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The potency of rice straw for ruminant feed on several rice varieties

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Abstract. Indonesia has a lot of rice varieties. However, to the authors' knowledge, studies on the potential of several rice varieties as ruminant feed have never been carried out. Therefore, this study aimed to analyze the potential of rice straws of several rice varieties for ruminant feed. The study was conducted in 2021 in South Lampung District, Lampung Province, Indonesia. Seven rice varieties (Inpari 30, Inpari 32, Inpari 33, Inpari 35, Ciherang, Bestari, and Cilamaya Muncul) were used in this study. The variables observed were vegetative and production characteristics. The vegetative characteristics observed were plant height, stump height, straw length, and the percentage of straw height and plant height. The production variables observed were the number of tillers per hill, straw weight, the ratio of straw and grain weight, and the percentage of straw length and plant height. The data obtained were analyzed using the single factor analysis of variance (ANOVA). The result showed that plant heights were significantly different among rice varieties ($P<0.01$). Inpari 35 variety has the highest plant and the widest straw length compared to others. Inpari 32, Ciherang, and Bestari, on the other hand, have the highest stump height. Inpari 33 and Inpari 35 have the widest straw length and plant height percentage. Meanwhile, Cilamaya Muncul has the highest number of tillers per hill, straw weight, the ratio of straw weight, and straw weight and plant weight percentage. It was concluded that the Cilamaya Muncul variety has the best potency for ruminant feed.

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1 Introduction

Straw is the vegetative part of a plant in the form of stems, leaves, and stalks. Decades ago, rice straw was known as waste in rice cultivation, but now, rice straw is one of the by-products of harvesting rice that can be used for many purposes. The improvement in rice cropping patterns caused by innovation and increasing the cropping index, has improved the amount of straw. In addition, the utilization time of rice land is also shorter because of the increasing cropping index, meaning the increase in the availability of rice straw. The use of combine harvester machines for harvesting has caused more rice straw to remain on rice land. The rise of rice straw for some farmers becomes a problem, especially when farmers have to speed up the planting time. For them, the easiest way to handle this problem is to burn the straws. However, burning straws harms human health because it causes air pollution [1]. It is necessary to use rice straw for other purposes than incinerate it.

Rice straw processing is determined by physical properties, thermal properties, and chemical composition [2]. Characteristics of physical properties refer to the amount of rice straw that is the basis for determining how to store it. The thermal properties are very suitable to be used as an energy source. Meanwhile, based on the chemical composition, it is appropriate to be used as animal feed and organic fertilizer.

Rice straw has been widely used by many people for mulch [3, 4]. Another way to utilize rice straws is compost. Rice straw compost is good quality because it provides an efficiency of inorganic fertilizers of about 20-80% [5] and increases soil porosity [6]. In addition, rice straws are also used as a growing medium for mushrooms [7] and as raw material for bioethanol [8, 9]. Rice straws also can be utilized as ruminants' feed. Some studies reported that the utilization of rice straw as feed could increase digestibility and feed intake [10], improve milk production in dairy cows [11] and dairy goats [12], increase feed intake and rumen ecology in buffaloes [13], and many other benefits.

Straw is the most agricultural waste in Indonesia [14]. The total straw biomass produced depends on several factors, such as variety, tillage, availability of nutrients, and weather [2]. Based on several functions of rice straw, especially for animal feed and the potential yield of the straw, this study aims to determine the potential of rice straw from several rice varieties in Lampung Province.

2 Methods

This research was conducted in Sidomulyo and Candipuro sub-districts, South Lampung District, Lampung Province, Indonesia, from October 2021 to March 2022. The rice varieties used were Inpari 30, Inpari 32, Inpari 33, Inpari 35, Ciherang, Bestari, and Cilamaya Muncul. The rice fields used in this study belonged to farmers with an average area of 0.5 ha. Each rice variety is planted by farmers on separate rice fields. The planting method of each rice variety was similar. Rice was harvested at 108-120 days after planting (DAP).

Vegetative characteristics observed were plant height (cm), stump height (cm), straw length (cm), and the percentage of straw length and plant height (%). Three replicates/plots consisting of 20 plants were observed from each parameter. Plant height was measured from the root neck to the highest leaf tip of the plant [15], while stump height was measured by measuring the height of the remaining stalks after being cut directly at the observation field [16]. Plant height and stump height were measured using a meter. Straw length is the difference between plant height and stump height. Straw length and plant height percentage were obtained by multiplying the ratio of straw length and plant height by 100%.

Production variables observed were the number of tillers per hill, straw weight (ton/ha), the ratio of straw weight and grain weight, and the percentage of straw weight and plant weight (%). The number of productive tillers was collected by counting the rice tillers that produced grains [16]. Straw weight was obtained by weighing the straw collected on the plots and then converted to hectares. Straws were weighed using digital hanging scales with a capacity of 40 kg. The ratio of straw weight and grain weight per plot was calculated by dividing the straw weight by the grain weight. Straw weight and plant weight percentage per plot were calculated by multiplying the ratio of straw weight and plant weight by 100%.

