Response of Jasmine rice to different levels of irrigation and organic fertilization under SRI cultivation method

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DOI: https://doi.org/10.36077/kjas/2023/v15i2.10351

Received date: 12/9/2022

Accepted date: 24/10/2022

Abstract

Maintaining a certain level of rice production must coincide with maintaining soil fertility, reducing pollution to the environment, and reducing water consumption. A field experiment was carried out during the 2020 summer growing season in a spot of Al-Issa county-Abbasiya district in the province of Najaf, in order to study the effect of different levels of irrigation and organic fertilizers on the growth, yield and components of the local rice variety Jasmine. The experimental plants were planted on June 17, according to the rice intensification system (SRI) method, by seedling method, at distances of 25 cm between seedlings and lines, with one seedling in the hole. Weeds were removed by hand three times. It was designed as a factorial experiment using a randomized complete block design (RCBD) with three replicates, where the irrigation levels (daily, 3 or 7 days irrigation intervals) as the main factor, while the organic fertilizers at two levels (10 and 5 ton.h^{-1}) were the secondary factor. The results showed that irrigation at 3 days intervals in clay soil mixed with the use of 10 ton.h^{-1} of organic fertilizers in SRI gave the highest rates of growth characteristics and yield components of Jasmine rice. In the case of irrigation and soil conditions in the study site, SRI is recommended to reduce water consumption and maintain an acceptable level of soil fertility, taking into account maintaining a level of production.

Keywords: Rice, Jasmine, Irrigation levels, Organic fertilizer, System of rice intensification (SRI

Introduction

Rice (*Oryza sativa* L.) is an important cereal crop all over the world. It is the main food for more than half of the world's population. Its annual global production is 744.4 million tons, and it comes second after wheat in terms of cultivated areas, which amount to 163.2 million.h^{-1}, with a productivity rate of 4.41 tons.ha^{-1} and more than 90% of rice is produced and consumed in Asia (9). In Iraq, rice is considered one of the strategic crops and comes after wheat and barley in cultivated and productive areas. Until 2019, it was planted with a total area of approximately 127,841 thousand hectares, with a production of approximately 392,950 thousand tons, with a productivity rate of 3.074 tons.ha^{-1} (Ministry of Planning, 2019). The nutritional importance of rice lies in the fact that it contains a high percentage of easily digestible carbohydrates, besides that rice protein has a balanced content of essential amino acids, especially lysine, compared to other grains (4).

In addition to its impact on the nature and quantity of production, water resources are the main determinant of agricultural production and expansion, especially in arid and semi-arid areas, as the agricultural sector is the main consumer of water (1). Although the worldwide water scarcity issue, the rice crop is the largest consumer of water and rice is always linked to the mention of water (2). The succession of planting wheat after rice caused a decline in soil fertility. In addition, following a traditional irrigation method by flooding the crop in water at a level of 5-10 cm throughout the growth period, requires large quantities of water. Such amounts of water are difficult to provide to irrigate rice fields at a time of water scarcity in Iraq annually, especially in summer, which requires higher amounts of water due to high temperatures. This was the reason for the fluctuation of the areas planted with the rice crop as a result of its dependence on the quantities of water available annually.

The current traditional practice of farmers in rice production in Iraq is to keep the plant in water at a depth of 5-20 cm throughout the growing season (7). This requires large amounts of water, which was estimated at 70,000 m^3/ha^{-1} for the length of the growing season of the crop according to the Japanese expert, Ito, who visited Iraq in 1963 (8). Therefore, it is necessary to think and make strategies to change the traditional methods of rice cultivation to enable farmers to improve productivity and quality of soil and environment. This is by making rice cultivation less demanding on water and moving towards raising the scientific and cognitive skill of farmers in understanding the crop environment to reduce production costs and increase farmer income. The System of Rice Intensification (SRI) method is a suitable alternative to solve the problems facing the current rice cultivation (21).

