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Abstract

Rice was still be main foodstuffs for Indonesian people. Method of paddy wet field harvesting could be done manually utilized sickle or mechanically utilized KUBOTA DC-60 combine harvester. Some problems often occured during paddy harvesting and threshing such as harvesting and threshing losses, and low harvesting and threshing capacities. The objectives of the research was to compare harvesting and threshing results utilized sickle and power thresher with harvesting results utilized KUBOTA DC-60 combine harvester. The research was held on March 2013 until May 2013 in Sukamandi, Subang, West Java. Paddy with Ciherang variety was harvested manually utilized sickle and then it was threshed utilized power thresher, and it was harvested mechanically utilized KUBOTA DC-60 combine harvester. Yield losses of harvesting and threshing, capacities of harvesting and threshing, and field capacities of harvesting and threshing were measured. Results of the research showed that yield losses of harvesting and threshing, capacities of harvesting and threshing, and field capacities of harvesting and threshing utilized sickle and power thresher were 46.1%, 18.39%, 0.19 ton/person.hour, 1.60 ton/hour, 0.006 ha/person.hour, and 0.28 ha/hour respectively. Yield loss of harvesting, harvesting capacity, and harvesting field capacity utilized KUBOTA DC-60 combine harvester were 2.73%, 1.56 ton/hour, and 0.49 ha/hour respectively. Yield losses utilized sickle and power thresher were higher than yield loss utilized KUBOTA DC-60, whereas harvesting capacity utilized sickle was lower than harvesting capacity utilized KUBOTA DC-60, so that paddy wet field harvesting utilized KUBOTA DC-60 was more effective and more efficient than harvesting utilized sickle and threshing utilized power thresher.

Keywords: harvesting, losses, capacity, sickle, power thresher, and combine harvester

Introduction

Rice was still being one of main foodstuffs for Indonesian people. It was obtained from paddy harvesting, which it can be harvested from paddy wet field areas. National rice necessity increased by increasing of sum of people that in 2013 it will reached 250 millions with population growth of 1.49/year (BKKBN, 2013). The Minister of Agriculture, Suswono, said that for fulfill the national rice necessity so target of paddy productions in 2013 was 7.5 million tons (Republika, 2013). If average national rice necessity was 5 ton/ha, so to reach the target it needed harvesting areas of 1.5 million hectares.

Paddy wet field harvesting activities in Indonesia were still be done manually or traditionally utilized sickle and manual threshing. Pedal threshers have already applied in several paddy wet field areas. If the manual harvesting and threshing methods were be applied for the 1.5 millions hectares harvesting, so that it needed too many manpower harvester and long time harvesting, because it's harvesting capacity was only 0.2

hectare/man/day so that it needed 750000 man.days. If available time for harvesting was 30 days, so it needed 25000 harvester manpowers.

Manual paddy harvesting result was harvested paddy so that it still need more thresher manpower to obtain unhusked rice. Paddy production target of 7.5 million tons would be difficult to reach if it still be done manually, because refering data from BPS (2013) the amount of farmers were 39% and its decreased until 3.1 millions farmers (7.42%) in 2011, and also average age of farmers were above 40 years old.

Setyono *et al.* (2007) said that yield loss of manual harvesting utilized sickle was 1.56% up to 3.31%. It would increased because harvesting process was consisting of cutting, compiling, transporting, and threshing. Beside that, the manual harvesting would produce low unhusked rice quality and low rice miling rendement.

Some machines that be developed for harvesting activities were power thresher, reaper, and rice combine harvester. According of Nugraha (2007) critical points of yield losses were in stage of cutting, compiling, and threshing. Machine that could combine all harvesting processes until it was obtained clean unhusked rice was rice combine harvester. Purwadaria *et al.* (1994) said that rice combine harvester would done activities of harvesting, compiling, and threshing in one stage of complete harvesting process so that the yield loss could be minimized up to 2.5%.

Related to above problems, so it can be studied performances of manual harvesting utilized sickle and mechanical harvesting utilized rice combine harvester, and also it can be compared results of the two harvesting methods. The machine has already applied in several paddy wet field areas in Indonesia. One of the machines that it have already utilized by farmers was rice combine harvester KUBOTA DC-60, which it was distributed by one of national private companies in Indonesia that is PT Bina Pertiwi.

Materials and methods

Sample

Research materials are: (1) harvested paddy samples, (2) diesel fuel for rice combine harvester operating, (3) gasoline for power thresher operating. Instruments, tools, and machines for research conducting are: (1) grain moisture meter MC-7821, (2) GPS Garmin, GPSmap 60CSx type, (3) measuring tapes, (4) balances, (5) stopwatch, (6) measuring glass, (7) sickle, (8) power thresher, (9) rice combine harvester KUBOTA DC-60.

