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# Effects of Water Deficit Role at Different Stages of Reproductive Growth on Yield Components of Rice

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**Abstract:** In order to study effect of water deficit role at different stages of reproductive growth on yield and yield components of rice, an experiment in split plot format based on randomized complete block design with 3 replications during 2009 in Rudsar township (north of Iran) was conducted. Main plots consist of 4 irrigation withholding time ($I_1$: Before of panicle exiting from sheath, $I_2$: before of flowering, $I_3$: at seed doughy stage and $I_4$: without irrigation withholding) and sub plots consist of 4 rice varieties ($V_1$: Hashemi, $V_2$: Binam, $V_3$: Rezajo and $V_4$: Khazar). Studied traits included grain yield, plant height, number of tillers per square meter, panicle length, number of filled grain per panicle, number of unfilled grain per panicle, 1000 grain weight and Maturing duration time. Effect of irrigation withholding time on grain yield, number of filled grain per panicle and maturing duration time in 1% and on plant height and number of unfilled grain per panicle in 5% probability level was significant. Also, on other traits was non significant. Effect of variety on grain yield, Plant height, number of tillers ($m^2$), number of filled grains per panicle and 1000 grain weight in 1% and on number of unfilled grain per panicle in 5% was significant and on other traits was non significant. Interaction effect on all studied traits except grain yield and plant height (1%) and number of filled grain per panicle (5%) was non significant.

**Key words:** Rice Varieties · Irrigation Withholding Time · Yield · Reproductive Growth

## INTRODUCTION

Rice (*Oryza sativa* L.) is the most important cereal crop in the world and it is the primary source of food and calories for about half of mankind [1]. More than 75% of the annual rice supply comes from 79 million ha of irrigated paddy land. Thus, the present and future food security of Asia depends largely on the irrigated rice production system. However, rice is a profligate user of water. It takes 3,000-5,000 liters to produce 1 kilogram of rice, which is about 2 to 3 times more than to produce 1 kilogram of other cereals such as wheat or maize [2]. Irrigation water is an important production factor in rice systems but is no longer available unlimited in rice-growing areas [3]. In recent years; due to unprecedented growth of demand for water consumption both in domestic and industrial sectors and because of lower and lower water content in underground reservoirs due to human consumption, the volume of water for irrigation of paddy fields has significantly declined. According to climate conditions Iran lies among semi-dry to dry belts of the world, the Guilan province has a high annual rainfall but experiencing water shortage problems in resent years. Rice, a major farming product of Guilan is a hydrophilic plant. Therefore, any water shortage means a rapid decline in its growth and yield as an agricultural product. Thus; by cultivation of varieties with high yields, this experiment aims to determine their water needs and requirements. This has several benefits. First, it prohibits addition of excess water to paddy fields after rice physiological water satisfaction. Second, it reduces production expenses and determines those varieties that are drought resistant with high qualitative and quantitative yield for cultivation in years to come. The future of rice production will depend heavily on developing and adopting strategies and practices that will use water efficiently in irrigation system. Numerous studies conducted on the manipulation of depth and interval of irrigation to save on water use without any yield loss have demonstrated that continuous submergence is not essential for obtaining high rice yield [4]. One method for reduce water consumption in rice planting is irrigation withholding at optimum time and blockage of flooding field for all duration of irrigation withholding. Drought stress of irrigation withholding causing to yield decrease and stress in flowering stage cause to increases unfilled grain

