Study of harvesting losses for sustainable agricultural production in Southeast Sulawesi (a case study in Konawe district)

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Abstract. Post-harvest technologies have been produced rapidly, but not at all have been adopted by farmers. Rice harvesting techniques with a group of farmers equipped with rice threshing machines can reduce crop losses and threshing to 5.9%. Moreover, the use of a stripper type of rice harvester can reduce crop losses to between 2-3%. In this era of mechanization, there is increasing use of combine harvester at the farm level. This study aims to know the performance of harvest management with combine harvester and post-harvest rice at the farm level and to find out the amount of crop loss with combine harvester and post-harvest rice. The study was conducted in the second crop season in 2017 in Konawe District which is the center of wetland rice in Southeast Sulawesi Province. The results of the study indicated that in general the farmer groups managing the Combine Harvester were not equipped with an organizational structure (73%). The average combine harvester manager is 5-6 people consisting of operators, grain harvesters, grain collectors, and tailor sacks. Unit of agricultural equipment and machinery management (UPJA) works with launchers and harvesting equipment carriers. The ability to harvest in a day is 2 ha, with a harvest time of 3 hours per ha, with fuel consumption of 34.6 liters/ha. While the ability of harvested area in annuals is 35 ha on average. The average weight of yield loss by various planting methods is not too different which is about 0.129 - 0.136 kg. However, the highest percentage of yield loss is in the method of planting tabel (direct scattering) which is equal to 2.084%, this is influenced by the amount of yield obtained from the planting method. While the yield loss due to transportation between distances of less than 500 meters and above 500 meters does not differ much, namely an average of 0.18 kg and 0.21 kg, with an average of 0.2 percent of the average weight before transporting.

Keywords: Thresher Machine, Post-Harvest, Rice, Harvesting Losses

1. Introduction

Rice is the predominant cash crop cultivated by farmers in Southeast Sulawesi. The area of rice in Southeast Sulawesi in 2015 was 103.812 ha, which consisted of 85.701 ha of irrigated rice fields and 18.111 ha of non-irrigated rice fields. Konawe District is an area that has the highest land area in Southeast Sulawesi, which is 34.040 ha consisting of 31.858 ha of irrigated rice fields and 2.182 non-irrigated rice fields [1]. The harvested area of wetland rice in Southeast Sulawesi, in 2015 was recorded at 135,003 ha with a total production of 646.206 tons with an average productivity of 4.8 tons/ha. The contribution of rice from Konawe Regency amounted to 233.935 tons or around 36%.
Abundant rice production during the harvest season requires serious harvest and postharvest handling. Improper handling of harvest and postharvest can cause losses, especially losses or loss of both quality and physical [2,3]. This might be caused by factors: (1) the technology produced is not yet suitable both technically, economically and socially in the local culture, the conditions vary in each region, (2) a basic price incentive system for rice or rice whose quality is better, cannot enjoyed by farmers, because of the prevailing market system in the community, so that farmers ignore good methods of handling rice [4].

[5] states that the main problem in postharvest handling of rice is the high yield loss and low-quality rice and rice produced [6] This happens in the stages of harvesting, threshing, and drying. The main problem faced in postharvest handling is high losses both quantitatively and qualitatively. These problems result in a tendency not to provide incentives to farmers to improve their income level [7]. During the crop transition from farm to consumer, it has to undergo several operations such as harvesting, threshing, cleaning, drying, storage, processing, and transportation [8]. During this movement, crop is lost due to several factors such as improper handling, and inefficient processing facilities. Most of the harvesting is performed manually in the developing countries, which is a highly labor-intensive and slow process [9]. During peak harvesting season, even countries such as India and Bangladesh encounter labor shortages, which results in delays in the harvesting and subsequently large losses [10].

2. Methods
2.1. Scope
The scope of this study is to assess the loss of crop yields using combine harvester. Combine harvester sampled is a combine harvester which is widely circulated in the field. The object of harvest is paddy fields that are planted with rice in the second crop season, within the land conditions when the harvest is dry. This aims to avoid harvesting tools embedded in rice fields, and avoiding grain from falling on the ground to be maximally taken as a sample. Whereas to measure yield loss due to transportation, it is carried out by using a motorcycle that has been modified by a group of grain transport service providers. To measure yield loss due to grain infestation, it is measured based on the distance traveled from the harvest location to the highway where the grain is collected, which will later be transported by car.

