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RICE-CUM-FISH CULTIVATION IN COASTAL PADDY FIELDS

PACKAGE OF PRACTICES FOR INCREASING PRODUCTION

CENTRAL INLAND FISHERIES RESEARCH INSTITUTE
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FOREWORD

India has a traditional system of paddy-cum-fish culture in coastal paddy plots in the States of Kerala and West Bengal. This system is largely based upon trapping of wild seed and culture during the fallow period when the paddy plots remain idle. The integrated system is practised in the low saline zones in deltaic zone of West Bengal. Only a single crop of paddy is cultuvated in the extensive tracts of paddy plots along the lower deltaic stretches in West Bengal. The Institute carried out studies covering a period of about 4 years in the lower Sunderbans in West Bengal conducting brackishwater aquaculture experiments in paddy plots during summer fallow period when salinity of water is about 20 ppt and fish-cum-paddy culture experiments in the kharif season. Under this system it is possible to achieve a production of 3,000 kg/ha in one crop of paddy and 1,000 kg/ha in two crops of fish in a year. The technology using medium saline water is however suitable only in areas where the rainfall is more than 1,500 mm/annum as that would assist the flushing of saline water taken during summer for aquaculture. The studies did not reveal any deterioration in soil quality in any manner. The technology has potential to transform the economic status of fishermen considerably besides giving year-long occupation to the paddy cultivators in the coastal area.

The manual has been designed for extension workers, entrepreneurs, bank officials and progressive fish farmers.

A. V. Natarajan
Director
Central Inland Fisheries Research Institute
Barrackpore, West Bengal

PACKAGE OF PRACTICES FOR INCREASED PRODUCTION IN RICE-CUM-FISH CULTIVATION IN COASTAL PADDY FIELDS

—Apurba Ghosh, G. N. Chattopadhyay & P. K. Chakraborty

1. INTRODUCTION

Coastal saline soils occupy an estimated area of about 3.1 mha in India which extend from the main sea coast to a few or even 50 km at places interior to the main land. The salinity of these soils is attributed to the inundation of the land with saline tidal water and ingress of sea water along the estuaries, creeks, canals and rivers. Moreover, the groundwater tables under these soils are generally present at shallow depths and contain high amount of soluble salts. These salts accumulate on the surface of the soils due to capillary rise of saline groundwater during dry periods of the year rendering the soils highly saline. Almost the entire area of the rainfed coastal saline soils is monocropped in nature, the major agricultural crop being kharif rice grown during monsoon period when soil salinity is low. During the rest part of the year, the lands usually remain fallow due to high salt content of the soils associated with the problem of want of good quality irrigation water.

The kharif paddy varieties widely used in such areas are Mahsuri, Sadamota, Kalomota, Talmugur, Damodar, Dasal, Getu, Nona-patnai, Jaya, Ratna, Pankaj, Patnai-23, Luni, Cuttackdhandi, Pokkali, Vytilla, Bilikagga, CSR-4, CSR-6, Matla, Hamilton, Palman 579, BKN, RP-6, FR-46B, Arya, etc., with traditional yield of 1.5-2.5 t/ha. However, paddy cultivation in these areas being almost entirely dependant on monsoon precipitation, getting a satisfactory yield every year is not possible. Paddy-cum-brackishwater fish culture system aims at utilising the summer fallow period of the coastal saline soils through a short term brackishwater aquaculture without affecting the subsequent kharif paddy crop. Thus, the farmers of such monocropped area are provided with a substantial subsidiary income during the otherwise fallow season in addition to what is obtained through uncertain monsoon dependant traditional agriculture.

In the upper and middle stretches of estuary as in West Bengal, where the salinity is either low or lowered by freshwater discharge diluting the tidal water, the cultivation of fishes in paddy fields is in vogue. In Pokkali fields of Kerala, summer fallow months are utilised by the traditional farmers for brackishwater aquaculture. The production of fish in such wild culture greatly varies from 300 to 1000 kg/ha. Freshwater prawn farming is also met within some of these plots during kharif. The prawn industry also thrive well in the paddy fields of Vembanad lake area covering over 5000 ha. Generally, *Metapenaeus dobsonii*, *M. monoceros* and to some extent *Penaeus indicus* among prawns and fishes like *Liza* spp., *Etroplus suratensis*, *E. maculatus*, *Chanos chanos*, *Platycephalus* sp., *Glossogobius* sp., etc. are harvested from Pokkali fields. In West Bengal coastal paddy plots, the production of *Liza parsia*, *L. tade*, *Rhinomugil corsula*, *Lates calcarifer*, *Mystus gulio*, *Macrobrachium rosenbergii*, *M. rude*, *Metapenaeus brevicornis*, *M. monoceros*, *Penaeus monodon*, etc. is often augmented with the stocking of carps and tilapia for better return.