The SRI system is an agricultural method developed in Madagascar that increases rice production while reducing expenditures on fertilizers and chemicals (29 and 22). Moreover, the SRI system is a method of reducing irrigation (Satyanarayana *et al*., 2007) with some practices that require more care in managing everything related to plants such as soil, water and nutrients (21). Some researchers have been conducted showing the possibility of rice growing naturally and with high yield under shallow water depth compared to deep immersion. The surface water causes the water temperature to rise during the day and lower it at night, this allows more panicle formation and better growth. Most rice cultivars produce the highest grain yield when the soil water content remains near saturation during the season, similar to continuous irrigation (14). This means that the best yield does not require water to remain above the soil surface and water applications can be reduced by adopting SRI methods without reducing the yield. A real increase in the yield can be achieved with less water and good soil drainage (13 and 21).

On the other hand, the intensive use of water for a long time will create some problems in depleting soil fertility in addition to the interaction with the elements causing deficiency of micro-nutrients (12). Moreover, chemical fertilizers pollute soil and water and make the environment more harmful to wild and aquatic lives. The use of inorganic nitrogen fertilizers is always expensive for crop production. In the near future, nitrogen fertilizer will be more expensive, so the proper use and management of organic fertilizer may reduce the need for chemical fertilizers and allow farmers to save part of the cost of crop production. SRI's method of growing rice in sustainable agriculture is increasing and spreading with time. This is for its advantages in improving soil quality from a biological rather than chemical point of view, especially when using organic fertilizers as complementary elements according to the recommended and balanced with mineral fertilizers (5).

Application of SRI with plant, soil, water and nutrient management often enriches soils biologically, but this is still being verified. Therefore, this study came to reveal the effect of water and fertilizer management through the application of the SRI system in the production of jasmine rice.

Materials and Methods

A field experiment was conducted during the 2020 summer growing season in a spot of Al Issa district-Abbasiya district in Najaf Governorate. The experimental plants were transplanted on June 17, when the seeds were sown in plastic dishes (28 x 58 x 3 cm) filled with fine soil. After germination, they were transferred to a nursery near the experiment site with an area of (2 x 3 meters), which was leveled with the aid of (2-3).) cm water layer above the soil surface. The seedlings at age of 15 days were taken and transplanted according to the System of Rice Intensification (SRI) method, using a square seedling method at distances of 25 cm between each two seedlings, one seedling per hole. Each experimental unit was (5x4 meters), where the plants were irrigated daily. Weeds were manually removed three times, and half of the recommended amount of chemical fertilizer was added to all the experimental units and the replications. The experimental units were distributed as a factorial experiment using a Randomized Complete Block Design (R.C.B.D) with three replicates, where the irrigation levels (daily, 3 or 7 days irrigation intervals) as the main factor, while the organic fertilizers at two levels (10 and 5 tons.ha^{-1}) were the second factor.

During the first ten days of seedlings, water was added to the treatments in the same amount at a depth of 7.5 cm daily to ensure a good foundation of the seedlings. For the continuous irrigation method, water is added daily with a layer of water 10 cm above the soil surface during the growing season. The 3 and 7 days intervals method was implemented for alternating irrigation, approximately 8.5 cm depth for each irrigation. A water meter was used to measure the amount of water consumed for the three

Table 1. Specifications and percentages of the elements and components of the organic fertilizer used in the study experiment

Propriety	Value	Propriety	Value
EC	2.40	Ca%	1.92
PH	7.07	Mg%	0.71
C%	47.4	Fe%	0.523
N%	2.61	Zn%	0.075
P%	0.62	Mn%	0.011
Na%	0.48	Cu%	0.006
K%	1.03	C/N	18.1

Source: The Organic Agriculture Center in the province of Najaf

Temperatures were recorded at the experimental site in Najaf during the rice growing season from June to November 2020 (Table 2).

Table 2. Agro-meteorological data in the experiment area during the growing season of the crop 2020

Month	Air temperature ºC			evaporation (mm/month)
	Max	Min	Average	
July	42.02	26.58	34.30	255.10
August	42.34	27.77	35.06	255.20
September	39.10	23.36	31.23	167.50
October	33.53	20.32	26.93	108.40
November	26.53	11.32	18.67	96.50
Total evaporation during the growing season of the crop 1,147.5 mm				

Source: Center Agricultural Meteorology, Ministry of Agriculture - Republic of Iraq

The soil was prepared in terms of tillage, smoothing and leveling, and random samples were taken to analyze the soil and determine some of its physical and chemical properties at the experiment site (Table 3).

