

## Original Article

**An evaluation on cropping system of rice and corn in dry land during dry season**

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**Abstract**

Dry land has wide and diverse agroecosystem, which potential as growth source to produce dietary crops (foodstuff). The objective of the research was to study the appropriate managerial technique of cropping system for rice and corn to increase production and income of the farm operation in dry land during dry season. The research was conducted on dry land during dry season (DS) I in 2018 at Jatisari Village, Arjasa Subdistrict, Situbondo Regency, on the area of 10,000 m<sup>2</sup> width. The research used Randomized Block Design with 4 treatments and 6 replications, includes : (a) Upland rice (20 cm x 20 cm), (b) Upland rice largo super (40 cm x 20 cm x 10 cm), (c) Upland rice largo super (40 cm x 20 cm x 10 cm) + corn (160 cm x 40 cm), and (d) Corn (75 cm x 20 cm). Results of the research showed that the intercropping system between upland rice largo super and corn produced higher yield, 8,151 kg/ha DGH and 2,092 kg/ha grains of corn. Besides that, yield of corn trimming was 2,446 kg/ha fresh biomass. The increase production of intercropping upland rice largo super with corn has increase income of the farmers, IDR. 41,923,100 with R/C ratio 3.25, so that it is economically feasible.

**Keywords:** Corn, cropping system, dry land, dry season, rice

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**Introduction**

Dry land has low fertility with thin tillage and low organic matters, as well as limited water availability along with fluctuation in rainfall and distribution pattern that affects on the increase of planting indexes. In order to increase land productivity, balanced inorganic and organic fertilizers should be applied by utilizing bioagent for the plants. Based on result of the research by Mulyaning-sih et al. (2015), it suggested that the application of bio-fertilizer of BioVam and Bioplus on upland rice may reduce 50% standard inorganic fertilizer (NPK) application as recommended without reducing the rice yield.

During dry season, water supply decreases, so that plants compete to absorb water (Turmudi, 2002). Annual rainfall is less than 2,000 mm/year with wet month duration is only 3 to 4 months that causes water supply, derived from rain, is only sufficient for one planting season (Mulyani 2013; Mulyani and Sarwani 2013). In order to obtain maximum productivity, it is important to apply the appropriate cropping system, which will be able to increase water supply, water use efficiency (WUE), and reduce erosion (Machado et al. 2008). Dry land is potential to increase cropping intensity by considering time duration between planting and harvest time as short as possible. In applying the technology, dry land management should be concerned with the effective technology

selection that can be adopted by the farmers (Abdurachman et al., 2008)

Dry land productivity can be increased through intercropping because it is able to maintain water content and moisture, as well as to reduce erosion and increase soil fertility (Samosir, 1998). Moreover, Gonggo et al. (2007) suggested that intercropping system may increase land use effectiveness, minimize the risk of yield failure, and increase the farmers' income. Furthermore, Warsono et al. (2002) suggested that intercropping is one of alternatives on farming intensification program, which is appropriate to multiply the farming yield at less productive area. In accordance with Ningsih and Noor (2011), the important thing that must be concerned is the appropriate planting time and planting pattern, based on moisture balance analysis, so that the crops will not run the risk of water deficiency and, of course, it will increase the farmers' income. Location specific cropping system management with crop density arrangement requires adaptive and tolerant superior variety to limited water, short harvesting period, and high potential production in order to increase crop productivity (Husnain et al., 2016). Furthermore, Rasool et al. (2012) suggested that the arrangement of upland rice density in dry land, which is planted in an array manner (*larikan*), will increase the yield. Crop density arrangement using double row (*jajar legowo*) planting system may increase crop population per area unit (Erythrina and Zaini, 2014).

The objective of the research was to study the appropriate managerial technique of cropping system for rice and corn to increase production and income of the farm operation in dry land during dry season.

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## Methods

### Materials

The evaluation on cropping system of rice and corn in dry land was conducted at Jatisari Village, Arjasa Subdistrict, Situbondo Regency, on the area of 10,000 m<sup>2</sup> widths. Rice crop used Inpago 10 variety and hybrid corn used HJ 21 variety. Doses of fertilizer application for monoculture are 300 kg Urea/ha, 300 kg Ponska/ha, and 1,000 kg organic fertilizer/ha (given to cover the planting hole). Fertilizer doses for rice crop are 200 kg Urea/ha, 300 kg Ponska/ha and 2,000 kg organic fertilizer/ha. The treatment on largo (*larikan padi gogo*) super applied the spacing of 40 cm x 20 cm x 10 cm along with the application of organic fertilizer and biofertilizer. For organic fertilizer, it will be supplemented with 4 sachets of bio-decomposer M-Dec/2,000 kg organic fertilizer/ha. Before the seeds being germinated, rice seeds were soaked in biofertilizer solutions of Agrimeth by doses of 8 sachets/50 kg/ha rice seeds.