A view of the coastal paddy plots of West Bengal which can be utilized for integration of rice-cum-fish culture. An additional brackishwater fish crop also can be raised from the plots during the summer fallow period.

2. PLOT SELECTION

Most of the coastal area is low lying, the elevation varying usually between sea level and 8 m above the MSL. These almost flat areas need coastal embankment for protection from free access of the tidal waters. Site for rice-cum-brackishwater fish culture is located within the embanked area in rainfed coastal saline zones. Fields having elevation between low and high tide levels are desirable for water exchange during brackishwater aquaculture period and also for frequent draining of monsoon water during desalination process. The sluice in the embankment is essential for regulating the flow of tidal and drainage waters. The area having more than 1 m tidal amplitude is considered fairly good for rice-cum-brackishwater aquaculture.

Medium textured soils are considered to be the most suitable as the light textured ones will prevent retention of water during pisciculture period, while heavy textured ones will affect desalination of the soils after brackishwater aquaculture. Hence, silty clay or silty clay loam soils should be preferred to clay or sandy-loam soils.

Heavy monsoon precipitation for the site (more than 1000 mm) is an essential requisite for desalination of the soils after brackishwater aquaculture and also to cope up with the monsoon evapo-transpiration rate (375-640 mm). A list of some important soil properties and distribution of rainfall in different Maritime States is given in Table 1 for providing a guideline before selecting the proper plot for rice-cum-brackishwater aquaculture operation.

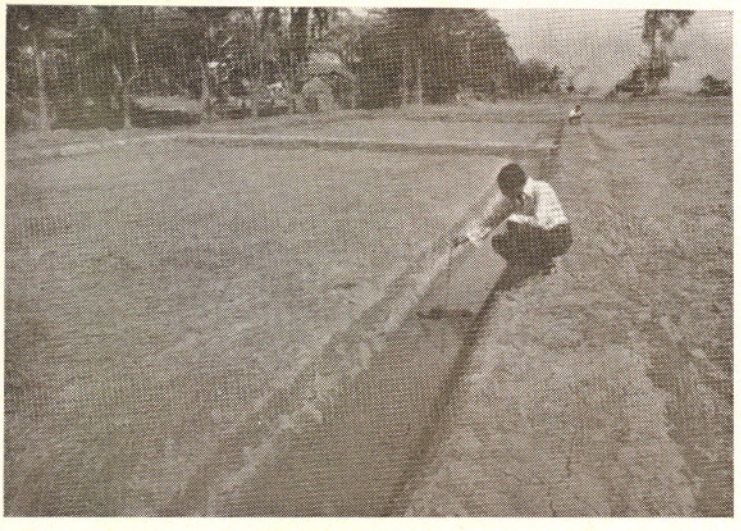
Availability of seeds for commercially important species of fishes and prawns is another important criterion which should be considered carefully before selecting the plot. Easy availability of such fish and prawn seeds will lead to more economic viability of the culture system not only through reduction of cost of stocking materials but also by getting better returns through culture of only those species which fetch high values in the market.

*TABLE—1 SOME IMPORTANT SOIL PROPERTIES AND RAINFALL DISTRIBUTION IN DIFFERENT COASTAL AREAS OF INDIA

States	Soil Texture	pH	ECe (mmhosh cm)	Rainfall during June-Sept. (mm)
Sunderbans, West Bengal	Silty clay—Silty clay loam	5.5-7.0	4-35	1325
Orissa	Clay loam—Clay	5.5-7.5	2-50	1140
Coastal Andhra Pradesh	Sandy loam—Clay loam	6.0-8.8	0.5-17	570
Tamil Nadu	Sandy loam—Loam	6.0-8.2	2-10	340
Kerala	Sandy loam—Loam	3.5-5.5	1-20	2010
Coastal Maharastra	Sandy loam—Clay	7.0-8.5	4-14	2700
Gujarat Region	Sandy loam	7.5-8.5	9-20	930
Coastal Karnataka,	Sandy loam—Loam	5.0-7.5	3-10	2850
Goa	Silty clay—Silty clay loam	5.0-6.0	4-15	2775 (approx.)

