Application of Rice-Corn Intercropping as an Optimization of the Land Use Utilization and Increasing of Farmer Income in Playen, Gunungkidul

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Abstract. Intercropping is an attempt to plant several types of crops on the land at the same time, arranged in such a way in a row of plants. Planting in this way can be done on two types of plants that are relatively different old. The application of Rice-Corn intercropping was carried out in Playen District of Gunungkidul. Rice seed was used Sidenuk and Inpari 42 varieties then planted at distance of 40 cm x 20 x 12.5 cm (Tajarwo 2:1). The corn seed used Pioneer 35 and they are planted at 60 cm x 25 cm. The purpose of this research is to examine the application of intercropping rice-corn compared to monoculture cultivation on the aspects of soil nutrients status, affects intercropping on both crops yield and feassibility analisys of the intercropping farming on the two different agricultural system. The results of study show that on intercropping pattern rice yield can reach 5.19 to 5.85 ton ha^{-1} and dry corn shells from 5.43 to 6.28 tons ha^{-1} and quite profitable with a B/C ratio of 2.68 and R/C ratio of 3.12 compared to rice or corn monoculture planting patterns alone with B/C ratios of 1.24 and 1.88, respectively.

1 Introduction

The cropping pattern is a planting effort on a plot of land by regulating the layout and sequence of plants during a certain period of time including the tillage period and the non-planting period for a certain period. The cropping pattern in Indonesia, which has a tropical climate, usually is arranged for one year by paying attention to rainfall, especially in areas or land that are completely dependent on rainfall. The condition of the land area that is getting narrower and the cost of production is increasing forcing farmers to innovate so that their income in farming can fulfill their daily needs.

The efforts to increase farmer's income can be carried out in a number of ways, for example by planting types of cultivated plants that have high economic value or by using superior quality seeds, improving farming techniques and systems and using organic

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materials to save production costs. Furthermore, increasing of agricultural production from the rainfed rice field that are not increased land area requires the right innovation. To maximize land use and increase farmers' income, the Agricultural Research and Development Agency implements cultivation using mixed or intercropping techniques. The technique of planting with an intercropping pattern is actually not new in the world of agriculture in Indonesia, since ancient times we have implemented this pattern. But along with the development of intercropping patterns began to be abandoned, but nowadays, considering the availability of agricultural land which keeps on narrowing, this mixed cropping pattern is being applied again. [1], said that the Ministry of Agriculture is targeting an increase in production of rice, corn and soybeans, by increasing the planting area through various breakthroughs. One of them is the intercropping system of rice, corn and soybean crops with a tight cropping system. With this intercropping system, its hoped that there will be no competition for land use between rice, corn and soybean commodities, but instead of it will increase the population of the three plants (rice, corn and soybean).

In the intercropping system, the selection of varieties to be planted is important because it must be adjusted to the conditions of available water or existing rainfall. Furthermore a researcher said that [2] the intercropping system is more profitable than the monoculture system, increases the efficiency of land use, produces a variety of commodities, saves the use of production facilities and reduces the risk of crop failure. In intercropping, plant population density and spacing are important factors to obtain high production. Different spacing will give different results due to different plant populations.

Furthermore, Intercropping is an effort to plant several types of plants on the land at the same time, which are arranged in such a way as a row of plants. Planting in this way can be done on two types of crops that are relatively old, for example maize and rice, but rice plants are planted 2-3 weeks in advance so that the canopy leaves of the corn plants do not obstruct the irradiation of the rice plants. [3] To be able to carry out the intercropping pattern properly, several environmental factors have to be considered, including water availability, soil fertility, sunlight and pests. This is intended to avoid competition (absorption of nutrients and water) in a plot of land between cultivated plants. In the intercropping cropping pattern, [4] it is better to choose and combine plants that have relatively deep roots and plants that have relatively shallow roots, such as upland rice and maize.

The purpose of this research is to examine the application of intercropping rice-corn compared to monoculture rice and corn cultivation on the aspects of soil nutrients status, affects intercrpping on both crops yield and feassibility analisys of the intercropping farming (economical value) on the two different agricultural system.

