The Optimization of Irrigated Rice Field and Improvement of Land Productivity Throught Development of Rice-Shrimp (*Macrobrachium rosenbergii*) Cultivation Technology on Bantul Regency

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Abstract. Transition of productive irrigated rice fields into other forms makes agricultural sector have to optimized using its field. Purpose of study was to determine application rice-shrimp technology on soil chemical properties, rice productivity, and economical feasibility. Treatments applied were U_1 = Control/ technology used by local farmers, U_2 = Rice-Shrimp cultivation by shrimp population 4,000 tails, U_3 = population 6,000, U_4 = population 8,000, U_5 = Shrimp population 4,000 + rice husk 400 kg, U_6 = population 6,000 + husk 400 kg, U_7 = population 8,000 + husk 400 kg. The research design was completely randomized block and replicated three times. Results showed number of shrimp populations did not significantly affect to change soil pH, Eh value, level of Fe, and Mg, but had a significant effect on C-organic, N-total, available P and K, CEC. Application of husk as 400 kg and shrimp population up to 6,000 tails had a significantly effect on the number of tillers, grains per panicle, fresh biomass weight, rice yields up to 43.26% and net profit up to 269.14% compared to control by BC and RC ratios are 1.92 and 2.93, respectively while MBCR is 3.34. It means rice-shrimp technology on Bantul classified as feasible.

1 Introduction

The transition of productive irrigated rice fields into other forms such as housing area, apartments and industrial area have made the agricultural sector shall be worked hard to fullfill the food needs in the midst of the constraints on the area of agriculture which has decreased from year to year, both in terms of the number, area and quality of agricultural land. In addition, Widodo et al. [1] stated that increasing the number of population causes

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the food needs or food supply to increase in productivity. The fact that is happening in the field is that the increase in population is not matched by existing agricultural production. Therefore, this is a challenge for all stakeholders to create an area that is still capable of realizing food security. Furthermore, to achieve food security, the agricultural sector is required to play its role amidst the decreasing land area. One of the things that the agricultural sector can do it is to make new breakthroughs in order to survive in limited national food stock condition. New breakthroughs in the agricultural sector include the development of *Mina-Padi* cultivation technology [2].

According to Akbar [3, 4, 5, 6] Mina-padi farming is a fish rearing system that is carried out together with rice in the fields. Mina Padi cultivation is an integrated cultivation that can increase the productivity of paddy fields and also produce fish. While Rice-shrimp cultivation is a technology that combines shrimp with rice cultivation in the same field. This system has several advantages, among others : farmers will get additional income from fish or shrimp without reducing income from rice, increase rice production, increase efficiency and land productivity, rice plants become more controlled and meet the animal protein needs of farmers. Dewani et al. [7] stated that, the Mina-padi farming system cultivating fish with rice or raising fish between rice plants. This is intended so that the benefits obtained from this method aim on multiple results, namely: from the rice itself and from fish or shrimp on the same field. Nadira et al. [8], [9] also added that there are other benefits obtained through raising fish in rice fields, namely that it can reduce pests and diseases in rice plants and increase soil fertility.

During application of Minapadi cultivation system, rice planting was used the jajar legowo system, which is a technological agriculture to obtain a plant population of more than 160,000 per hectare. In addition, Prasetyo and Kadir [10] stated that the application of the jajar legowo system aside to increasing the cropping population, it is also that rice plants are able to photosynthesize better than conventional rice planting system. The application of jajar legowo planting system is recommended to use a 25 cm spacing between clumps in rows; 12.5 cm spacing in rows; and 40 cm as the distance between rows or it can be written (25x12,5x40) cm. The rice planting pattern with the jajar legowo row system recommended by the Ministry of Agriculture has benefits and advantages for rice farmers. [11] these benefits can be obtained from several aspects such as increasing population size, ease of maintenance, reducing pest populations especially rats pest, saving fertilization costs, and increasing the quality and quantity of grain production.

Some researchs stated that the fish or shrimp harvested from rice fields are often the main source of protein for farmers. Shrimp cultivation in the rice-shrimp system in lowland rice field provides greater economically benefits for farmers, especially from shrimp harvests because the price is quite good [12]. Some results of field test have shown that farmers' profits increase by including fish / shrimp into the rice production system, by knowing the optimum fish / shrimp population per land area, it is hoped that rice growth and production will not be disturbed and farmers' income will be improved both from rice yields and fish / shrimp harvest. The application of rice-shrimp cultivation is carried out in technically or semi-technical irrigated rice fields because the presence of water in the paddy fields is very much needed. Another advantage of the Rice-shrimp cultivation system is that farmers can save fertilizers because the irrigation water is mixed with shrimp manure and organic shrimp food, which can minimize the use of chemical fertilizers. According to Damayanti [13,14,15] a number of benefits obtained by farmers by implementing rice-shrimp include fertile rice fields with shrimp manure that contains various nutrients so that it can reduce the use of fertilizers which will have a positive impact on reducing methane gas (CH_4) produced from the residual inorganic fertilization.

