WEED MANAGEMENT IN RICE - FISH - AZOLLA FARMING SYSTEM - A REVIEW

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ABSTRACT

Rice-fish-azolla farming system increases total production, decreases inorganic fertilizer and pesticide requirements, reduces the incidence of insect pests and weeds, gives additional fish yield and improvement of soil fertility and higher economic benefit. Grass carp (Ctenopharyngodon idella) effectively controls most of the aquatic weeds. Dual cropping of azolla in rice fields add benefit of suppressing weed growth besides fixing atmospheric 'N'. A review of research on weed management in rice-fish-azolla farming system has been presented in this paper.

Rice-fish farming system

Rice-fish culture increased N uptake of rice by 10.2% (Sinhababu et al., 1983). Rice grown with fishes Singhi (Heteropnaustes fossilis) and Magur (Clarias butrachus) yielded more than rice alone and the plots with supplemental feed produced more grain and reduced grain sterility percentage (Datta et al., 1984). In fields with fish culture, rice growth was better and yield of rice was increased by 8.0 to 47.3% (Nie Da-Shu et al., 1985). Growing Clarified cat fish with rice under intermediate rainfed lowland condition with provision of the fish shelter pit, could boost farm returns by 55.4% per cent over rice monocropping (Datta and Tripathy, 1986).

Although rice area was reduced by 14 % there was little difference in grain yield from plots with fish (4.6 t/ha) and control plots (4.7 t/ha) (Manjappa et al., 1987). A 10 % increase in N uptake of rice was observed when 4,350 fish/ha were stocked to rice fields, uptake of Fe by rice and its concentration in straw recorded two fold increase in presence of fish (Panda et al., 1987). Rice-fish farming was suggested for double crop wetland regions of Malaysia (Ali, 1988). Rice-cum-fish culture with fruit crops was suggested for West Bengal region (Chatterjee and Mandal, 1988). The integration of other farming activities into the rice/fish - capture farming system are being tried in order to fully optimize land (Ali, 1990). Integrating rice and fish in lowlying wetlands would improve the farm productivity through recycling of nutrients (Lightfoot et al., 1990). Cultivation of rice and fish made good use of agricultural lands, produced fish for home consumption, increased rice yields and generated additional income from fish sales (Mathew, 1991; Fedorck and Leleapatra, 1992; Das et al., 1993). Release of grass carp gave higher economic return as compared to cultivating rice along (Rekha Ghosh et al., 1994; Mathur, 1996). Due to synergetic effect of fish on rice, the rice yield increased by 10%, weeds and insects were controlled by fish (Kiran Dube, 1995; Mathur, 1996).

Rice-fish-azolla farming system

Feeding fresh and dried azolla to Tilapia (Oreochromis niloticus) in integrated rice-fish culture was beneficial (Almazen et al., 1986). Azolla microphylla as fertilizer in rice-fish farming system favoured higher rice and fish yields (Cagauan and Nerona, 1986). Integration of rice-fish-azolla system fully utilized the space and other resources and provided an ecosystem of multistrata structure with multigrade utilization (Likangmin, 1988; Liu and Zheng, 1989). Advantages of rice-fish-azolla farming system over traditional rice cropping systems included increase in fish production, decrease in inorganic fertilizer and
pesticide requirements, reduction in incidence of insect pests and weeds, improvement of soil fertility and higher economic benefits (FAO, 1988). Integrated farming systems comprising the components such as pig, duck, fish, azolla for the rice was suggested to La union regions of Philippines (Gavina, 1990).

There was an increase in rice yield and light use efficiency in rice-azolla-fish farming system in China (Huashan et al., 1992). Introduction of azolla and fish in the rice ecosystem rendered some manurial value which might have favourably influenced the rice yield (Shanmugasundaram and Ravi, 1992).

Rice-fish-azolla system recorded higher N, P and K uptake at both the seasons compared to rice farming alone and it was attributed due to degradation of azolla, fish manure and fish feed (Shanmugasundaram and Balusamy, 1993c). Rice-azolla produced the highest grain yield which was at par with rice-fish-azolla-calotropis system whereas rice-fish-azolla-calotropis system was more profitable than rice alone (Shanmugasundaram and Balusamy, 1993a and b). Maximum net return and per day profit were obtained in rice-fish-azolla farming system as compared to conventional cropping under lowland condition (Balasubramanian, 1994). Addition of azolla to rice-fish systems provided fodder for fish and fertilizer nutrient to rice crop (Liu Chung Chu, 1995). Sustainable aquatic weed control through the use of herbivorous fish, grass carp was reported in Europe and USA (Zon, 1984).

