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EFFECT OF PLANT SPACING SYSTEM AND SOIL AMENDMENT IN GROWTH AND YIELD OF RICE PLANTS (*ORYZA SATIVA* L.)

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Abstract

A field experiment was carried out at the Rice Research Station in the Mashkhab Sub-District, Department of the General Committee for Agricultural Research during the 2014 growing season to study the effect of different types of transplant spacing and soil amendment in growth and yield of rice cultivar Yasmin. The experiment was RCBD factorial with three replicates. First factor was three plant spacing (10x20, 15x25 and 20x30 cm) while the second factor was using three types of plant residues (organic matter) including corncobs, river algae powder and hornwort *Ceratophyllum* residues. The results showed a decrease in the number of days from planting until the physiological maturity in the 20x30 spacing. The 10×20 spacing resulted in the highest numbers of filled grains/panicle, panicles/unit area, yield and biological yield. Whereas, the treatment of the 20 × 30 spacing had the highest plant height, weight of 1000 grains and harvest index. The control treatment (no soil amendment) resulted in least number of days from transplanting to maturity and number of panicles/unit area, while corncobs amendment had the length of the dahlia, the number of grains filled, the weight of 1000 grains, the grain yield and the biological yield was greater. The addition of algae powder was higher in plant height and harvest index. The maximum yield of 10 × 20 and the addition of corn calves were given. The highest yield was 6.9 tons. Therefore, we recommend cultivating the Jasmine category with a distance of 10 × 20 with the addition of the corn shell.

Keywords : (organic matter) including corncobs, river algae powder and hornwort *Ceratophyllum* residues, *Oryza sativa* L.

Introduction

Rice (*Oryza sativa* L.) is one of the most important grain crops in the world. It is a major food for more than half of the world's population. It occupies the second rank after wheat in terms of economic importance and cultivated area. The annual production of rice is estimated to be 744.4 million tons in 114 countries out of 193 countries (REF). Fields that continuously cultivated with rice usually suffers from lack of nutrients (REF). This causes rice farmers and growers to seek and use various fertilization methods (artificial and natural) to increase production in soil of these fields, which in turn, raises the cost of production. Chemical fertilizers are favorable for their rapid effect. However, they do not last in the field, do not improve physical properties of soil structure and they increase soil salinity; resulting in soil fertility decline (REF). Recent researches concentrate on the use of plant residues for fertilization in order to improve soil properties, increase organic compounds and enhance soil microbial activities. This will help to accelerate organic materials decomposition, increase minerals availability and plant root growth, in addition to the role of organic matter in increasing the soil's ability to conserve water and nutrient retention (MohdKhairi,2011). On the other hand, organic fertilizer added to the soil is friendly to the environment, providing a slow release of nutrients through the microbial activities for better plant growth (Sabh *et al.*, 2008). (Atti, Alaa Saleh *et al.*, 2005) showed that the addition of crushed yellow corncobs to the soil of different types resulted in increasing soil content of humics and viscosity of Fulvic acid over time.

Amelung *et al.* (1998) indicated that higher rates of organic matter in the soil helps to increase the effectiveness of soil microorganisms due to higher water content that helps in decomposition of organic matter. It was found by (Al-hadithy *et al.*, 1999) that application of ceratophylum plants powder as seed germination medium holds 4-6 times amount of water over its actual weight, in addition to its high content of nitrogen, potassium and calcium and a low proportion of phosphorus.

Dwayne (1999) stated that soil amendment with organic matter plays a major role in increasing the soil fertility, provision of nutrients and minerals and improving soil's chemical and physical properties including ionic capacitance water holding capacity and the release of stimulants amino acids. It has been shown by (-O'Dell, 2003) that the seaweed extracts contain nutrients and active compounds essential for plant growth such as macro elements (K, P, N) and micro nutrients (Fe, B, Mg, Zn, Mo, Cu) as well as plant promoting hormones (oxins, gibberellins and cytokines). These hormones can be sprayed on plant shoot or applies to plant soil to when added to soil to stimulate root growth, increase leg thickness and increase vegetative growth by increasing the efficiency of photosynthesis. They may also reduce stress due to adverse conditions such as drought, coldness and aging.

