.88b | 25.10±0.61 | 26.75±0.40a | 13.91±0.96b | 14.00±0.46ab |
| T3 | 119.48±11.34a | 113.93±10.08a | 25.17±0.37 | 27.35±1.13a | 15.02±0.58a | 15.29±3.79a |
| T4 | 92.23±10.26c | 98.83±8.14c | 23.17±0.65 | 24.43±0.78b | 13.0±0.58c | 13.30±0.56b |

Means in columns followed by the same letter are not significantly different at P ≤ 0.05 . $T_1$: 800 kg perl humus ha$^{1}$, $T_2$: 1000 kg perl humus ha$^{-1}$, $T_3$: 1200 kg perl humus ha$^{-1}$, $T_4$: recommended chemical fertilizers.

**Table 5.** Rice growth parameters (mean ± SE) as affected by comination of variety and fertilizer treatments at the two seasons of 2016 and 2017

| Varieties X Fertilizer treatment | Plant height (cm) | | Panicle length (cm) | | No. of tiller hill$^{-1}$ | |
|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 |
| Anber-33 ×T1 | 131.80±10.75b | 125.40±3.23 | 23.00±2.40 | 24.83±0.73 | 14.30±0.41b | 14.82±0.05 |
| Anber-33 ×T2 | 146.97±9.80a | 129.40±2.38 | 24.80±1.30 | 26.00±0.43 | 15.82±0.84a | 15.00±0.42 |
| Anber-33 ×T3 | 147.67±10.63a | 136.37±2.02 | 24.53±0.23 | 26.30±0.51 | 16.00±0.68a | 15.92±0.96 |
| Anber-33 ×T4 | 107.53±1.04c | 116.67±3.53 | 22.60±1.00 | 23.37±1.07 | 14.00±0.58b | 14.30±0.98 |
| Yassmin × T1 | 81.13±1.55e | 83.47±0.76 | 25.80±0.98 | 27.80±0.11 | 11.11±0.57d | 12.00±0.55 |
| Yassmin × T2 | 89.30±2.28d | 85.47±0.13 | 25.40±0.34 | 27.50±0.28 | 12.00±0.58c | 13.00±0.51 |
| Yassmin × T3 | 91.30±2.64d | 91.50±0.96 | 25.80±0.52 | 28.40±2.25 | 14.03±0.51b | 14.66±7.5 |
| Yassmin × T4 | 76.93±0.57e | 81.00±1.00 | 24.70±0.05 | 25.50±0.87 | 12.00±0.60c | 12.31±0.34 |

Means in columns followed by the same letter are not significantly different at P ≤ 0.05. $T_1$: 800 kg perl humus ha$^{-1}$, $T_2$: 1000 kg perl humus ha$^{-1}$, $T_3$: 1200 kg perl humus ha$^{-1}$, $T_4$: recommended chemical fertilizers.

(Fe, Zn, Cu and Mn) (Chen *et al*., 2010). Saha *et al*., (2013) reported that plant height, total tillers per hill and panicle length might be increased with application of humic acid due to greater availability of nitrogen which is essential for vegetative growth. According to Vaughan and Linchan (1976) the humic acid influences the nutrition and growth of plants in an indirect manner, and might also influence the plant growth directly either through its effect on ion uptake or by more effects on the growth regulation of the plant. In our study, the perl humus fertilizer looks to be with good quality depending on its physiochemical characteristics, macronutrients content (N, P and K) and micronutrients content in form of humic acid complexes (Table 2), consequently, improved soil properties (Figures 1, 2 and 3). It combines the good characteristics of organic and inorganic sources to improve the poor nutritional status of calcareous soil, then will enhance plant growth. So, the using of perl humus has really met the expected impact in improving soil properties and plant growth.

The combination of variety and fertilizer treatments affected the growth parameters of rice at the two seasons with significant differences for plant height and number of tiller per hill at the season of 2016 (Table 5). The interaction of variety Anber-33 and 1200 kg Perl humus ha$^{-1}$ ($T_3$) produced higher values of plant height and number of tiller per hill, whereas variety Yassmin with 1200 kg Perl humus ha$^{-1}$ produced higher values of panicle length. This result indicated that application of perl humus at level of 1200 kgha$^{-1}$ resulted in maximum growth parameters with the two varieties. On the contrary, lowest growth parameters were recorded with conventional treatment ($T_4$) at the two varieties. These trends were similar at both seasons.