Methods

The research was conducted in paddy wet field areas of PT Sang Hyang Sri, Sukamandi, Subang, West Java from March 2013 until May 2013. Paddy that be harvested was Ciherang variety with harvest age of 125 days.

Data collecting was conducted during manual harvesting utilized sickle continued by power threshing, and it conducted during mechanical harvesting utilized rice combine harvester KUBOTA DC-60 in another harvesting area. Examples of sickle, power thresher, and rice combine harvester KUBOTA DC-60 were shown in Figure 1.

(a) (b) (c)

Figure 1. Examples of sickles (a), power thresher (b), and KUBOTA DC-60 (c)

Research parameters were consisted of: (1) harvesting capacity, (2) threshing capacity, (3) field capacity of harvesting, (4) field capacity of threshing, (5) yield loss of harvesting, and (6) yield loss of threshing.

Research methods referred schematic diagram of manual harvesting and power threshing methods (Figure 2), and schematic diagram of mechanical harvesting utilized rice combine harvester KUBOTA DC-60 (Figure 3).

Data analysis

Formulas that be used to analyze research data were noted on equation 1 up to equation 8 below.

$$C_H = W_{UR} / T_{EH} \quad \ldots\ldots (1)$$
$$C_{MH} = W_{HP} / T_{EH} / S_H \quad \ldots\ldots (2)$$
$$C_T = W_{UR} / T_{ET} \quad \ldots\ldots (3)$$
$$FC_H = A_{AH} / T_{EH} \quad \ldots\ldots (4)$$
$$FC_{MH} = A_{AH} / T_{EH} / S_H \quad \ldots\ldots (5)$$
$$FC_T = A_{AH} / T_{ET} \quad \ldots\ldots (6)$$
$$YL_{HP} = (P_{SHP} - P_{AHP}) / P_{SHP} \quad \ldots\ldots (7)$$
$$YL_{UR} = (P_{SUR} - P_{AUR}) / P_{SUR} \quad \ldots\ldots (8)$$

Where C_H = capacity of harvesting, ton/hour
W_{UR} = weight of actual unhusked rice, ton
T_{EH} = effective harvesting time, hour
C_{MH} = capacity of manual harvesting, ton/hour/person
W_{HP} = weight of actual harvested paddy, ton
S_H = sum of harvester, person
C_T = capacity of threshing, ton/hour
T_{ET} = effective threshing time, hour
FC_H = field capacity of harvesting, ha/hour
A_{AH} = area of actual harvesting, ha
FC_{MH} = field capacity of manual harvesting, ha/hour/person
FC_T = field capacity of threshing, ha/hour
YL_{HP} = yield loss of harvested paddy, %
P_{SHP} = productivity of sampling harvested paddy, ton/ha
P_{AHP} = productivity of actual harvested paddy, ton/ha
YL_{UR} = yield loss of unhusked rice (yield loss of threshing), %
P_{SUR} = productivity of sampling unhusked rice, ton/ha
P_{AUR} = productivity of actual unhusked rice, ton/ha