Furthermore Allahyari and Noorhosseini [16],[17] stated that minapadi or rice-shrimp farming can reduce pollution and ensure environmental sustainability through reducing the use of chemical pesticides and fertilizers, increasing the income of rice farmers, and increasing the fertility of their rice fields. According to Grassi et al. [18], [19, 20] the rice–shrimp yearly brings in a gross return 2.4 times higher than rice– rice (US$2 838/ ha versus US$1 186/ ha). However, because the cost of material inputs for rice–shrimp production is over four times higher than it is for rice–rice production, the BCR for rice–shrimp is actually slightly lower than it is for rice–rice (the rice–shrimp system brings in US$2.13 for every dollar spent and rice–rice US$2.20). This brings to light another important difference between the two systems: the high cost of material inputs required for shrimp production makes engaging in rice–shrimp a financially risky enterprise for smallholders.

The purpose of this study was to determine the application of Rice-Shrimp cultivation technology to soil chemical properties, the productivity of rice plants, and the economic feasibility of the farming system compare to the rice monoculture cultivation in irrigated rice fields of Bantul Regency.

2 Material and Method

2.1 Time and place of the research

The research of optimization irrigated rice field throught the development of Rice-Shrimp was conducted on Planting Season II (February - May 2020) in Kebon Agung village, Imogiri District, Bantul Regency. This activity involved the Local extension agents and under the guidance of the Agriculture and Fisheries Office of Bantul Regency also it was assisted by the staff researcher from Yogyakarta AIAT.

2.2 Material of the research

The research materials were used Inpari 42 Green Super Rice and Ciherang rice seed varieties, shrimp fry (age about 3 month), agricultural lime, shrimp feed. The chemical fertilizers were used Urea, KCl and NPK Phonska (15:15:15). Organic manure used cattle manure by dose of 5 $ton.ha^{-1}$

The equipment research were used a set of soil test kit for rice field samples, soil tillage equipment, a field knife, ring sample, field length measurement, a hoe, harvesting tools, a sickle and a pedal threser for harvesting rice grain, plastic sample, plastic bucket volume 20 litre, bamboo, sack, paper label, digital balancing scales, pH meter and net for shrimp harvesting.

2.3 The implementation of rice-shrimp cultivation

The assessment was carried out on a stretch of irrigated rice fields that have water flows easily and it is not contaminated by industrial waste materials. The research operations assisted by cooperator farmers (on farm research) with a total area about 0.6 ha. The kinds of technological treatments consisted of 7 technology packages, which each of package was repeated 3 times or the field of cooperator farmer as the replications. The treatments of tehnological innovation namely : U_1=control/ technology used by local farmers which apply monoculture rice farming (without rice-shrimp cultivation), U_2= rice-shrimp cultivation with a density of shrimp 4,000 tail, U_3=rice-shrimp cultivation with a density of shrimp 6,000 tails, U_4=rice-shrimp cultivation with a density of shrimp 8,000 tails, U_5= rice-shrimp cultivation with a density of shrimp 4,000 tail plus rice husk 400 kg, U_6= rice-shrimp cultivation with a density of shrimp 6,000 tails plus rice husk 400 kg, U_7=rice-shrimp cultivation with a density of shrimp 8,000 tail plus rice husk 400 kg. Every treatment occupies an area of 1,000 m^2 of the rice field owned by farmers.

The maximum age of the rice seedlings to be planted is 15 days from the time of the seeds which is sown in the field. The basic fertilizer of rice plants are Ponska NPK (15:15:15) fertilizer as much as 250 $kg.ha^{-1}$, Urea fertilizer 150 $kg.ha^{-1}$ (given 2 times, which were 7 DAS and 35 DAS) then KCl as much as 75 $kg.ha^{-1}$ (given 2 times), while the organic manure was given as much as 5 $ton.ha^{-1}$. The provision of irrigation water for rice plants was carried out by intermmiten irrigation system and the first irrigation is done when the rice plants were at 8 days after transplanting with a water height about 5 cm above the field ground.

