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SUMMARY

Three field experiments were conducted at the experimental farm of Rice Research and Training Center (RRTC), Sakha, Kafr El-Sheikh, Egypt during 2000, 2001 and 2002 rice seasons. The study, mainly, aimed to investigate the impact of water withholding at varying critical growth stage on behavior of some rice cultivars regarding growth attributes, yield potential and some grain quality. Furthermore, some water relations under direct seeded rice (drilling method) were studied.

A strip-plot design with four replications was used. The horizontal plots were devoted to eight water withholding treatments, i.e. :

1. Continuous flooding through the season and it is referred As (I_1).
2. Water withholding for 12 days at mid-tillering stage (MT) and it is referred as (I_2).
3. Water withholding for 24 days at mid-tillering stage plus at panicle initiation stage (PI) as a combination (MT+PI) and it is referred as (I_3).
4. Water withholding for 12 days at panicle initiation (PI) and its referred as (I_4).
5. Water withholding for 24 days at panicle initiation stage plus at heading stage (H) as a combination (PI+H) and it is referred as (I_5).
6. Water withholding for 12 days at heading stage (H) and it is referred as (I_6).

7. Water withholding for 24 days at mid-tillering stage plus at heading stage as a combination (MT+H) and its referred as (I_7).
8. Water withholding for 36 days at three stages as a combination, mid-tillering plus panicle initiation plus heading (MT+PI+H) and it is referred as (I_8).

The vertical plots were allocated to the three rice cultivars viz., Sakha 101, Giza 178 and Giza 182.

The studied characteristics were taken as follows :

A. Growth traits :

1. Dry matter production (DM) g/m^2
2. Leaf area index (LAI)
3. Chlorophyll content (SPAD)
4. Heading date
5. Light penetration

B. Yield and yield attributes :

1. Plant height (cm)
2. Number of tillers/m^2
3. Number of panicles/m^2
4. Panicle length (cm)
5. Panicle weight (g)
6. Number of filled grains/panicle
7. Percentage of unfilled grains
8. Sink capacity
9. 1000-grain weight (g)
10. Grain yield (t/ha)
11. Straw yield (t/ha)
12. Harvest index (HI)

C. Grain quality :

1. Protein % in grain
2. Hulling %
3. Milling %
4. Head rice %

D. Water relations :

1. Total water used m^3/ha
2. Water saved %
3. Yield reduction %
4. Water use efficiency (WUE)

The main results obtained from this investigation could be summarized as follows :

a. Growth traits :

a.1. Water withholding effect :

Drought stress at any growth stage and their combination had marked significant effect on dry matter production, leaf area index, chlorophyll content, heading date and light penetration in the three seasons. Also the severity of drought stress varied from growth stage to other. So that, the plants were grown under continuous flooding throughout the growing season gave the highest values of dry matter production, leaf area index and chlorophyll content. On the contrary, the intensive water withholding for 36 days at the three stages in combination of MT+PI+H gave the lowest values of dry matter production, leaf area index and chlorophyll content. It is worthy to mention that drought stress at the three stages in combination of stress at MT+PI+H gave the highest values of light penetration i.e. it severely affected plant stand while the lowest value of light penetration was obtained when the plants were grown under well watering i.e. higher plant stand. The longest period to heading was obtained when the rice plants were subjected to drought stress at the three stages in combination

of MT+PI+H. On the contrary, the continuous flooding gave the shortest period to heading. It is worthy to mention that drought stress at panicle initiation was more restricting to plant growth and its phenology followed by the stress at mid-tillering stage. It was obvious that water stress at heading stage was affected slightly plant growth and its phenology.

a.2. Rice cultivars performance :

Data showed that varietal differences were demonstrated among the tested cultivars regarding dry matter production, leaf area index, chlorophyll content, heading date and light penetration in the three seasons. Generally, Giza 178 rice cultivar performed better concerning the above mentioned criteria. On the other hand, Giza 182 rice cultivar badly behaved in this concern. Sakha 101 intermediated the both mentioned cultivars.