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percentage and decreases in rice yield. According to several researches there is a significant reductions in tillers and panicles numbers as well as plant height and grain yield were found when water stress was imposed at tillering stage, in the other hand moisture stress at late vegetative and reproductive stage resulted a reduction in number of panicles per plant, percentage of filled grains and 1000-grain weight. Also the reduction in grain yield was occurred when plants were exposed to water stress at panicle initiation stage, while the moisture stress at the milk ripe or dough ripe had significant effects on grain yield [5-7]. Nour *et al*, reported that exposing rice plant to water stress for 36 days without flush irrigation during both tillering and panicle initiation significantly reduce plant height, number of tillers per plant, total dry matter, crop growth rate and grain yield [8]. Boonjung and Fukai, reported that drought stress at duration of filling grains period with acceleration in ripening time, casing to growth period duration and filling grains decreased [9]. Abou Khalifa, with study three levels of irrigation withholding time included: ($w_1$) Irrigation withholding at complete heading. ($w_2$) Irrigation withholding after 10 days from complete heading. ($w_3$) Irrigation withholding after 20 days from complete heading on two variety of rice included: H1 hybrid rice and Giza 177 inbred rice, found that the highest amounts of traits grain yield, panicle length and number of grains per panicle obtained of $w_3$ treatment respectively with 10.59 t/ha, 18.80cm and 144 number [10].

## MATERIALS AND METHODS

In order to study effect of water deficit role at different stages of reproductive growth on yield and yield components of rice, an experiment in split plot format based on randomized complete block design with 3 replications during 2009 in Rudsar township (north of Iran) with 37°7' N latitude and 49°35' E longitude on a land parcel of 1000 square meter area was conducted. Soil analysis results show that (Table 1), the soil texture was loamy clay and pH 7.4. Climate conditions of experiment site show that Table 2. Main plots consist of 4 irrigation withholding time ($I_1$: Before of panicle exiting from sheath, $I_2$: before of flowering, $I_3$: at seed doughy stage and $I_4$: without irrigation withholding) and sub plots consist of 4 rice varieties ($V_1$: Hashemi, $V_2$: Binam, $V_3$: Rezajo and $V_4$: Khazar). The operations of preparing land include first plough in winter and secondary plough along with giving phosphorus and potash was done. According to soil analysis, amount of fertilizers N, K and P were implemented. Sowing in nursery was done April 15 and transplanted to field May 22. All options consist of weeding, fighting with pests and diseases up to harvest stage have been done. In maturity time, according measurement instruction, grain yield, plant height, number of tillers per square meter, panicle length, number of filled grain per panicle, number of unfilled grain per panicle, 1000 grain weight and Maturing duration time were measured. The yield and yield components were analyzed

Table 1: Chemical and physical properties of soil of the experimental location.

| Depth (cm) | 0-30 | Soil texture | loamy clay |
|---|---|---|---|
| pH | 7.4 | Total Nitrogen (%) | 0.136 |
| Sand (%) | 11 | Available K (ppm) | 186 |
| Silt (%) | 39 | Available P (ppm) | 11.2 |
| Clay (%) | 50 | Organic Carbon (%) | 1.28 |
| Sp (%) | 79 | EC (ds/m) | 1.64 |

Table 2: Mean value of precipitation, temperature and rainfall in Roudsar

| | Precipitation (%) | | Temperature (°C) | |
|---|---|---|---|---|
| | Max | Min | Max | Min |
| Mar-Apr | 99 | 71 | 15 | 8 |
| Apr-May | 99 | 64 | 21 | 12 |
| May-Jun | 97 | 54 | 30 | 19 |
| Jun- Jul | 96 | 2 | 28 | 20 |
| Jul-Aug | 97 | 57 | 32 | 22 |
| Aug-Sep | 98 | 57 | 30 | 20 |

by using MSTAT-C software. The Duncan's multiple range tests was used to compare the means at 5% of significant.