The size of pond in the rice field is shown on Figure 1. The wide pond for shrimp storage is 200 cm and the depth of pond is about 80 cm, while the depth of the trench rice field around 60 cm and width of pond is 150 cm.

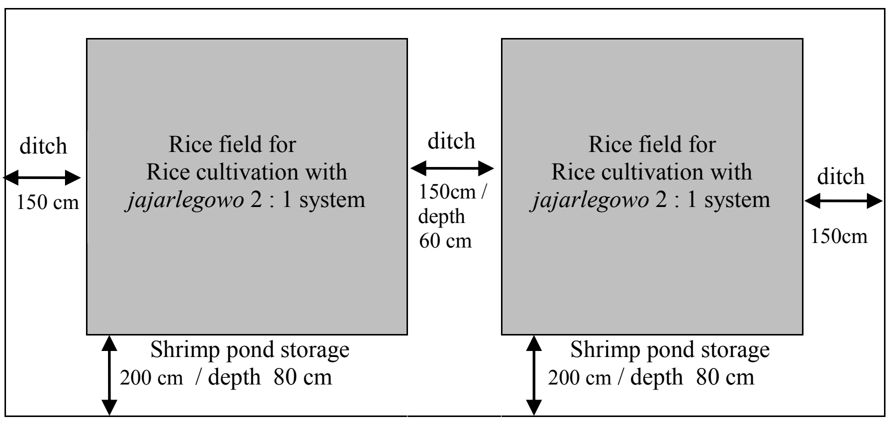

Fig.1. The size of shrimp pond for rice-shrimp cultivation

The shrimp frys are spread to the rice field (rearing pond) at about 2 month from the time of nursery shrimp eggs and they are free from pests / diseases and predatory animals. The stocking application should be done in the afternoon or night so that the giant shrimp do not experience stress. The spread of giant shrimp is carried out based on the density standard of the biota, for the optimum density is around 5,000-6,000 shimp tails /1,000 m^2.

Providing the shelters as a place of shrimp shelter / footing, in the form of a net with bamboo sticking at the ends and then put the water hyacinth plants (*Eichhornia crassipes)* on surroundings that place. The pH optimum of water in the shrimp pond is around 7.5 - 8.5 which is measured regularly by pH meter. If the pH is low it is necessary to add lime, while if the pH is high it is necessary to add irrigated new clean water.

The total feed of shrimp is given in accordance with the number of shrimp that is maintained. The time of feeding is morning and evening with the largest portion of feed at the night. For prawn feed, pellets (30% protein) are given as much as 1% of the body weight of shrimp / day with a frequency of feeding 2 times a day.

The data originating from rice-shrimp cultivation system were analyzed by the SAS version 9.0 program to determine the response of some treatments, which was applied by the analysis of variance. Furthermore, to differentiate the significance between treatments, it was continued with Duncan's Multiple RangeTest with a significance level of 5%.

3 Result and Discussion

3.1 The application of rice-shrimp cultivation on rice field fertility

The development farming system, which is consider on environmentally friendly and low inputs production, is one way to increase the farmer income and their families, because the applied technology in the system have considered the importance of interactions between components and their relation to activities outside the agricultural system and the importance of the role of bio-physical, socio-cultural, institutional and economic conditions of farmer community groups.

The integrated farming system of rice-shrimp cultivation on irrigated rice field can be increased the paddy field productivity and soil fertility. In rice-shrimp cultivation, farmers usually use a lower dose of chemical fertilizer than the region recommended dose, because of the ecological correlation between the amount of feed and shrimp cultivation. The excess feed that is not consumed by shrimp will be overhauled by microbes and become natural fertilizer for the soil and water. This condition are presented on Table 1a and 1b that showed the chemical soil characteristic before application of rice-shrimp cultivation and after application based on shrimp densities. The soil pH before application on all plots of rice field was shown above 6.8 then after application of rice-shrimp cultivation the pH soil on rice monoculture plots relatively fix, but on rice-shrimp plots are slightly decreased in pH due to the decomposition of organic matter derived from shrimp manure and feed residue (Table 1a and 1b). The content of N-total, C-org, P and K available and CEC soil after the application showed a significant increase compared to monoculture rice cultivation systems, especially in the technology package F (population of shrimp 6,000 tail/1,000 m^2, used Inpari 42 rice variety + rice husk 400 kg/1,000 m^2).