Potter (2005) pointed out that plant application with marine algal extracts increase leaf area and chlorophyll content and thus increase total carbohydrates formed through photosynthesis. They also stimulate formation of vigorous and complex root mass, which increase nutrients uptake, general plant health and consequently plant resistance pests and pathogens. Rice productivity per unit area varies from a country to another. Several factors can play major roles in the countries with low production of rice crop. One of the most important factors is the omission of using modern methods in rice cultivation. Transplanting in rice cropping is one of these methods which came with several advantages over other cultivation methods. It increases rice productivity per unit area and seeds quality. In addition to its low requirement of seeds quantity which estimated to be one third of that used in traditional sewing method, it helps in selection of strong seedlings and enable growing rice in the wheat fields where to be proper for late harvest. Transplanting method for rice cultivation can also reduce the amount of irrigation water during the growing period, costs of weeds control and facilitate early weed management in rice fields while rice plants are in the nursery. This method also allows controlling planting distances, as the wide distances between plants leads to maximum roots growth and shoot branching and more appropriate plant canopy which allows highest plant's performance based on its genetic traits (Al-Mashhadani, 2010). It was mentioned by (Henri, 1993) that distances between seedlings depends on the choice of the farmers and their experience. Planting spacing is generally decided according to rice cultivar/variety, nature of growth, soil type, climatic conditions and density of seedlings (REF).

Higher yield can be obtained mostly at wider distances (40-50 cm) between plants in good soil conditions. SRI's practical applications include early seedling, wide spacing and planting a single plant/hall, with the least use of irrigation water while maintaining maximum growth of branches and roots (REF). (Mustapha, 2002) used three different planting densities at planting spacing of (20x20), (30x30) or (40x40) cm for two rice varieties with SRI system. The two distances 20 x 20 cm and 30 x 30 cm resulted in similar grain yield, but the biological yield increases with increasing distance. (Qingquan, 2002) emphasized on more spacing between seedlings for better plant growth and nourishment, but closer plant spacing may also appropriate with some varieties. In recent years, China's agricultural applications have seen the transition from narrow to wide spacing distances in high-yield varieties, especially hybrid rice varieties. It was found to be effective for more improved plant photosynthesis and vegetation, an increase in branch formation and number of grains per panicle and to lessen irrigation water needed (REF). According to (Uprety, 2005) recommends plant spacing of 30x30, 25x25 or 20x20 cm depending on the nature of growth and branching rate of the variety. However, some farmers use spacing of 25x20 cm, while (Al-Mashhadani *et al.*, 2010) recommended (10 × 30) cm and (15 × 20) cm. This study is to evaluate the effects of three planting spacing and three different plant residues and their interactions on growth and yield of rice 'Yasamine Hybrid'.

Materials and Methods

A field experiment was carried out at the rice research station in Al-Mashkhab district, province of Najaf during the 2015 growing season. The experiment was 3X3 factorial in RCBD with three replicates. The first factor was three types of organic material which are corncobs, river algae and hornwort (T1, T2 and T3) in addition to the control T4 while the second factor was three planting spacing of 10 × 20, 15 × 25 or 20 × 30 cm (C1, C2, C3), respectively. Rice seeds cultivar Yasamin Hybrid were sewed in growing treys and maintained in the seed nursery for one month then transferred to the temporary field nursery before planting in the experimental plots. Plots were subjected for plowing, smoothing and leveling process while flooded. The experimental field was divided into 36 (2x3 m) plates (units) with 50 cm between plates. The plant residues (algae residues, corncobs and hornwort) were prepared by drying and grinding. The urea was added at rate of 30 g / kg residue powder and the mix was subjected for partial composition for two months by moisturizing and flipping every two weeks. The mix then was added to the experimental plates by 10 ton/hectare. The control plates were treated with only NPK (18-18-0) at rate of 400 kg/hectare. Urea 46%N) was applied to all units 10 and 40 days post transplanting at rate of 140 kg/ha. Plant's growth parameters were measured for five random plants of each experimental unit. Total yield and the biological yield were measured for three 1.5 m protected lines of each experimental plate. Plants were harvested manually, dried at 75 C ° for 48 hours and plants and grains were weighed to calculate the biological yield with relative humidity equal to or below 14%. The data were statistically analyzed using Genstate Discovery Edition 3 and the least significant difference (LSD) was used at 5% to compare differences between means among treatments.

Table 1 : Some of chemical and physical properties of the experiment soil

Ph	EC	pH GW	EC GW	NO_3	P Ppm	K Ppm	Soil texture
8.4	3.77	7.10	2.87	32.3	144.8	9.45	Clay-silt

Table 2 : Some of chemical contents of plant residues used in the study

Plant material	pH	EC	Organic Matter%	C/N %	P g/kg	K g/kg
Corncobs	6.21	6.15	68.21	34.49	4.31	9.36
Algae powder	7.87	5.68	54.47	44.95	5.53	10.30
Hornwort	7.11	5.40	57.51	11.30	5.38	10.90

