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# Assessment the Effect of Water Stress and Calcium Silicate on Rice (*Oryza sativa* L.) Yield in North of Iran

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RESEARCH ARTICLE

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**ABSTRACT**

In order to consider the effect of irrigation cut off and calcium silicate on seed yield and its components of rice (Local cultivar, Tarom Hashemi), a research was carried out as split plot experiment based on randomized complete block design in three replications in 2014 in Sari, Mazandaran, Iran. Irrigation cut off arranged 15 days in 4 growth stages (At beginning, middle and last of tillering stage and 50% of flowering stage) as main factor and calcium silicate in three amounts (0, 500 and 1000 $kg.ha^{-1}$) as subfactor applied 15 days before transplanting. Results of analysis of variance showed that effect of irrigation cutoff on all measured traits (except percentage of filled spikelet per panicle) was significant. Effect of calcium silicon and interaction effect of treatment on all measured traits were no significant. According to mean comparison cut off of irrigation at beginning of tillering stage showed significantly decrease in panicle length, number of panicle per $m^2$, number of spikelet per panicle and drastically reduce in seed yield. Cut off of irrigation at middle of tillering stage caused to decrease in 1000-seed weight. Maximum number of panicle per $m^2$ and grain yield (405.78 $gr.m^{-2}$) was found in cut off of irrigation at 50% of flowering stage. Correlation between traits showed number of spikelet per panicle (0.58*), number of panicle per $m^2$ (0.56*), 1000-seed weight (0.59*) and percentage of filled spikelet per panicle (0.51*) have a significant and positive correlation with seed yield at 5% probability level. In general, it can be concluded that beginning of tillering stage was too sensitive to cut off irrigation because it caused to reduce of yield and yield contributing.

**Keywords:** *Agronomical parameters, Irrigation cutoff, Nutrition.*

## INTRODUCTION

The development of strategies to reduce water stress in arid and semiarid regions is a sustainable alternative to mitigate the negative impacts of global climate changes. In view of the complexity of drought stress, only an approach that will consider soil-plant-environment interactions may generate relevant knowledge that can be used in the near future to guarantee sustainability (Marques *et al*., 2016).

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Rice being one of the most cultivated cereals in all over the world (Golshani et al., 2010) and the demand for rice will increase dramatically because of the steady increase in population (Liu et al., 2012). Access of water is main factor for plant yield in semi-arid areas (Stone et al., 2001). Rice is more sensitive to drought stress in vegetation stage and stress in this stage caused to more decrease in yield compare to reproductive stage (Pantuwan *et al.*, 2002). Most crops particularly are sensitive to water shortage stress during flowering phase to seed development. Even plants cultivating in dry and semidry regions are influenced by drought stress (Mitra, 2001). Decrease of leaf growth in rice can occur because water stress in period of seed formation, when maximum leaf area is needed for yield increase. The reasons of decrease in leaf growth in water stress are reduce of flexibility in cell walls, osmotic potential and turgor pressure (Lu and Neumann, 1998). Sabetfar *et al.* (2013) showed that rice crop (cultivar Hashemi) is susceptible to drought stress in middle tillering and panicle initiation phase compared to 50% flowering phase. Effect of water deficiency of water on cell expansion by change of physical and metabolic process, led to limit leaf area, prevent light absorption and decrease in photosynthesis and seed yield (Lu and Neumann, 1998). The need for proper silicate management to increase yield and sustain crop productivity appears to be necessary in temperate as well in tropical countries. In addition, the silicate diminution in soil can occur in intensive cultivation practices and continuous monoculture of high-yielding cultivars. As a result, these soils are generally low in available Silicate. Rice and sugarcane grown in rotation on organic and sandy soils have shown positive responses to the pre-plant applications of calcium silicate (Anderson *et al.*, 1991). Silicon nutrition increases drought tolerance in crops by maintaining plant water balance, photosynthetic efficiency, erectness of the leaves and structure of xylem vessels under high transpiration rates due to higher temperature and moisture stress (Hattori *et al.*, 2005). Mukhtar *et al.* (2012) revealed that silicate nutrition has significant effect on crop growth, physiological attributes and yield parameters. The effect was more significant for wheat variety Chakwal-50 under 10% silicate application with irrigation as compared to other genotypes under other levels of silicate concentrations. It boosted up crop growth and accumulation of more photo-assimilates from source to sink and consequently, it led to higher grain yield. Marques *et al.* (2016) by evaluate potential of calcium silicate to mitigate the effects of water deficiency on maize yield concluded that silicon mitigated the impact of water deficiency in maize crop and increased the xylem water potential. Gong *et al.* (2003) reported that application of silicate can increase dry matter of wheat in well watered conditions and improve the growth under drought conditions by maintaining high leaf area. Khabbazkar *et al.* (2012) by evaluated effect of different amounts of silica and chloric potassium fertilizers on yield and yield components of rice (Hashemi and Ali Kazemi cultivars) concluded that silica fertilizer reduced number of fertile tillers in both cultivars and increased the number of fertile tillers. Increase the number of fertile tillers led to increase the straw yield. Castro and Crusciol (2013) by evaluate efficiency of superficial liming and calcium/magnesium silicate application on the soil chemical attributes, plant nutrition, yield components and final yield of a soybean/white oat/maize/bean rotation under no-tillage system in a dry winter region concluded that products from silicate dissociation reach deeper soil layers after 18 months from the application, compared to liming. The aims of the present study was to find out the sensitive phase of rice growth to water deficiency, consider the effect of calcium silicate and cutoff irrigation on yield and its components and assessment effect of calcium silicate concentration with water cutoff in different plant growth stages.