2 Material and Method

2.1 Time and place of the research

The research of application intercropping rice-corn pattern was conducted at Planting Season II (February - May 2019) in North Plumbon, Logandeng Village, Playen District, Gunungkidul Regency. This activity involved the Local extension agents and also assisted by the Farmers Group Management, as well as guidance from the officer from Yogyakarta AIAT and Gunungkidul Regency Agriculture officer.

2.2 Material research

The research materials were used Rice seed with Sidenuk and Inpari 42 Green Super Rice varieties, while the corn seeds used Pioneer 35 variety. The chemical fertilizers were

used Urea, SP-36 and KCl, as well as NPK Phonska (15:15:15) and cattle manure by dose of 3 tonha^{-1}

The equipment research were used a set of Soil Test Kit for Rice Field, a field knife, a soil drill, some ring sample, field length measurement, a hoe, tillage and harvesting tools, a sickle and a pedal threser for harvesting rice grain, plastic sample. plastic sack, bamboo, plastic strap, paper label, digital balancing scales.

2.3 The implementation of the rice-corn cropping pattern

The Socialization activity of technology related to cropping pattern according to the Integrated Planting Calendar recommendation was applied as the demonstration plot of rice-corn cropping on a field area about 2 ha farmer's land. The treatment was applied includes technology in accordance with the recommended of Katam, among others namely the right planting on season II (February – May 2019).

Before planting, corn seeds were given Saromyl and rice seeds were given Agrimeth as the seed treatment. Rice seeds are planted at a distance of 40 cm x 20 x 12,5 cm (Tajarwo row 2:1) and rice seed were planted 30 days before corn seed by directly planting. While corn seeds are planted at a distance of 60 cm x 25 cm by one seed / planting hole. The application of rice-corn intercropping patterns were used six rows of rice plants and two rows of corn crops.

The fertilizer dosage of intercropping system is according to the fertilization rules is balanced for each commodity. For rice plants use Phonska fertilizer 250 kg / ha, Urea 150 kg/ha and KCl 50 kg/ha, while for corn plants are Phonska fertilizer 350 kg / ha and Urea 200 kg / ha dan KCl 100 kg/ha. [5] While for for monoculture rice and corn is according to the existing farmer. The parameters for rice were measured pest and disease attack, plant growth and development, rice production and analysis of soil sample and farming system analysis (social economic), while for corn crops include plant growth development and corn production, weight of 100 maize grains and analysis of farming economically of corn intercropping and monoculture cultivation of corn and rice as farmer's existing. The lay out of planting distance on intercropping patern is presented on Figure 1.

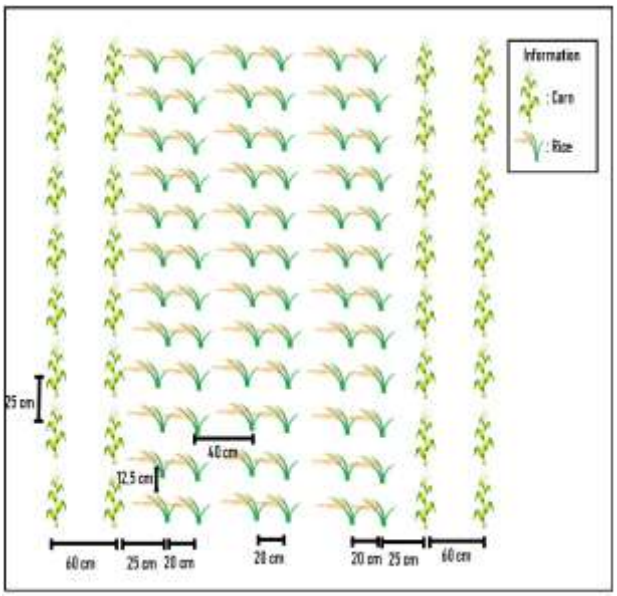

Fig.1. The lay out of planting distance on rice-corn intercropping pattern on Playen,Gunungkidul

The data collected from the demonstration plot's cultivation validation were the effect of intercropping for soil fertility, agronomic component and yield component. These data were tabulated and analyzed statistically by using T test analysis for treatment which only have 2 factors and Duncan Multiple Range Test (5%) if the teatment and replication have more than 15. [6] (treatment factor : 2 and replication 8 times as land farmer holder) Farming economically analysis is calculated based on the value of the B / C ratio and the R / C ratio.