Table 1a. The chemical soil characteristic before application of rice-shrimp cultivation

Code	Treatments	Soil pH (H_2O)	N total (%)	C-org. (%)	P-avail. (ppm)	K-avail. (me/100g)	CEC (me/100g)
A	Rice monoculture (Farmer treatment) Ciherang rice variety	6.8	0.14	1.16	14.27	2.87	23.32
B	R-S cultivation shrimp density 4,000 Inpari 42 rice variety	6.7	0.17	1.18	13.48	2.65	28.46
C	R-S cultivation shrimp density 6,000 Inpari 42 rice variety	6.9	0.15	1.14	15.19	2.74	26.72
D	R-S cultivation shrimp density 8,000 Inpari 42 rice variety	6.8	0.16	1.12	12.53	2.41	22.81
E	R-S cultivation shrimp density 4,000 + Rice husk 400 kg Inpari 42 rice variety	6.9	0.13	1.19	14.17	2.26	29.64
F	R-S cultivation shrimp density 6,000 + Rice husk 400 kg Inpari 42 rice variety	7.0	0.18	1.17	13.46	2.53	30.37
G	R-S cultivation shrimp density 8,000 + Rice husk 400 kg Inpari 42 rice variety	6.9	0.14	1.15	15.95	2.48	26.75

According to Sismiyati et al. [21,22,23], generally organic materials available and utilized include plant residues or forage plant. Furthermore Nugroho et al. [24,25,26,27], stated that in the process of decomposition of organic matter will produce organic acids, so it causing the pH soil to drop.

The use of rice-shrimp cultivation system is carried out for efforts to utilize land so that rice field can be used optimally and efficiently. This utilizes shrimp manure system to increase soil fertility by improve the physical, chemical and biological properties of the soil. Amino acids found in protein shrimp feed and ammonia derived from shrimp waste have the potential to become nitrogen elements plants need. Soils in paddy fields with inundation will induce electrochemical changes that affect the supply and nutrient uptake.

Tabel 1b. The chemical soil characteristic after application of rice-shrimp cultivation base on shrimp dentisities

Code	Treatment	Soil pH (H_2O)	N total (%)	C-org. (%)	P.avail (ppm)	K.avail (me/100g)	CEC (me/100g)
A	Rice monoculture (Farmer treatment) Ciherang rice variety	6.9 a	0.10 a	1.14 a	11.34 a	2.15 a	22.68 a
B	R-S cultivation shrimp density 4,000 Inpari 42 rice variety	6.8 a	0.21 b	1.73 b	17.62 b	3.21 b	30.27 b
C	R-S cultivation shrimp density 6,000 Inpari 42 rice variety	6.8 a	0.26 bc	2.28 bc	16.09 b	3.62 bc	33.81 b
D	R-S cultivation shrimp density 8,000 Inpari 42 rice variety	6.7 b	0.24 b	2.15 bc	18.61 b	3.45 bc	32.63 b
E	R-S cultivation shrimp density 4,000 + Rice husk 400 kg Inpari 42 rice variety	6.8 a	0.25 bc	2.04 b	17.58 b	3.37 b	34.05 bc
F	R-S cultivation shrimp density 6,000 + Rice husk 400 kg Inpari 42 rice variety	6.7 a	0.29 c	2.57 c	21.37 c	3.94 c	38.74 c
G	R-S cultivation shrimp density 8,000 + Rice husk 400 kg Inpari 42 rice variety	6.8 a	0.28 c	2.49 c	20.24 c	3.78 c	36.38 c

* The numbers accompanied by the same letter in one column are not significantly different based on DMRT on the 5%level

3.2 The effect of rice-shrimp cultivation on plant growth and yield

One of the optimization of the potential of irrigated rice fields and increasing farmers' income is by designing the land with appropriate technology. The way that can be done is by changing the agricultural strategy from a monoculture system to an agricultural diversification system, one of which is by applying the rice-shrimp cultivation technology with the *jajar legowo 2:1* planting system. In addition, the jajar legowo 2 :1 planting system is designed by manipulating rice plants so that they are made into more edges. Those located on the side rows will result in higher production and better grain quality because this side of the plants will get more sunlight then the process of photosynthesis can run well.

Moreover Nurhayati et al. [28], [29], give stated that rice-fish with *legowo* system as an engineering plant by adjusting a spacing between the clumps and widening the distance between rows so that it is as the rice clumps are on the edge of the crop which benefits as side plants (*border effect*). In the *Jajar legowo* 2:1 planting system each of the two rows of rice plants empty interspersed with wide row spacing twice in a row. While plant spacing in the row that extends narrowed down to half a spacing in the row.

