DIRECT SEEDED RAINFED RICE IN COASTAL TRACT- A REVIEW

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ABSTRACT
Rainfed rice in the coastal saline tract is generally cultivated during the northeast monsoon, which contributes about 50 per cent of total annual rainfall due to the depression and cyclonic effect in the Bay of Bengal. Direct seeding of rainfed rice is commonly followed in the coastal saline tracts. Direct seeding reduces the duration by one or two weeks. Under rainfed conditions, the adoption of management practices such as drought and nutrient management will improve the grain yield. Application of Azospirillum, better seed hardening, nutrient management and weed management practices help in better crop establishment and increase the productivity of rice under rainfed conditions.

In India about 20 – 25 per cent of rice is grown under rainfed conditions. Direct seeding of rainfed rice is commonly followed in the coastal saline tracts. Direct seeding reduces the duration by one or two weeks. Rainfed rice is generally cultivated during the northeast monsoon, which contributes about 50 per cent of total annual rainfall due to the depression and cyclonic effect in the Bay of Bengal. Sowing coincides with the onset of monsoon and irregular pattern and erratic distribution of rainfall are the regular features. Many times, the crop may need to be sown twice or thrice for establishment due to early dry spells. During the peak rainy season, heavy intensity of rainfall up to 250 mm per day causes flooding. Early withdrawal also affects the crop. The yield of rainfed rice is thus low and variable depending on the vagaries of the monsoon.

Upland rice is grown in fields that are not banded but is prepared and seeded under dry condition and depend on rainfall for moisture (De Datta, 1975). Rice grown under upland condition is characterized by use of fewer inputs with low yields. Drought when rains do not occur or severe flooding during excess rainfall characterizes this ecosystem. (IRRI, 1984). Soils are generally sandy loam with poor native fertility and low moisture and nutrient retention capacity (Maurya and Vaish, 1984). Alluri et al. (1979) found that for direct seeded upland rice, early seedling vigour is extremely important for successful competition with weeds, a major production constraint. Monocropping of rice is a common feature in the rainfed coastal ecosystems (Pradhan, 1996).

Direct wet seeded rice has the advantage of quicker and easier crop establishment, earlier crop maturity by 8 to 10 days and more efficient water use due to reduced crop duration over transplanted rice (Suddhaiah and Balasubramaniyan, 2000). Rajakumara et al. (2003) observed that direct wet seeding has the potential to occupy the place of transplanted rice in the command area of Karnataka, Andhra Pradesh, Tamil Nadu and Uttar Pradesh. In rice, among irrigated and direct seeded rice, the number of panicles and panicle length and 1000 grain weight were significantly lowest in rain fed rice due to reduced moisture content in the root zone during dry periods of the rainy season and increase in N up to 90 kg ha\(^{-1}\) could influence the above character (Prasad et al., 1992).

Drought stress in rainfed direct seeded rice

The plant growth and yield is limited by drought stress and the extent of damage
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depends on the physiological stage of the plant and degree of drought stress. Plant height was reduced drastically due to drought stress at germination stage of upland rice (Gupta and O’Toole, 1986). Sorte et al. (1993) observed that the dry matter production get reduced up to 36 to 46 per cent during water stress at different stages viz., at 30, 50, 70 DAS in upland rice. Lenka and Garnayak (1991) reported that rice plants with well developed root system during early stages helped the plant to recover better from drought stress compared to less developed root system.

Drought stress at any growth stage reduced the yield (Yoshida, 1981). Drought stress at tillering decreased the tiller production (Murthy, 1987), productive tillers (Bhattcharjee et al., 1971) number of panicles per plant (Ram et al., 1988) and grain and straw yields (Krishnayya and Murthy, 1991). Sorte et al. (1992) found that drought stress during 50 to 70 DAS reduced the panicle number; number of spikelets per panicle, 1000-grain weight and grain yield. The yield reduction was 21.6 and 30 per cent when drought stress occurred during 30 DAS, 50 –70 DAS respectively.

**Seed hardening techniques**

Pre-sowing hardening is a treatment in which seeds are moistened and dried back to activate certain physiological processes which will enable the plant to resist drought with normal yield (Saxena and Pandey, 1994). Pre-sowing seed treatment improved the germination and establishment of various crops leading to better crop stand in the field (Chinoy and Saxena, 1978). Vanangamudi et al. (1986) reported that pre-sowing seed treatment with potassium salt improved the germination, seedling vigour index and seedling dry matter production. Haloi (1994) observed hastened germinability and better establishment under severe water stress when seeds were primed with CaCl₂ or 1 per cent KH₂PO₄ solution.