3 Result and Discussion

3.1 The effect of intercroping rice-corn on soil nutrient status

The results of research on the effect of rice-corn intercropping on soil nutrient status are presented in Table 1 below. Based on the table, it is shown that the application of rice-corn intercropping gives an increase in C-organic content as much as 13.74 %, P available as much as 12.87%, K available and CEC have increase 16.83% and 12.27%, respectively. While in the monoculture rice and corn system, there was no significantly increase. The total N organic and C content of soil nutrient status actually decreased slightly after harvesting monoculture crops (Table1).

In considering the sustainability, the multiple cropping is better than monocropping, because the multiple cropping need less inputs such as chemical fertilizer and pesticides. Higher crop diversity in cropping system reduce the occurance of harmfull, insect or deseases, furthermore the mixture of sereal crops reduced the incidence of take-all diseases of its plant and soilborne pathogen.[7] Multiple cropping emphasis rotation or intercropping left more crops residues or roots on soil and increase soil organic matter content indirectly [8].

Several researchers stated that [9], through the problems of pests and diseases could be handled through the use of synthetic and non synthetic pesticides or through the use of biological agent, as well as the use of resistant varieties.These and other problems associated with the use of chemical control approach have made intercropping system which is environmentally safe and less costly a better alternative.

Table 1. Soil nutrient status in various cropping systems before assessment and after harvest time on Playen district, Gunungkidul Regency

Cropping system	**Soil Nutrient Status**					
	pH	**N total (%)**	**C org. (%)**	**P avail. (me/100g soil)**	**K avail. (me/100g soil)**	**CEC (me/100g)**
Rice monoculture (A)	6.90	0.27	1.39	36.58	23.72	42.26
Corn monoculture (A)	6.86	0.25	1.28	38.49	24.86	44.63
Rice-corn intercropping (A)	6.79	0.22	1.31	40.54	22.81	45.31
Rice monoculture (B)	6.96	0.23	1.33	37.63	23.3	40.29
Corn monoculture (B)	6.83	0.21	1.22	39.64	25.41	41.04
Rice-corn intercropping (B)	6.75	0.29	1.49	45.76	26.65	50.87

A : soil nutrient status before planting crops
B : soil nutrient status after harvesting time

On the Table 1 has showed that monoculture planting of rice and corn continously can erode nutrients in the soil. It had detimentral effect on soil organic matter and nitrogen content. [9] Soil losses and run off problem were more seriously in continously monocropping pattern than multiple cropping (intercropping) system. Apart from that, population and diversity of microbial soil become reduced

3.2 The effect of intercroping rice-corn on rice growth and yield

In general, rice growth in the monoculture pattern was better than the intercropping pattern (Table 2). However, plant hight of rice crop on intercropping pattern (105 cm) was lower than the monoculture pattern (113 cm). This is because on intercropping system, the crop was shaded by the leaf of corn plant. In the monoculture pattern, the weight of 1,000 grains was 22.3 g, while on intercropping pattern only reached 21.7 gr. The yield of rice on the monoculture pattern (6.29 ton /ha) was significantly higher than the intercropping pattern (5.32 ton/ha). The competition factor of plants in obtaining nutrients and the light from intercropping causes rice plants in the intercropping pattern to have lower productivity (Table 1). According to [10], in low light conditions, plant growth will disturbed as a result of deficiency energy supply and the ATP needed in the photosynthesis process.