2.2. Time and place
The activity is carried out from January - December 2017, in the Konawe Regency with the consideration that Konawe Regency is the largest rice-producing center in Southeast Sulawesi Province.

2.3. Method
This study uses a Single Factor design (Standard Deviation). Measurement of yield loss in harvesting using combine harvester which is widely circulated in farmers in the field. For testing, each combine harvester will harvest 3 replications. In addition, measurements of yield loss will be carried out in the post-harvest period, namely during transportation, drying losses, milling yields. The survey of prospective farmers/managers and prospective locations was conducted to see the distribution of use of combine harvester harvesting equipment at locations of rice development centers in Konawe District. The manager of the combine harvester that will be chosen is the manager who is used to operating the combine harvester.

2.4. Data analysis
The data collection included measurements of yield loss handling with combine harvester and postharvest rice in rice mills ranging from drying to grain grinding. To calculate yield loss from harvest to grinding using the following methods [11,12].
2.4.1 Loss of yield when harvesting with the combine harvester
The method of measuring loss when harvesting using a combine harvester is (a) collecting and weighing grain thrown out of a combine harvester by collecting grain in a 2m x 5m combine
harvester track, (b) collecting and weighing grain tucked into the body combine harvester, (c) weighing grain collected in sacks of crops with combine harvester. The loss when harvesting with a combine harvester is calculated based on the formula:

\[
KHCH = \frac{G_1 + G_2}{G_0 + G_1 + G_2} \times 100\%
\]

Information:
KHCH = Loss of combine harvester harvesting (%)
G1 = grain thrown outside combine (kg)
G2 = grain tucked into body combine (kg)
G0 = crop yield (kg)

2.4.2 Loss of transportation
The method of measuring transport loss is by comparing the difference in grain weight before and after transport. Shipment is carried out using grain motorcycle taxi from the harvest location to the grain collection point on the highway.

\[
KHPk = \frac{BG_1 - BG_2}{BG_1} \times 100\%
\]

Information:
KHPk = Loss on transport, (%)
BG1 = Grain weight before transport, (kg)
BG2 = grain weight after transport, (kg)

The collected data will then be tabulated and processed in the form of a simple table, then calculated according to the formula of each loss of results in various activities, using excel software. Then narrated in the form of exposure to the results of these calculations.

3. Results and discussion
3.1 Management of Combine Harvester at the Farmer Level
To accelerate harvest time acceleration improvements, the Ministry of Agriculture through the Department of Agriculture and Horticulture in Konawe District has been distributing agricultural tools and machinery aid which includes a Combine Harvester. The management is regulated by the issuance of the General Guidelines for the Management namely Brigade issued by the Ministry of Agriculture. The formation of the Brigade was aimed to optimize the utilization of tools and machinery by the Provincial or by the Regional Command Unit as well as by the farmer group.

The effort to form the Alsintan’s Brigade is a form of the Alsintan utilization which is carried out through the Ministry of Agriculture's budget. The intended use is for management. Utilization of Alsintan’s Brigade can provide examples as well as guard the use of machinery by farmer groups. With this pattern, alsintan assistance that has been carried out and distributed to farmer groups or (Machinery Management Services Unit) namely UPJA can be used optimally to encourage the acceleration of land cultivation, planting and harvesting activities simultaneously to achieve increased production of rice, corn, and soybeans.