**Weed control by butachlor**

Butachlor @ 1 kg/ha was found effective in controlling the weeds in rice fields (Mehrotra and Ghosh, 1977 ; Joy et al., 1991). Major rice weeds viz., *Cyperus iria, Echinochloa crus-galli, Leptochloa chinensis, Ludwigia parviflora* and *Cyperus difformis* were effectively controlled by butachlor @ 1.5 kg/ha (Areco et al., 1979; Chela and Gill, 1980). Butachlor granules at 1.5kg/ha gave the best weed control (Mukhopadhyay and De Datta, 1979). When compared to hand weeding, butachlor at 1 to 2 kg/ha was more effective in checking weed growth (Sharma and Singh, 1981). Herbicide treated plots required less time for hand weeding at later stages than plots which were hand weeded once at 35 DAS and the economic benefits were greatest with butachlor (Erlinda et al., 1983). Butachlor performed superior against *Ammania multiflorum* (Fatemi, 1983). Butachlor @ 1.25 to 1.82 kg/ha applied on 0 to 4 DAP of rice effectively controlled the grass weed *E. crus-galli*, annual sedges like *C. iria* and *C. difformis*, broad leaved weeds like *Eclipta alba, L. parviflora* and *Sphencolea zeylanica* (Srinishavan, 1983). Butachlor 1.5 kg/ha applied on one DAT in rice significantly increased the yield and yield components (Azad et al., 1989). Application of butachlor at 1.5 kg/ha (pre-emergence) was superior in reducing weed dry matter and increasing grain yield compared to two hand weedings in rice (Mishra and Singh, 1989 ; Sathyaram et al., 1989 ; Ramiah and Muthukrishnan, 1992).

Herbicides-butachlor, oxadiazon, benthiocarb and pendimethalin were as effective as hand weeding in transplanted rice (Jitendra Pandy and Sokla, 1990). Higher grain yields over farmers’ practice in transplanted rice was noticed in butachlor granule application at 30 kg/ha as pre-emergence (Purushothaman and Hosmani, 1990).

**Use of fish for weed control**

Herbivorous feeding adversely affected weed growth, some fish species like *Puntius gonionotus* especially was reported to be in possession of the habit of uprooting or at least dislodging in some way many sedges (Hickling, 1961). Many fish species which were herbivorous feeders increased water turbidity which inturn inhabited weed photosynthesis (Avault et al., 1966). Tilapia preferred photoplankton, detritus and small weeds such
as *Lemna minor* and *Azolla pinnata* (Lahser, 1967). Weeding expense was reduced by the introduction of herbivorous fishes in rice-fish-farming systems (Hickling, 1971). The addition of herbivorous fish increased rice production by 40% (Chizhov *et al*., 1972). Weeds in irrigated rice fields were observed to be controlled by herbivorous fish such as *Tilapia rendalli*, *Puntius javanicus* under Brazilian environment (Moraes, 1976). Fish, when grazing on epiphyton, inadvertently damaged weeds to varying degree, thereby inhibiting weed growth (Bowen and Allanson, 1982). Common carp reduced the weed growth by 30% during the period between transplanting of the rice and first hand weeding (Ruddle, 1982; Fagi *et al*., 1989; Fagi *et al*., 1992). Controlled water supply and the herbivorous feeding habits of many fish species in intensive rice-cum-fish culture offered the opportunity for biological weed control (Vincke and Micha, 1985; Wan and Wang, 1991). Blue tilapia (*Tilapia aurea*) stocked at densities of 500 to 2500 adults/ha, with their offspring, successfully controlled submerged vegetation dominated by *Najas* and *Chara* (Schwartz *et al*., 1986). Reduced weed growth was observed in rice-fish-azolla system compared with system of rice-fish or rice alone (FAO, 1988). With the introduction of fish in deep water rice field, the rice crop became almost free from the dense mass of aquatic weeds that were abundant in the fish-free rice field (Biswas, 1990). The presence of fish resulted in a depression in the densities of sedges and broad leaved weeds in comparison to the controlled plots (Piepho and Alkamper, 1991; Piepho, 1993). Weed biomass was reduced by 67% by common carp and tilapia and they were found to be most effective in controlling weeds (Dela Cruz and Cagauan, 1992). It was possible to obtain 40% weed control by using rice-shrimp culture in rice fields (CRRI, 1994).