Performance of rice yields and farmers' income can also increase soil fertility and reduce pest attacks on rice plants. The legowo technology is an designal technique of planting by adjusting the spacing between clumps and between rows so that there is compaction of the rice clumps in rows and

The results of observations of rice growth using rice-shrimp *jajar legowo* technology and farmers' existing systems using conventional technology are shown in Table 2 below.

Table 2. Observation of plant height and the number of tiller on various treatments

Code	Treatments	Plant height 21 DAP (cm)	Plant height 45 DAP (cm)	Plant height 60 DAP (cm)	The number of tiller on 21 DAP	The number of tiller on 45 DAP
A	Rice monoculture (Farmer treatment) Rice variety Ciherang	45.63	79.15	90.79 c	16.48	22.68 a
B	R-S cultivation shrimp density 4,000 Rice variety Inpari 42	50.72	93.26	102,58 b	14.65	18.79 c
C	R-S cultivation shrimp density 6,000 Rice variety Inpari 42	51.46	94.74	103.26 b	13.37	19.15 a
D	R-S cultivation shrimp density 8,000 Rice variety Inpari 42	51.63	93.29	104.62 b	14.78	19.75 bc
E	R-S cultivation shrimp density 4,000 Rice variety Inpari 42 + Rice husk 400 kg	51.94	94.62	103.78 b	14.97	20.19 b
F	R-S cultivation shrimp density 6,000 Rice variety Inpari 42 + Rice husk 400 kg	52.17	95.48	108.43 a	15.37	20.74 b
G	R-S cultivation shrimp density 8,000 Rice variety Inpari 42 + Rice husk 400 kg	53.84	93.17	107.24 a	15.04	20.26 b

* The numbers accompanied by the same letter in one column are not significantly different based on DMRT on the 5% level

Based on the table above, it is proven that rice fields with the application of rice-shrimp (technology package innovation) are able to make better plant growth due to the application of the jajar legowo 2:1 (40 x 12.5 x 25 cm) system, while in the existing land farmers still used tile planting system (20 x 20 cm).

In the observation of maximum plant height growth at the age of 60 DAP, the application of the introduction of package D, E, F and G with a population of about 6,000 up to 8,000 shrimps per 1,000 m^2 have a higher productivity than package B (the total population of shrimp is around 4000 heads) and the existing land of local farmers, package A so this will stimulate plant growth. Rice to produce better rice. This is in accordance with the statement of Ikhwani et al. [30],[31,32,33], who stated that the advantage of the *jajar legowo* planting system is that put more plants become in border side (*border effect*). This cropping system manipulates the layout of the plants, so that the rice plants are mostly have sunlight in carry out the photosyntetic process, good air circulation, more evenly distributed nutrients, and easier maintenance of plant growth because of the wider aisle distance, resulting in higher grain with better quality.

The result of study from [34],[35], give stated that, the number of tillers will be maximized if the plant has good genetic characteristics coupled with favorable environmental conditions or in accordance with plant growth and development. The maximum number of tillers is also determined by the spacing, because the spacing determines solar radiation, mineral nutrients and the cultivation of the plant itself. According to Siavoshi et al. [36], the number of tiller will be maximized if the plant has good genetic characteristics coupled with favorable environmental conditions or in accordance with plant parts and plant development.

Furthermore, the effect of the application rice-shrimp cultivation system with various densities on the yield components is presented in table 3 below.

Table 3. The observation of rice yield component on various treatments at Kebon Agung village, Imogiri District, Bantul

Code	Treatments	Length of panicles	The number of panicles per clumps	The number of grains per panicle	The number of filled grain per panicle	The weight of 1,000 grains
A	Rice monoculture (Farmer treatment) Rice variety Ciherang	21.74 c	23,48 a	146.34 d	115.62	24.13 c
B	R-S cultivation shrimp density 4,000 Rice variety Inpari 42	25.23 ab	19.47 c	194.65 c	171.82	27.37 ab
C	R-S cultivation shrimp density 6,000 Rice variety Inpari 42	24.69 a	20.19 bc	209.37 b	174.51	28.16 a
D	R-S cultivation shrimp density 8,000 Rice variety Inpari 42	23.53 b	19.68 c	211.24 b	173.68	26.81 b
E	R-S cultivation shrimp density 4,000 Rice variety Inpari 42 + Rice husk 400 kg	25.84 ab	20.59 bc	212.72 b	184.55	27.92 ab
F	R-S cultivation shrimp density 6,000 Rice variety Inpari 42 + Rice husk 400 kg	26.64 a	21.73 b	223.51 a	189.73.	28.75 a
G	R-S cultivation shrimp density 8,000 Rice variety Inpari 42 + Rice husk 400 kg	26.82 a	21.47 b	219.51 a	186.43	28.27 a

* The numbers accompanied by the same letter in one column are not significantly different based on DMRT on the 5% level

Based on the data in Table 3, it is shown that the Inpari 42 rice variety has advantages in panicle length, the number of grains per panicle and the weight of 1,000 grains are higher than the Ciherang variety and its significantly different, while the number of panicles per clump for Ciherang is higher than Inpari 42 in various treatments.

