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LEGUME-FISH INTEGRATION: CULTIVATION OF SOYBEAN AND BUSH BEAN UNDER SATURATED SOIL CONDITIONS WITH BLUE GOURAMI

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Abstract

*Benefits of an integrated culture of expensive ornamental fish species with economically important legume crops in rotation with rice could be accrued by farmers at low profit margins. Possibility of developing such an integrated system was attempted by conducting an experiment in eight paddy plots of 49 m^2 each with a pond refuge of 1 m^2 at the centre. Two legume crops, Bush bean (**Phaseolus vulgaris** L.) and Soybean (**Glycine max** (L.) Merr.) were used with four replicates each. Treatments were the conventional irrigation (CI) practice and saturated soil culture (SSC) where a permanent water column of 5 cm was allowed in the furrows on either side of ridges where the seeds were sown. Pond refuges were fertilized with layer litter at 1,000 kg/ha and supplementary fertilisation (layer litter) was done at 400 kg/ha/wk for three randomly selected pond refuges. Each SSC plot was stocked with sixty fingerlings of Blue gourami (**Trichogaster trichopterus**). Soybean seed yield from SSC plots (2458.9 kg/ha) was significantly (P<0.05) higher than that of CI plots (1263 kg/ha). Maximum fresh pod yield of beans (5239 kg/ha) was obtained from the SSC plots. Significantly (P<0.05) higher weight at harvest (4.70 g/30 days) was recorded in the plots, which received supplementary poultry manure though their survival rate was significantly (P< 0.05) lower than those raised in indoor tanks. These kinds of integrated models can be promoted in small-scale farming units.*

keywords :*Phaseolus vulgaris* L., *Glycine max* (L) Merr., Conventional irrigation, Saturated soil culture, *Trichogaster trichopterus*

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1 Introduction

The possibilities for integration of fish culture with agricultural crops and animal husbandry has special significance. Such combinations are unique and lucrative ventures, specially in reducing environmental pollution.

Riçe-fish integration has been practised in Asia for over a thousand years and importance of such integrated systems has felt again in south Asian countries[1]. Legume-fish integration in association with rice-fish integration provides an additional income together with other benefits during the fallow period of the rice field. In such systems, there is potential for culturing ornamental fish species with high market demand.

Legumes occupy a unique position in our agricultural system due to the low protein content of the major staple food crops and scarcity as well as high price of animal proteins[2]. Furthermore, legumes have an important role in animal feeds, soil conservation, fertility maintenance as a green manure and as a cash crop.

Adequate as well as easily controlled water sources are required for the continuous operation of this kind of farming system. In 1997 about 730,000 hectares of rice were cultivated and this was 45.7% of the total agricultural land use[3]. Out of this, 45% of land is located in the Intermediate and Wet Zones where water is available year around[4].

Saturated soil culture of legume is a new technology, but it has precedents. This system is used in Netherlands and southern USA and has resulted in high yields[5]. Similarities with SSC are also found among indigenous mound and ditch systems for farming wetlands, which was widely used in Latin America[6]. Recent studies have proved that the growth rate and yield of continuously waterlogged Soybean usually exceeded those of well-watered plants[7] and response of Bush bean to SSC has provided an instructive contrast[8].

This study was conducted to determine the growth parameters and survival rate of the fish species Blue gourami (*Trichogaster trichopterus*) and to assess the compatibility of two economically important legume crops, Bush bean (*Phaseolus vulgaris* L.) and Soybean (*Glycine max* (L.) Merr.) to saturated soil culture.

2 Materials and methods

Experiment was conducted at the Department of Animal Science, Faculty of Agriculture, University of Peradeniya. Two legume crops, Soybean (*Glycine max* (L.) Merr.) variety PB_1 and Bush bean (*Phaseolus vulgaris* L.) variety Top-crop were used with four replicates. Eight paddy plots of 49 m^2 with a pond refuge of 1 m^2 were used (Edirisinghe, 1994)[4]. Longitudinal ridges with a height of 15-20 *cm* and furrows were prepared with a spacing of 55 *cm*. A permanent water column of about 5 *cm* was allowed to exist in each furrow of each SSC plot, while control plots were conventionally irrigated at 7-10 day interval. Inorganic fertiliser was applied as basal and top dressings.

At 14 days after sowing of seeds, sixty fingerlings of Blue gourami (*Trichogaster trichopterus*) of 1-2 *cm* in total length were introduced to each pond refuge. The same type of fish was raised in aquarium tanks (60 fingerlings per tank of 4.5 m^2) simultaneously.

Basal fertiliser (Layer litter) was added to each pond refuge and furrow at 1000 *kg/ha*. Supplementary fertilisation was done with layer litter at 400 *kg/ha/wk* for three randomly selected plots. The fish raised in aquarium tanks were fed with formulated feeds.