**Adopted from Bulletin No. 5, Central Soil Salinity Research Institute.*

3. PLOT DESIGN



Plots are renovated by constructing dykes and digging perimeter canals.

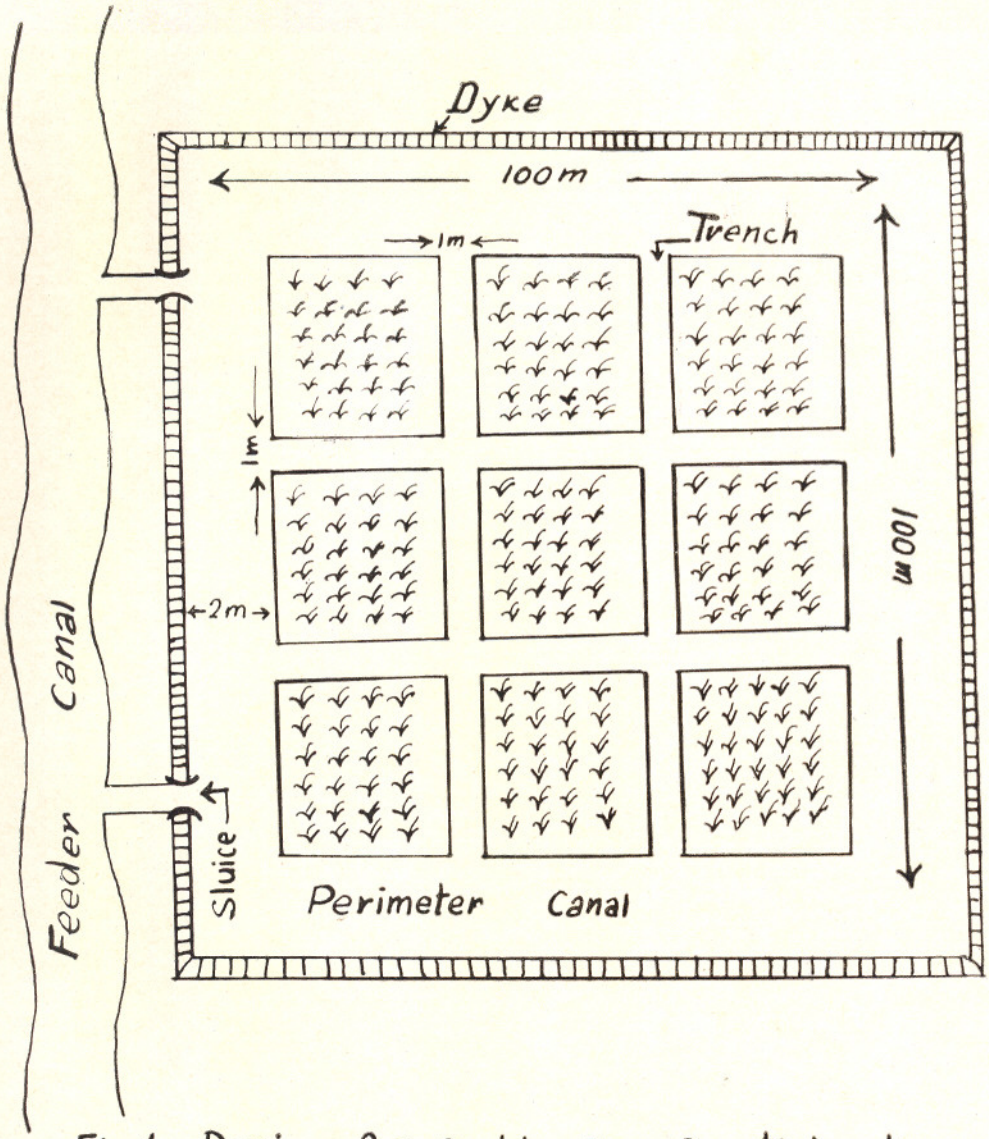


Fig.1. Design of a Paddy-Cum-Brackishwater Fish Culture Plot. (1 ha)