Table 3. Some physical and chemical properties of the study soil before transplanting

Properties	Unit	Value
pH 1:1	-	7.4
E.C. 1:1	Ms/cm	3.7
Available Nitrogen	Ppm	77.0

Available potassium	Ppm	560.0
Available phosphorous	Ppm	35.6
Organic matter	%	1.65
CaSO4	%	0.91

irrigation levels during the growing season of the crop by using a hydrometer: for daily irrigation (75550 $m^3.ha^{-1}$), for irrigation every 3 days (37443 $m^3.ha^{-1}$), and for irrigation every 7 days (21490 $m^3.ha^{-1}$).

At the physiological maturity stage, 3 m^2 samples were randomly taken from each treatment to determine the grain yield. Also, ten random panicles samples were taken from all the treatments to measure the yield components. The data were statistically analyzed using the analysis of variance method and the statistical program GenStat (10) was used to analyze the data for each of the traits, then the means were compared using the Least Significant Difference (L.S.D) at 5% probability level.

Results and Discussion

From the presented results (Table 4), it is noted that there are significant differences between the averages of some vegetative growth characteristics of the treated plants. The interaction treatment of 10 $tons.h^{-1}$ fertilizer and irrigation at interval of 3 days led to the highest plant height (90.40 cm), panicle length (25.63cm), biological yield (24.50 g), and the number of panicles per square meter (341.7). Whereas, the lowest values of the mentioned indicators were in the treatment of 5 $tons.h^{-1}$ with the application of daily irrigation or alternating irrigation with7 day's interval, which differed significantly. This is mostly attributed to the availability of nutrients as a result of using organic fertilizers and the activity of microorganisms in organic matter decomposition, which increased as the soil aeration increased when using alternating irrigation at 3 days intervals. Thus, increasing root system activities, carbonic representation, and thus plant height to obtain more light which is important in carbon metabolism. This is in addition to the high cation exchange capacity, which may have increased the availability of other elements to plant roots. The application of alternating irrigation every 3 days interval allowed good aeration and better root growth (18). The increase in panicle length is also due to much nutrients availability as a result of adding organic fertilizers and its significant effect on increasing plant growth in general, including cluster length (2 and 5). The interaction treatment of applying 10 $tons.h^{-1}$ and 3 days interval alternating irrigation led to 34.24% higher of biological yield compared to continuous irrigation at the same level of fertilization. This result agreed with Dawe *et al.* (5) and Hameed *et al.*(8) who showed the highest biological yield of organic rice when alternating irrigation was applied.

As for the number of panicles per square meter, it decreased when the irrigation intervals increased. Irrigation at long intervals may lead to a reduction in the growth of stem nodes under soil surface and increases competition between old and new tillers for nutrients in the main stem under conditions of water stress. These materials are often insufficient to meet the requirements of the tillers to continue growing, which leads to the death of a large number of branches and a decrease in their number, and their ineffectiveness in carrying clusters (11 and 17).

It is clear from the results (Table 5) that there is a significant effect in irrigation levels on the panicle content of true grains and infertility rate. The interaction treatment of 5 tons.h^{-1} and the application of alternating irrigation at an interval of 7 days gave the lowest number of grains in the panicle (85.90 seeds/panicle) and the highest infertility rate (17.03%) and lowest average of 1000 seed weight (15.47g) and total yield (3.933 ton.h^{-1}), compared to (172.37 seeds/panicle) and lowest infertility rate (4.53%) and highest average of 1000 seed weight (25.41g) and total yield weight (8.067 ton.h^{-1}) in the treatment of 10 tons.h^{-1} with irrigation at an interval of 3 days. The lack of water and the prolonged period of water stress especially at day higher temperature (Table2) have negatively affected the process of pollination and fertilization, and thus led to a clear increase in the number of failed seeds and infertility rate (11).