## RESULTS AND DISCUSSION

**Effect of Irrigation Withholding Time:** Results of variance analysis show that (Table 3), the effect of irrigation withholding time had significant differences on grain yield, number of filled grain per panicle and maturing duration time in 1% probability level. Also, on plant height and number of unfilled grain per panicle showed significant differences in 5% probability level. Effect of irrigation withholding time had not significant influence on panicle length, number of tillers per square meter and 1000 grain weight. Comparison of mean between irrigation withholding time treatments show that (Table 4), the highest grain yield with 5.8 t/ha, plant height with 98.41 cm, number of filled grain per panicle with 78.50 and maturing duration time with 105.3 day was obtained by irrigation withholding in seed doughy stage ($I_3$). The lowest grain yield, plant height, number of filled grain per panicle and maturing duration time respectively with 5.2 t/ha, 94.75 cm, 72.33 grain and 96.2 day was obtained by irrigation withholding before of panicle exiting from sheath ($I_1$). The highest number of unfilled grain per panicle was found from irrigation withholding before of panicle exiting from sheath ($I_1$), with 9.2 and the lowest amount of this trait was found from irrigation withholding in seed doughy stage ($I_3$) with 7.5. Although, the effect of irrigation withholding time on panicle length, number of bearer tillers per square meter and 1000 grain weight was non significant, the highest amount of panicle length and 1000 grain weight was recorded from irrigation withholding in seed doughy stage ($I_3$) respectively with 28.50 cm and 27.35 g. on the other hand the maximum bearer tillers per square meter with 229.25 was found from irrigation withholding Before of panicle exiting from sheath ($I_1$). Similar results were reported by Badawi and Ghanem [3], van der Hoek *et al.* [11], Mohammadian Roshan *et al.* [12] and Abou-Khalifa [10].

**Effect of Variety:** Results of variance analysis show that (Table 3), the effect of variety on grain yield, Plant height, number of tillers per square meter, number of filled grains per panicle and 1000 grain weight had significant differences in 1% probability level and on number of unfilled grain per panicle in 5% probability level. Also, effect of variety on panicle length and maturing duration time was non significant. Comparison of mean between varieties show that (Table 4), the highest grain yield and plant height respectively with 5.9 t/ha and 102.9 cm was found from Binam variety ($V_2$). The lowest grain yield with 5.2 t/ha and plant height with 91.08 cm respectively was obtained from Hashemi ($V_1$) and Rezajo ($V_3$) variety. Maximum number of bearer tillers with 256 and 1000 grain weight with 31.23 was found from Khazar variety ($V_4$). Minimum number of bearer tillers with 205.25 was recorded from Rezajo variety ($V_3$). Also, the lowest 1000 grain weight was found from Hashemi variety ($V_1$) with 24.79 g. The highest number of filled grains per panicle with 80.91 was recorded from Rezajo variety ($V_3$) and the lowest amount of this trait was recorded from Khazar variety ($V_4$) with 57.25. Maximum number of unfilled grains per panicle with 9.5 was recorded from Hashemi variety ($V_1$). Also, the lowest number of unfilled grains per panicle with 6.6 was obtained by Binam variety ($V_2$). Although, the effect of variety on panicle length and maturing duration time was non significant, but the highest panicle length 28.12 cm was recorded from Hashemi variety and the highest maturing duration time was obtained by Khazar variety with 104.6 day. Similar results were reported by Faraji *et al.* [13], Mohammadian Roshan *et al.* [12] and Amiri *et al.* [5].

Table 3: Analysis of variance studied traits of rice varieties under different levels of irrigation withholding times

| Source of variance | df | Grain yield (t/ha) | Plant height (cm) | No.of tillers ($m^2$) | Panicle length (cm) | No.of filled grains per panicle | No.of unfilled grains perpanicle | 1000 grain weight (g) | Maturing duration time (day) |
|---|---|---|---|---|---|---|---|---|---|
| | | MS | | | | | | | |
| Irrigation withholding time (I) | 3 | 0.89$^{**}$ | 33.16$^{*}$ | 0.69$^{ns}$ | 4.96$^{ns}$ | 23.19$^{**}$ | 4.89$^{*}$ | 4.29$^{ns}$ | 277.85$^{**}$ |
| Error I | 9 | 0.01 | 3.39 | 10.43 | 1.67 | 12.94 | 0.24 | 1.02 | 1.7 |
| Variety (V) | 3 | 1.09$^{**}$ | 332.61$^{**}$ | 1456.12$^{**}$ | 3.61ns | 1749.41$^{**}$ | 19.5$^{*}$ | 109.99$^{**}$ | 1.57$^{ns}$ |
| I×V | 9 | 0.15$^{**}$ | 8.85$^{**}$ | 0.52$^{ns}$ | 10.28$^{*}$ | 6.23$^{ns}$ | 2.75$^{ns}$ | 2.3$^{ns}$ | 1.52$^{ns}$ |
| Error V | 36 | 0.02 | 1.35 | 46.44 | 1.13 | 3.5 | 1.77 | 4.98 | 3.59 |