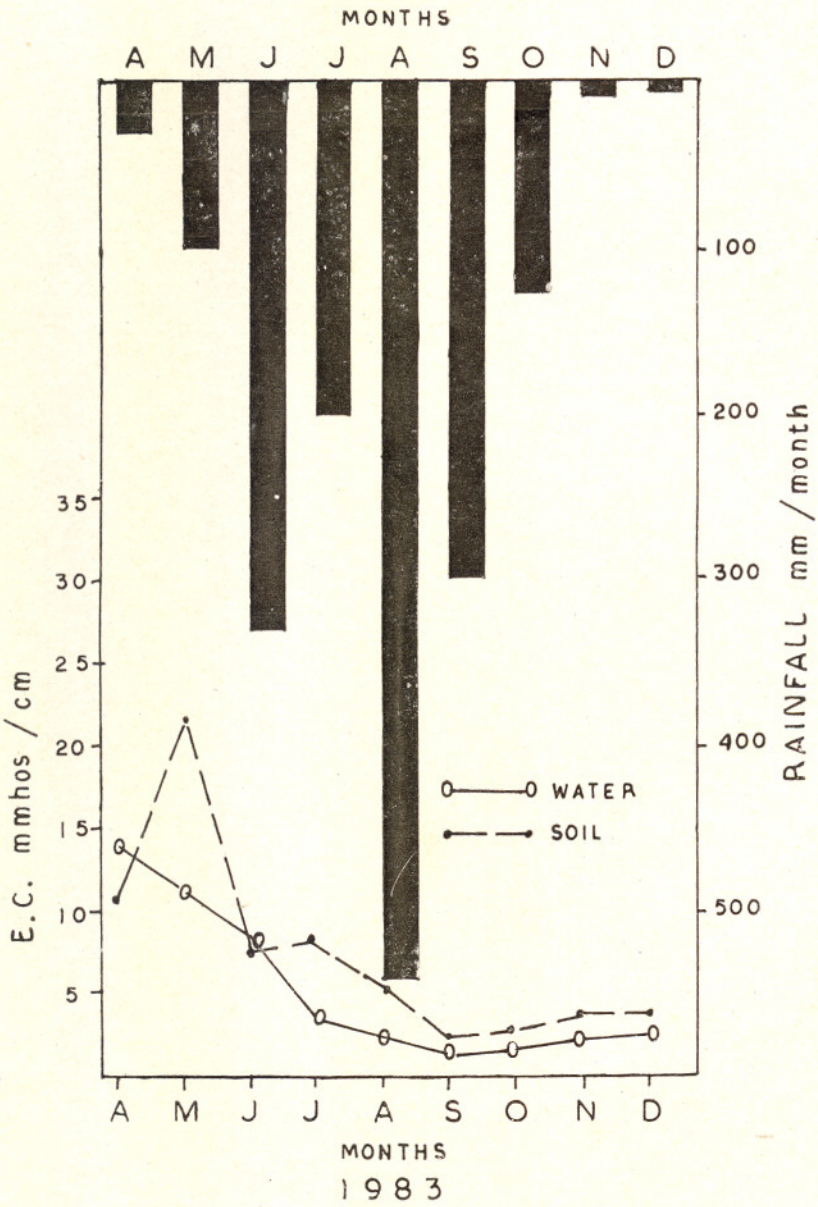

MONTHS
A M J J A S O N D
100
200
300
400
500
RAINFALL mm / month
35
30
25
20
15
10
5
E.C. mmhos / cm
WATER
SOIL
A M J J A S O N D
MONTHS
1983

Fig. 2

For the purpose of paddy-cum-brackishwater aquaculture, paddy plots should be renovated suitably. Construction of an earthen dyke surrounding the paddy plot is essential for retaining water and also for holding the fishes and prawns during aquaculture. The height of the dyke is required to be maintained between 50 and 100 cm depending upon the topography of the plot and tidal amplitude at the site. A perimeter canal is necessary on the inner periphery of the plot. For a one ha paddy plot, the width and depth of the canal may be about 2 m and 1 m respectively. The earth removed in excavating the canal may be utilized for constructing or strengthening the dyke. In addition to the perimeter canal, two cross trenches of about 1 m width should also be constructed at both the directions, each of which will join the perimeter canal in opposite directions. The bottom of the trenches should be above the perimeter canal so that during the course of desalination, entire water can easily be removed to the canal. The area covered by the perimeter canal and the trenches will be about 12% of the total land area. Entry of tidal water during brackishwater aquaculture is made through the feeder canal and the flow into the paddy field is regulated by a box type sluice gate fitted with wooden shutters and placed at about 30 cm height from the main plot. During the high tide, water is taken into the plot after sieving through velon nets and split-bamboo mats to prevent entry of undesirable species, especially carnivores. Another sluice box is used for draining out the water from the culture plot to the feeder canal at low tide periods for water exchange, desalination and drainage of excess water. The mechanisms of these sluice boxes are very simple. Each sluice system comprises of a strong wooden box, long enough to penetrate through the dyke. On the entry and exit mouths of the box, wooden shutters are provided to regulate the movement of water. A figure depicting the design of a typical rice-cum-brackish-water fish culturing plot is given in text Fig. 1.