Table 2.The effect of intercropping Rice-Corn and monoculture system on rice growth and Yield of Planting Season II 2019

Planting pattern	Plant height (cm)	The number of tiller (stem)	The length of panicles (cm)	The amount of filled grain (grain)	Weight of 1.000 grains (gr)	Productivity (t/ha)
S1 (monoculture)	113 b	17.4 a	21.9 a	207 a	22.3 a	6.29 a
S2 (intercropping)	105 a	16.7 a	20.6 b	203 a	21.7 b	5.85 b
CV (%)	11.3	11.8	9,3	10.5	6.3	18.4

The numbers of same column followed by the same letter are not significantly different according to T-test

The growth component of corn in the intercropping pattern was not significantly different from the monoculture pattern except weight of 100 corn grain, because the corn plant on intercropping system was higher than the rice plant so that it became a stronger competitor, especially in the use of sunlight [11]. However, the corn yield in the monoculture pattern was higher (average 6.35 t /ha) than the intercropping pattern (average 5.85 t /ha) (Table 3). This is probably due to the high nutrient uptake of corn and low competition between crops in the monoculture pattern.

Table 3. The effect of intercropping Rice-Corn and monoculture system on corn growth and Yield of Planting Season II 2019

Planting pattern	Plant Height (cm)	The length of cob without leaves (cm)	The amount of grain /cub (grain)	Weight of 100 grain (g)	P Productivity (t/ha)
1 (monoculture)	209 a	17.5 a	374 a	25.6 b	6.35 a
2 (intercropping)	215 a	18.6 a	386 a	24.2 a	5.85 b
CV (%)	12,5	10.3	17.4	21.7	19.4

The numbers of same column followed by the same letter are not significantly different according to T-test

3.3 The effect of rice varieties of rice-corn intercropping on plant growth and yield

The growth conditions and yield componen of the Sidenuk and Inpari 42 varieties, which planted 21 days earlier than the corn was presented on Table 3 as below. Based on the observations, it was found that the percentage of filled grain of rice Inpari 42 variety was more higher and significantly different to the Sidenuk variety, as well as the number of panicle and number of grains per panicle (Table 4).

Table 4. Yield componens of rice variety plant on each intercropping pattern

Planting pattern	Number of panicle	Number of grain per panicle	Percentage of fiiled grain (%)	Grain weight per panicle (gr)	Weight of 1000 grains (gr)
Sidenuk rice variety- Corn	13.28 a	187 a	88.26 a	17.46 a	22.37 a
Inpari 42 rice variety- Corn	15.74 b	234 b	93.41 b	18.83 a	22.84 a
CV (%)	14.6	18.2	15.4	10.7	10.3

The numbers in one column followed by the same letter are not significantly different according to DMRT (5%)

The productivity for both two rice varieties on intercropping pattern, which were Inpari 42 and Sidenuk rice variety, were not as high as when planting by the monoculture system (Table 4). This condotion can be happened because during the age of 45 DAP, plant height of corn is more than 100 cm, while plant height of rice crop is less than 60 cm, so that both of rice crop varieties were shaded. According to [12], The rice crop which are shaded by corn in the rice-corn intercropping system shown on the lower the sunlight received by the rice plants, the more dense the level of shade will cause the growth and yield of rice become to decrease.The high population density of plant is not always followed by increasing the yield, due to the level of competition inter individual plants also increase.

Furthermore, the effect of solar radiation on the rice yield are stated [13] one of the most dynamic environmental factors, is the principal source of energy for photoautotrophic plants. [14] Under shading treatment, the photosynthetically active radiation that plants capture for photosynthesis and the intensity of solar radiation that determines the level of photosynthetically active radiation are reduced, thereby it can be altered the morphology, physiology, yield and quality of rice plants [15]

Planting rice varieties have exerted highly significant effects on plant height, number of tillers, wet weight biomass and dry weight biomass [16]. The difference in biomass production and yield are shown in Table 5 which applies Inpari 42 and Sidenuk rice varieties.