## Yield and yield components

Grain yield was significantly differed with different varieties (Table 6). Higher grain yield was observed at

**Table 6.** Rice yield and yield components (mean ± SE) as affected by different varieties at the two seasons of 2016 and 2017

| Varieties | Grain yield(t ha$^{-1}$) | | Straw yield (t ha$^{-1}$) | | Filled grain panicle$^{-1}$ | | 1000-grain weight(g) | |
|---|---|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 |
| Anber-33 | 6.22±0.93b | 5.24±0.21b | 6.70±0.37a | 6.63±0.26a | 187.7±9.39a | 196.7±8.48a | 17.92±0.19b | 18.00±0.24b |
| Yassmin | 7.26±0.18a | 6.72±0.17a | 5.12±0.30b | 4.69±0.14b | 166.8±6.18b | 173.2±6.37b | 21.92±0.82a | 21.83±0.63a |

Means in columns followed by the same letter are not significantly different at P≤0.05 .

**Table 7.** Rice yield and yield components (mean ± SE) as affected by fertilizer treatments at the two seasons of 2016 and 2017

| Fertilizer treatment | Grain yield (t ha$^{-1}$) | | Straw yield (t ha$^{-1}$) | | Filled grain panicle$^{-1}$ | | 1000-grain weight (g) | |
|---|---|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 |
| T1 | 6.62±0.14b | 5.95±0.37ab | 5.91±0.52b | 5.61±0.43a | 168.6±12.11b | 183.6±4.01b | 19.50±0.71c | 19.00±0.57c |
| T2 | 7.14±0.20a | 6.20±0.38ab | 6.49±0.47ab | 5.92±0.49a | 194.1±4.99a | 197.5±4.34a | 20.83±1.30a | 20.67±1.22b |
| T3 | 7.21±0.29a | 6.54±0.41a | 6.67±1.44a | 6.23±0.56a | 196.7±5.68a | 200.7±4.10a | 21.67±1.52a | 21.50±1.28a |
| T4 | 5.99±0.09c | 5.24±0.38c | 4.58±0.34c | 4.89±0.44b | 149.6±9.06c | 157.9±7.37c | 17.67±0.21d | 18.50±0.56c |

·Means in columns followed by the same letter are not significantly different at P ≤ 0.05. $T_1$: 800 kg perl humus ha$^{-1}$, $T_2$: 1000 kg perl humus ha$^{-1}$, $T_3$: 1200 kg perl humus ha$^{-1}$, $T_4$: recommended chemical fertilizers.

variety Yassmin at the seasons of 2016 and 2017. Normally, the rice grain yield is strongly influenced by the number of grains per panicle, number of panicle per plant and grain weight. In this study, the number of filled grains per panicle for variety Anber-33 was more than that for variety Yassmin (Table 6), so the reason for higher grain yield at variety Yassmin might be attributed to grain weight.

Another growth parameter that positively correlated with grain yield in term varieties, is panicle length (Table 3). That means, the increase in grain weight overcome the decline in the number of grain per panicle for affecting grain yield. This result was in accordance with a studies conducted by Latheth (1987) and Hossain *et al*. (2008) which showed that rice grain yield was positively correlated with the number of grain per panicle. However, many studies resulted a positive correlation between rice grain yield and each of 1000-grain weight and the number of grain per panicle (Satyanarayana *et al*., 2002; Al-Jbori *et al*., 2012).

Straw yield was also affected by different varieties at the two seasons (Table 6). Higher straw yield was obtained from Anber-33, which was due to the higher plant height and more number of tillers (Table 2). The maximum filled grains per panicle and minimum 1000-grain weight were obtained at variety Anber-33 as compared to variety Yassmin at the two seasons, with significant differences. The negative relationship between filled grains per panicle and 1000-grain weight in rice (also in other cereals) was reported by several studies and attributed to the fact that in the same panicle, the competitive among large number of grains for photosynthates results in small grain.