The 2 and 3 year old grass carp stocked at 50 to 80 fish/ha and 15 to 20 fish/ha, respectively completely controlled all weeds in rice of which the chief were weed millets (*Echinochloa* sp.), clubrushes (*Scripus* sp.), rush (*Juncus* sp.) waterwort (*Elatine* sp.) and stoneworts (*Chara* sp.), the addition of herbivorous fish increased rice production by 40 to 44% (Chizhov *et al*., 1972; Dubbers *et al*., 1980). Stocking 30 g grass carp at 1 to 6 per 10 m² completely controlled weeds in a rice field, floating weeds disappeared followed by submerged species, the grass carp had a preference for cereals and so it was not stocked until rice seedlings were well established (Tscuhiya, 1979). Costs of weed control with grass carp in Egypt were evaluated and they proved to be less than half of those of conventional methods (Khattab *et al*., 1981; Zon, 1984). In rice fields, where fish *C. idella*, *Cyprinus carpio* and *Tilapia nilotica* were cultured, 19 weed species of 13 families were effectively controlled (Yu *et al*., 1989). *Salvinia*, the floating aquatic weed was fed for grass carp and common carp fingerlings (Murthy and Devaraj, 1991; Nie *et al*., 1992; Kum Kum Shah *et al*., 1996). In biological control of weeds, the herbivorous Chinese grass carp was released at 40 DAT with carps of 17 cm average length at a stocking density of 1064 number/ha (Mitre *et al*., 1992).

**Rice-fish farming system on pest control**

Pupa of *Tryporyza incertulus*, adults of *Nephotetix impicticeps* and larvae of *Sesbania repens* were easily consumed from the base of the infected plants as the fishes nibble in search of food (Chakraborty and Ghosh, 1981).

Fish consumed insect pests, soil borne pathogens and improved soil fertility and rice growth (Liu, 1985; Lu and Huang, 1988). Introduction of fish into flooded rice fields in North East Thailand to control nematodes and insects increased the rice grain yields by 330 kg/ha and produced 125 kg fish/ha (Siripatra
and Vander, 1989). Fish in the rice fields reduced both stem borer population and its damage to rice plants (Biswa, 1990) and grass carp effective in controlling sheath blight of rice (Xiao-Qing-Yuan, 1992).