Table 5. The yield of harvested dry rice grain and weight of milled rice grain on Playen Gunungkidul

Planting pattern	Weight of biomass rice straw (ton/ha)	Weight of harvested rice grain (ton/ ha)	Weight of milled rice grain (ton/ ha)
Sidenuk rice variety- Corn	5.47 a	5.19 a	4.17 a
Inpari 42 rice variety- Corn	5.96 a	5.85 b	4.94 b
CV (%)	9.4	10.6	12.7

Numbers in one column followed by the same letter are not significantly different according to DMRT (5% test)

On the table 5 above, it was shown that weight of biomass rice straw and weight of harvested rice grain of Sidenuk variety is not given significantly different to Inpari 42 rice variety. While for weight of milled rice grain, there is given significantly different to Inpari 42 variety GSR. The difference of rice yields both two rice varieties was caused [17] Inpari 42 GSR is New Superior Varieties (VUB) of rice which was released in 2016. Varieties this has productivity potential which is high, as much as 10.58 ton/ ha and has a wider tolerance against drought. Moreover, this variety is a one of the rice varieties designed to be grown on both optimum conditions and sub optimum condition (water availability and limited fertilizer) have resistance to major pests and diseases. It also have resistance to major pests and rice diseases so that it can minimize pesticide application.

Furthermore, they are presented the corn yields in the application of the rice-corn cropping pattern on Table 6 below.

Table 6. The weight of corn biomass and corn yield at various rice varieties of intercropping

Planting pattern	Weight of dry corn biomass (kg/ha)	Weight of 100 corn kernels (gr)	Weight of dry kernels corn yield (kg/ha)
Sidenuk rice variety- Corn	11.35 a	23.24 a	5.43 a
Inpari 42 rice variety-Corn	12.16 b	23.97 b	6.28 b
CV (%)	11.8	10.9	12.5

Numbers in one column followed by same letter are not significantly different according to DMRT test (5%)

Based on Table 6, it can be seen that the yield of corn in the form of dry kernels at intercropping with Inpari 42 rice crop can be reached 6.28 ton /ha and it more higher than the application of intercropping corn with the Sidenuk rice variety (5.43 ton/ha). This was happened because the root of Inpari 42 rice variety can absorb nurtient uptake quite synergy by corn plant so that they reduce competition during plant growth and the filling grain of rice crop than the Sidenuk variety. Besides that Inpari 42 rice variety is more resistant to pest and disease attack so this can be affected the environmental growth [18].

The agricultural system in the intercropping pattern must also pay attention to sustainable organic fertilization. This is according to research [19], which describes that the use of fertilizers inorganic continuously without the use of fertilizers organic will have a bad impact because it causes physical and biological characteristics soil microorganisms become disturbed. Moreover [20] has stated, that continuous use of chemical fertilizers causes the soil biological ecosystem become unbalanced, so that goal fertilization to meet the nutrients in the soil is not achieved. Potency plant genetics can't be achieved anywhere near the maximum. While appliation of organic fertilizers are able to maintain soil nutritions balance and increase productivity as well as reducing the environmental impact of the soil.

3.4 Analysis of farming systems on corn-rice intercropping pattern

BC ratio or Benefit cost ratio is the ratio between the benefits and costs of farming. The value of BC ratio can be negative or positive, BC which is negative means that the farm is experiencing economic loss, and on the other hand, a positive BC ratio indicates that the farming is profitable. For example, the resulting BC ratio is 0.8, meaning that every rupiah issued can provide a profit of 0.8 rupiah or get an interest return of 80 percent.

The RC ratio is a value obtained from dividing the total revenue with the cost of farming. An RC value less than 1 means that revenue is less than the cost. If the value of RC is equal to 1, it means that each revenue generated can only cover the costs incurred. Conversely, if the RC value exceeds 1.0 the resulting farming has an advantage [21].

In Table 7 below, it can be seen that in monoculture agriculture alone for rice and corn crops have the value of BC ratio 0.86 and 1.12, respectively, meaning that for corn farming (monoculture), every expense incurred gives a little benefit to corn but for rice monoculture farming system the BC ratio was less than 1, it can be said that rice farming cultivation is not feasible. Whereas the BC ratio of the corn-rice intercropping pattern can reach 1.73 and the RC value of the ratio is 2.74 so it can be concluded that the intercropping of rice-corn cultivation in Logandeng village, Playen district, Gunungkidul Regency can be classified is feasible to apply during planting season II and it can develope on the land that has

agroclimatic and soil conditions which has similar to the conditions in Logandeng-Playen, Gunungkidul.