Especially for Combine Harvester since 2016, Office of Food Crops and Horticulture and Animal Husbandry District of Konawe has distributed 15 units of Combine Harvester in 10 Subdistricts (Wonggedukdu, Umaaha, Uepai, Amonggedo, Padangguni, Konawe, Morosi, Wawotobi, Uepai, and Lambuya) While a large combine Harvester is 5 units in 5 Subdistricts (Anggaberi, Wonggeduku, Pondidaha, Uepai, and Lambuya). The management of a good and organized combine harvester at the farm level greatly determines the success of UPJA progress. Therefore the ability of
the Chairperson / Manager at the farmers’ group Level who oversees UPJA is very important. Below is the management of Combine Harvester conducted in Konawe District, 2017.

| No | Justification                     | Available | Not Available |
|----|-----------------------------------|-----------|---------------|
| 1  | Organizational Structure of UPJA  | 27 %      | 73%           |
| 2  | Combine Harvester Management      | 100 %     | 0             |
| 3  | Partnership Model                 | 100 %     | 0             |

Table 1 shows that in general the farmer groups (gapoktan) managing the Combine Harvester are not equipped with an organizational structure (73%), so that management will have a negative impact, especially in financial management in the UPJA. While Gapoktan which has completed the organizational structure of UPJA consists of Chairperson/manager, secretary, and treasurer. However, the administrators have not been able to work professionally, due to limited knowledge in financial management, as well as organizations, so training is needed in the management of the UPJA. If seen from the manager of the combine harvester in the field, all the gapoktan that obtained the combine harvester had been going well. The average combine harvester manager is 5-6 people consisting of operators, grain harvesters, grain collectors, and tailor sacks.

In carrying out its business, UPJA managers worked with launchers (people looking for harvest land), with an average salary of Rp. 4,000 / sack. In addition to working with other parties in transporting combine harvester to the harvest location at a cost of Rp. 300,000 - 500,000, - per return transportation.

3.2. Combine Harvester Performance
Combine harvester circulating in the field consists of AW 88, AW, 85, AW 70, and AW 60, however, AW 70 and AW 60 are the main type in the field in Konawe District. The performance of the Combine harvester at the farm level is presented in Table 2.

| No | Kinerja                               | Minimal | Maximal | Rata-rata |
|----|--------------------------------------|---------|---------|-----------|
| 1  | Harvesting ability in a day (ha)      | 1       | 3       | 2         |
| 2  | Harvesting ability per ha (hours)     | 2       | 4       | 3         |
| 3  | Harvesting ability in a peak season   | 20      | 50      | 35        |
|    | (ha)                                 |         |         |           |
| 4  | Fuel Consumption (liter)              | 26      | 40      | 34.6      |

Table 2. shows that when viewed from the performance of a combine harvester, the average harvesting capacity in a day is 2 ha, with a harvest time of 3 hours per ha, with fuel consumption of 34.6 liters/ha. While the ability of harvested area in annuals is 35 ha on average. Thus the combine harvester only operates for 17.5 days in harvest season.

3.3. Weight Losses due to Harvesting and Transportation
3.3.1 Harvesting Losses Using Combine Harvester
To calculate the yield loss due to the use of a combine harvester machine, 3 locations were chosen based on different planting methods, and each location was taken 3 replications with an area of 2 m x 5 meters. The Combine Harvester used is an AW 70 combine type with a 2 year usage period. The data taken is the loss of yield on the combining path of 2 m x 5 meters, that is by weighing the yields with combine, grains that fall on the ground, the grain is still snared and the grain is scattered on the machine. As detailed as the loss of yields with combine harvester in different planting methods is presented in Table 3.
Table 3. Harvesting Losses using Combine Harvester Machine in North Tongauna Sub District Konawe District 2017

| No. | Planting method               | Square meters average (kg) | Losses (Average) | Percentage of Losses Average |
|-----|-------------------------------|----------------------------|------------------|------------------------------|
| 1   | Seed Direct Planting          | 6,200                      | 0,132            | 2,084                        |
| 2   | Transplanting Method          | 6,637                      | 0,129            | 1,916                        |
| 3   | Legowo Method of 4 : 1        | 7,300                      | 0,136            | 1,824                        |

Table 3 shows that the average weight loss results with various planting methods are not very different, 0.129 - 0.136 kg. However, the highest percentage of yield loss is in the method of planting tabela (direct scattering) which is equal to 2.084%, this is influenced by the amount of yield obtained from the planting method. The greater the products produced, the smaller the percentage loss results because the yield loss due to the use of the combine harvester tends not to be significantly different (Abbas et al. 2014).