Sample areas of 1 m^2 were selected and dry weight of Soybean seeds, weight of 100 seeds, plant height at maturity, number of branches, pods and nodules per plant were taken. Fresh weight of nodules per plant was measured weekly from 30 days onwards (Table 3).

Fresh weight of Bush bean pods was recorded in areas of 1 m^2. In addition, plant height at maturity, number of branches, flowers, pods and nodules per plant at peak flowering stage (day 35) were recorded.

Weight and length (total and standard) of fish at stocking and at harvesting were measured. The number of fish recovered and survival rate at the end of the culture period were also recorded.

3 Results

3.1 Determination of growth parameters and survival rates of Blue gourami

The maximum weight gain of fish raised in replicates, which did not receive supplementary fertilisation, was 4.1 *g*/30 days. There was a significant difference ($P<0.05$) in weight gain among fish raised with and without supplementary fertilisation. The mean weight gain of fish raised in pond refuges was significantly higher ($P<0.05$) than those raised in aquarium tanks (1.0 *g*/30 days)(Table 1).

The mean percentage survival of Blue gourami raised in the field with and without supplementary fertiliser was 45.0% and 35.7% respectively, and did not differ significantly ($P>0.05$). Significantly higher ($P<0.05$) survival rate (91%) was observed from fish reared in aquarium tanks (Table 1).

3.2 Effects of application of saturated soil culture (SSC) technique on Bush bean

The saturated soil culture plots reported the highest fresh pod yield of 5238.9 *kg/ha*, which was significantly higher ($P<0.05$) than the yield of (3192.2 *kg/ha*) control plots. The mean number of flowers per plant in SSC plots were significantly higher ($P<0.05$) in contrast to that of control plots, which was associated with significantly

Table 1: Growth parameters and survival rates of Blue gourami (X ± SE) in different treatments

Parameter	Unit	Fertiliser level: Basal+ Supplementary	Fertiliser level: Basal only	Control
		(X+SE)•	(X+SE)•	(X+SE)•
Weight at stocking	*g*	$0.15^{\natural} \pm 0.0$	$0.15^{\natural} \pm 0.0$	$0.15^{\natural} \pm 0.0$
Weight at harvest	*g*	$4.70^{\natural} \pm 0.1$	$4.20^{\natural} \pm 0.2$	$1.10^{\star} \pm 0.1$
Body length at harvest				
Total length	*cm*	$6.20^{\natural} \pm 0.3$	$5.30^{\dagger} \pm 0.3$	$3.30^{\star} \pm 0.1$
Standard length	*cm*	$5.10^{\natural} \pm 0.3$	$4.70^{\dagger} \pm 0.1$	$2.40^{\star} \pm 0.1$
Survival rate	%	$45.0^{\dagger} \pm 4.7$	$35.7^{\dagger} \pm 10$	$91.0^{\natural} \pm 0.3$

• Mean ± Standard error

$\natural, \dagger, \star$, Within comparisons, means with different superscripts across the column differ significantly (P<0.05)

higher (P<0.05) pod setting (14.6/plant) (Table 2).

All plants in SSC plots entered a chlorotic stage shortly after the emergence of seedlings. All the plots except the CI plots were distinctly chlorotic 10 days after sowing. Chlorosis was most severe on Day 14 after and the plants recovered fully on Day 24 after sowing.

3.3 Effects of saturated soil culture on growth, development and yield of Soybean

Seed yield responsiveness to saturated soil culture (2458.9 ± 336 kg/ha) was significantly higher (P<0.05) in contrast to the yield of conventionally irrigated plants (1263.3 ± 31 kg/ha) (Table 3). Reduction in growth rate was observed during the period of chlorosis and subsequent growth was vigorous after recovery and over Days 40-44, all plots began to lodge. It resulted in a significantly higher (P<0.05) height in SSC plants in contrast to the control plants.

After 30 days of sowing, excellent nodulation was apparent in both treatments. At the initial stage of nodulation, control plants were dominated and resulted significantly higher (P<0.05) number as well as fresh weight (g plant^{-1}) of nodules. Subsequently, the nodules proliferated more rapidly in SSC plants. The mean number of nodules per plant at Day 53 was 84.8 ± 1.8 and 61.2 ± 4.9 in SSC and control plots respectively and it was significantly higher (P<0.05) in SSC plants. Profuse crown nodulation was observed in SSC plants above the water table and profusion

Table 2: : Effect of saturated soil culture (SSC) on yield, yield components, growth and development of Bush bean (X ± SE).