Application of humus significantly increased grain yield over conventional treatment with an increase percentages of 11, 19 and 20% at the season of 2016 and 14, 18 and 25% at season of 2017, for $T_1$, $T_2$ and $T_3$ treatments, respectively (Table 7).$T_3$ treatment (1200 kg ha$^{-1}$) produced highest grain yield at seasons of 2016 and 2017 with insignificant differences from$T_2$ treatment receiving 1000 kg perl humus ha$^{-1}$.

A similar trend was also noticed for straw yield, filled grains per panicle and 1000-grain weight (Table 7) which substantially increased by increasing humus rates over conventional treatment. This is consistent with results of Herriyanti *et al*. (2012) and Saha *et al*. (2013) which showed the application of humus substances to rice plants could improve grain yield and straw yield, as well as other yield components. This was due to the higher the dose of humus, the better the growth parameters (Table 4), so that the higher grain and straw yield. This is in accordance with Hossain *et al*.,(2008) who justified the higher rice grain yield to the long panicles and heavy grains, and justified the higher rice straw yield to the long plant. Thakur *et al*., (2013) also suggested that humic substances (humic acid and fulvic acid) with its auxin activity induce hormonal effect on catalytic cell permeability and increases nutrient uptake and dry matter. On the other hand, conventional treatment ($T_4$) produced plants with the lowest growth and yield, possibly because of the lack of organic matter in the soil to retain nutrients (Chen, 2006).

The interaction effect of variety and fertilizer treatments showed that the highest grain yield and 1000-grain weight were obtained in the interaction of variety Yassmin and $T_3$ treatment. However, the highest straw yield and filled grains per panicle were obtained in the interaction of variety Anber-33 and $T_3$ treatment (Table 8). The lowest values of yield parameters were obtained in plant under conventional treatment at the two varieties. These results suggest that application of 1200 kg ha$^{-1}$of perl humus offered better conditions when used with each of the two varieties which provided the maximum rice yield, but the differences between $T_3$ (1200 kg ha$^{-1}$)

**Table 8.** Rice yield and yield components (mean ± SE) as affected by combination of variety and fertilizer treatments at the two seasons of 2016 and2017

| Varieties X Fertilizer treatment | Grain yield (t ha$^{-1}$) | | Straw yield (t ha$^{-1}$) | | Filled grain panicle$^{-1}$ | | 1000-grain weight (g) | |
|---|---|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 |
| Anber-33 ×T1 | 6.24±0.15cd | 5.26±0.37 | 6.54±0.62 | 6.46±0.45 | 179.6±14.28 | 189.3±6.32 | 18.00±0.00de | 18.00±0.57d |
| Anber-33 ×T2 | 6.36±0.10cd | 5.44±0.38 | 7.37±0.17 | 7.00±0.18 | 202.4±1.50 | 212.1±3.05 | 18.00±0.57de | 18.00±0.57d |
| Anber-33 ×T3 | 36.40±0.21c | 5.83±0.49 | 7.87±0.38 | 7.40±0.42 | 203.1±6.07 | 214.4±5.88 | 18.33±0.33d | 18.67±0.33c |
| Anber-33 ×T4 | 5.88±0.04e | 4.45±0.11 | 5.02±0.35 | 5.65±0.54 | 165.7±19.46 | 170.8±14.38 | 17.33±0.33e | 17.33±0.33d |
| Yassmin × T1 | 7.00±0.15b | 6.63±0.31 | 5.29±0.77 | 4.76±0.12 | 157.6±0.60 | 177.9±6.36 | 21.00±0.57c | 20.00±0.57b |
| Yassmin × T2 | 7.92±0.21a | 6.97±0.30 | 5.60±0.56 | 4.83±0.19 | 185.8±10.85 | 182.8±8.79 | 23.67±0.33b | 23.32±0.33a |
| Yassmin × T3 | 8.02±0.49a | 7.26±0.28 | 5.06±0.40 | 5.06±0.17 | 190.3±7.77 | 187.1±4.79 | 25.00±0.57a | 24.33±0.33a |
| Yassmin × T4 | 6.11±0.17de | 6.03±0.29 | 4.14±0.53 | 4.12±0.41 | 133.4±4.78 | 145.1±6.94 | 18.00±0.00de | 19.67±0.33bc |

