

Full Length Research Paper

Effect of planting pattern and drought stress on amylase content in rice grain

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In order to determine the effects of planting pattern and drought stress on rice in Western Iran during 2005 to 2006, this research was performed. Experiment form was split plot in randomized complete block design with four replications. In this research, patterns of irrigation (I_1 , I_2 and $I_3 = 10$ cm water irrigation, five-day alternate irrigation, and five-day alternate irrigation until the beginning of heading with 10 cm flooding till it gets to the ripening time, respectively) were the major factors and rice variations (Anbar boo, Tarem, Neda, Line 6 and Kadoos as V_1 , V_2 , V_3 , V_4 and V_5 , respectively) were the minor factors. The results of this research showed that water limitation in procreative period and loading of seed induced decrease in the time required for it to reach the maximum weight and maximum amount of amylases, and also, water limitation in this period of growth and germination, decreased seed weight and amount of amylase in rice. The time of reaching the maximum amount of amylases in all treatments was less than the time of reaching the maximum seed weight. Also, water limitation in vegetable growth period is not efficient on seed weight and amount of amylases.

Key words: Drought stress, amylases, rice.

INTRODUCTION

Drought is one of the most serious world-wide problems of agriculture. Seven-tenths of the world's agricultural land lies in arid or semi-arid regions. Deficiency of water and lack of a real planting pattern are two important challenges in developing rice cultivation in semi-arid areas. Water limitation is one of the main factors in developing rice culture. Rice cultivation is the second most cultivated crop after wheat in the West of Iran. One of the important factors in assessing the rice quality in amylases content is the determination of the water use pattern and maintenance of the quality of this crop (Pantuwan, 2001; Pantuwan et al., 2002; Yamauchi and Winn, 1996). It suggest that amylases content is 0 to 33% in all rice cultivars (Jonhn et al., 1956; Virginia, 1958). Rice quality

studies showed that changing amount of amylases induced differences in rice grain quality (Juliano, 1982; Krishnasamy and Seshu, 1989; Olivem et al., 1957; Williams et al., 1958). These differences are very important in baking quality and consumers taste (Sanjiva et al., 1953; Virginia, 1958). All rice cultivars divided to Vaxi (0% amylases) and non-Vaxi (including little amylases 10 to 20, 20 to 25 and rich amylases 25 to 33%, respectively) groups (Juliano, 1970; Singh et al., 2000; Olivem et al., 1957). Meal amylases of rice are commercially more desirable than others due to swelling after baking; this kind also remains soft for a long time after baking and is found with less mucilage (Juliano, 1982). Water deficit in reproductivity stage is affected by the number of tillering but has no effect on grain weight and amylases content (Ouk et al., 2003). Pantuwan (2001) indicated that limited irrigation reduces seed weight, amylose amount and accelerates the time to reach

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Figure 1. Map of study site in Iran.

maximum amylases content. He also concluded that amylases content increases by water sufficiency during generative stage and filling grain stage. Studies showed that water deficit reduce tillering number during vegetative stage and seed weight and quality, during filling grain stage (Juliano and Pascal, 1980). Water deficit stress induce reduced amylases and filling grain stages (Juliano and Pascal, 1980; Singh et al., 2000). Sufficient water induced increase of tiller number, panicle and spikelet number during flowering stage and increase filling grain stage (Ouk et al., 2003). There is a relation between amylase content and drought resistant. Therefore, this investigation was carried out to detect amylases content variability of rice as affected by drought stress.

MATERIALS AND METHODS

This experiment conducted in Gillangharb region in Western Iran (Figure 1) in 2005 to 2006. In this region, mean temperature was 6 to 33°C, the highest and the lowest temperature are 39 and -6°C. Clay, silt and sand content of experimental area of the soil are 36, 50 and 14%, respectively. So, soil texture is silty clay loam. In this study, five rice cultivars were studied. Experiment conducted as split plot with three irrigation regimes was based on randomized complete block design with four replications. In this research, patterns of irrigation (I_1 , I_2 and I_3 = 10 cm water irrigation, five-day alternate irrigation, and five-day alternate irrigation until the beginning of heading with 10 cm flooding and till it gets to the ripening time, respectively) were the main factor and rice varieties

(Anbar boo, Tarem, Neda, Line 6 and Kadoos as V_1 , V_2 , V_3 , V_4 and V_5 respectively) were regarded as the minor factor. In this study, rice cultivars were the second most cultivated crop after wheat. Planting line space was 25 cm. Planting was done in July 1st after harvesting wheat (as previous crop). The main plot space was 2 m to prevent the entering of water into adjacent plots. First sampling was 20 days after flowering and next sampling was done in 10 days intervals. Amylases content changes during filling grain period. Given degree-growth days calculated by Ouk et al. (2003) and Yamauchi and Winn (1996):

$$GDD = \frac{T_{\max} + T_{\min}}{2} - T_b$$

Where;

GDD is growth degree day,

T_{\max} is maximum daily temperature,

T_{\min} is minimum daily temperature that is in range of 12 to 41°C T_b denote based temperature of plant which is 12°C for rice (Ouk et al., 2003; Pantuwan et al., 2002; Redona and Mackill, 1996; Yamauchi and Winn, 1996). Data were analyzed and graphs were plotted using SAS and Excel software. Data were compared by Duncan's multiple range test (DMRT).

