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Water use efficiency in rice culture

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Abstract. Water resources in Egypt are limited to 55.5 x 10^9 m^3 a year. With tremendous increase in the population, production has to be increased and irrigation water has to be well managed and has ways for increasing water use efficiency.

Several field experiments were conducted to rationalize water use. These experiments included (1) substituting the long duration varieties with short duration varieties, (2) using different irrigation interval (3) withholding water at certain growth periods which are no sensitive to water deficit, (4) using different methods for planting with the combination with land preparations. The available results indicated that, by substituting long duration variety Giza 171 (160 days) with Giza 177 or Sakha 102 (120) days could save about 20% of the irrigation water.

Results showed also that irrigation every 6 days along the growing season gave reasonable production compared with continuous flooding or irrigation every 3 days. Rice varieties showed higher sensitivity at early tillering stage; panicle initiation stage as well as early tillering. Most of the rice varieties were less sensitive in the later tillering stage as well as late maturity stage. Using mechanical transplanting could save about 3-5% water which used in seedling in the nurseries. Data showed also that dry leveling using laser technique help in good distribution to the irrigation water in the rice field preventing water accumulation in some areas while other areas are dry. Drill seeded rice can save some of the irrigation water compared to the wet direct seeded methods such as broadcast, seeding and dibbling methods.

The investigation concluded that long duration varieties must be substituted by short duration varieties. Drought tolerance variety (Giza 178) is recommended at the terminals.

Introduction

Commonly rice is grown under continuous flooding with about 5 cm depth of standing water throughout the growing season. Almost all rice varieties show better growth and higher productivity under continuous flooding conditions than ones exposed to water deficit at certain growth stages.

Several research workers showed that rice can grow normally with high yield under shallow water depth than under deep submergence that because shallow water causes rising to the water temperature during the day but a decrease during the night that allow more tillering and better growth. Most of Egyptian rice varieties produced higher grain yield when water content of the soil was kept near saturation throughout the season and this was comparable to that of continuous flooding (MTC,Annual Report, 1996). That means better yield not necessarily requires standing water on the soil surface.

Since the water resources in Egypt are limited to 55.5 x 10^9 m^3 a year and with tremendous increase in the population, production has to be increased and irrigation water has to be well managed and we have to find the way for saving more irrigation water.

There is a clear constraint on reducing in Egypt based on the necessity to control salinity in the Northern Delta. The saline aquifer which underlines the Northern Delta will cause soil salinity problems due to upward migration when the hydraulic pressure gradient permits. Periodic flushing with sufficient fresh water is required to reduce this upward migration. There is evidence that rice cultivation has actually improved some of the relatively saline soils in the Northern Delta. So that rice cultivation is very important conservation of soil fertility and reducing salinity hazard in particular areas such as Northern Delta.

I – Effect of various agronomic practices on water saving And increasing water use efficiency

1. Varietal substitution

One of the most important ways for saving some of irrigation water without reduction in rice areas is to substitute long duration varieties with short duration varieties. For example if Giza 171 rice variety (155 days) substituting with Giza 177 (120 days) and /or Sakha 102 (120 days) consequently, about 20% of irrigation water will be saved without any reduction in rice area. This amount of saved water is corresponding to about 2.5 x 10^9 m^3 under continuous flooding. This amount of saved water can be increased to about 30-40% with soil saturation condition.

Also if Giza 171 (155 days) is replaced by medium duration varieties such as Giza 178 (135 days) and Sakha 101 (135 days), about 10-15% of the irrigation water can be saved which is corresponding to 1.4 x 10^9 m^3 a year. This amount of water can be utilized by any of the summer crops.

2. Water stress at different growth stage

The performance of rice to water deficit at different growth stages has been reported by several investigators. Bhattacharjee et al (1973); De Datta (1973) Singh and Misra (1974); IRRI (1976 & 78) found that 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. Krupp et al(1971); De Datta (1973)concluded that 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. Singh and Misra (1974) reported that the reduction in grain yield was pronounced 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. Nour et al (1994) 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 (Table 2).

Data in Table 1 indicated that significant reduction in grain yield was found when rice varieties were either irrigated every 12 days interval or 6 days then shifted to 12 days for 36 days during tillering and panicle initiation. On the other hand, varieties were less sensitive to water deficit at flowering stage.