## MATERIALS AND METHODS

### *Field and treatment information*

This experiment was conducted in 2014 in Sari region, Mazandaran province, at north of Iran. Geographical information of the experiment field was latitude 36° 25 N, longitude 53° 8 E and altitude 14 meters above sea level. Chemical and physical properties of the soil experiment were shown in table 1. The soil texture was clay loamy contained sand (18 %), silt (39 %), and clay (43%). A split plot experiment based on randomized complete blocks design with three replications was carried out. Irrigation cutoff was done 15 days in 4 plant growth stages: at beginning, middle and last of tillering stage and 50% of flowering stage as main factor. There were rain at the beginning of tillering and 50% of flowering stages but in all four stages were observed severe cracking. Calcium silicate amounts: 0, 500 and 1000 $kg.ha^{-1}$ were obtained from mineral ashes in cement factory and were used as a sub-factor 15 days before transplanting. Local verity of Tarom-Hashemi was selected as tall height and sensitive to lodging.

**Table 1.** Soil properties information of experimental site

| Depth (cm) | EC ($\mu m.cm^{-1}$) | pH | O.M (%) | N (%) | P (ppm) | K (ppm) | Soil texture |
|---|---|---|---|---|---|---|---|
| 0-30 | 0.74 | 7.2 | 1.6 | 0.12 | 18.2 | 285 | Clay Loamy |

### *Traits measurements*

Panicle length was measured for all panicles of plant and then mean value was used. At the time of harvesting crop yield components including number of panicle per $m^2$, spikelets per panicle, percentage of filled spikelet per panicle, and 1000-seed weight were also recorded. In addition, seed yield was determined at harvesting time using fallowing formula (Yoshida, 1981):

**Formula 1.** Seed Yield ($g.m^{-2}$) = panicle number/$m^2$ × spikelet number/panicle × filled spikelet percent × 1000 grain weight (g) × $10^{-5}$

### *Statistical analysis*

Data were analyzed by MSTAT-C statistical software and using Duncan's Multiple Range Test at 5% probability level for means comparison.