RESULTS AND DISCUSSION

Results indicated that amylases content vary about 1250 GDD after planting in all cultivars from 8.2 for V_2 cultivar to 11% for V_5 cultivar (Figure 2). Treatments did not show differences among amylase contents affected by irrigation in 1300 GDD, but I_2V_1 , I_2V_2 and I_1V_3 treatments

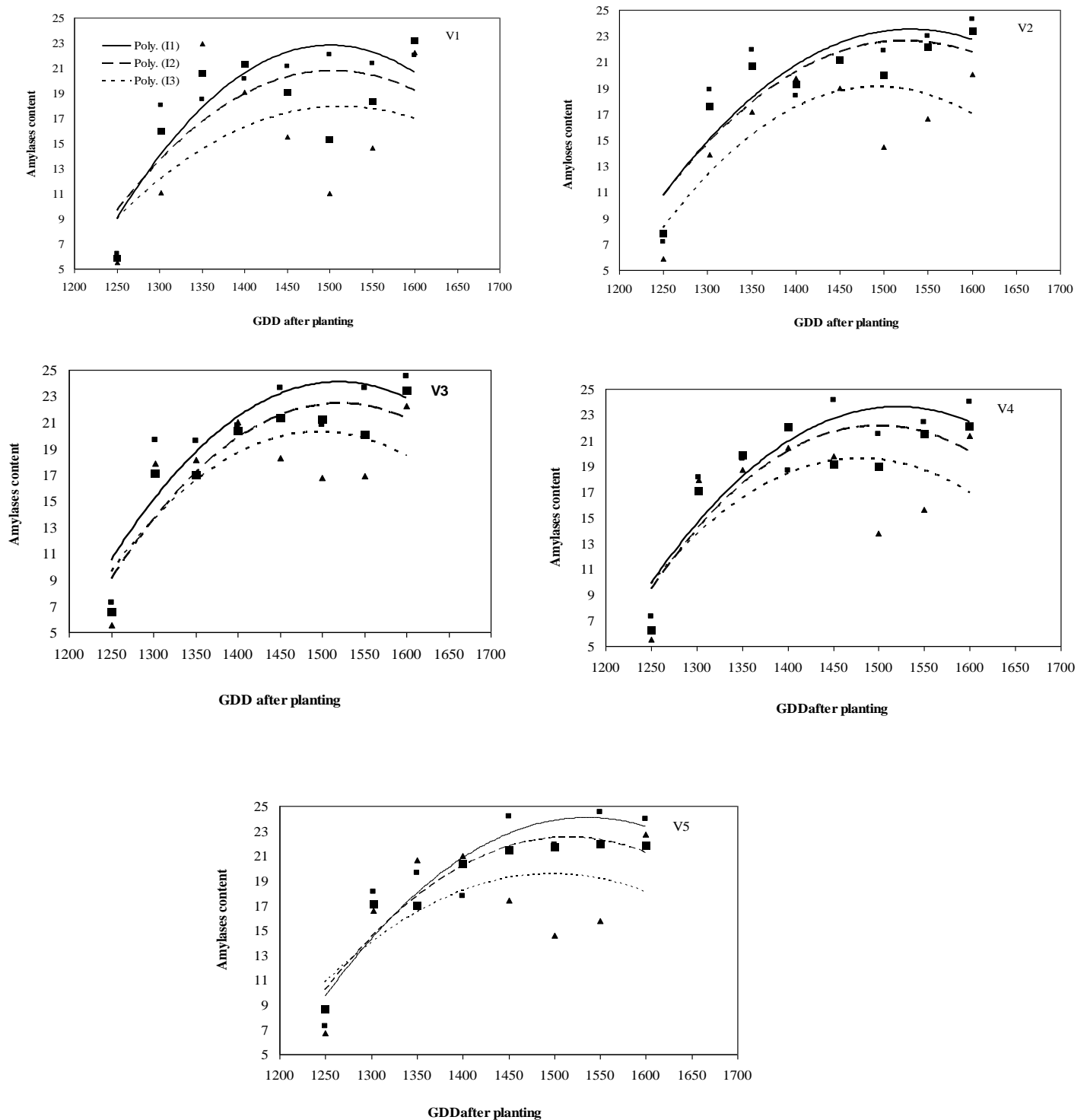


Figure 2. Changes of amylases amount of rice cultivars at different levels of deficit water at grain filling stage.

showed some significant differences. Graphs showed that all cultivars had maximum amylases content during creating and reserving amylases stage under I1, I3 and I2 treatments, respectively (Figure 2).