The seedling density was also higher because of the ability of the seedlings to withstand mild and moderate drought (Sankaran and Mathew, 1994). Seed hardening with 1 per cent KCl solution increased the plant height, LAI and DMP (Chockalingam et al., 1988; Porpavai 1990) and the total number of tillers and DMP (Kalaimani et al., 1979). The root length and root dry matter of semidry rice was favourably enhanced at 15 and 30 DAS when seeds were hardened with 1 per cent KCl solution (Porpavai, 1990). Haloi (1994) observed that seed primers such as CaCl₂ and KH₂PO₄ influenced the physiological parameters in upland rice. Higher grain and straw yields were reported due to seed hardening with 1 to 2 per cent of KCl and KH₂PO₄ (Ramanathan, 1980).

The seed hardening treatment techniques increased yield attributes and yield (Peeran and Nadanasabapathy, 1980; Kundu and Biswas, 1985). Yield attributes such as productive tillers (Ramanathan, 1980) number of panicles per plant, percentage of filled grains and test weight of grains were increased by seed hardening (Singh and Chatterjee, 1980). Mohandas et al., (1988) revealed that seed hardening increased the grain yield. Ramadass (1996) found that seed hardening enhanced the tillering ability of the crop from 46 – 92 per cent with various chemicals viz., KCl, KH₂PO₄, CaCl₂ (46 per cent), DAP and ammonium molybdate at 1 per cent each compared to untreated seeds and the yield increase ranged from 16 – 32 per cent. Seed hardening with succinic acid 100 ppm and cycocele 100 ppm influenced the grain and straw yield in rice under semi dry, direct conditions (Narayanasamy et al., 1991). Mehrotra et al. (1968) observed that seed hardening treatment with KCl and KH₂PO₄ each at one to two per cent increased the grain and straw yield of rice.

**Application of biofertilizers**

Azospirillum species is a nitrogen fixing bacteria that is found in association with the roots of
Monocots, particularly grasses and grain crops. Rao et al. (1979) found that in rice, *Azospirillum* inoculation increased the yield under laboratory conditions and under field conditions as observed by Kannaiyan et al. (1983). Murty and Ladha (1988) reported yield increases in rice inoculated with strains of *Azospirillum,* due to an increased root surface area and increased rate of NH$_4$ and PO$_4$ uptake. *Azospirillum* inoculation resulted in higher leaf water potential, lower canopy temperature, greater stomatal conductance and transpiration (Sarig et al., 1988). *Azospirillum* produced growth promoting compounds such as gibberellins, cytokinins and auxins such as IAA (Tien et al., 1979). Fullik et al. (1989) observed that *Azospirillum* inoculated maize seedlings with higher levels of IAA and IBA may be associated with yield increase.

Kapulnik et al. (1987) found that *Azospirillum* inoculated wheat showed enhanced root development and branching which helped to withstand drought conditions and yields better than uninoculated control. *Azospirillum* inoculation results in stimulating yield growth and surface area that results in plants taking up more nutrients that promotes improved water uptake and yield responses (Summer, 1990). Purushothaman (1988) found that rice inoculated with *Azospirillum* cultures had significantly increased grain and straw yields with enhanced root proliferations under upland conditions. *Azospirillum* inoculation in rice produced more number of productive tillers, filled grains, higher particle length and 1000 grain weight (Jeyaram and Ramiah, 1996).

Manjappan (2001) observed that there was a significant interaction effect of *Azospirillum* and nitrogen levels on grain and straw yields applied to rice cultivated in rainfed lowlands. Sushila and Giri (2000) revealed that *Azospirillum* application in wheat significantly increased plant height, tillers m$^{-2}$ and yield attributes. In maize, application of *Azotobacter* and *Azospirillum* increased green forage, dry matter and crude protein yields (Ratil et al., 1992). Narayanaswamy et al. (1994) reported that yield and root growth of maize were increased by soil and seed inoculation with *Azospirillum.* Under rainfed conditions, the interaction between nitrogen and biofertilizers were significant and application of *Azotobacter* and *Azospirillum* separately and their combined application had given yield of 2.67, 2.66 and 5.57 t ha$^{-1}$ (Rout et al., 2001).