## RESULTS AND DISCUSSION

The ANOVA results showed that effect the of irrigation cutoff on all measured traits (except percentage of filled spikelet per panicle) such as panicle height ($p\leq0.01$), number of panicle per $m^2$ ($p\leq0.01$), total number of spikelet per panicle ($p\leq0.05$), 1000-seed weight ($p\leq0.01$) and seed yield ($p\leq0.05$) was significant. Effect of calcium silicon and interaction effect of treatment on all measured traits were not significant (Table 2). Water stress at flowering stage had a greater grain yield reduction than other water stress conditions. Hence, the reduction of grain yield of genotype largely resulted from the reduction in fertile panicle and filled grain percentage. Water deficit during vegetative, flowering and grain filling stages reduced mean grain yield by 21%, 50%

and 21% on average in comparison to control respectively. Pirdashti *et al.* (2004) was conducted a field experiment to evaluate the effect of water stress on yield and yield components of four rice cultivars commonly grown in Mazandaran province, Iran. Their results showed that water stress at vegetative stage significantly reduced plant height of all cultivars. Davatgar *et al.* (2009) reported that there is significant difference between intensity of drought stress particularly in middle tillering, gestation and 50% flowering for plant organs and rice plant performance (cultivar Hashemi). Result of mean comparison showed that irrigation cutoff treatment at the beginning of tillering had obtained minimum panicle height (22.70 cm), number of panicle per $m^2$ (266.90), total number of spikelet per panicle (74.55), and seed yield (329.22 $g.m^{-2}$) (Table 3).

**Table 2.** Analysis of variance of agronomical traits

| S.O.V | df | Panicle length | Number of panicle per $m^2$ | Spikelet per panicle | Percentage of filled spikelet per panicle | 1000-seed weight | Seed Yield |
|---|---|---|---|---|---|---|---|
| **Replication** | 2 | $1.77^{ns}$ | $9054.19^{ns}$ | $2012.11^{**}$ | $130.53^{ns}$ | $2.17^{ns}$ | $33397.86^{*}$ |
| **Irrigation cutoff** | 3 | $7.74^{**}$ | $73164.25^{**}$ | $1772.59^{*}$ | $163.36^{ns}$ | $4.47^{**}$ | $10788.66^{*}$ |
| **Error (I)** | 6 | 0.74 | 3818.75 | 394.7 | 110.08 | 0.47 | 4226.41 |
| **Calcium silicate** | 2 | $0.19^{ns}$ | $991.69^{ns}$ | $96.19^{ns}$ | $57.52^{ns}$ | $1.81^{ns}$ | $884.69^{ns}$ |
| **Irrigation Cutoff * Calcium Silicate** | 6 | $4.37^{ns}$ | $5676.25^{ns}$ | $235.89^{ns}$ | $57.86^{ns}$ | $1.07^{ns}$ | $4728.25^{ns}$ |
| **Error (II)** | 22 | 2.37 | 9943.65 | 268.63 | 72.82 | 1.03 | 5454.98 |
| **CV (%)** | - | 6.40 | 8.77 | 7.47 | 10.10 | 4.65 | 5.49 |

ns, *, **: Non significant, significant at 5 and 1 % probability level, respectively.

**Table 3.** Mean comparison effects of irrigation cutoff and calcium silicate on measured traits

| Treatments | Panicle length (cm) | Number of panicle per $m^2$ | Spikelet per panicle | Percentage of filled spikelet per panicle | 1000-seed weight (g) | Seed yield ($g.m^{-2}$) |
|---|---|---|---|---|---|---|
| **Time of Irrigation cutoff** | | | | | | |
| At beginning of tillering | $22.70^{b*}$ | $266.90^{c}$ | $74.55^{b}$ | $90.77^{a}$ | $22.75^{a}$ | $329.22^{b}$ |
| At middle of tillering | $24.80^{a}$ | $356.89^{b}$ | $101.66^{a}$ | $82.55^{a}$ | $21.11^{c}$ | $360.22^{ab}$ |
| Last of tillering | $24.00^{a}$ | $380.11^{b}$ | $106.33^{a}$ | $83.11^{a}$ | $21.38^{bc}$ | $343.56^{ab}$ |
| 50% of flowering | $24.50^{a}$ | $486.22^{a}$ | $92.55^{ab}$ | $81.44^{a}$ | $21.94^{b}$ | $408.78^{a}$ |
| **Calcium silicate** | | | | | | |
| Control | $24.00^{a}$ | $366.67^{a}$ | $93.00^{a}$ | $87.00^{a}$ | $21.56^{a}$ | $350.92^{a}$ |
| 500 $kg.ha^{-1}$ | $23.90^{a}$ | $367.92^{a}$ | $96.91^{a}$ | $83.25^{a}$ | $21.58^{a}$ | $367.58^{a}$ |
| 1000 $kg.ha^{-1}$ | $24.00^{a}$ | $383.00^{a}$ | $91.44^{a}$ | $83.16^{a}$ | $22.25^{a}$ | $362.83^{a}$ |