The weight of 1,000 grains of grain is influenced by the growing environment of the plant such as the availability of nutrients in the soil during rice cultivation. Lack of nutrients at the time of planting will result in the weight of 1000 grains of grain produced being lower than it should be. The Ciherang variety in farmer conventional planting methods gave the lower weight of 1,000 grains and was significantly different from inpari 42 in various treatments. In accordance with Sitohang [37], who stated that the special characteristics and traits possessed by each variety appear different because of the genetic differences of each variety. This is supported by the results of Talihun [38] and Misran research's [39] were shown that the row planting system has a significant effect on the yield and yield components of rice, especially on the panicle length, number of grain per panicle, dried grain yield and 1,000 grains weight.

Table 4. The observation of harvesting rice biomass, weight of dried rice yield and weight of dried grind on various treatments of rice-shrimp cultivation

Code	Treatments	The weight of rice biomass (ton. ha $^{-1}$)	The weight of dried rice yield (ton. ha $^{-1}$)	The weight of dried grind (ton. ha $^{-1}$)
A	Rice monoculture (Farmer treatment) Rice variety Ciherang	12.09 c	6.75 c	5.46 c
B	R-S cultivation shrimp density 4,000 Rice variety Inpari 42	14.17 b	9.16 b	8.73 b
C	R-S cultivation shrimp density 6,000 Rice variety Inpari 42	15.82 ab	9.86 b	8.97 b
D	R-S cultivation shrimp density 8,000 Rice variety Inpari 42	15.97 ab	10.12 a	9.28 a
E	R-S cultivation shrimp density 4,000 Rice variety Inpari 42 + Rice husk 400 kg	14.82 b	9.57 b	8.64 b
F	R-S cultivation shrimp density 6,000 Rice variety Inpari 42 + Rice husk 400 kg	16.56 a	10.93 a	9.75 a
G	R-S cultivation shrimp density 8,000 Rice variety Inpari 42 + Rice husk 400 kg	15.43 a	10.25 a	9.51 a

* The numbers accompanied by the same letter in one column are not significantly different based on DMRT on the 5% level

Based on the data in Table 4, it showed that the weight of dried rice yield with the introduction of technology F treatment package (shrimp population 6,000 tails/1000 m^2 and plus rice husk charcoal 400kg) had the highest yield compared to other innovation packages and treatment package A (technolgy existing local farmers). This is due to the increasing number of shrimp populations until the optimum limit is able to increase soil fertility in paddy fields by increasing the amount of manure and left over shrimp food that is not consumed. So that the organic matter can be decomposed by microbes to add macro nutrients in irrigated rice fields, which are used as rice-shrimp cultivation ponds.

The researcher [40], declared that the density treatment population can be increased the yield of harvesting shrimp in the rice ponds provided that the conditions of rice field ecosystem including free pollution for irrigation water, pH water irrigation according to the required standard, availability of shelter for shrimp and adequate feed.

3.3 The harvesting of shrimp on rice-shrimp cultivation based on its densities

The rice-shrimp cultivation system can be an alternative to an ecological approach to sustainable farming systems without reducing the productivity of existing food crops, with rice plants as an ecological buffer [41]. The integration of the rice-shrimp system has not been well developed in Bantul Regency, even though the demand for shrimp in the market is quite high at a good price.

The local farmer mainly develop monoculture rice cultivation by local rice variety, with some traits : low yields ranging from 4.0 to 5.0 ton.ha^{-1} and it is not resistant to pest and diseases. Productivity of shrimp monoculture also remains low, ranging between 40 and 50 kg/1,000 m^2 in the paddy field area, as more than 90% of farmers still practise the traditional extensive method characterized by low stocking density, poor feed quality and water irrigated management.