In other study at the Rice Research and Training Center Report withholding irrigation water at certain time of the growth stages of rice can save some of irrigation water. Before doing this withholding, the sensitive stages have to be determined. Data in Table 1 present the production of Sakha 102 rice variety as affected by withholding of irrigation water for 12 days started two weeks after transplanting up to maturity. The study indicated that rice plants can tolerate water deficit for 12 days at 4 weeks after transplanting and at either 8, 9 or 10 weeks after transplanting or after the full grain filling. While, it found to be very sensitive early after transplanting which is seedling stage, at 6 and 7 weeks after transplanting which is the panicle initiation stage and during the milk stage of the grain filling. These three periods, plants should not be exposed to any water deficit otherwise, yield will be reduced significantly.

Table 1. Effect of irrigation withholding at different times on productivity of Sakha 102 rice variety

Treatments	**Yield** (t/ha)
1-12 days withholding,15 DAT	6.39 d
2-12 days withholding, 21 DAT	6.81 cd
3-12 days withholding, 28 DAT	8.01 ab
4-12 days withholding, 35 DAT	7.40 bc
5-12 days withholding, 42 DAT	5.61 e
6-12 days withholding, 49 DAT	6.80 cd
7-12 days withholding, 56 DAT	8.09 ab
8-12 days withholding, 63 DAT	8.13 ab
9-12 days withholding, 70 DAT	8.06 ab
10-12 days withholding, 77DAT	6.67 cd
11-12 days withholding, 84DAT	7.83 b
12-12 days withholding, 91 DAT	8.74

DAT= Days after transplanting
Source: RRTC Annual Report 1997

More irrigation water can be saved particularly with Giza 178 which is more tolerant to water deficit than the short duration varieties (Table 2). This variety can tolerate withholding irrigation water for at least two times, the first during the vegetative growth (4 weeks after transplanting) and the other during the ripening stage. This variety is suitable in areas suffer from irregular irrigation such as at the terminals.

The complete replacement of long duration varieties by short or medium duration rice varieties by the year 2000, irrigation intervals for rice could be started early May and ended early September which is about 45 days less than usual with about 1.5 x 10^9 m^3 of irrigation water can be used either for soil reclamation or for other summer crops.

An adequate water supply is one of the most important factors in rice production. The main reason for flooding a rice field is that most rice varieties maintain better growth and produce higher grain yields under these conditions.

Water use and moisture stress effects vary at different growth stages. Some of the rice growth stages are more sensitive to water stress than others.

It is generally became clear now that rice plants show a marked sensitivity to water stress at early growth stage and during the formation of panicles and flowering. If rice plants were exposed to any water stress during these stages, tremendous reduction in grain yield will be expected.

Total water requirement for rice is depends mainly on the growth duration of the varieties. (Tables 2 and 3).

Varieties are different in their tolerance to water deficit. Giza 178 rice variety was found to be more tolerant than Giza 177 which is very much affected by water deficit, so that Giza 178 was recomrnended for areas which receive irrigation water irregularly as at the end of terminals (Table 2).

3. Irrigation intervals

Other way of saving irrigation water is to use the alternate irrigation during the rice season. Nour et al (1997) in one of their study (Table 3). The amount of water saved due to increasing irrigation intervals ranged from about 19 to about 39%. Highest saving of irrigation water was found when irrigation intervals increased from continuous (every 4 days) to irrigation every 12 days. Highest saving was found with Giza 177 with prolonged irrigation. While, the lowest saving of irrigation water was found with Giza 178 and Giza 176 rice varieties.

Table 2. Water used, water saved and water use efficiency of some rice varieties as affected by water regime

Treatments	Water Relations		
	Water used m3/ha	Water saved %	Water use efficiency (WUE)
Irrigation every 4 days			
Giza 176	11 550	–	0.72
Giza 177	9 240	–	0.83
Giza 178	10 626	–	0.95
IET 1444	10 164	–	0.95
Mean	***10 395***		***0.86***
Irrigation every 8 days			
Giza 176	9 321	19.30	0.62
Giza 177	7 170	22.40	0.61
Giza 178	8 604	19.03	0.89
IET 1444	7 887	22.40	0.99
Mean	***8 223***	***20.78***	***0.78***
Irrigation every 12 days			
Giza 176	7 200	37.66	0.62
Giza 177	5 600	39.39	0.57
Giza 178	6 400	37.89	0.84
IET 1444	6 400	37.03	0.85
Mean	***6 400***	***37.99***	***0.72***

Source: Nour et al., 1997.