The need of corn seeds for monoculture (75 cm x 20 cm) is 20 kg/ha with 1 seed/hole, and for corn (160 cm x 40 cm) intercropping with rice require 10 kg/ha corn seeds with 2 seeds/hole, which are planted after the rice aged 10 day after planting (DAP). Rice planted by dibbling (*tugal*) 4-5 seeds per hole require 50 kg/ha.

### Methods

The research on cropping system of rice and corn in dry land was conducted at Jatisari Village, Arjasa Subdistrict, Situbondo Regency. Characteristics of the region is based on Oldeman climate that has type E2 with 2 wet months and 6 dry months, as well as low soil fertility. The research used Randomized Block Design with 4 treatments and 6 replications, such as: (a) Upland rice (20 cm x 20 cm), (b) Upland rice largo super (40 cm x 20 cm x 10 cm), (c) Upland rice largo super (40 cm x 20 cm x 10 cm) + corn (160 cm x 40 cm), and (d) Corn (75 cm x 20 cm).

Organic fertilizer was applied as basic fertilizer before planting the rice, but the organic fertilizer was applied to cover the planting hole when planting the corn. Inorganic fertilizers, 1/3 dose of Urea and 1/2 dose of Ponska, were applied simultaneously when the rice was planted by dibbling; while 1/3 dose of Urea and 1/2 dose of Ponska were applied at 28 DAP and 1/3 dose of Urea was applied at 35 DAP. In corn cultivation, at 15 days before harvesting, trimming of stems on the cobs and leaves under the cobs to accelerate the ear drying in the field. The yield of corn trimming (biomass) can be used as feed.

Parameter of observation include: plant height, number of corn leaves, number of tillers, panicle of rice, number of cobs. After harvest time, weight of 1000 seeds of rice and corn, weight of corn trimming, yield of rice and corn (t/ha), Land Equivalent Ratio (LER). The increasing income or revenue of the farming operation was conducted by financial analysis in accordance with properness of the rice and corn farming operation using R/C ratio.

LER is relative land area of intercropping to gain yield in comparison with monoculture. Mathematically, LER calculation (Palaniappan, 1985), is as follows:

$$LER = \sum_{i=1}^m \frac{Y_{ij}}{Y_{ii}}$$

Where,  $Y_{ij}$  = Yield of the first component under intercropping condition,

$Y_{ii}$  = Yield of the component under monoculture in intercropping area.

If, LER = 1: Yield of intercropping equals to each yield of both crops in the same area of intercropping.

LER > 1: Yield of intercropping is higher (profitable) than each of both crops in the same area of intercropping.

LER < 1: Yield of intercropping is lower (unprofitable) than each of both crops in the same area of intercropping.

The farming properness of monoculture and intercropping, between rice and corn, was done by calculating R/C ratio (Soekartawi, 2002) as follows:

$$R/C \text{ ratio} = NPT/BT$$

In which, R/C = Revenue and Cost Ratio

NPT = Total production value (IDR/ha)

BT = Total cost value (IDR/ha)

If, R/C > 1: Feasible to be developed

R/C = 1: Break even

R/C < 1: Not feasible to be developed

## Results

Location of the research is on dry land as old volcanic soil with low fertility.

### Growth and Yield

Height of the rice crops, among upland rice, upland rice largo super, and upland rice largo super + corn, did not show any significant difference under observation at 30 DAP, 60 DAP, and 90 DAP (Tab. 1).

**Table 1.** Plant height of rice and corn in dry land of Jatisari Village, Arjasa Subdistrict, Situbondo Regency, DS I 2018

Cropping system	Plant height of rice (cm)			Plant height of corn (cm)		
	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP
A Upland rice	31.4a	66.8a	94.2a	-	-	-
B Upland rice largo super	27.3a	71.3a	99.9a	-	-	-
C Upland rice largo super +corn	26.1a	68.3a	90.4a	37.6a	149.4 b	151.8 b
D Corn	-	-	-	47.6a	195.1a	191.9a
C V (%)	11.41	6.28	7.71	20.97	3.09	2.84

The numbers followed by the same letters in the same column are not significantly different from DMRT at the level of 5%

The observation at 30 DAP, corns did not show significant difference in height, but at 60 DAP and 90 DAP, they showed some difference in height from cultivation of corn monoculture with corn against the intercropping between corn and upland rice largo super.

