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WATER MANAGEMENT PRACTICES FOR RICE – A REVIEW

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ABSTRACT

Rice responds well to water management practices. The practice of land submergence in rice culture is widely adopted due to its many inherent advantages. However, attempts were made to economise water usage and maximise yield by intermittent submergence and similar other water management practices. Research carried out on other aspects on rice is reviewed in this paper.

Continuous submergence

In lowland rice cultivation, continuous submergence is the common practice. Maintaining a thin film of water under perfect levelling resulted in higher grain yield with minimum water use (Padmanabhan, 1984). Submerged soil conditions were reported to be congenial for optimum growth and yield of rice (Krfshnamurthy *et al.*, 1980). Many researchers reported the superiority of continuous submergence in terms of better performance and higher yield (Mandal and Chatterjee, 1984; Islam *et al.*, 1986; Kamalam Joseph and Hawanagi, 1988; Tayagi, *et al.*, 1991; Jayaprakash and Wahab,1995; Bhuiyan *et al.*, 1995). Continuous submergence (3 ± 1 cm) resulted in significantly higher grain yield than saturation (Satyavan *et al.*, 1989). Continuous submergence of rice crop produced higher grain yield than 5 cm irrigation applied 5 and 10 days after disappearance of ponded water (Tarafdar, 1990). Continuous submergence of 2.5 cm throughout the crop period resulted in higher grain yield, net return with a saving of about 25% irrigation water (Biswas, 1987). In areas of acute water scarcity, irrigating 2.5 or 5.0 cm depth one or 3 days after disappearance of ponded water recorded efficient use of water with marginal yield and net income losses (Balasubramanian, 1998). Higher mean grain and straw yields of 4.30 and 6.29 t ha^{-1} respectively were obtained by subjecting the crop to submergence of 5 ± 2 cm during tillering and reproductive stages with 7cm irrigation a day after disappearance of ponded water during the rest of the period (Panda *et al.*, 1997).

Intermittent submergence

Increased WUE with intermittent submergence was recorded as compared to continuous submergence (Jaggi *et al.*, 1985; Hukker and Sharma,1980). Intermittent submergence after crop establishment performed as good as continuous submergence without yield reduction (Sandhu *et al.*, 1980). Irrigation after two days of subsidence of ponded water at vegetative and four days of subsidence at reproductive stage gave better performance as that obtained by the land submergence in loamy sand soil (Uppal *et al.*, 1991). In Terai region, optimum rice yield with high water use efficiency could be obtained by intermittent irrigation 3 to 5 days after the water vanished from the surface of the soil with shallow water table and one to three days with medium water table (Mishra *et al.*, 1990). Under limited water supply, the practice of irrigation immediately after disappearance of ponded water was most suitable (Wahab *et al.*, 1996). In Tamil Nadu, continuous submergence during the critical growth stages and maintenance of submergence to saturation during the rest of the stages gave yields comparable to those obtained under continuous submergence (WTC, 1985; Yellamanda Reddy, 1985). During panicle initiation stage, maintenance of 2.5 cm shallow submergence is better than 5.0 cm and 7.0 cm submerged conditions (Sinha *et al.*, 1994).

Alternate flooding and drying

No significant differences were observed between continuous flooding and alternative flooding and drying as long as there was no water stress during the critical stages of crop growth (Bajpai *et al.*, 1992; Parihar *et al.*, 1995; Veeraraghavalu and Reddy, 1985). Tillering phase and primordia initiation to flowering stages were critical stages of rice when submergence was found essential (Rajaram, 1988). Irrigation one day after disappearance of ponded water gave yields comparable to that of continuous submergence besides considerable saving of irrigation water (Dawood *et al.*, 1990; Sandhu *et al.*, 1980; Ajula *et al.*, 1984; Krishnakumar, 1986; Purushothaman *et al.*, 1988). Comparable yield as that of continuous submergence and nearly 30% saving of irrigation water by providing with 7 cm irrigation on 3 days after disappearance of ponded water (Pandy *et al.*, 1989; Parasad *et al.*, 1990). Compared with continuous shallow submergence (5±2cm), 7 cm irrigation one day of subsidence of water saved nearly 21% irrigation water (Sinagandhupe and Rajput, 1988; Palchamy *et al.*, 1989; Sundar Singh *et al.*, 1995). Irrigation could be withheld upto 2 to 3 days after disappearance of ponded water (Jaggi, 1986; Mohankumar *et al.*, 1988; Choudhury *et al.*, 1991; Nageswara Reddi and Raju, 1992). Maximum grain yield of rice was recorded by the crop which received irrigation one day after disappearance of ponded water and reduction in grain yield to the tune of 12 to 22% in kharif and 12 to 16% in rabi season under irrigation 3 days after disappearance of ponded water and 21 to 43% in kharif and 28-36% in rabi season under irrigation with 5 cm of water 5 days after disappearance of ponded water (Manickasundram, 1992).