On Table 5 it is presented the weight of harvesting shrimp on rice-shrimp cultivation in different denities stock. In treatment A did not get a shrimp harvest, because it only applied a monoculture system of planting rice without stocking shrimp in paddy fields. The highest shrimp yield was obtained on treatment F (using rice variety Inpari 42, shrimp density population 6,000/1000m^2 plus rice husk charcoal 400 kg) which was 85.72 kg and significantly different from other treatments but not different from treatment G with a shrimp density population of 8,000/1000 m^2. This indicates that the optimum density population of shrimp in the rice-shrimp cultivation system is 6,000tails /1,000 m^2 on the aged 2 months.

This is in accordance with the opinion of Tahir dan Pasaribu [42], who stated that shrimp will grow well in a wide range of motion and well maintained ecosystem conditions., it showed from fresh weight /tails that the best results were in the treatment of rice-shrimp cultivation with shrimp density of 6,000 tails / plot and 8,000 tails /1,000 m^2 of irrigated rice fields.

Table 5. The weight of harvesting shrimp in different densities per 1,000 m^2 of rice field

Code	Treatments	The weight of shrimp (gr / tail)	The weight of harvesting shrimp (kg / 1000 m^2)
A	Rice monoculture (Farmer treatment) Rice variety Ciherang	Non	Non
B	R-S cultivation shrimp density 4,000 Rice variety Inpari 42	27.86 a	57.18 a
C	R-S cultivation shrimp density 6,000 Rice variety Inpari 42	26.75 a	75.64 b
D	R-S cultivation shrimp density 8,000 Rice variety Inpari 42	28.27 b	78.35 b
E	R-S cultivation shrimp density 4,000 Rice variety Inpari 42 + Rice husk 400 kg	28.19 b	64.58 ab
F	R-S cultivation shrimp density 6,000 Rice variety Inpari 42 + Rice husk 400 kg	30.54 c	85.72 c
G	R-S cultivation shrimp density 8,000 Rice variety Inpari 42 + Rice husk 400 kg	30.22 c	83.19 c

* Numbers accompanied by the same letter in one column are not significantly different based on DMRT test on the level of 5%

3.4 The analysis of farming systems on rice-shrimp cultivation

Presently, there are different types of culture systems practised for shrimp aquaculture in Bantul Regency, though most of the farmers follow traditional methods and generally do not practice well-defined rice field pond preparation, liming, fertilisation, predator control or artificial feeding. Where production is still low, water exchange is irregular, and water management irrigation is very poor.

The development of a sustainable rice-shrimp farming system must refer to the conditions of economic feasibility, local investment capacity and the level of adoption of local farming communities [43].

Net farm income is the difference between the output value of agricultural production reduced all costs incurred in a period of real period of production and of course its value of farm income must be greater than zero if it is to be stated profitable for farmers. In other words, the gross income from the harvest must be able to cover the total expenses per unit area of land.

The gross margin for each treatment was calculated based on average market prices and farm production. The cost included all inputs (rice seed, young shrimp, lime and inorganic fertilizers, plastic mulch, pralon pipe, net around the rice field), field preparation, labour, fuel for pumping irrigation water. The net return was calculated as the gross margin minus the cost. The benefit cost ratio (BCR) represents the gross margin divided by the cost.

On Table 6 it is shown the analysis of farming system on rice-shrimp cultivation and existing farmer as below. in treatment A (existing farmer), the total benefit obtained is IDR 2.235.000 /1,000 m^2 with a value of BC ratio 1.18 and RC ratio 2.18, while the highest benefit was achieved by the package F (used inpari 42 rice variety and the shrimp density is 6,000/1000 m2 plus 400 kg rice husk charcoal) with a value of BC ratio 2.82 and RC ratio 3.82, followed by Package E treatment (used inpari 42 rice variety and the shrimp density is 4,000/1000 m^2 plus 400 kg rice husk charcoal) with a value of BC ratio 2.57 and RC ratio 3.57. This can happen because the application of rice-shrimp cultivation in addition to obtaining a potentially high yielding of rice with the use of a new high yielding variety (Inpari 42), is also obtained by harvesting shrimp with optimum density (almost the same time with rice harvesting), so that a double benefit of rice and shrimp harvesting are obtained at a good price in the market.

According to Gupta et al. [44, 45,46] the farmer income and net profit of monoculture rice system is lower than that of rice-shrimp system. Actually, in the cultivation of rice - shrimp, its shrimp is the main production target. While other products are treated as by-products. Approximately 35 percent of gross return income arrive from by-products of the rice-shrimp farming system, which is less risky than the only shrimp farming system, because a certain portion of income was added from rice yield in rice-shrimp farming.

Moreover Rasowo et al. [47,48] explains that the rice-shrimp cultivation farming system generates more income larger than the rice monoculture system. However, when the disease is attacked, the rice monoculture system actually more profitable.