The cultivation of upland rice, upland rice largo super, and upland rice largo super + corn during the observation at 30 DAP, 60 DAP and 90 DAP did not significantly show any difference in numbers of rice tillers (Tab. 2).

**Table 2.** Number of rice tillers and number of corn leaves on dry land of Jatisari Village, Arjasa Subdistrict, Situbondo Regency, DS I 2018

Cropping system	Number of rice tillers			Number of corn leaves		
	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP
A Upland rice	7.6a	21.8a	22.0a	-	-	-
B Upland rice largo super	6.7a	19.4a	19.9a	-	-	-
C Upland rice largo super +corn	7.2a	20.3a	20.7a	5.7 b	11.4a	11.4a
D Corn	-	-	-	7.2a	12.7a	12.7a
C V (%)	16.39	15.99	17.75	6.81	8.60	7.92

The numbers followed by the same letters in the same column are not significantly different from DMRT at the level of 5%

The observation at 30 DAP, the corn in monoculture system showed the increase in numbers of leaf significantly in comparison with the corn in intercropping system with upland rice largo super, but at 60 DAP and 90 DAP, they did not any significantly difference in numbers of leaf. Upland rice cultivation has significantly produced the highest numbers of panicles per clump and then followed by upland rice largo super and upland rice largo super + corn (Tab. 3).

biomass and weight of cobs on monoculture have significantly difference in comparison with intercropping. Rice and corn cultivation, both monoculture and intercropping, did not show any significant difference for weight of 1000 seeds (Tab. 4).

In monoculture system, rice and corn cultivation showed higher yield of seeds for each of them, in comparison with intercropping system (Tab. 5). Upland rice largo super intercropped with corn has the highest LER of 1.27.

The numbers of cobs have no significantly difference between monoculture and intercropping, but weight of

**Table 3.** Number of panicles/clumps of rice and number of cob/corn plants and weight of fresh corn biomass and weight of corn cobs on dry land of Jatisari Village, Arjasa Subdistrict, Situbondo Regency, DS I 2018

Cropping system	Number of panicles/clumps of rice	Number of cob/corn Plants	Weight of corn biomass (t/ha fresh)	Weight of corn cobs (t/ha dry)
	A Upland rice	16.7a	-	-
B Upland rice largo super	14.1 b	-	-	-
C Upland rice largo super +corn	11.3 c	1.1a	2.4 b	3.0 b
D Corn	-	1.2a	7.0a	8.8 a
C V (%)	8.77	3.39	15.18	18.94

The numbers followed by the same letters in the same column are not significantly different from DMRT at the level of 5%

**Table 4.** Weight of 1000 seeds of rice and corn on dry land of Jatisari Village, Arjasa Subdistrict, Situbondo Regency, DS I 2018

Cropping system	Weight of 1000 grains of rice (g)	Weight of 1000 grains of corn (g)
	A Upland rice	28.0a
B Upland rice largo super	30.1a	-
C Upland rice largo super +corn	30.0a	137.0a
D Corn	-	139.2a
C V (%)	5.66	1.77

The numbers followed by the same letters in the same column are not significantly different from DMRT at the level of 5%

**Table 5.** Yields of rice dried grain harvest (DGH), corn dried grain and LER on dry land of Jatisari Village, Arjasa Subdistrict, Situbondo Regency, DS I 2018

Cropping system	Yield of rice (t/ha DGH)	Yield of corn (t/ha dry grain)	LER
	A Upland rice	6.0 b	-
B Upland rice largo super	8.6a	-	1
C Upland rice largo super +corn	8.2a	2.1 b	1.27
D Corn	-	6.2a	1
C V (%)	8.65	10.32	

The numbers followed by the same letters in the same column are not significantly different from DMRT at the level of 5%

### Rice and Corn Farming

The cropping system management of rice and corn in dry land at DS I 2018 showed that the best R/C ratio for

yield of rice and corn was found by applying intercropping system of upland rice largo super with corn (Fig. 1 and Tab. 6).