The application of manure to the rice and corn monoculture farming system or rice-corn intercropping system are same amount, which as much as 3 ton.ha^{-1}.The distinguishing of two farming systems is the number of workers for transporting and applying manure on the land. It can be seen that with the same labour worker as the monoculture crop system, they can cover or maintain two crps in the same time and same land. This is indicated that using the number of workers on intercropping system was more save than monoculture system.The outpouring of labor worker in agriculture was stated by [22], that the workforce absorbs the most labor family is rice farming system followed by corn cultivation. The type of activity that consumes the number of workers in rice cultivation is land tillage, as much as 70 hours /year and corn cultivation has only 44.75 hours/year.

The implementation of intercropping with two types of plants in one season is also supported by [23], that stated strategies to increase the farmer income of lowland rice farmer can be done through crops diversification (cropping rotation patterns) and yield management in the land. Because using intercropping system can be minimize pests and plant diseases and also increase land productivity.

Table 7. The Analysis of Farming System on Monoculture and Intercropping Rice-Corn Cultivatio on Logandeng Village, Playen District Gunungkidul Regency during Planting Season II

Number	Description	Cropping Pattern system		
		Corn monoculture (IDR/0.1 ha)	**Rice Monoculture (IDR/0.1 ha)**	**Intercropping pattern Corn - Rice (IDR/0.1 ha)**
A. Explicit Cost		760,000	665,000	1,032,500
I.	**Production facilities**			
1	Seed (3.0 kg)	130,000	60,000	97.500 40.000
2	Fertilizer			
	Urea (15 kg)	75,000	90.000	50.000 100.000
	NPK 15:15:15 (20 kg)	120,000	150,000	100,000 75,000
	Pupuk kandang (300 kg/)	120,000	120,000	75,000 75,000
3	Pesticides	65,000	65,000	60,000 60,000
II.	**External workforces**	200,000	180,000	150,000 150,000
III.	**Others**	50,000		
B. Implisit Cost		480,000	360,000	600,000
IV.	**Internal / family labour**	480,000	360,000	360,000 360,000
C. Additional irrigation cost		200,000	200,000	100,000 100,000
D. Total Cost (A+B+C)		1,440,000	1,225, 000	1,832,500
E. Receipt of Funds		4,155,000	2,750,000	6,758,000
	Yield of corn / Weight of milled dry rice grain	3,005,000	2,250,000	2,927,500 2,480,500
	Biomass of corn or rice crop	1,150,000	500,000	950,000 400,000
F. Income (E-A)		3,395,000	2,035,000	5,725,500
G. Benefid (E-D)		2,715,000	1,525,000	4,925,500
H. Farming system feasibility indicator				
1. B/C (Rasio Benefid vsTotal cost), Feasible >1		**1.88**	**1.24**	**2.68 (feasible)**
2. R/C (Rasio Income vs Total cost), Feasible >2		**2.35**	**1.66**	**3.12 (feasible)**

4 Conclusion

- Rice-corn intercropping gives an increase in C-organic content as much as 13.74 %, P available as 12.87%, K available and CEC increase 16.83% and 12.27%,respectively. While the rice monoculture and corn system was no significantly increase and the total N and C organic content of nutrient status actually decreased slightly
- The yield of rice on monoculture farming system (6.29 ton.ha^{-1}) was significantly higher than the intercropping pattern (5.85 ton.ha^{-1}). The competition factor of plants to obtaine some nutrients and the light from intercropping pattern causes rice plants in the intercropping system have more lower production.
- The intercropping pattern is more productive than the monoculture pattern and can be an alternative for rice and corn cultivation because it can increase land productivity, soil nutrien status and optimize land use in rainfed lowland area.
- The application of rice-corn intercropping pattern in Logandeng, Playen-Gunungkidul was able to produce dry kernel corn about 5.43 - 6.28 ton.ha^{-1} plus harvested rice yield as much as 5.19 - 5.85 ton.ha^{-1} and this cultivation system is more profitable with the value of BC ratio 2.68 and RC ratio 3.12 compared to the rice monoculture and corn cultivation with BC ratio 1.24 and 1.88, respectively.

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