Among the treatments, I1V2 and I2V1 had the highest and lowest amylases content in rates of 24.6 and 18.1,

respectively (Table 1). 1000 grain weight of white rice was 2.2 to 7.2% in I1V4 and I2V3, respectively. Reduction of 1000 grain weight was about 4.8, 0, 4.75, 14.8 and 3.8% in V1, V2, V3, V4 and V5 cultivars but reduction of amylases content was 4.9, 5.4, 1, 4.3 and 0%, respectively (Table 1).

Table 1. Effect of irrigation pattern on time and amount of maximum 1000-grain weight and amount of maximum amylases percent in rice cultivars.

| Amount of amylases in percent | | 100 grain weight white rice with moisture of 12% per gram | | Cultivars | Irrigation pattern |
|---|--------------------|---|-------------------|----------------|--------------------|
| Time to reach the maximum amount of amylases at GDD | | Time to reach the maximum 100 grain weight at GDD | | | |
| 23 ^{bc} | 1525 ^b | 2.4 ^b | 1560 ^b | V ₁ | I ₁ |
| 24.6 ^a | 1530 ^a | 2.3 ^b | 1560 ^a | V ₂ | |
| 23.2 ^{bc} | 1520 ^b | 2.6 ^a | 1578 ^b | V ₃ | |
| 23.8 ^b | 1525 ^b | 2.7 ^a | 1562 ^b | V ₄ | |
| 24.2 ^{ab} | 1522 ^b | 2.6 ^a | 1535 ^b | V ₅ | |
| 18.1 ^d | 1510 ^{cd} | 2.1 ^{bc} | 1530 ^d | V ₁ | I ₂ |
| 19.2 ^{cd} | 1490 ^{de} | 2.0 ^c | 1525 ^d | V ₂ | |
| 20.2 ^c | 1495 ^{de} | 2.2 ^{bc} | 1507 ^e | V ₃ | |
| 19.7 ^{cd} | 1475 ^e | 2.1 ^{bc} | 1525 ^e | V ₄ | |
| 19.5 ^{cd} | 1500 ^d | 2.3 ^b | 1510 ^f | V ₅ | |
| 22.5 ^c | 1523 ^b | 2.4 ^b | 1560 ^b | V ₁ | I ₃ |
| 23.9 ^b | 1525 ^b | 2.3 ^b | 1547 ^c | V ₂ | |
| 23 ^c | 1520 ^b | 2.5 ^{ab} | 1531 ^d | V ₃ | |
| 22.2 ^c | 1500 ^d | 2.5 ^{ab} | 1525 ^e | V ₄ | |
| 23.3b ^c | 1515 ^c | 2.5 ^b | 1525 ^e | V ₅ | |

Means, in each column, followed by similar letters are not significantly different at the 5% probability level- using Duncan's Multiple Range Test. I₁, I₂ and I₃= 10 cm water irrigation, five-day alternate irrigation, and five-day alternate irrigation until starting heading with 10 cm flooding from starting heading until ripening time respectively; V₁, V₂, V₃, V₄ and V₅= Anbar boo, Tarem, Neda, Line 6 and Kadoos, respectively.

Data showed that maximum amylases content obtain from maximum 1000 grain weight. Maximum and minimum weight obtain from I1V3 and I2V5 treatments with 1578 and 1510 GDD, respectively (Table 1). Differences of weight obtained during this period was 2% between I1 level and I2 level were 2.3, 4.5, 2.4 and 1.6 in V₁, V₂, V₃, V₄ and V₅ cultivars. Among three irrigation patterns growth period reduced under I2 condition (where there was no water limitation during vegetative and reproductive stages). So, this reduction was in I3 treatment at vegetative stage. Growth period is more sensitive to water deficit during reproductivity stage (Table 1). This is in agreement with the study of Juliano and Pascal (1980), Pantuwan (2001) and Singh et al. (2000), but is in contrast with the study of Ouk et al. (2003). 1000 grain weight reduced under I2 treatment compared with other two patterns, thus water limitation during the vegetative stage had no effect on grain weight, but was affected during reproductivity and filling grain stages (Table 1). This is in agreement with Pantuwan (2001) and Juliano and Pascal (1980), but in contrast with Ouk et al. (2003). Maximum amylases content was obtained faster without water deficit during the reproductivity period (I2), but water deficit during the vegetative stage (I3) had no effect on this time period when compared with I1 (Table 1). It was observed that differences in amylases content were not high during I1 and I3 irrigation regimes. These results are in line with the study of Juliano and Pascal (1980), Ouk et al. (2003), Pantuwan (2001) and Singh et al. (2000).

Conclusion

Grain weight and amylase content reduced during reproductivity and grain filling stages as affected by drought stress. Data showed that maximum amylases content was obtained from maximum 1000 grain weight.

Water deficit has less effect on time of obtaining maximum grain weight, time of obtaining maximum amylases content rice during vegetative stage, but this time, becomes shorter during reproductivity and grain filling stages. Also, time of obtaining maximum amylases content in rice was faster than the time of obtaining maximum grain weight.

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