Furthermore Berg and Tam [49], stated that the problems faced in the development of rice-shrimp cultivation are the number of pests such as weasel, snakes, leaf hoppers and birds, the use of pesticides for rice pest and disease control. Pest attacks and excessive use of pesticides on rice plants can also affect the life of shrimp, causing farm production of rice-shrimp cultivation system was decreased. But if the environmental conditions are controlled, actually culturing shrimp in the rice fields can help control pests and weeds, promote nutrient availability to rice plants and enhance nutritional benefits and financial returns from what are widely regarded as low input, environmentally friendly and more sustainable farming systems [50, 51].

Table 6. The analysis of economical farming system on Rice-Shrimp cultivation and existing farmer

Number	Description	Rice – shrimp cultivation system					
		Package A	Package B	Package C	Package D	Package E	Package F
		IDR/ 0.1 ha	IDR/ 0.1 ha	IDR/ 0.1 ha	IDR/ 0.1 ha	IDR/ 0.1 ha	IDR/ 0.1 ha
A. Explicit Cost		1,265,000	2,903,000	3,563,000	4,043,000	3,143,000	3,393,000
I.	Production facilities	665,000	2,263,000	2,263,000	3,343,000	2,443,000	2,693,000
1	Seed (3,0 kg)	60,000	48,000 1,200,000	48,000 1,800,000	48,000 2,400,000	48,000 1,600,000	48,000 1,800.000
2	Fertilizer						
	Urea (15 kg)	175,000	75,000	75,000	75,000	75,000	75,000
	NPK 15:15:15 (20 kg)	240,000	160,000	160,000	160,000	160,000	160,000
	Organic fertilizer (300 kg/)	90,000	60,000	60,000	60,000	60,000	60,000
3	Pesticides / Shrimp feed	100,000	500,000	560,000	600,000	500,000	550,000
II.	External work forces	450,000	500,000	500,000	500,000	500,000	500,000
III.	Other costs	150,000	200,000	200,000	200,000	200,000	200,000
B. Implisit Cost		250,000	350,000	350,000	400,000	350,000	350,000
IV.	Internal / family labour	350,000	350,000	350,000	400,000	350,000	350,000
C. Total cost (A+B)		1,615,000	3,253,000	3,913,000	4,443,000	3,493,000	3,743,000
D. Total income		3,850,000	8,872,400	12,161,200	12,663,000	11,761,000	13,982,000
	Yield of dried rice yield	2,700,000	3,628,000	4,160,000	4,420,000	4,590,000	4,875,000
	Biomass of rice yield	1,150,000	1,150,000	1,950,000	1,975,000	2,000,000	2,250,000
	Yield of harvested shrimp		4,094,400	6,051,200	6,268,000	5,166,400	6,857,600
E. Income (D-A)		2,585,000	5,969,400	8,598,200	8,590,000	9,018,000	10,589,000
F. Benefid (D-C)		2,235,000	5,619,400	8,248,200	8,220,000	8,668,000	10,239,000.
G. Farming system feasibility indicator							
1. B/C (Rasio Benefid vs Total cost), Feasible >1		1.18	1.73	2.10	1.93	2.57	2.82
2. R/C (Rasio Income vs Total cost), Feasible >2		2.18	2.74	3.10	2.93	3.57	3.82

4 Conclusions

The productivity of irrigated rice fields by application of rice-shrimp cultivation in Bantul Regency will increase by distibuting the population of shrimp on a certain optimum density (6,000 tails/1,000 m^2). The culturing shrimp in paddy fields can help control pests and weeds, increase the availability of nutrients for rice plants and increase the content of organic matter derived from decomposition of feed residues and weeds as well as financial benefits for farmers with low inputs, and encourage environmentally friendly. The highest production of rice and shrimp on rice-shrimp cultivation is obtained by technology package F : using Inpari 42 rice variety, disributed shrimp population of 6,000 tails/1,000 m^2 plus 400 kg of rice husk charcoal to improve dried rice yield 9.75 ton.ha^{-1} and harvested shrimp 85.72 kg/1,000m^2 and its significantly different from other treatments. The utilization of irrigated rice fields by development of rice-shrimp cultivation has economically feasible and improve net profit for the farmer, which is increased 3.58 times compared to rice monoculture system, this is indicated by the value of BC ratio of rice-shrimp innovation technology (Package F) becomes 2.82 and the RC ratio is 3.82 compare to the existing cultivation pattern of local farmer, that only have BC and RC ratios 1.18 and 2.17, respectively.

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