**Nutrient management practice in rainfed rice**

Application of 50 per cent N at 3 weeks after sowing and remaining 50 per cent in two splits at 6 weeks after sowing and booting stage increased the plant height, tiller number and total dry matter of upland rice (Ratnaik et al., 1971, Dixit and Singh, 1977). Rao and Murty (1975) found that application of N at maximum tillering maintained optimum N content in leaf and enhanced tiller survival and dry matter production. Raj (1994) observed better root establishment and hastened crop maturity due to top dressing. Senthivel and Palaniappan (1985) observed that top dressing of K along with N at tillering, panicle initiation and flowering stage registered higher leaf area index, plant height and dry matter production.

Split application of one-third N, full P, half of K at thinning and one-third N at active tillering and one-third N and half K at panicle initiation stages increased the plant height, number of tillers and LAI of rainfed rice (Sheela and Alexander, 1995). The ear bearing tiller and the number of grains per panicle increased due to the application of N along with the K (Singh and Singh, 1972). Combined application of N, P and K (P as basal, N and K as basal and top dressing) at tillering and panicle initiation stage increased significantly the yield parameter of semidry rice (Ravi, 1992). In direct seeded rice, maximum grain yield was obtained with application of 60 kg N
and the yield was significantly superior to application of 40 kg N ha\(^{-1}\) (Kalita and Sarmah, 1992).

**Potassium and rainfed rice**

The quality of grain is improved by potassium. In wheat, quality parameters such as 1000 grain weight, protein content in grain, grinding quality, baking quality and absorptive capacity of water by flour are affected by potassium. Potassium has an indirect influence in increasing the uptake of N that in turn increased the plant height (Tisdale and Nelson, 1985). The uptake of potassium differs according to the growth stage of the crop, 24 per cent of total K uptake is between 0-37 days, 41 per cent between 38-58 days and 35 per cent between 59-88 days in rice (Golakiya and Polara, 2003). In rice due to interaction effect of nitrogen and potassium, the yield attributes of rice such as productive tillers were enhanced and highest K use efficiency was recorded at N80K40 followed by split application of K (half K at basal and half K at panicle initiation) Singh and Singh, (2000).

The foregoing review revealed the importance of management practices for rice under coastal saline ecosystems. With recent accentuation on sustainability and crop productivity exploitation of coastal ecosystems would pave way for boosting rice yield under adverse environments. It is evident that there is possibility of integrating organic and inorganic sources of plant nutrients for higher productivity under rainfed conditions. Management practices like Azospirillum application, seed hardening with various chemicals viz., KCl, KH\(_2\)PO\(_4\), CaCl\(_2\), (46 per cent), DAP and ammonium molybdate, application of Potassium etc, helps to improve the productivity of rice under rainfed conditions.

**Weed management**

In direct seeded rice, weed emergence occurs almost at the same time as that of rice plants and therefore, the competition is severe at early stages of the rice crop (Reddy et al., 1994).

Pulling weeds by hand is the reliable way to control weeds and in older times it was the only direct method of controlling weeds in rice (De Datta and Baltazar, 1996). Though hard weeding is very effective, it is labourious, time consuming and expensive due to high cost of labour particularly during peak period of labour requirement (Moody, 1993). In broadcast seeded rice, hand weeding is difficult as it may cause physical damage, while weeders fail to remove some of the grassy weeds (Moody, 1993).

Non-chemical methods of weed control for rice though beneficial, seldom control weeds adequately (Smith and Moody, 1979). The success of direct seeded rice is fundamentally dependent on weed control with herbicides (Moody and Cordova, 1985). However, herbicide selectivity is marginal because of similarities in morphological characters between rice and grass seedlings of the same age (Moody and Cordova, 1985) and its damage to crop is one of the factors limiting their use (Moody, 1980). Herbicides have to be applied at the right stage of weed growth either as pre or post emergence or the combination of these two.

Use of herbicides may become an economically viable and inevitable alternative to hand weeding where labour availability is a question as discussed earlier. Chemical weeding has many advantages through the achievement of weed free condition right from early stage of the crop providing early vigour without competition for vital resources.

Pretilachlor, a chloroacetamide group herbicide is selective to transplanted rice but only marginally selective in direct seeded rice without an antidote (saferner). Christ (1984) observed that the pre-mix formulation of pretilachlor + saferner (Sofit) was safe on wet
as well as dry sown paddy. Pre emergence application of pretilachlor + safener gave effective control of annual grasses, sedges and certain broad leaved weeds in direct seeded (dry and wet) rice. (Christ, 1984). Pretilachlor was found to be safe in wet seeded rice with excellent weed control and has positive effect on grain yield (Allard and Andreas, 1990).

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