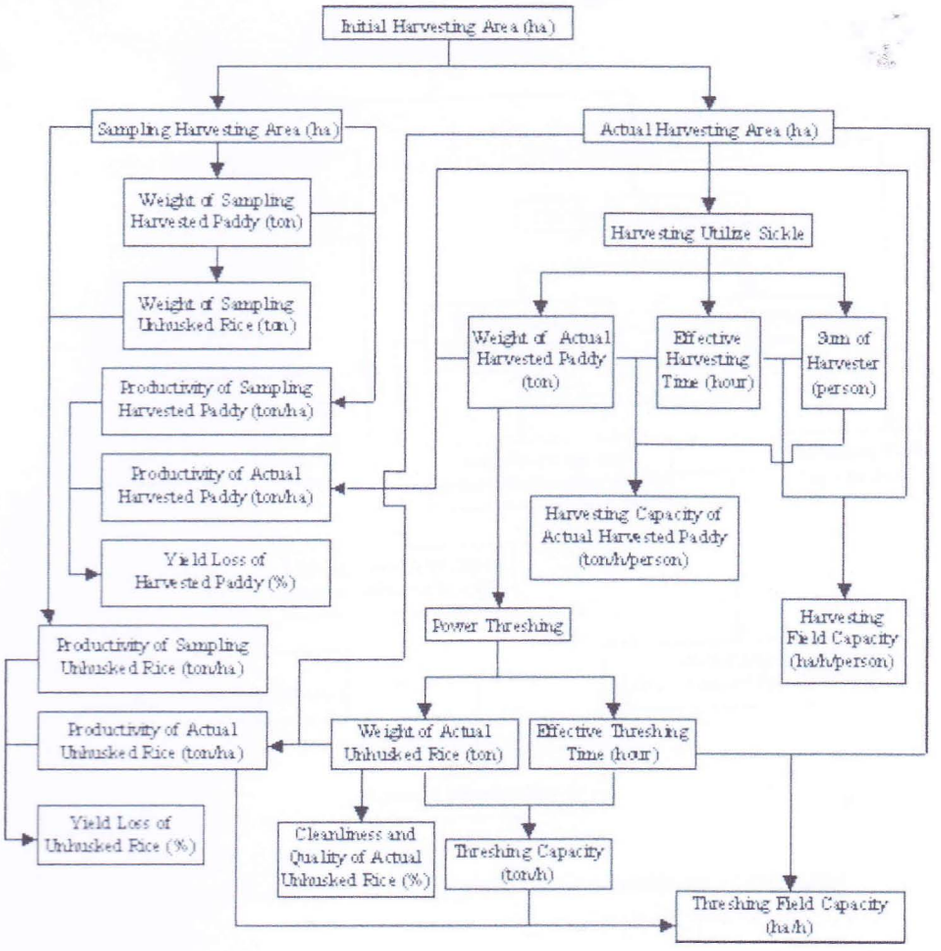

Figure 2. Schematic diagram of manual harvesting

Results and discussion

Paddy plants that be used in the research was Ciherang variety with harvest age of 125 days. This plant age was suitable for harvesting because it was in optimum age range of 116 days up to 125 days (BBPD, 2008). The plants conditions were in exempted from weeds, pests, and diseases. Measurement results of paddy wet field conditions can be shown on Table 1.

Table 1. Measurement results of paddy wet field conditions

Field	Plant height (cm)	Space between rows (cm)	Plant density (clump/m^2)	Plant amount (plant/clump)	Plant wetness %
Manual harvesting	102.6	27.7 x 26.7	11.3	17.4	17.2
Combine harvesting	104.2	34.0 x 34.0	7.3	18.5	18.4
Average	103.4	30.9 x 30.4	9.3	17.9	17.8

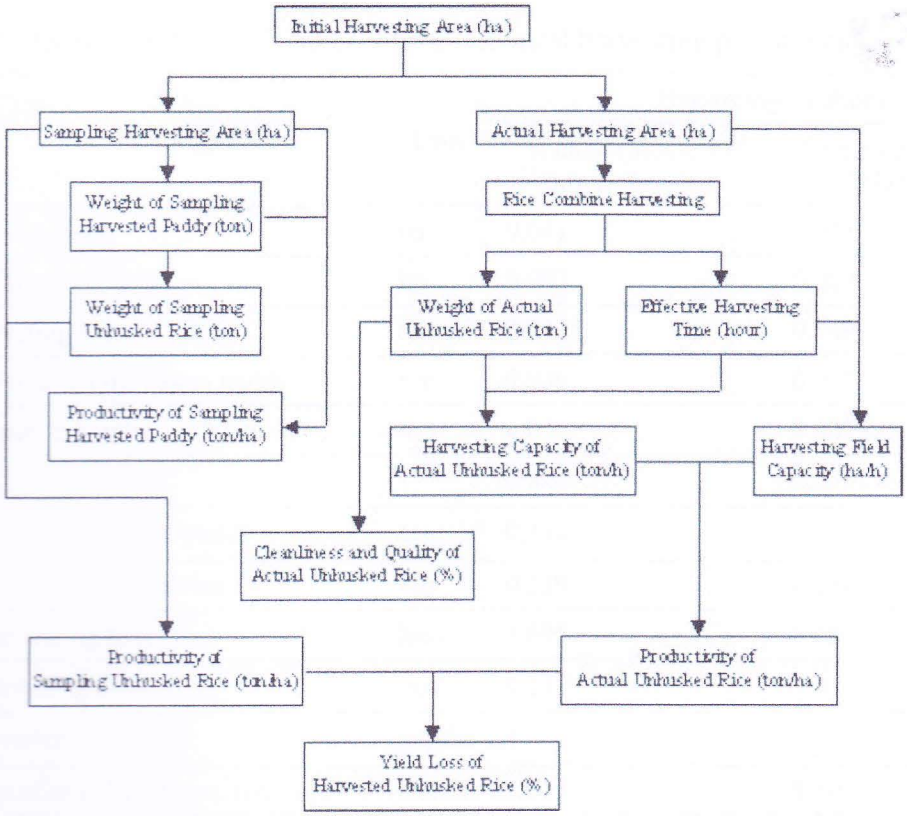

Figure 3. Schematic diagram of rice combine harvesting

Results of the research showed that performance of manual harvesting was different with mechanical harvesting performance, especially in the case of harvesting capacity and yield loss of harvesting as shown on Table 2.