Means in columns followed by the same letter are not significantly different at P≤0.05 . $T_1$ : 800 kg perl humus ha$^{-1}$ , $T_2$ : 1000 kg perl humus ha$^{-1}$, $T_3$ : 1200 kg perl humus ha$^{-1}$, $T_4$ : recommended chemical fertilizers.

and $T_2$ (1000 kg ha$^{-1}$) treatments were insignificant. That means, the rate of 1200 kg ha$^{-1}$ of perl humus was not effective from the economic point of view, thus 1000 kg ha$^{-1}$ of perl humus was a most optimal one. Chan *et al.*, (2010) observed similar findings.

In addition, data given in tables (7 and 8) indicated that grain yield and other yield components of rice plant treated with the lowest level of perl humus (800 kg ha$^{-1}$) were significantly higher than that of rice plant treated with recommended chemical fertilizer ($T_4$). It is evident that the improvement of rice yield was obvious at all levels of perl humus fertilizer that is suitable in essential nutrients as well as enhancing their availability (Figures 1, 2 and 3) and uptake which confirmed by good plant growth, resulted in a higher grain yield.

It is clear from the obtained results of our study that rice growth and yield recorded under application of all perl humus levels were significantly higher than the growth and yield recorded under recommended dose of chemical fertilizer. Consequently, rice of both varieties can be grown organically with reasonable yield under conditions of the study area. Thus application of perl humus fertilizer has potential of not only improving rice yield, but also reducing dependence on chemical fertilizers, thereby reducing hazards caused by continuous and indiscriminate use of chemical fertilizers (Satyanarayana *et al.*, 2002). The rice yield increasing at organic fertilizers compared with recommended inorganic fertilizers also supported by Quyen and Sharma (2003) and Jien (2012).

**Organic C, available N and available P in soil:**

Organic C, available N and available P contents of soil after harvesting of rice plants at the season of 2017 were not significantly affected by rice varieties, whichhad significantly responded to humus levels (Figures 1, 2 and 3). Increasing rate of humus from 800 to 1200 t ha$^{-1}$ increased organic C from 11.23 to 12.86 g kg$^{-1}$ for variety Anber-33 and from 12.00 to 12.74g kg$^{-1}$ for variety Yassmin (Figure 1). Hanafi and Salwa (1998) and El-Etr *et al.* (2011) reported that organic C and organic matter increased as humic acid application increased. These results may be due to that the humic acid is the major component of soil organic matter, and when the organic materials in soil decay, macromolecules of a mixed aliphatic and aromatic are formed (Chen and Aviad, 1990). The lowest values of organic C were obtained for conventional treatment (T4) of 11.0 and 11.11g kg$^{-1}$ for variety Anber-33 and Yassmin, respectively with significant differences from $T_2$ and $T_3$ treatments (Figure 1).

With regard to available N, data presented in Figure 2 indicated a significant increase in available N with increasing humus levels in soils cultivated with both varieties. Available N was 92.92, 100.06 and 113.12 mg kg$^{-1}$ at variety Anber-33 and was 91.0, 98.93 and 111.13 mg kg$^{-1}$ at variety Yassmin, for $T_1$, $T_2$ and $T_3$, respectively. El-Etr *et al.* (2011); Al-Tameeni *et al.* (2014); and Sarwar *et al.*(2014) found that increasing humic acid levels increased available N in soil. The increase in available N could be attributed to the N contributed from the perl humus composition (Table 1). Furthermore, Vaughan and Ord (1991) reported that humic acid reduce the urease activity led to reduce the loss of nitrogen volatilization. This was in accordance with Al-Tameemi *et al.* (2014) who found that ammonia loss reduction were 44.02 and 68.35% for Abul-Khasseb soil and 10.20 and 28.10% for Zubair soil at the rates of 2.5 and 5.0g humic acid kg$^{-1}$ soil as compared with control treatment. As compared with $T_4$ treatment, all humus treatments recorded a