Ns, ** and * respectively: non significant, significant in 1% and 5% area

Table 4: Comparison of mean Effect of different varieties and irrigation withholding times

| Treatments | Grain yield (t/ha) | Plant height (cm) | No.of bearer tillers ($m^2$) | Panicle length (cm) | No.of filled grains per panicle | No.of unfilled grains per panicle | 1000 grain weight (g) | Maturing duration time (day) |
|---|---|---|---|---|---|---|---|---|
| Irrigation withholding time | | | | | | | | |
| $I_1$ | 5.2d | 94.75c | 229.25a | 27a | 72.33b | 9.2a | 25.93a | 96.2b |
| $I_2$ | 5.4c | 95.16bc | 229a | 27.58a | 75.33ab | 7.8b | 26.85a | 97.3b |
| $I_3$ | 5.8a | 98.41a | 228.75a | 28.50a | 78.50a | 7.5b | 27.35a | 105.3a |
| $I_4$ | 5.7b | 96.66ab | 228.75a | 27.33a | 77a | 7.9b | 26.94a | 104.7a |
| Variety | | | | | | | | |
| $V_1$ | 5.2b | 93.16b | 217.25c | 28.12a | 80.25a | 9.5a | 24.79bc | 101.3a |
| $V_2$ | 5.9a | 102.9a | 237.25b | 27.79a | 82.75a | 6.6b | 26.05b | 100.5a |
| $V_3$ | 5.6a | 91.08b | 205.25c | 26.83a | 80.91a | 9a | 25.02bc | 100.9a |
| $V_4$ | 5.4b | 97.8a | 256a | 27.66a | 57.25b | 8.3a | 31.23a | 104.6a |

Within each column, means followed by the same letter do not differ significantly at P<0.05

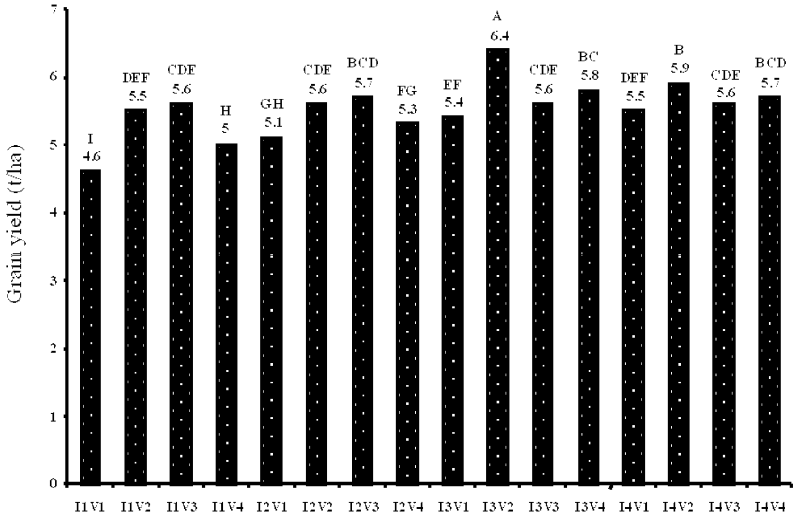


Fig. 1: Interaction effects of irrigation withholding time and variety on grain yield