**Table 6.** Analysis of farming systems for rice and corn planting on dry land Jatisari Village, Arjasa Subdistrict, Situbondo Regency, DS I 2018

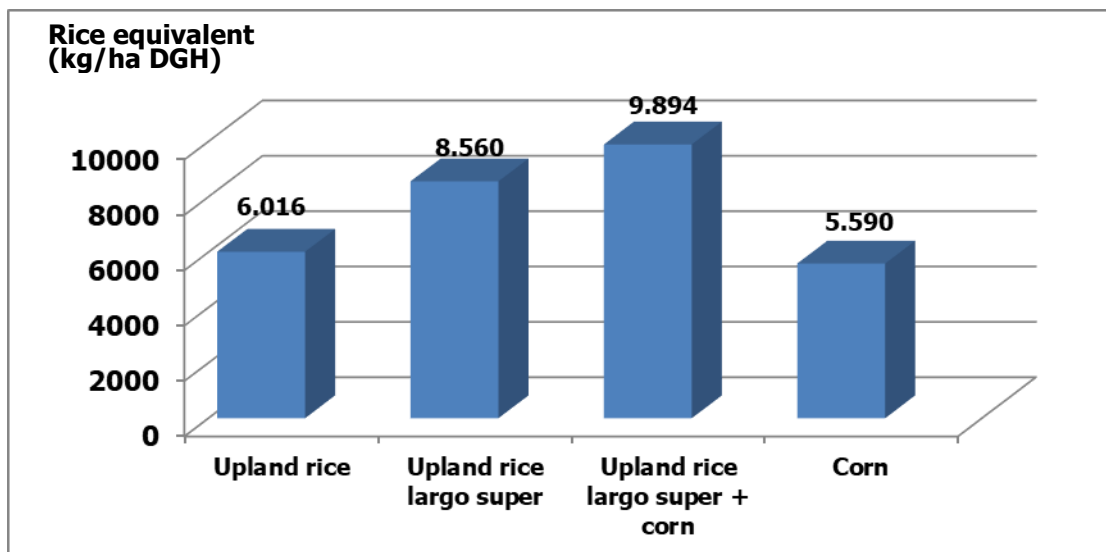
Activity	Upland rice		Upland rice largo super		Upland rice largo super + corn		Corn	
	vol.	value (IDR)	vol.	value (IDR)	vol.	value (IDR)	vol.	value (IDR)
<i>A. Labor (WD)</i>								
1. Tillage	10	1.000	10	1.000	10	1.000	10	1.000
2. Planting	30	1.800	34	2.040	40	2.400	22	1.320
3. Fertilization	8	480	8	480	8	480	8	480
4. Weeding	35	2.100	35	2.100	35	2.100	20	1.200
5. Pest control	6	360	6	360	6	360	4	240
6. Irrigation	5	300	5	300	5	300	4	240
7. Corn trimming					4	240	8	480
8. Harvesting	24	1.440	24	1.440	30	1.800	18	1.080
9. Post harvest	12	720	13	780	18	980	12	720
<i>B. Prod. Facilities (kg)</i>								
1. Seed (kg)								
- Rice	40	360	50	450	50	450		
- Corn					10	450	20	900
2. Fertilizer (kg)								
- Organic	2.000	1.000	2.000	1.000	2.000	1.000	1.000	500
- Urea	200	360	200	360	200	360	250	450
- Phonska	250	575	250	575	250	575	250	575
- Agrimeth (Sachet)			10	60	10	60		
- M-Dec (Sachet)			4	40	4	40		
3. Pesticide (Bottle)	4	240	4	240	4	300	2	120
<i>C. Production Cost</i>								
		10.735		11.225		12.895		9.305
<i>D. Yield of rice (DGH)</i>								
	6.016	25.267	8.560	35.952	8.151	34.234,2		
<i>E. Yield of corn (dried grains)</i>								
					2.092	7.322	6.708	23.478
<i>F. Weight of corn trimming</i>								
					2.446	366,9	7.094	1.064
<i>G. Total of yield</i>								
	6.016	25.267	8.560	35.952	10.243	41.923,1	6.708	24.542,1
<i>H. Profit</i>								
		14.532		24.727		29.028		15.237,1
<i>I. R/C ratio</i>								
		2,35		3,20		3,25		2,64

Information :

Prices of rice grain (DGH): IDR. 4,200/kg

Price of corn dry grains : IDR. 3,500/kg

Price of biomass fresh (corn trimming) of feed : IDR. 150/kg



**Figure 1.** Rice equivalent yield from the management of rice and corn cropping systems on dry land of Situbondo Regency at DS I 2018

## Discussion

The soil in location of the research containing C-organic was very low, N-total and P<sub>2</sub>O<sub>5</sub> were low and K<sub>dd</sub> was medium with sandy clay loam texture and soil solum 5.5-9.5 cm were very shallow. The dominant shallow soil with solum condition in dry land area of dry climate (BBSDLP 2012; Dariah et al. 2013; Mulyani and Sarwani 2013; Mulyani 2013), causing tolerable soil loss becomes very low.