Irrigation scheduling at soil saturation

Highest rice yield was obtained when irrigated at saturation throughout the crop period (Suraj Bhan *et al.*, 1987). Irrigating rice at saturation during tillering and panicle initiation stages gave better results than irrigating at saturation during other stages. Seeding under saturated conditions improved seedling establishment and lodging resistance of wet-seeded rice (Pablico *et al.*, 1995).

Water requirement and consumptive use

In general, the water requirement of the crop ranges from 1500 to 2500 mm for different parts of the country (Varade and Dhanpal, 1988). Wet-seeded rice requires 20% lesser water as compared to transplanted rice since wet seeded rice does not require nursery preparation. The rate of ET and seepage + percolation losses from wet seeded rice field were 429 and 469mm respectively in Philippines (Bhuiyan *et al.*, 1995a). Rice requires 521 and 821 mm of water during kharif and summer seasons respectively of which 410 and 510 mm were required for crop ET and 181 and 311 mm were required for percolation during kharif and summer seasons respectively. The peak water requirement was found to be at panicle initiation stage in kharif and reproductive stage in summer in Coimbatore (Ilangovan *et al.*, 1991). On an average, more than 5000 liters of water is used to produce one kg of rice (Bhuiyan *et al.*, 1995b). Higher consumption of water (1701 cm) was resulted due to continuous submergence of 5 cm depth of water and the cyclic submergence of impounding 7 cm depth of water at 2, 4 and 6 days after disappearance resulting in decreased water requirement (IRRI, 1981). Irrigation to 5 cm depth 2 or 3 days after disappearance of water resulted in water economy of 4.2 to 5.3 % as compared to that of continuous submergence (Sharma *et al.*, 1988). The consumptive use of the rice variety IR 20 for the submergence depths of 1.5, 2.5 and 3.0 cm was 749, 1100 and 1132 mm of water respectively (Rangasamy *et al.*, 1984). The consumptive use of water was 926 and 637 mm under continuous submergence and irrigation at 2 days after disappearance of ponded water respectively (Alexander and Latif, 1988). In Tamil Nadu, water requirement for varying types of soils under different seasons varied from 1600 to 2500 mm (Chandramohan, 1970). The water requirement for field preparation ranged from 500 to 600 mm which account for 1/3 rd of the water used in traditional rice cultivation (Wickham and Sen, 1984). The water requirement of rice was 1280 mm under continuous submergence as against 1040 mm with 7 cm irrigation one day after disappearance of ponded water (Palchamy *et al.*, 1989). Wet-seeded rice is more water efficient and it requires 20% less water because wet seeding takes only 7 to 10 days of water intensive land preparation compared to 25 to 30 days for transplanted rice. This significant potential for improving the WUE of rice grown in irrigated areas (Bhuiyan, 1993). WUE for transplanted and dry sown broadcasted rice was 4.61 and 5.56 kg ha mm^{-1} respectively (Narayansamy *et al.*, 1993). 35 and 44 % water was saved for transplanted and direct-seeded rice respectively with saturated soil conditions compared to continuous standing water without significant yield reduction in Philippines (Abdus Sattar, 1992). The total water requirement of transplanted, wet sown and dry sown rice was 1154, 1105 and 1040 respectively with WUE of 3.07, 3.65 and 3.77 kg ha mm^{-1} respectively (Thabonithy *et al.*, 1994). Water used for land soaking, land preparation and for normal irrigation in wet seeded rice was 171, 569 and 1009 mm respectively while transplanted rice used 173, 722 and 1300 mm respectively for the same purpose. Yield was also higher to the tune of 10% in wet seeded rice than in transplanted rice (Bhiuyan *et al.*, 1995a). The WUE of rice on sandy clay loam soil varied with depth of irrigation and was 7.34, 4.73 and 3.93 kg ha mm^{-1} respectively for the depths 1.5, 2.5 and 3.0 cm (Rangasamy *et al.*, 1984). Irrigation one day after disappearance of ponded water resulted in high WUE (Reddy and Raju, 1987). Irrigation 2 days after disappearance of ponded water produced the highest WUE (Mastan and Vijayakumar, 1993). Irrigation with 2.5 cm depth of water was sufficient to produce higher grain yield rather than 5.0 and 7.5 cm depth (Biswas, 1987).