Results and Discussion

The number of days of cultivation until physiological maturity

The number of days for maturity was reduced with the reduction of spacing between plants and vice versa (Table 3). The number of days decreased significantly from 138.3 to 136.7 days with a decrease of 1.01% when increasing the plant density. The narrow spacing distances between plants does not allow the plant to grow normally (Al-Issawi, 1998), (Krishna and Biradarpatil, 2009) and (Al-Mashhadani, 2010). The addition of plant residues significantly affected the number of days from transplanting till physiological maturity. The lowest number of days (135.5 days) was recorded in the control (T4) treatment in the least spacing, while longest period of 140 days was in the T1 in the type 3 spacing. This is mostly due to the high proportion of organic substance in the corncobs (Table2) which provided the appropriate conditions and nutrients for normal plant growth. The period from transplanting to maturity was highly affected by the interaction of organic material type and plant spacing

Plant height

The effect of plant spacing was significant on plant height (Table 3). Similar to that of period to maturity, plant height increases as the spacing increased. C3 spacing resulted in the highest plant height of 78 cm while C1 had the lowest that of 76.3 cm with a decrease of 1.98%. It was found that plant density had a negative effect on vegetative growth due to competition among plants (Al-Mashhadani, 2010). The T2 treatment was more effective to increase plant height than the other treatments. This can be attributed to Table 3.

Table 3 : Effects of plant spacing and plant's residues amendment on number of days to maturity, plant height, panicle's length and number of panicles/unit area of rice var. Yasmin Hybrid

Soil amendment	Number of days to maturity			Plant's height cm			Panicle's length cm			number of panicles/unit area		
	plant spacing			plant spacing			plant spacing			plant spacing		
	C1	C2	C3	C1	C2	C3	C1	C2	C3	C1	C2	C3
T1	138.4	138.5	140.1	75.2	76.3	76.4	21.3	21.4	21.6	372.6	317.0	302.0
T2	136.3	136.5	137.4	78.6	79.8	81.5	20.7	20.9	21.2	380.6	357.0	355.3
T3	137.1	137.8	138.6	77.2	77.8	79.4	20.2	20.5	20.0	403.0	398.0	377.0
T4	135.5	136.3	137.1	74.3	74.6	74.8	19.3	19.3	19.8	420.0	415.3	400.0
	T	C	T*C	T	C	T*C	T	C	T*C	T	C	T*C
LSD (*P*<0.05)	1.4	0.7	0.8	1.7	0.9	1.0	0.2	n	0.1	3.2	1.6	1.9

Table 4 Effects of plant spacing and plant's residues amendment on number of filled grains/panicle, 1000 grain's weight, grain yield, biological yield and harvest index of rice var. Yasamine Hybrid

Soil amendment (treatments)	No. of filled grains/panicle			1000 grain weight			Grain yield T/h			Biological yield T/h			Yield index		
	plant spacing			plant spacing			plant spacing			plant spacing			plant spacing		
	C1	C2	C3	C1	C2	C3	C1	C2	C3	C1	C2	C3	C1	C2	C3
T1	114.2	129.3	132.2	22.6	23.6	24.0	6.9	6.7	5.6	13.8	12.3	11.8	30.3	36.5	46.1
T2	110.0	118.7	121.3	22.6	22.4	23.8	6.3	6.2	5.6	14.8	13.7	12.6	49.9	49.1	44.4
T3	100.3	106.5	104.6	21.0	21.8	22.0	6.8	6.3	6.0	14.8	14.6	13.5	45.9	43.2	44.6
T4	91.6	95.4	97.6	20.5	20.3	20.0	5.4	4.5	6.2	16.1	15.8	14.6	39.3	39.6	38.7
	T	C	T*C	T	C	T*C	T	C	T*C	T	C	T*C	T	C	T*C
LSD (*P*<0.05)	1.7	0.9	1.0	0.3	0.2	0.2	0.09	0.04	0.05	1.80	0.09	0.10	0.8	0.4	0.4

The high contents of nitrogen and phosphorus and potassium in algae powder (Table 2). Again, positive interaction effect was also found between plant residues and the wider plant spacing. The C3+T2 interaction treatment resulted in the highest plant height (81.5 cm) compared to the lowest (74.3 cm) from the C1+T4 treatment.

The length of the panicle

The panicle's length was also affected by plant spacing system, but not by different plant residues applications (Table 3).

The highest panicle's length was recorded in treatments C2 and C3 compared to C1. Although plant residues had no significant effects on panicle's length, the T4 treatment again resulted in the highest length among other treatments. The reason was due to the increase in organic matter in the corncobs (Table 2) and the slow decomposition of the organic material provided nutrients for vegetative growth until maturity and production. Interaction of C3+T1 had also the highest value (21.6 cm) while the C1+T4 and C2 +T2 resulted in the lowest value of 19.3 cm.