## Growth and Yield

On observation at 30, 60, and 90 DAP, height of the rice plant did not show significant difference. The corn height at 30 DAP did not significant difference, but at 60 and 90 DAP, they showed significant difference through monoculture in comparison with the intercropping between corn and upland rice largo super.

Numbers of upland rice tiller did not show significant difference during observation at 30, 60, and 90 DAP. In

accordance with Kurniasih et al. (2008), the increasing radiation interception by canopy of the plant (monoculture) may increase numbers of rice panicles. Furthermore, Sasmita et al. (2006) suggested that a consistency occurred between shade tolerance and adaptive toward intercropping condition, rice and corn, by the emergence of similar response of growth and yield of upland rice. The corn, which was cultivated in monoculture system and intercropped with upland rice largo super, did not show significant difference on numbers of cobs per plant.

At 30 DAP, the corn that was cultivated in monoculture has significantly increased its numbers of leaf in comparison with the intercropped corn, but it did not show significant difference at 60 and 90 DAP.

In monoculture system, weight of cobs was higher (8.8 t/ha dry), while in intercropping system between corn and largo super produced 3.0 t/ha dry. Trimming the corn leaf, 15 days before harvesting the monocultured corn, has significantly produced the highest weight of trimming in comparison with the intercropped corn. High monocultured corn trimming (7.0 t/ha fresh biomass) is affected by high population of corn (twice more) than intercropped corn (2.4 t/ha fresh biomass). In accordance with Permanasari and Kastono (2012), the corn leaf trimming may not decrease the yield if it is done in the right time, during the photosynthetic process; the leaf has not been optimal. Fresh biomass of corn has great potential to be used for feed, which is difficult to be available during dry season.

Weight of 1000 seeds of rice and corn, which are cultivated in monoculture, has increased weight of seeds in comparison with the intercropping system, but such increase of seed weight did not any significant difference.

The highest yield of rice was significantly found on upland rice largo super by monoculture were 8.6 t/ha DGH, followed by upland rice largo super intercropped with corn were 8.2 t/ha DGH, and upland rice 6.0 t/ha DGH. These yields showed that the application of upland rice largo super has increased the yield 2.2-2.6 t/ha DGH in comparison with upland rice. Less light intensity intercepted by the canopy may affect low production of upland rice intercropped with corn. Along with results of the research by Dewi et al. (2004), the closer the spacing of sweet corn, the lower light may be intercepted by the rice plants. Low light intensity may disturb photosynthesis and carbohydrate synthesis, as well as reduce growth and productivity of the plants (Chozin et al., 1999). In general, the shade affects the processes of photosynthesis, respiration, transpiration, nitrate reduction, protein synthesis, hormone production, translocation, and aging. The shade also changes micro-climate elements, such as temperature, soil temperature, and relative humidity, as well as reduce air circulation from outside the canopy.

The highest yield of corn was significantly found by monoculture system in comparison with intercropping, monoculture corn produced 6.2 t/ha dry grains and intercropping system between corn and upland rice largo super produced 2.1 t/ha dry grains, or increase 4.1 t/ha dry grains.

Intercropping system between upland rice largo super and corn has LER 1.27, so that the land use efficiency gets 27% profit in comparison with monoculture system

of rice and corn. Therefore, in order to gain yield of upland rice largo super 8.2 t/ha DGH and corn 2.1 dry grains (Table 9), it required land equals to 1.27 ha to obtain the same yield as in monoculture. It conformed to the opinion of Hairid (2002, *in* Susanti et al., 2017), it is presumed that intercropping system is more productive than monoculture if LER is more than one. Along with result of the research by Arifin et al. (2014), it reported that the application of intercropping between soybean and corn has increased LER and income of the farming operation, yield of corn and soybean seeds, as well as fresh biomass of the corn trimming yield. Moreover, result of the research by Prasetyo et al. (2009) suggested that intercropping between upland rice and castor plants (*Jatropha curcas* L.) resulted grain (unhulled rice) 5.16 t/ha, by yield ratio 1.02 and LER value is 1.42

### Rice and Corn Farming

Based on analysis of rice and corn farming, by the application of monoculture system for upland rice largo super, the yield resulted 8,560 kg/ha DGH and R/C ratio 3.20; while the yield from intercropping system between upland rice largo super and corn even it showed a little decrease was 8,151 kg/ha DGH, but it was contributed from yield of corn seeds, 2,092 kg grains (9,894 kg/ha equals to DGH), besides that the yield of corn's leaf trimming was 2,446 kg/ha fresh biomass, so that the income or revenue increased IDR. 41,923,100 and R/C ratio was 3.25.

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