a.3. Water withholding and rice cultivars interaction :

The interaction between rice cultivars and drought stress had significant impact on dry matter production and chlorophyll content in the three seasons, and on heading date in 2000 and 2001 seasons but not in 2002 season. Generally, the best combination was Giza 178 and continuous flooding while the worst combination was Giza 182 and drought stress at MT+PI+H in the above mentioned traits. It could be discriminated that Giza 178 rice cultivar was more drought tolerant one while Sakha 101 rice cultivar came in the second rank in this concern. Giza 182 showed its inferiority under drought stress in the terms of more drought sensitive. In

addition, stress at panicle initiation was more harmful while, drought stress at heading stage was less harmful regarding physiological studied traits.

b. **Yield and yield attributes** :

b.1. Water withholding effect :

Water withholding significantly affected plant height (cm), tillers number/m^2, number of panicles/m^2, panicle length (cm), panicle weight (g), number of filled grains/panicle, sink capacity, unfilled grains percentage, 1000-grain weight (g), grain yield (t/ha), straw yield (t/ha) and harvest index in the three seasons. Generally, drought stress at any growth stage and their combination significantly diminished the yield and yield attributes. Subsequently, the drought stress at the combination of MT+PI+H gave the lowest values of the above mentioned characters, while, the continuous flooding gave the highest values of them. It was clear that drought stress at heading stage sharply restricted the panicle weight (g), 1000-grain weight (g) and number of filled grains/panicle and it, obviously, increased panicle sterility percentage, while, drought stress at mid-tillering stage severely decreased number of tillers/m^2, number of panicles/m^2 and sink capacity. On the other hand, drought stress at panicle initiation stage sharply restricted the plant height (cm), panicle length (cm) and grain yield (t/ha).

b.2. Rice cultivars performance :

The three tested cultivars significantly varied in their plant height (cm), tillers number/m^2, panicle number/m^2, panicle length (cm),

panicle weight (g), number of filled grains/panicle, sink capacity, unfilled grains percentage, 1000-grain weight (g), grain yield (t/ha), straw yield (t/ha) and harvest index. Giza 178 rice cultivar surpassed other two cultivars since it produced the highest values of previous characters. Also, Giza 182 rice cultivar confirmed its inferiority against other two cultivars regarding yield and yield attributes. Thereby, Giza 182 rice cultivar produced the lowest values of yield and yield attributes. It is worthy to mention that Sakha 101 rice cultivar gave the highest values of panicle weight (g) and 1000-grain weight (g).

b.3. Water withholding and rice cultivars interaction :

The interaction between water withholding treatments and rice cultivars had significant effect on panicles number/m^2, number of filled grains/panicle, sink capacity, unfilled grains % and grain yield (t/ha) in the three seasons. Also, the interaction between drought stress and rice cultivars had significant effect on number of tillers/m^2 in 2000 and 2001 seasons and harvest index in 2000 and 2002 seasons. Generally, the best combination in this study was continuous flooding and Giza 178 rice cultivar, whereas, it gave the highest values of the above mentioned traits. Whereas, the combination of drought stress at MT+PI+H and Giza 182 rice cultivar was the worst one since it gave the lowest values of number of tillers/m^2, number of panicles/m^2, number of filled grains/panicle, sink capacity, grain yield, and harvest index. While, the highest values of unfilled grains % were obtained from the treatments combination of Giza 182 rice cultivar and drought stress at MT+PI+H (I_8) i.e. sterility %.