*Similar letters in each column show non-significant difference at 5% level in Duncan's Multiple Rang Test.

Brar *et al*. (2009) conducted a field experiment to find out the suitable timing of withholding irrigation to Basmati rice, by maintaining water saving and quality characters of grains intact. They reported cut-off timings of last irrigation at 28 and 35 days after 50% flowering, being at par with each other gave significantly higher yield and yield attributes of basmati rice than at 21 days after 50% flowering. Total water expense was 6.7 and 12.5% less under 21 days after 50% flowering cut-off timing than 28 and 35 days after 50% flowering respectively. However, water use efficiency was increased with delay in termination of irrigation from 21 days after 50% flowering. Among the milling recoveries, head rice recovery improved significantly with delay in termination of irrigation from 21 to 28 days after 50% flowering and thereafter remained at par. While, other quality parameters like brown rice recovery, length and breadth ratio and cooking qualities were influenced non-significantly with differential timings of cutoff irrigation to basmati rice. Irrigation cutoff at 50% of flowering stage had maximum panicle height (24.50 cm), number of panicle per $m^2$ (486.22) and seed yield (408.78 $g.m^{-2}$). Maximum (22.75 g) and minimum (21.11 g) 1000-seed were obtained in treatment of irrigation cutoff at the beginning and middle of tillering stage respectively (Table 3). According to Duncan test there were non significant differences between different level of calcium silicate in seed yield and its components traits (Table 2). These results were compatible with the findings of Pirmoradian *et al*. (2004) and Kumara *et al*. (2016).

### Correlation between traits

Table 4 showed traits number of spikelet per panicle (58*), number of panicle per $m^2$ (0.56*), 1000-seed weight (0.59*) and percentage of filled spikelet per panicle (0.51*) have a significant and positive correlation with seed yield at 5% probability level. Some researchers reported same results (Kato *et al*., 2006; Meena *et al*., 2014; Zubaer *et al*., 2007).

**Table 4.** Correlation between measured traits

| Traits | Panicle length | Number of spikelet per panicle | Percentage of filled spikelet per panicle | 1000-seed weight | Seed Yield | Number of panicle per $m^2$ |
|---|---|---|---|---|---|---|
| Panicle length | 1 | | | | | |
| Number of spikelet per panicle | 0.28 | 1 | | | | |
| Percentage of filled spikelet | -0.34 | -0.41* | 1 | | | |
| 1000-seed weight | 0.01 | -0.40* | 0.21 | 1 | | |
| Seed yield | -0.08 | 0.58* | 0.51* | 0.55* | 1 | |
| Number of panicle per $m^2$ | 0.23 | 0.22 | -0.15 | -0.07 | 0.56* | 1 |

$^{ns}$, *, **: non significant, significant at 5 and 1 % probability level respectively

## CONCLUSION

The results have shown that the beginning of tillering stage was so sensitive to irrigation cut off because seed yield decreased by reducing of yield contributing to panicle length, number of spikelet per panicle and number of panicle per $m^2$. Maximum seed yield was obtained with irrigation cut off at 50 % of flowering stage. Seed yield had positive correlation with its components at 5% probability level.

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