4. MANAGEMENT OF PADDY FIELDS FOR AQUACULTURE

Judicious field management is essential for the conversion of monocropped coastal saline areas into multicropped ones. During summer months, short term brackishwater aquaculture with commercially important species may be undertaken as a rotational crop. The water salinity during this culture period may vary between 10 and 40 mmhos/cm which builds up top soil salinity to an extent of about 25 mmhos/cm. Work done by CIFRI reveals that in suitably managed plots the ecological condition generally remains favourable for the growth of brackish-water fishes and prawns.

Intake of brackishwater must be suspended before the onset of monsoon, the cultured species harvested, and then the land should be exposed to monsoon precipitation for the purpose of desalination. With the advent of rainy season the soil salinity decreases rapidly depending upon the extent of monsoon precipitation and E. C. values go down to nearly 4 mmhos/cm or even less. After restoration of congenial soil condition, the transplantation of kharif paddy seedlings is done. Following appropriate anchorage of the transplanted seedlings, juveniles and fingerlings of freshwater prawns and fishes are released into the plot to obtain the second crop of fish along with paddy. Plankton concentration usually declines during paddy cultivation period as compared to that during brackishwater aquaculture period while the benthos density generally improves. Hence introduction of more benthic feeders will help to increase the yield during freshwater phase.

Generally, paddy is harvested by the end of November. Freshwater aquaculture may be extended further upto December depending upon availability of water. After this, the plot is dried completely and prepared for next crop of brackishwater aquaculture.

5. PLOT PREPARATION

Plots are prepared in two phases, once for brackishwater fish crop and again for kharif paddy cultivation along with freshwater fish. For summer aquaculture crop, the plot is sun dried after the kharif harvest. If necessary, to rectify acidic soils, lime is applied depending on the requirement of the soils as stated below :

TABLE—2 LIME DOSES AT DIFFERENT pH VALUES OF SOILS

pH	Soil condition	Dose of lime kg/ha
4.0-4.5	Highly acidic	1000
>4.5-5.5	Medium acidic	700
>5.5-6.5	Slightly acidic	500
>6.5-7.0	Near neutral	200

Usually no inorganic fertilization is done. However, urea may be used in extreme cases of nitrogen deficiency of soils @ 60 kg N/ha. Broadcasting of rice-bran @ 1000 kg/ha over the soils has been observed to encourage the growth of lab-lab. At this stage the perimeter canal and the trenches are filled up with the tidal water and 5 cm high water sheet is maintained over the paddy plot for about a week. Within 3-5 days lab-lab grows and gradually covers the soil surface like a green carpet. The remains of paddy stumps within the field decompose and build up ideal condition for the growth of periphyton and diatoms. Periphyton growth is further encouraged by putting date palm leaves over the field. Some shady zones are provided over the perimeter canal with twigs, hay, palm leaves, etc. so that during summer heat the fishes and prawns can take shelter and also hide themselves from predation. In this manner the plots are to be prepared for brackishwater aquaculture.

Palm leaves are placed in the field to enhance periphyton growth.

Following summer fish crop, the salt water is completely drained out before onset of monsoon. The rain water is allowed to wash down the salt from the soil surface to the trenches and then finally to the estuaries through the sluice

gate during low tide period. The flushing operations are repeated till the soil salinity declines to nearly 4 mmhos/cm or less. To ensure better desalination, the top soil may be scrapped and small heaps be made on the soil surface. Thus the monsoon precipitation can act upon more surface area of the soils and desalination process is quickened.