Harvesting capacity utilized KUBOTA DC-60 (1.56 ton/hour) was higher than manual harvesting utilized sickle (0.19 ton/man-hour). The amount of harvesting capacity utilized one unit of KUBOTA DC-60 was equal with 8 manpower up to 9 manpower, so that the using of KUBOTA DC-60 would obtained unhusked rice of 12.48 tons, whereas the using of sickle would obtained harvested paddy of 1.52 ton/manpower.

Threshing capacity utilized a power thresher was 1.60 ton/hour. It means that in one-day would obtain 12.80 tons unhusked rice. This unhusked rice production was higher than KUBOTA DC-60, but it involved much manpower for harvesting and power threshing.

Harvesting field capacity utilized KUBOTA DC-60 was 0.49 hectare/hour that it was higher than harvesting field capacity utilized sickle of 0.006 hectare/man-hour. It can be said that one unit of KUBOTA DC-60 was equal with 81.67 (≈ 82) harvester manpower utilized sickle. In one day (8 working hour a day) KUBOTA DC-60 had ability to harvest 3.92 hectares paddy wet field area, whereas harvester manpower utilized sickle was only able to harvest 0.048 (≈ 0.05) hectare/manpower.

Harvesting and threshing field capacities utilized sickle and power thresher were 0.006 hectare/man-hour and 0.28 hectare/hour. It means that for each 1-hectare paddy wet field area was needed harvesting and threshing time of 166.67 hour/man, or 21 days/man, and 3.57 hours. In order to keep running power thresher for 3.57 hours so it would needed 46.67 manpower, or 46 manpower up to 47 manpower

Table 2. Results of manual and mechanical harvesting performances

Parameters	Unit	Harvesting Methods	
		Manual (Sickle and power thresher)	Combine harvesting (KUBOTA DC-60)
Total harvesting area	ha	0.041	0.051
Sampling harvesting area	ha	0.002	0.002
Actual harvesting area	ha	0.039	0.049
Weight of sampling harvested paddy	ton	0.030	0.017
Weight of sampling unhusked rice	ton	0.014	0.007
Grain straw ratio		0.824	0.635
Weight of actual harvested paddy	ton	0.318	
Weight of actual unhusked rice	ton	0.219	0.158
Effective harvesting time	hour	1.695	0.101
Effective threshing time	hour	0.137	
Sum of harvester manpower	person	4	
Productivity of sampling harvested paddy	ton/ha	15.17	8.50
Productivity of sampling unhusked rice	ton/ha	6.85	3.30
Productivity of actual harvested paddy	ton/ha	8.09	
Productivity of actual unhusked rice	ton/ha	5.58	3.21
Harvesting capacity	ton/h	0.19 *	1.56
Harvesting field capacity	ha/h	0.006 *	0.49
Threshing capacity	ton/h	1.60	
Threshing field capacity	ha/h	0.29	
Yield loss of harvested paddy	%	46.10	
Yield loss of unhusked rice	%	18.39	2.73
Cleanliness of actual unhusked rice	%	97.70	98.30
Quality of actual unhusked rice (head rice)	%	96.20	97.60

Note: * Per manpower

One of the problems in paddy wet field harvesting was yield loss during harvesting and threshing. Yield loss of harvesting utilized KUBOTA DC-60 was 2.73%, whereas yield loss of harvesting utilized sickle and power thresher were 46.10% and 18.39%. In other case, KUBOTA DC-60 produced cleanliness and intact unhusked rice of 98.30% and 97.60%, whereas the use of sickle and power thresher produced cleanliness and intact unhusked rice of 97.70% and 96.20%. These cases indicated that the use of KUBOTA DC-60 was more effective, more efficient, and more profit than the use of sickle and power thresher.

Conclusion

Conclusions from the results of the research were: yield losses of harvesting and threshing, capacities of harvesting and threshing, and field capacities of harvesting and threshing utilized sickle and power thresher were 46.1%, 18.39%, 0.19 ton/person.hour, 1.60 ton/hour, 0.006 ha/person.hour, and 0.28 ha/hour respectively. Yield loss of harvesting, harvesting capacity, and harvesting field capacity utilized KUBOTA DC-60 combine harvester were 2.73%, 1.56 ton/hour, and 0.49 ha/hour respectively. Yield losses utilized sickle and power thresher were higher than yield loss utilized KUBOTA DC-60, whereas harvesting capacity utilized sickle was lower than harvesting capacity utilized KUBOTA DC-60, so that paddy wet field harvesting utilized KUBOTA DC-60 was more effective, more efficient, and more benefit than harvesting utilized sickle and threshing utilized power thresher.

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