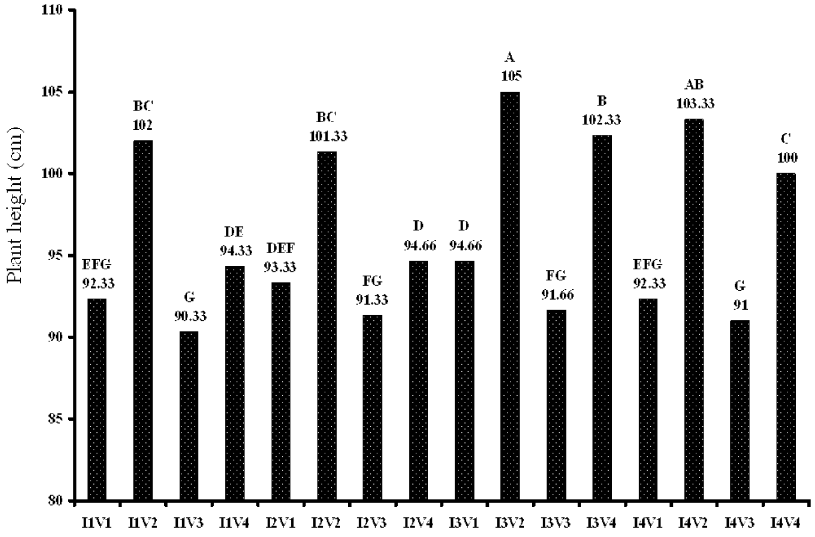


Fig. 2: Interaction effects of irrigation withholding time and variety on plant height

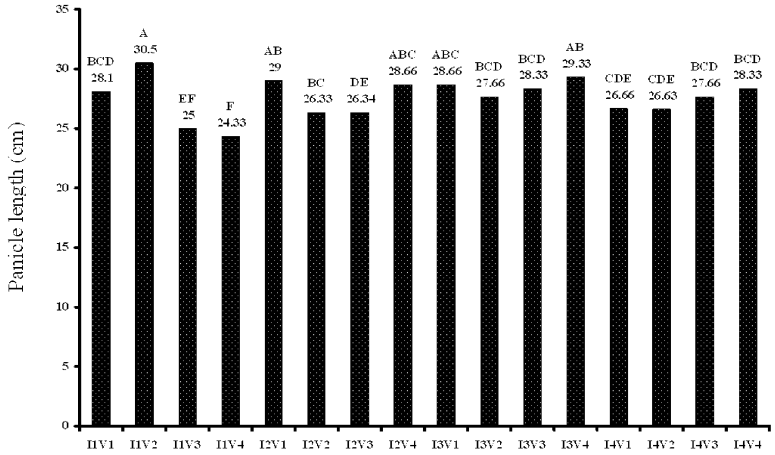


Fig. 3: Interaction effects of irrigation withholding time and variety on panicle length

**Interaction Effect:** Data presented in Table 2 showed that, the interaction effect of irrigation withholding time and variety had significant differences on grain yiel and plant height in 1% probability level. On the other hand interaction effect was significant on number of filled grain per panicle in 5% probability level. Interaction effect on number of tillers per square meter, number of filled grains per panicle, number of unfilled grains per panicle, 1000 grain weight and maturing duration time was non significant. With attention to Figure 1 and 2, the highest grain yield with 6.4 t/ha and plant height with 105 cm was recorded from $I_3V_2$ treatment (Irrigation withholding at seed doughy stage along with Binam variety). The lowest grain yield was found from $I_1V_1$ treatment (Irrigation withholding before of panicle exiting from sheath along with Hashemi variety) with 4.6 t/ha (Figure 1). Minimum amount of plant height with 90.33 cm was recorded from $I_1V_3$ (Irrigation withholding before of panicle exiting from sheath along with Rezajo variety). The interaction treatment of $I_1V_2$ (Irrigation withholding before of panicle exiting from sheath along with Binam variety) was obtained the highest amount of panicle length with 30.5 cm. also, the lowest panicle length was found from $I_1V_4$ treatment (Irrigation withholding before of panicle exiting from sheath along with Khazar variety) with 24.33 cm (Figure 3). Similar results were reported by Guerra *et al.* [4], Faraji *et al.* [13], Sabeti Rad and Amiri [14], Zulkarnain *et al.* [15] and Abou-Khalifa [10].

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