Table 3. Yield reduction and some water relations under different irrigation regimes

Irrigation intervals	Yield reduction n %	Water saved %	Total water used m3/ha
Irrigation every 3 days	–		16 200
Irrigation every 6 days	4.2	16.7	13 496
Irrigation every 9 days	31.0	27.4	11 756
Irrigation every 12 days	40.0	36 7	10 239

Source: RRTC 1996.

Regarding water use efficiency, it decreased significantly as irrigation intervals increased and it varied among the different varieties

Generally, understanding the cultural practices is the only way for increasing rice production. All rice grower have the right to receive the full cultural practices recommendations in understandable way regularly particularly with the newly released rice varieties.

II – Plant spacing and irrigation intervals

Plant spacing play significant in irrigation water. Wider spacing increases the evaporation from the soil surface and consequently increases the evapotranspiration (ET). It might also enhance weed growth which consume some of the irrigation water sometimes higher than those used by the rice itself since the growth rate of weeds is very much higher than those of rice.

Generally, plant spacing depends upon the variety and it stillering ability. Some varieties have low tillering capacity (Giza 177) so that it has to be grow in narrow spacing and the inverse will be with those varieties having high tillering capacity (Giza 178).

1. Mechanization management

Methods of planting including direct seedling and transplanting are varied in their water consumption and water use efficiency. Mechanical and manual transplanting were found to consume less water than direct seeded methods besides it have higher water use efficiency values.

2. Laser and dry leveling

Dry leveling plays an important role in rice planting particularly in the direct seedling methods. Its control the water distribution in the field and prevent the accumulation of the water in one part of the field and dryness in other parts.

3. Effect of seeded preparation water requirement and water use efficiency

Seedbed preparation practices generally gave greatest effects on plant growth, which provide conditions for rapid water intake and for temporary storage of water on the soil surface or the tilled layer, which help to prevent water runoff. Soil compaction helps the soil to cut down percolation losses Study to the effect of seedbed.

Table 4. Total water requirement and water use efficiency as affected by land preparation and irrigation interval

	Total used	**Water**	**Water used efficient**	
Treatement	Giza 177	Giza 101	Giza 177	Giza 101
Land preparation				
Chisel plough (2 passes) + wet leveling	6 394	7 182	0.423	0.507
Chisel plough (1 pass) + dry leveling	6 572	7 413	0.373	0.406
Moldboard plough + disk + dry leveling	7 975	9 079	0.361	0.372
Zero tillage	6 092	6 500	0.251	0.415
LSD 5%	216	286	0.038	0.036
Irrigation interval				
Every 3 days	7 987	8 556	0.394	0.468
Every 6 days	6 896	7 823	0.404	0.487
Every 9 days	6 333	7 180	0.332	0.401
Every 12 days	5 818	6 615	0.278	0.326
LSD 5%	232	254	0.041	0.034

Preparations on water requirement and water use efficiency by Giza 177 and Sakha 101 rice varieties was conducted by AbouEI-Hassan(1997).Four treatments were used namely, Chisel plough (2 passes)+ wet leveling; Chisel plough (one pass)+ dry leveling; moldboard plough + disk + dry leveling and zero tillage withfour irrigation interval namely irrigation every 3, 6, 9 and 12 days. Data showed that zero tillage used less water than either any one of the land preparation methods with either wet leveling or dry leveling. The highest amount of irrigation water was used when moldboard plough + disk + dry leveling was use. Chisel plough either one or two passes + wet leveling gave the highest water use efficiency compared with moldboard plough. The study indicated also that less amount of irrigation water was consumed when irrigation every 12 day was used for both varieties. Lower water use efficiency values were accompanied with prolonged interval (Table 4).

4. Direct seeding methods

Direct seeding methods such as broadcast-seeded, drill-seeded and dibbling became popular and widely increasing in some of the rice areas. This mainly due to on one hand the shortage of well trained labors for transplanting besides the development and improvement of small machines which help in planting. On the other hand that mechanical transplanting is facing some constraints.