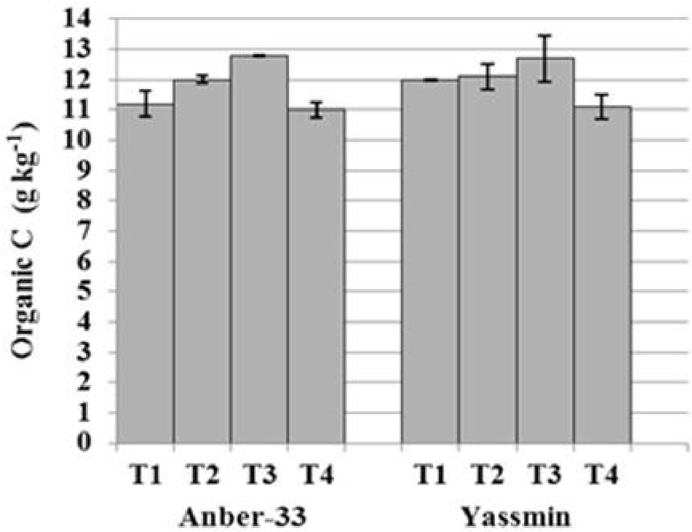


**Figure 1.** Effect of rice variety and fertilizer treatments on organic C in soil at the end of 2017 season. (T1: 800kg perl humusha$^{-1}$; T2: 1000kg perl humusha$^{-1}$; T3: 1200 kg perl humusha$^{-1}$; T4: recommended chemical fertilizers)

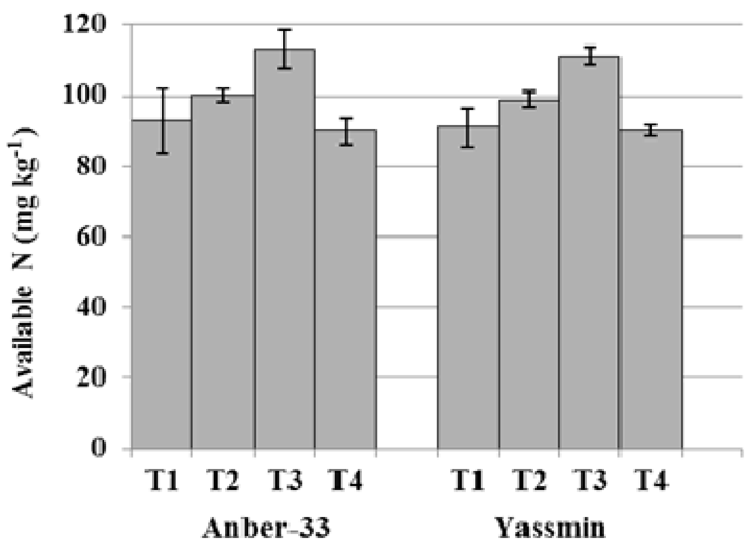


**Figure 2.** Effect of rice variety and fertilizer treatments on available N in soil at the end of 2017 season. (T1: 800kg perl humusha$^{-1}$; T2: 1000kg perl humusha$^{-1}$; T3: 1200 kg perl humusha$^{-1}$; T4: recommended chemical fertilizers)

highest values of available N with significant differences for $T_2$ and $T_3$ treatments.

Increasing levels of perl humus could increase the soil P available in both plots cultivated with Anber-33 or Yassmin (Figure 3). This increase was related to the P content in perl humus fertilizer. Results also indicated that available P values at all humus levels were significantly higher than that of conventional treatment. This result is in accordance with Herviyanti *et al*. (2012) and Sarwar *et al*. (2014) who reported a positive effect of humic acid on available P in soil due to reducing the P fixation and increases its availability through chelation effect. Moreover, Malcoln and Vaughan (1979) suggested that soil P activity improved by humic acid as a result of increasing phosphatase which hydrolyses the phosphate esters into inorganic P.