For the cultivation of kharif paddy in coastal saline soils, use of only nitrogenous fertilizers is generally advocated @ 60 kg N/ha in three equal doses at basal, tillering and flowering stages. During kharif no substrate for periphyton growth and shelter of prawn is necessary becuase at this stage the paddy plants fulfil such requirements. Between two cropping seasons, the maintenance work for the dykes, sluice boxes, trenches, etc. are to be attended. No ploughing but simply tilling of the top soil is required for paddy transplantation. Maintenance of low level of water during transplantation of paddy seedlings also encourages development of lab-lab during kharif containing important algal species *viz.*, *Lyngbya* sp., *Anabaena* sp., etc. and other zooplankton components in the matrix. This provides feeding materials for freshwater fishes and prawns cultured along with paddy.

6. SUMMER FISH CROP

Once the lab-lab is formed, the tidal water level of the paddy plot is raised to 20-60 cm. By March, *P. monodon* and *L. parsia* are stocked at a combined density of 40,000 to 50,000/ha in the ratio of 1 : 1. For stocking, juvenile prawns (40 mm) are always preferred to postlarvae (12 mm) for better survival and for mullets, stocking size recommended is around 3 g. The stocking materials are generally procured from the seed collecters. If required, the seeds may also be collected by the farmer through his own efforts from the estuarine areas situated in the near vicinity of the farm site by operating shooting net, scoop net for prawns and 'hapa' or other drag nets for juvenile fishes during known period of abundance in winter and summer months. The species should be acclimatized before release and stocking is done in the morning or evening hours. For monitoring, samples are drawn with the help of traps placed near the sluice boxes during tidal ingress. Supplementary feeding with rice-bran and MOC in 1 : 1 proportion @ 2-3% of the body weight is recommended to prevent early cannibalism among prawns. Plots are flushed with tidal water during full moon and new moon days when the tidal amplitudes are maximum, High level of putrification

bringing down the D.O. level of pond water below 3 ppm at times needs constant vigil and monitoring. Feeding may be discontinued during such critical periods. By June end the water should be eompletely drained out and the fishes and prawns harvested.

Brackishwater fishes and prawns are harvested before the onset of monsoon.

A harvest of brackishwater prawns and fishes from paddy plot.

7. KHARIF CULTIVATION OF PADDY ALONG WITH FISHES

Desalination period falls between July and August depending upon the advent of monsoon. When congenial conditions of cultivation of paddy are restored, one month old paddy seedlings grown in non-saline seed beds are transplanted keeping spacing of 15 x 15 cm. A list of some promising paddy varieties under different water depth and soil salinities are given in Table-3. Depending on the condition of the plot, the suitable variety may be selected. Seed required for transplantation of one hectare land is 45, 50 and 55 kg for fine grain, medium grain and

TABLE—3 PADDY VARIETIES SUITED TO DIFFERENT WATER DEPTHS AND SOIL SALINITIES

Water depth (cm)	Soil salinity (mmhos/cm)	Paddy varieties
15-25	<5	Jaya, Mahsuri, Pankaj, IR-8,
,,	5-8	CSR-1, CSR-2, CSR-3, SR 26-B, Nona-Sail (S), Nona-Bokra.
,,	8-10	CSR-1, CSR-2, CSR-3, SR 26-B, Nona-Sail(S)
,,		Hamilton, Matla, Nona-Bokra.
25-50	<5	SR 26-B, NC 1281, Kalomota (Sel)
,,	5-8	SR 26-B, NC 1281, Nona Sail (S), Nona-Bokra, Hamilton, Matla, Kalomota (Sel).

coarse grain respectively. Ideal water level to be maintained for the seedlings in the field is about 15 cm. The coastal paddy is susceptible to attack of fungus due to high humid conditions (above 60%). To prevent infestation of pests, a mixture of 0.2% aqueous solution of Hinosan and 0.1% aqueous solution of Dimecron by equal volumes may be applied @ 500-550 litres/ha. Three doses *i.e.*, the first during initial phase, the second during growing phase for reinforcement and the third during flowering stage to avoid loss of crop are recommended. The associated prawn and fish population of the integrated system has not been observed to be affected by such applications. During November the paddy is reaped.

When paddy seedlings have taken root by the end of August or by the begining of September, carp fingerlings (5-10 g) preferably *Cirrhinus mrigala*, *Labeo bata*, *Puntius javanicus*, etc. are released into the plot along with juveniles of *Macrobrachium rosenbergii* (3 g size). The combined stocking density maintained is 25,000/ha

with the ratio for prawn and fish at 2 : 1. No additional manuring of the soil is necessary for the fish crop. Usually rice-bran and MOC mixture (1 : 1) @ 2% of the body weight of the stocked prawn and fish is provided daily for favourable growth of stocked population. No tidal water but only the rain water is hold upto the desired lavel *i.e.*, 15-30 cm depending on the nature and situation of the plot. Any excess water is drained out through the sluice box during low tide.