**Effect of azolla on weed**

Dual cropping of azolla in rice fields had the added benefit of suppressing weed growth besides fixing atmospheric nitrogen. Since it formed a mat over the surface, it reduces the entry of sunlight and aeration into the soil thereby weed growth was suppressed (Kannaiyan et al., 1983). Azolla rapidly formed a cover in rice fields and weeds trying to grow under it received little sunlight and eventually died (Nguyen, 1993). A common aquatic weed *Lemna* sp. was successfully displaced by azolla caroliniana (Olsen, 1972). A thick light proof azolla mat effectively suppressed weeds particularly young seedlings (Singh, 1977). Dual culturing of azolla reduced weed weight of *C. diffusum, E. crus-galli* and *Polygonum* sp. (Talley et al., 1977). *A. pinnata* failed to suppress the growth of *Salvinia molesta* (Heddy et al., 1979). Azolla suppressed the germination of *E. crus-galli* and that the degree of suppression increased as the percentage of azolla cover and water depth increased (Ngo gia Dinh, 1979). When azolla was inoculated into rice fields @ 500 g fresh weight m⁻² it covered the water surface rapidly and suppressed the weeds reducing the weed dry weight by 79% at 50 DAT (Anonymous, 1980; Chandran et al., 1985). Weeds with strong stature and abundant food supply can pierce through an azolla mat and weeds growing above the water surface before mat formation and largely floating weeds were unaffected by azolla (Lumpkin and Plucknett, 1980). Azolla rapidly formed a cover in rice fields and under this cover, weeds such as *E. crus-galli* and *Sagittaros* sp. received very little sunlight and eventually died (Anonymous, 1981). Azolla inoculation reduced the weed weight by 80% compared to unweeded control (Janiya and Moody, 1981; Latha, 1985). The population of *Marsilea quadrifolia* was much affected by a thick azolla cover (Srinivasan, 1986). Effective suppression of *E. colonum, E. crus-galli, Monochoria vaginalis, Paspalum sp. E. glabrescens, Brachiaria mutica, Digitaria sp.* and the late emergence sedges viz., *Cyperus rotundus, C. diffusum, C. iria* were achieved by azolla (Peters and Clavert, 1982; Janiya and Moody, 1984). Culturing azolla in flooded rice fields after transplanting reduced the weed quantity by 50%, azolla suppressed the growth of *M. quadrifolia* and *Scirpus articulatus* (Satapathy and Singh, 1985). Azolla was most effective in suppressing weed growth when grown in dual culture as a cover crop with periodic incorporation under appropriate management systems (Peters et al., 1986). Inoculation of azolla as dual crop with rice @ 1 t/ha had significantly suppressed the weed flora of grasses and sedges during early to maximum tillering stage of rice (Jeyaraman, 1991). The azolla inoculated plot recorded less weed count over unweeded control (Divakaran and Sundaram, 1995). Azolla significantly suppressed the weed growth in rice upto 45 days, with particular reference to grasses, sedges and broad leaved weeds (Srinivasan and Veerabadran, 1995).

**Effect of herbicide on azolla**

Application of 2, 4-D at 1000 to 10,000 ppm resulted in proportional necrosis in azolla (Lang and Seaman, 1964). Herbicides viz., butachlor, thiobencarb and propanil showed deleterious effect on azolla biomass production when applied 4th to 21st days after azolla inoculation (Janiya and Moody, 1981). Dicamba and simazine both at 1.0 ppm caused 99% reduction in N fixation (Kapusta et al., 1982). To avoid the deleterious effect of herbicide butachlor, azolla was dual-cultured, three weeks after herbicide application (Singh, 1982). Reduction in growth of azolla had been
observed at higher doses of butachlor, which was useful for rice crop by supplying organic nitrogen (Venkataramanan and Kannaiyan, 1984). Azolla was quite sensitive to butachlor and propanil (Sarkar and Jana, 1985).

Rice herbicides, thiobencarb and butachlor significantly reduced the azolla fresh weight at 10 days after treatment of herbicide, by 20 days after treatment the reduction was the highest, thiobencarb was the least harmful, reducing azolla fresh weight by 29% (Janiya and Moody, 1986). Application of EPTC + 2, 4-DEE to rice and inoculation of azolla on 3rd day after herbicide application, did not affect the growth and multiplication of azolla (Srinivasan, 1986). The herbicide treatments were imposed three days after transplanting and azolla was safe for inoculation at 9 DAT and incorporation at 30 DAT (at the time of weeding) (Srinivasan and Pothiraj, 1988). Irrespective of herbicide, inoculation of azolla six days after herbicide application had the highest fresh biomass and relative growth rate (Srinivasan et al., 1990).

**Effect of azolla on rice growth and yield**

Grain yield were increased by 4.4% with azolla treatments and by 22.2% with azolla + 60 kg N/ha giving highest yield with an inoculation rate of 200 gm² (Mather et al., 1981). Significant increase in rice yield was observed with azolla incorporated at 6 t/ha which was on par with azolla inoculated and allowed to grow with rice (Krishnaraj and Balasubramanian, 1983; Singh and Singh, 1995). Stimulated rice growth and increased grain yield were recorded with azolla incorporation along with 100 kg N/ha (Tahmida and Kader, 1983). Azolla inoculation increased tiller production, panicle number and grain yield (Venkataramanan, 1983; Johal, 1986; Satapathy, 1993). Azolla application together with 75 kg N/ha level gave 24.2% increase in grain yield and 34.4% increase in the straw yield (Nazeer and Prasad, 1984).

**REFERENCES**

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