The increase in nutrients from organic fertilizers led to an improvement in the root and vegetative growth, which was reflected in an increase in the efficiency of photosynthesis and thus led to an improvement in the performance of the cereal crop, which was reflected in an increase in true fertilized grains (3 and 7) and Hassan *et al.*, 2015). The 3-day irrigation intervals helped in providing adequate air and moisture conditions, which led to the formation of active, prolific and healthy roots. This helped an increase in the absorption of nutrients from the soil to plant parts and panicle in the stage of emergence and maturity, and thus increasing yield weight (8). The presence of high nutrients from organic fertilizers led to an improvement in the root and vegetative growth and an increase in efficient photosynthesis and consequently an improvement in the crop performance, which was reflected in the increase in fertilized grains (3 and 7). The use of irrigation with long intervals and the prolonged period of water stress has negatively affected the overall vital processes in the plant, which affected the stages of vegetative growth and flowering, and thus affected the total grain yield. The increase in yield in the treatment of 10 tons.h^{-1} fertilizer and 3 days interval irrigation due to the superiority of this treatment in the number of panicle and the weight of 1000 grains, agreeing with previous similar results by Haque and Pervin, (9).

Conclusion

It is concluded from this experiment that fertilization with 10 tons.h^{-1} decomposed organic fertilizer in combination with irrigation at 3 days interval in clay mixture soil resulted in the highest growth rates and yield of jasmine rice. The adoption of System of Rice Intensification (SRI) is a suitable alternative to solve the problems facing current rice cultivation processes to reduce water and increase soil fertility.

Conflict of Interest

The author have no conflict of interest

Table 4. Effect of different levels of irrigation and fertilizers on plant height, cluster length, biological yield, and No. of clusters/m² of jasmine rice cultivated in SRI method for the 2020 season

	Plant height			Cluster length			Biological yield			No. of cluster.m^2		
	Irrigation			Irrigation			Irrigation			Irrigation		
Fertilizer	Daily	3 days interval	7 days interval	Daily	3 days interval	7 days interval	Daily	3 days interval	7 days interval	Daily	3 days interval	7 days interval
5 ton.h^{-1}	69.23	77.03	63.27	16.27	19.53	14.20	10.43	12.27	8.40	162.9	199.4	147.4
5 ton.h^{-1}	81.50	90.40	73.57	21.33	25.63	18.37	20.23	24.50	17.77	291.7	341.7	257.8
Average	75.37	83.72	68.42	18.80	22.38	16.28	15.33	18.38	13.08	227.3	270.5	202.6
LSD ($P\leq0.05$)	Fertilizer 1.057	Irrigation 1.294	interaction 1.830	Fertilizer 1.180	Irrigation 1.445	interaction 2.044	Fertilizer 1.110	Irrigation 1.359	interaction 1.922	Fertilizer 7.41	Irrigation 9.07	interaction 12.83

Table 5. Effect of different levels of irrigation and fertilizers on No. of true grains per cluster, weight of 1000 seed, infertility rate, and total yield (ton.h^{-1}) in Jasmine rice cultivated in SRI method for the 2020 season

	No. of true grains per panicle			1000 seed weight			Infertility rate			Total yield (ton.h^{-1})		
	Irrigation			Irrigation			Irrigation			Irrigation		
Fertilizer	Daily	3 days interval	7 days interval	Daily	3 days interval	7 days interval	Daily	3 days interval	7 days interval	Daily	3 days interval	7 days interval
5 ton.h^{-1}	108.20	135.00	85.90	16.83	20.00	15.47	14.40	10.20	17.03	4.900	6.400	3.933
5 ton.h^{-1}	140.83	172.37	114.43	21.80	25.43	18.50	6.40	4.53	8.70	6.233	8.067	4.833
Average	124.52	153.68	100.17	19.32	22.72	16.98	10.40	7.37	12.87	5.567	7.233	4.383
LSD ($P\leq0.05$)	Fertilizer 3.886	Irrigation 4.760	Interaction 6.732	Fertilizer 0.969	Irrigation 1.187	interaction 1.679	Fertilizer 0.746	Irrigation 0.914	interaction 1.292	Fertilizer 0.2527	Irrigation 0.3095	interaction 0.4377

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