Paddy crop raised in the same plot during kharif season.

After the reaping of paddy, the rain water cannot be retained beyond December due to water loss through evaporation and seepage. Hence harvesting of fresh-water prawn and fishes is required to be initiated soon after paddy harvest.

8. YIELD AND PRODUCTION RATES

The summer fish crop of 3 months duration gives an yield of 400-600 kg/ha, of which about 60% is *P. monodon* and the rest is mullet. Survivals of 40-50% for prawn and 70-80% for mullet are usually obtained from such a cropping system.

During kharif, the production of prawn and fish harvested along with paddy is 500-600 kg/ha/3 months. Of these, about 40% is contributed by *M. rosenbergii* and the rest by carps. The survival rates are generally observed to be more than 90% for the prawn and about 65% for the carps.

Harvest of freshwater prawns (above) and fishes (below) raised alongwith paddy crop.

Thus from the two aquaculture crops, a total yield of 900-1200 kg/ha/6-7 months of commercially important species of fishes and prawns may be obtained, besides a normal yield of 3000 kg/ha paddy during kharif. Of the aquacultural produce, 400-600 kg/ha is obtained from the brackishwater aquaculture during summer season when the lands would be otherwise remaining fallow. This bi-commodity culture sytem is an ideal example of appropriate land use to increase production.

9. ECONOMICS Based on experiments of CIFRI and CSSRI

The economics of the culture system, calculated on per hectare basis, are as follows :

A Capital cost

a)	Different fixed costs	Rs. 16,500
b)	Annual interest (@ 12%)	Rs. 1,980
c)	Depreciation vaiue/year	Rs. 1,370

B. Prime cost

a)	Factor services	Rs. 6,500
b)	Material inputs	Rs. 10,200
c)	Annual interest (@ 15%)	Rs. 2,505

C. Expenditure in a year

i)	Prime cost	Rs. 16,700
ii)	Interest on prime cost	Rs. 2,505
iii)	Interest on capital cost	Rs. 1,980
iv)	Depreciation value	Rs. 1,370
	Total	Rs. 22,555

D. Return

	Item	Quantity (kg)	Rate (Rs/kg)	Price
a)	*P. monodon*	228.0	50	Rs. 11,400
b)	*L. parsia*	164.5	20	Rs. 3,290
c)	*M. rosenbergii*	147.0	20	Rs. 2,940
d)	*P. javanicus*	216.7	20	Rs. 4,334
e)	Misc. prawns & fishes	138.9	10	Rs. 1,389
f)	Paddy	3156.0	2.50	Rs. 7,101
			Total	Rs. 30,454

E. Economic Return

i) Return to enterprise	Rs. 7,899
ii) Return to investment	35.0%
iii) Profit to turnover	25.6%
iv) Return to fixed cost	42.7%

10. GENERAL OBSERVATIONS & CONSTRAINTS

Success of rice-cum-brackishwater aquaculture system depends largely on adaption of suitable management practices and also on monsoon precipitation. The brackishwater aquaculture must be stopped before the onset of monsoon precipitation and the saline water should be drained out to ensure maximum desalination of soils during monsoon. Moreover, desalination of such soils being dependant almost entirely on monsoon precipitation, the agriculture may be affected if rainfall is not sufficient during kharif paddy cultivation period. However, paddy cultivation as a whole in coastal saline soils is dependant almost entirely on monsoon rains. Hence, scarcity of such precipitation during monsoon period will not only aflect the paddy production in rice-cum-brackishwater fish culture plots but also in ordinary agricultural plots.

In some states, due to land ceiling act, agricultural plots cannot be used for fishery purposes. There is also a strong body of opinion that the use of paddy plots for brackishwater aquaculture in fallow months may adversely affect paddy cultivation in the long run. But it has been observed that in areas receiving high monsoon precipitation of the order of 1000 mm and above, the saline accretion on account of intake of tidal water in summer months for brackishwater aquaculture will be flushed or leached out. It is, therefore, desirable to re-examine the act for modification to promote export of tiger shrimp. This wohld also improve the economy of the farmers in the coastal belt.