3.3.2 Weight Losses due to Transporting

Transporting grain with motorcycles to the collection location will result in loss of yield. The shock of two-wheeled vehicles, terrain conditions, and the proximity of the distance to the location of the grain harvesting greatly influence the magnitude of yield loss [13]. In addition to how to sew, the quality of the sack used and the experience of the grain ojeg itself is very influential in reducing yield loss. In calculating the yield results due to transportation, here using a sack provided by the provider of harvest services, and sewn by the manager of the combine harvester, so that the grain taxi drivers only need to transport it to the destination location. Because the measurements are carried out in the second planting season, the terrain situation is in a dry condition, then it is divided into the distant categories of nearby transportation destinations. Calculating yield loss due to shrinkage by calculating the grain weight difference before transport and after transport, in detail is presented in Table 4.

Table 4. Weight Losses due to transporting in North Tongauna Sub District, Konawe, 2017

| No | Distance from the field | Weight before transporting (Kg) | Weight after transporting (kg) | Weight Losses (kg) | Percentage |
|----|-------------------------|---------------------------------|-------------------------------|--------------------|------------|
| 1  | > 500 m                 | 106.15                          | 106.05                        | 0.10               | 0.09       |
| 2  |                         | 101.75                          | 101.60                        | 0.15               | 0.15       |
| 3  |                         | 104.45                          | 104.25                        | 0.20               | 0.19       |
| 4  |                         | 104.85                          | 104.50                        | 0.35               | 0.33       |
| 5  |                         | 104.50                          | 104.25                        | 0.25               | 0.24       |
|    | Average                 | **104.34**                      | **104.13**                    | **0.21**           | **0.20**   |
| 6  | < 500 m                 | 106.05                          | 105.70                        | 0.35               | 0.33       |
| 7  |                         | 103.40                          | 103.10                        | 0.30               | 0.29       |
| 8  |                         | 106.10                          | 105.90                        | 0.20               | 0.19       |
| 9  |                         | 107.25                          | 107.10                        | 0.15               | 0.14       |
| 10 |                         | 106.50                          | 106.45                        | 0.05               | 0.05       |
|    | Average                 | **105.81**                      | **105.64**                    | **0.18**           | **0.17**   |

Table 4 shows that yield losses due to transportation between distances of less than 500 m and above 500 meters do not differ greatly, namely an average of 0.18 kg and 0.21 kg, with an average of 0.2 percent of the average weight before transportation. If you add the loss of crop yields
with combine harvester and transportation, you get the results as in Table 5 shows that the total yield loss due to the use of combine harvester and average transportation is 2.125%.

Table 5. Weight Losses due to using Combine Harvester dan Transporting in North Tongauna Sub District Konawe, 2017

| No. | Planting Method                  | Percentage weight losses using combine harvester (%) | Percentage weight losses due to transporting (%) | Total  |
|-----|---------------------------------|------------------------------------------------------|-------------------------------------------------|--------|
| 1   | Seed Direct Planting Method     | 2.084                                                 | 0.18                                           | 2.27   |
| 2   | Transplanting Method            | 1.916                                                 | 0.18                                           | 2.10   |
| 3   | Legowo Method of 4:1            | 1.824                                                 | 0.18                                           | 2.01   |
|     | Average                         | 1.941                                                 | 0.184                                          | 2.125  |

4. Conclusion
In general, UPJA managers are not yet equipped with an organizational structure. The daily performance of the combine harvester is 2 ha, with a harvest time of 3 hours per ha, fuel consumption of 34.6 liters/ha, and harvesting capacity in an annual average of 35 ha. Harvesters using combine harvester can reduce yield loss by 1.941%. Loss of harvesting due to transportation as much as 0.184%.

Combine harvester machines is very useful to help farmers to tackle reducing farming income due to minimize grain losses and the utilization of this machine making the smallholder farming system more effectively and efficiently due to the lack of labor in the village. Moreover, increasing productivity whilst farmers cannot store excess farm output may increase post-harvest losses, reduce economic viability and profitability, and maybe unsustainability in the farming system.

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