Direct seeding methods with rationalizing water use could save some of the irrigation water particularly because it requires good soil leveling which helps in the homogeneity of the water distribution in the field. Beside, direct seeding methods require low and shallow water depth at least for the first month where the seedlings are very short.

5. Broadcast seeding

Although this method of planting requires water for one month than that of transplanting, it requires very shallow depth of just saturation. This method is preferable with the short duration varieties with low tillering capacity which in turn less water consumed.

Three rice varieties namely Giza 176. Giza 181 and IET 1444 were directly seeded under three different irrigation interval namely, every 6, 9 and 12 days. The study was conducted at the Rice Research and Training center by Nour et al (1994).

The study indicated that increasing the irrigation interval more than 6 days significantly decreased plant height, biomass production, rice grain yield as well as yield components.

6. Drill seeding method

In drill seeded rice, some of the irrigation water could be saved since the irrigation regimes during the first month after seeding is flush irrigation which consume low amount of water compared with broadcast seeding methods. Extensive work is being done on this method of the planting but the water consumed by this method is not yet available.

7. Irrigation system and water resources

The competition for irrigation water is increased due to the limiting water resources in Egypt. Irrigation needs are expanding year as a consequence of increasing population growth. Egypt is almost depends on a fixed supply of water of about 55.56 billion cubic meters international agreement. Over the past two decades, improved water control in the Nile Base in has permitted the government to invest in new land. As a result, the areas which depend on irrigation, have been increased from 66 million feddan in 1974 to 7.97 million in 1977. In the past two years, the government has announced a commitment to further expansion of irrigated agriculture into Toshka and Sinai. So that, improved management of the currently available water resources is urgently needed and other resources of water have to be developed such as the lifting and transporting of deep groundwater to the new lands and using drainage water as it is or mixed with fresh water in irrigation.

Conclusion

In order to increase the effficiency of the irrigation water in rice fields the following alternatives should be used:

❑ substituting long duration varieties with short duration varieties in all rice growing areas ;
❑ convince farmers to use the laser technique in land leveling ;

- ❏ use the optimum plant with the specific rice varieties ;
- ❏ use the drought tolerance varieties such as Giza 178 at the end terminals ;
- ❏ withholding irrigation water for short time at medium tillering stage and during late grain filling stage ;
- ❏ improving the irrigation and drainage system to minimize water losses ;
- ❏ extensive public awareness campaign on the importance of the water and the possible methods for saving ;
- ❏ other water resources have to be developed such as ground water particularly for the reclaimed areas.

References

• **Abou El-Hassan W. H. M.** (1997).- *Effect of different methods of seedbed preparation and irrigation treatments on productivity of rice crop*. M. Sc. Thesie, Fac. Agric., Kafer El-Sheikh, Tanta Univ.

• **Bahattacharjee D.P.; G.R. Krishnayya; and A.K. Ghosh** (1973).- Analyses of yield components and productive efficiency of rice varieties under soil moisture deficit. IN: *Indian J. Agron.*, 16(3):314 -343.

• **De Datta S.K.; W.P. Abilay; and Kalwar** (1973a). 1.*Water stress effect on flooded tropical rice*. 2.*Water management in Philippines irrigation system research and operation*. pp 16-36.

• **Krupp H.K.; S.K. De Datta; and S.N. Balaoing** (1971). The effect of water stress at different growth stages on growth and yield of lowland rice. In : Proceeding of the Second Annual Scientific Meeting. *Crop Science Soc. of the Philippines*. pp 398-411.

• **Nour M.A.; A.E. Abd El-Wahab; F.N. Mahrous** (1994). *Effect of water stress at different growth stage on rice yield and contribu - ting variables*. Rice Research and Training Center. 1996. Annual Agronomy Report.

• **Nour M.A.; A.E. Abd El- Wahab; A.A. El-Kady; and R.A. Ebaid** (1997). Productivity of some rice varieties under different irriga-tion intervals and Potassium level. In : *Egypt. J. Appl. Sci12* (6): 137-154.

• **Nour M.A.; S.A. Ghanem; A.E. Abd EL Wahab and A.D. Bastawisi.** (1996). Behavior of some rice cultivars under different water regimes. In : *Menofiya. J. Agric. Res*. 21 (4): 837-850.