**Economic analysis**

Data in Table 9 showed that gross margin per hectare of perl humus levels were higher than chemical fertilizer

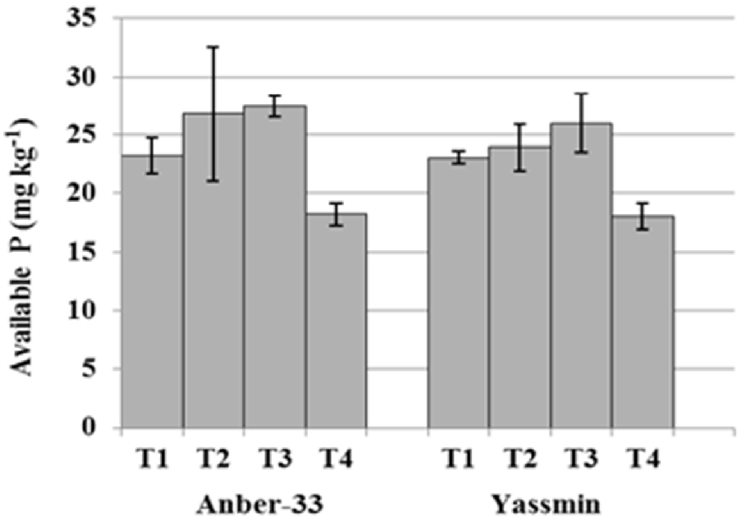


**Figure 3.** Effect of rice variety and fertilizer treatments on available P in soil at the end of 2017 season. (T1: 800kg perl humusha$^{-1}$; T2: 1000kg perl humusha$^{-1}$; T3: 1200 kg perl humusha$^{-1}$; T4: recommended chemical fertilizers)

**Table 9.** Economic analysis of perl humus fertilizer and chemical fertilizers for variety Yassmin at 2016 and 2017 seasons.

| Season | Fertilizer treatment | Gross return (ID) | Total available cost (ID | Gross margin (ID) | Net margin of perl humus over chemical fertilizers (ID) |
|---|---|---|---|---|---|
| 2016 | 800 kg perl humus ha$^{-1}$ ($T_1$) | 4, 802, 000 | 880, 000 | 3, 922, 000 | 1, 350, 600 |
| | 1000 kg perl humus ha$^{-1}$ ($T_2$) | 4, 977, 000 | 1, 100, 000 | 3, 877, 000 | 1, 305, 600 |
| | 1200 kg perl humus ha$^{-1}$ ($T_3$) | 5, 075, 000 | 1, 320, 000 | 3, 755, 000 | 1, 183, 600 |
| | Chemical fertilizers ($T_4$) | 4, 277, 000 | 1, 705, 600 | 2, 571, 400 | -------- |
| 2017 | 800 kg perl humus ha$^{-1}$ ($T_1$) | 4, 641, 000 | 880, 000 | 3, 761, 000 | 1, 245, 600 |
| | 1000 kg perl humus ha$^{-1}$ ($T_2$) | 4, 879, 000 | 1, 100, 000 | 3, 779, 000 | 1, 263, 600 |
| | 1200 kg perl humus ha$^{-1}$ ($T_3$) | 5, 082, 000 | 1, 320, 000 | 3, 762, 000 | 1, 246, 600 |
| | Chemical fertilizers ($T_4$) | 4, 221, 000 | 1, 705, 600 | 2, 515, 400 | ---------- |

1 US $ = 1,250 Iraqi Dinnar (ID)

treatment ($T_4$) at the two seasons, consequently net margins per hectare over $T_4$were 1, 350, 600; 1, 305, 600 and 1, 83, 600 Iraqi Dinnars (ID) at the season of 2016 and were 1, 245, 600; 1, 263, 600 and 1, 246, 600 ID at season of 2017, for $T_1$, $T_2$ and $T_3$ treatments, respectively. Data also revealed that the higher net margin per hectare was recorded at T1 treatment at season 2016, but with little differences (45, 000 ID ha$^{-1}$) for $T_2$ treatment, while the higher net margin per hectare at season of 2017 was recorded at $T_2$ treatment. The higher gross margin at perl humus fertilizer was obtained as a result of high rice yield and low cost of fertilizer as compared with chemical fertilizers used (NPK + Urea).

## CONCLUSION

The application of perl humus fertilizer at rate of 800, 1000, or 1200 kg ha$^{-1}$ significantly improved rice growth and yield as compared with recommended chemical fertilizers. Rice growth and yield were increased with increasing perl humus rate, however, the application of 1200 kg ha$^{-1}$ was statistically at par with 1000 kg ha$^{-1}$. It may be concluded that rice of both varieties (Anber-33 and Yassmin) can be grown organically with reasonable yield and therefore reduce fertilizer cost and ensuring a safe environment.

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