Attribute	Unit	Irrigation method	
		SSC (X+SE)•	Control (X+SE)•
Fresh pod yield	$kgha^{-1}$	$5238.9^{\natural} \pm 588$	$3192^{\dagger} \pm 60$
No. of pods	$No.plant^{-1}$	$19.3^{\natural} \pm 0.4$	$14.56^{\dagger} \pm 0.3$
Pod weight	g	$8.5^{\natural} \pm 0.07$	$8.8^{\natural} \pm 0.04$
Branches	$No.plant^{-1}$	$6.4^{\natural} \pm 0.3$	$6.7^{\natural} \pm 0.2$
Flower	$No.plant^{-1}$	$34.7^{\natural} \pm 0.7$	$21.1^{\dagger} \pm 0.5$
Plant height	cm	$34.5^{\natural} \pm 1.5$	$33.7^{\dagger} \pm 0.6$
Nodules	$No.plant^{-1}$	$42.8^{\natural} \pm 0.9$	$39.9^{\natural} \pm 0.8$

• Mean ± Standard error

$^{\natural,\dagger}$ Within comparisons, means with different superscripts across the column differ significantly ($P<0.05$)

Table 3: : Effect of application of saturated soil culture on yield, yield components, growth and development of Soybean (*Glycine max* (L) Merr.).

Attribute	Unit	Irrigation practice	
		SSC (X+SE)•	Control (X+SE)•
Seed yield	$kgha^{-1}$	$2459^{\natural} \pm 336$	$1263^{\dagger} \pm 31$
Seed weight	$g100^{-1}$	$13.7^{\natural} \pm 0.3$	$13.0^{\natural} \pm 0.2$
Plant height	cm	$54.03^{\natural} \pm 3.9$	$56.92^{\dagger} \pm 0.6$
Branches	$No.plant^{-1}$	$8.7^{\natural} \pm 0.7$	$8.7^{\natural} \pm 0.6$
Nodules	$No.plant^{-1}$	$84.8^{\natural} \pm 1.8$	$61.2^{\dagger} \pm 4.9$
Pods	$No.plant^{-1}$	$43.2^{\natural} \pm 4.05$	$31.8^{\dagger} \pm 0.1$

• Mean ± Standard Error

$^{\natural}$ Within comparisons, means with the same superscript across the column do not differ significantly ($P<0.05$).

$^{\natural,\dagger}$ Within comparisons, means with different superscripts across the column differ significantly ($P<0.05$).

of fibrous roots and masses of nodules were concentrated in the aerobic area of the soil. Fresh weight of nodules per plant increased gradually in all the plots and the increment was significantly higher (P<0.05) in SSC plants from Day 44 onwards.

Discussion

The natural habitats of the T. *trichopterus* are lakes, reservoirs, swamps, irrigation canals and paddy fields[9]. Therefore, they are capable of adjusting and performing the best in the field. Being labyrinth fishes, they have the unique ability of obtaining atmospheric oxygen, which is also another advantage for adapting to the environment.

Maximum weight at harvest was observed in those fish, which were raised in pond refuges with supplementary fertilisation. Survival rate of fish raised in the field was considerably less and it was directly associated with high intensity of predation such as kingfisher, white breasted water herons and herons. Considerable losses of fish stocks in fresh water aquacultural systems are caused due to predation by reptiles, carnivorous fish, birds and mammals[9][10]. Significantly higher (P<0.05) survival rates were observed in fish reared in aquarium tanks where there was no threat of predation.

An increment of fresh pod yield up to 39% was obtained with SSC when compared with CI plants. However, the heavy rains which caused flower abscission to a greater degree, and only around 45-50% of flowers set pods.

Maturity was delayed with saturated soil culture, but not the flowering. The results obtained in yield responses agree with previous experiments where positive effects of SSC were attributed to improved crop water status for Soybean and Bush bean[8][11]. A yield increment of 43.3% has been obtained from SSC plots, over the control plots. This is primarily due to an increase in number of pods per plant and seed weight (Table 2)

Experimental yield equivalent of 5-8.6 $ton\ h^{-1}$ has been obtained with SSC[11][12]. The yield increment has resulted from increase in the total biomass[13] and harvest index[12]. SSC treatments had a longer flowering and particularly post flowering period, hence longer growing period.

Plants grown in SSC developed severe chlorosis 14 days after seeding and remained until Day 24 to 30. Plants regained the greenish colour after the commencement of flowering. Analogous responses were recorded in previous experiments performed in glass house studies[13][14] and subsequent studies[7][12][15], which has shown that the chlorotic phase of growth represents an acclimation phase where the chlorosis dissipates as symbiotic nitrogen fixation becomes sufficient to match the requirement for adequate growth. Therefore this model could be developed further by incorporating organic wastes to cultivate suitable cash crops, so that the dwindling profit margin of Sri Lankan paddy farmers could be significantly increased.

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