Influence of water management practices on rice

Application of water at higher regimes promoted growth of rice by increasing plant height (De Datta, 1981, Uppal *et al.*, 1991), tiller production (Reddy and Raju, 1987), leaf area index (Turner, 1979, Prasad *et al.*, 1990) and dry matter production (Subbaiah, 1985), root length (Ramamoorthy *et al.*, 1993), root volume and dry weight (Yellamanda reddy and Kulandaivelu, 1992), number of panicles m^{-2} (Tilak *et al.*, 1980), lengthier panicles (Sinha *et al.*, 1994; Kamalam Joseph and Havanagi, 1988), greater number of filled grains $panicle^{-1}$ (Ramamoorthy *et al.*, 1993) and higher 1000 grain weight (Uppal *et al.*, 1991). Maintaining a shallow submergence of 5±2 cm during the entire growth period was beneficial to rice in terms of yield (Subbiah *et al.*, 1989; Thorat *et al.*, 1987; Jha and Sahoo, 1988).

Water management in relation to weed growth

Water serves as an effective means of weed control since many weeds can not germinate under flooded conditions (Moody, 1978; Bhagat *et al.*, 1996; Ahmed and Moody, 1982; Nartsomboon and Moody, 1988). Control of weeds due to flooding is accomplished by an interaction of the changes in the physical, chemical and biological properties of the submerged soils (Tabbal *et al.*, 1992). Inverse relationship was observed between weed dry matter and degree of water application (Krishnakumar, 1986). Too low or too high soil water content prevent the growth of lowland rice weeds (Zimolahl *et al.*, 1987). Flooding the rice field is an effective method of controlling weeds (Fujarado *et al.*, 1990; Moody, 1978; Raju *et al.*, 1995; Mohankumar and Alexander, 1989). In flooded conditions, C_3 weeds dominated over C_4 weeds. Water depth suppressed some weeds like *Echinochola* spp. and *Leptochloa* spp. (Raju and Reddy, 1987). Shift in weed population from perennials to annual weeds due to change to soil and water management practices (De Datta, 1988).

Water management in relation to nutrient availability and uptake

The availability of phosphorus, potassium, calcium, silica and iron is increased by land submergence (De Datta, 1981; Padhihar and Dikshit, 1985). Soil availability of P is increased by flooding (Iruthayaraj and Morachan, 1980; Joshi and Sharma, 1980). Zinc availability was increased under flooded conditions (Neue and Mamaril, 1985). Increased N and P content in grain and straw with continuous submergence over alternate wetting and drying but the concentration and uptake of K were not influenced by water logging (Biswas and Mahaptra, 1980; Tyagi and Agarwal, 1989). Nitrogen use efficiency was higher due to broadcasting of sulphur coated urea under continuous flooded conditions (Shad and De Datta, 1988). The uptake of N, P, K, Fe, Mn and Zn increased due to early flooding (Jose Mathew and Sankaran, 1993).

Interval between submergence

The grain yield did not vary much with 4 to 8 days interval between irrigations and greater lodging resistance was reported (De Datta, 1981). In rotational irrigation system, yield did not vary with land submergence to 5 cm at weekly interval (Phamsy Tan and Pillai, 1981). A rotation interval of less than 8 days did not affect rice yield while an interval exceeding 8 days reduced the yield (Escalante *et al.*, 1982). In Pampanya valley project (Philippines) and Mahaveli irrigation project (Sri Lanka), scheduling irrigation at 5 days interval showed good results. Increased rice yields with land submergence to 5cm depth at 3 days interval as against continuous submergence

(Singh *et al.*, 1977; Reddy and Raghavalu, 1987). Recouping 5cm submergence once in four days recorded higher grain yield, net returns with a saving of about 30% in irrigation water (Sahu and Rath, 1972; Chandrasekaran, 1996).

Critical growth stages

Moisture stress during vegetative stage did not affect the grain yield whereas stress at flowering caused yield reduction (Nayak *et al.*, 1974). The yield of rice dropped steeply due to moisture stress at flowering (IRRI, 1980). Reproductive and ripening phases were crucial for moisture stress which resulted in permanent damage to yield attributes (Suryaprakasa Rao and Venkateswaralu, 1983). Stress during tillering, panicle initiation and flowering stages caused yield reduction upto 50% (Rajaram, 1988). Water deficiency during vegetative stage had no significant effect on grain yield whereas stress at panicle initiation, flowering and early grain filling reduced the yields by 70, 88 and 52% respectively (Yambo and Ingram, 1988).

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