In this concern, it was clear that Giza 178 rice cultivar was more drought tolerance, while, Giza 182 rice cultivar was drought sensitive one. Sakha 101 rice cultivar came in the intermediate between the two other cultivars regarding drought tolerance. Also, the drought stress happened at panicle initiation stage was more hazard on yield and yield attributes for all tested cultivars followed by the drought stress at heading stage.

c. **Grain quality traits :**

c.1. Water withholding effect :

Water withholding significantly affected on protein % of grains, hulling %, milling % and head rice % in the three seasons. While, drought stress at any growth stages or their combinations die-escalated the above mentioned traits. The highest values of the grain quality traits were obtained when rice plants were grown under continuous flooding while, the lowest values were recorded when rice plants were severely subjected to drought stress due to treatments combination of (MT+PI+H).

c.2. Rice cultivar performance :

The three tested cultivars significantly varied in protein % of grains, hulling %, milling % and head rice %. The highest mean values of hulling %, milling %, and head rice % were obtained by Sakha 101. While, the lowest mean values of them were obtained by

Giza 182. The highest mean values of protein content in grains were produced by Giza 178 rice cultivar, whilst, Giza 182 rice cultivar gave the lowest mean values of this character.

c.3. Water withholding and rice cultivars interaction :

The interaction between water withholding treatments and rice cultivars had significant effect on hulling % but it failed to exert any significant effect on the rest of grain quality characters. The combination treatment of Sakha 101 and well watering irrigation gave the highest values of hulling % while, the treatment combination of Giza 182 rice cultivar and drought stress at MT+PI+H gave the lowest value of hulling %.

d. Water relations :

Concerning the water relations as affected by water withholding treatments, it was found that continuous flooding treatment (I_1) consumed the highest values of total water used m^3/ha (13854, 14406.3 and 14691.0 m^3/ha) during 200, 2001 and 2002 seasons, respectively, followed by drought stress at heading stage (I_6) and then drought stress at panicle initiation. The lowest mean values of total water used (10548, 10855.3 and 11218.7 m^3/ha) were obtained when rice plant were subjected to severe water stress at MT+PI+H (I_8) during 2000, 2001 and 2002 seasons, respectively. Also, water used throughout treatments had similar trend for those obtained by total water used. Concerning water saved %, data clarified that drought stress at MT+PI+H (I8) gave the highest mean values of water saved % (23.91, 24.70 and 23.68) in 2000, 2001 and 2002 seasons, respectively while, water stress at MT+PI occupied the second order as

water saved % was concerned followed by both PI+H (I_5) and MT+H (I_7). Water stress at tillering stage saved more water followed by stress at panicle initiation and then stress at heading stage. In connection to yield reduction at each stress stage separately, it was recognized that stress at panicle initiation stage exerted the highest amount of yield reduction followed by stress at heading stage. The highest values of yield reduction % were recorded when rice plants were adversely subjected to water deficit at MT+PI+H (I_8) followed by water stress at PI+H (I_5). It is worthy to mention here that stress at mid-tillering stage gave the highest values of water use efficiency (0.77, 0.67 and 0.71 kg/m^3) in 2000, 2001 and 2002 seasons, respectively. While, drought stress at the combination of MT+PI+H (I_8) gave the lowest values of water use efficiency.

From data collected on water relation regarding rice cultivars, it was found that Sakha 101 rice cultivar consumed more water, while Giza 182 rice cultivar used less water because their short duration. Subsequently, Giza 182 rice cultivar saved more water followed by Giza 178, while Sakha 101 rice cultivar saved less water.

For yield reduction resulted from various drought stress treatments, it was found that Giza 182 rice cultivar recorded the highest value of yield reduction followed by Sakha 101 rice cultivar. Giza 178 rice cultivar gave marginal yield reduction, while it recorded the highest value of water use efficiency. Both rice cultivars of Sakha 101 and Giza 182 gave almost the same water use efficiency and occupied the second rank after Giza 178 rice cultivar.

CONCLUSION

It could be concluded that water deficit at both panicle initiation and heading stages must be avoided to obtain considerable grain and straw yields. Furthermore, drought stress at tillering stage can be practiced without more considerable reduction in grain yield. Also, Giza 178 rice cultivar could be recommended under drought stress circumstances, since it proved to be more tolerant to water withholding as this treatment was concerned. Water withholding for 12 days at mid-tillering stage of Giza 178 rice cultivar saved water by about 9.0 to 10.50% with slight reduction in grain yield (from 1.65 to 2.90%).