Number panicles per unit area

As shown in table 3 that the number panicles per unit area were highly affected by plant spacing, but not due to plant residues applications. The highest number was found in the C1 (394.1) while the lowest was in the C3 (358.5) with an increase of 9.93%. This may be due to the increase in the branching percentage per unit area, since the rice plant has the capacity to produce higher number of branches base on availability of light, nutrients and other suitable conditions (Al-Mashhadani,2010) and (Krishna et al,2009). The addition of plant residues was significant in the number panicles per unit area. The control (T4) gave the highest number of panicles (411.8) while other treatments of plant residues resulted in lower values. This may be due to the rapid degradation and releasing of chemical fertilizers as compared with other plant residues, which provided nutrients for plant growth, especially in the early stages of plant growth. Except for the control treatment (mineral fertilizer), plant residues interacted with plant spacing had no significant effect on the number of panicles per unit area. C1+T4 had the highest number of kernels (420) while the treatment C3+T1 resulted in the lowest (302.2).

Number of filled grains per panicle

The wider plant spacing had significant positive effect on number of filled grains per panicle (Table 4). The C3 resulted significantly in the highest number of filled grains per panicle over the two spacing systems. The increase in plant density increased competition among plants. The number of grains is controlled by the available quantities of nutrition stored in the plant body. The increase in number of panicles per unit area is usually accompanied by a decrease in the number of filled grains per panicle (Table 4). This is in line with findings of (Al-Mashhadani, 2010) and (Vijayakumar *et al.*, 2006) where increased spacing between plants leads to much higher number of grains per panicle. The addition of plant residues was significant in producing higher number of filled grains/panicle (Table 4). T1 had the highest number of filled grains/panicle (125.1) while the T4 treatment resulted in the lowest (94.8). Similarly, interaction treatment C3+T1 significantly resulted in the highest number of filled grains (132.2) compared to the lowest (91.6) from the C1+T4 interaction.

1000 grain's Weight

The weight of 1000 grains was significantly affected by both plants spacing system and plant residue amendment (Table 4.) generally the more spacing between plants resulted in higher grain's weight. In the same way, the corncobs resulted in the highest grain's weight over the other plant residues treatments including the control. The grain's weight is one of the most vulnerable yield components to environmental conditions because it is formed in late stages of plant vegetative growth. Planting density and high competition among plants may cause severe stresses on plant photosynthesis and carbonation processes during flowering and grain maturation stages. Plants in the high density tend to increase vegetative growth at the expense of fruit formation which is reflected negatively on the weight of the grains. Plant residue (Al-Mashhadani, 2010) and (Vijayakumar, 2006) amendment had significant effect on weight of 1000 grain. The highest weight (23.4 g) was recorded in the T1 treatment while the lowest (20.3 g) was in the T4. The low weight in the control treatment is mostly due the largest number of panicles per unit area detected in this treatment (Table 4). The weight of 1000 grains was significantly affected by interaction of soil amendment and plants spacing system.

Grain yield

Generally, higher grain yield was detected in the reduced plants spacing where C1 resulted in the highest yield (6.3 T/h), while the C3 gave the lowest yield (5.3 T/h). The increase in the number of panicles per unit of area was also in relation to the increase in the number of days to maturity (Table 3) which led to increase of the leaf area exposed to solar radiation and contributed to the increase in activities during developmental stages of the grain (Al-Mashhadani, 2010) And (Sarath *et al.*, 2003). Soil amendment treatments also differed in their effects on grain yield. Highest yield value was recorded in the T1 while the lowest was in the T4 (control). This came to be supportive to T1 former results in which highest values where recorded in terms of length of panicle, number of panicles/unit area and the weight of 1000 grains. The highest yield was in the interaction treatment of C1+T1 compared tio the lowest yield from the interaction of C3+T4.

Biological yield

The biological yield was significantly affected by both plant spacing system and soil amendment treatments (Table 4). The results showed that the increase in the number of branches in the unit of area (Table 4) was always in relation with reduced spacing and more plants density. It (Longxing *et al.*, 2002) and Al-Mashhadani, (2010) it is not difficult to achieve high production of dry matter during highly favorable conditions such as high plant densities, high solar radiation and abundance of nitrogen (Longxing *et al.*, 2002) and (Al-Mashhadani, 2010). Plant residues 9 soil amendment) had negatively significant effect on the biological yield, as the control treatment T4 resulted in highest value (15.5 T/h) especially when interacted with the least spacing C1 (16.1 T/h) while the treatment T1 interacted with the widest spacing C3 gave the lowest biological yield (11.8 T/h). This is mostly due to the increase in the number of branches and panicles per unit area.

Harvest index

Harvest index was affected by plant spacing and different soil amendment treatments (Table 4). Higher mean values of the harvest index were recorded in wider spacing, as C3 resulted in the highest values while C1 gave the lowest. The harvest index depends on grain production and biological yield, and the increase of each of them is inversely proportional to the other. Harvest index was more positively affected by the T1 (Algae powder amendment) than the other treatments. However, C1 interacted with T2 resulted in the highest harvest index value (49.9) while the C1 Spacing interacted with T1 soil amendment gave the lowest harvest index value (30.3).

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