The data collected were analyzed statistically using the single factor ANOVA. When the F-test for the treatment was significant (P<0.01), treatments were compared using the Duncan Multiple Range Test with a significance value of 1%.

3 Results and discussion

3.1 Vegetative characteristics

The variables of vegetative characteristics, such as plant height, stump height, straw length, and the percentage of straw height and plant height, are shown in Table 1.

Plant height is one of the crucial agronomic properties that influence the preference of farmers to adopt rice varieties. The results of the ANOVA showed that rice variety had a very significant effect (P<0.01) on plant height. The tallest rice variety is Inpari 35, while the lowest is Inpari 32. Different plant varieties will have different genotypes. According to [17], the genetic factors possessed by each genotype will determine the difference in plant height between one genotype and another. The interaction between genetic factors and the cropping system will show maximum growth and production characteristics [18].

The results showed that the rice varieties with plant heights less than and equal to 125 cm were the Inpari 30, Inpari 32, Inpari 33, Ciherang, and Bestari varieties. According to [19], those varieties are categorized as medium because they have a plant height of 90-125 cm. While other varieties, Inpari 35 and Cilamaya Muncul, have plant heights above 125 cm. Most rice plant breeders targeted the medium category plant height [20]. Taller plants are not a goal in the plant breeding selection process [21] because taller plants signify easy to fall [22] and produce a lot of empty grain [23].

Table 1. Vegetative characteristics of several rice varieties.

Variety	Plant height (cm)	Stump height (cm)	Straw length (cm)	Percentage of straw length and plant height
Inpari 30	115.43 ± 3.63^{D}	20.03 ± 4.02^{B}	95.40 ± 4.40^{C}	82.67 ± 3.35^{B}
Inpari 32	108.30 ± 2.79^{F}	33.43 ± 1.99^{A}	74.87 ± 3.54^{E}	69.11 ± 2.08^{D}
Inpari 33	112.82 ± 10.83^{DE}	14.88 ± 3.69^{C}	97.93 ± 9.03^{C}	86.89 ± 2.75^{A}
Inpari 35	134.88 ± 6.43^{A}	18.23 ± 2.73^{B}	116.65 ± 8.02^{A}	86.41 ± 2.35^{A}
Ciherang	110.30 ± 4.28^{EF}	34.33 ± 1.90^{A}	75.97 ± 4.08^{E}	68.85 ± 1.74^{D}
Bestari	121.53 ± 3.66^{C}	34.60 ± 3.07^{A}	86.93 ± 4.07^{D}	71.53 ± 2.47^{C}
Cilamaya	126.77 ± 7.20^{B}	19.97 ± 3.29^{B}	106.80 ± 7.91^{B}	84.20 ± 2.77^{B}

Note: Different letters in the superscript in the same column indicate that values are significantly different by the Duncan's test (P < 0.01).

In this study, the rice varieties with the highest stump height (P<0.01) were Inpari 32, Ciherang, and Bestari, while the lowest was Inpari 33. The highest stump height in this study was in the range of the stump height of Van et al. [24], viz. 31.7-39.9 cm. The difference in stump heights was due to the difference in the cutting made by farmers. It is based on their habits in harvesting and cultivation. Stump height will be higher when using a combine harvester machine than when harvesting with a sickle, followed by a thresher. Stump height will affect the amount of straw produced [2]. In the ratoon system, stump height affects the flowering and harvesting age [25]. The higher the stump cutting, the faster the flowering and harvesting will be. In the ratoon rice cultivation system, the height of the stump cut is affected by knowledge and farmers' skills [16].

The Inpari 35 variety had the highest straw length (P<0.01), while the Inpari 32 and Ciherang varieties had the lowest length. Straw length is highly dependent on plant height and stump height. Rice plants that have high plant height and low stump height will produce long straw lengths and vice versa. Straw length in all varieties of this study is descriptively longer than the results of the study of Suretno [26], which reported straw lengths ranging from 61.20 to 69.87 cm.

The results of the ANOVA on the percentage of straw length and plant height showed that Inpari 33 and Inpari 35 varieties had the highest percentage (P<0.01). Meanwhile, the lowest was in Inpari 32 and Ciherang varieties. The percentage of straw length and plant height is in the range of 68.85 to 86.89%. It means only 13.11 to 31.15% of the straws remained on land and will be returned to the land during soil processing.

3.2 Production variables

The production variables observed were the number of tillers per hill, straw weight (ton/ha), straw weight (ton/ha), and the ratio of straw weight and plant weight (%). The data are shown in Table 2.

The results of the ANOVA showed that the variety had a highly significant effect (P<0.01) on the number of tillers per hill. The highest number of tillers in this study was the Cilamaya variety. The same result was reported by Slameto [27] that the Cilamaya Muncul variety has the highest number of tillers (30 tillers) among other rice varieties. The number of tillers per hill will determine the number of panicles, which is a fundamental component in rice production. The greater the number of tillers per hill indicates the greater the chance to form productive tillers or tillers that produce panicles [28]. Rice production is mostly controlled by three factors, namely, the number of panicles per plant, the number of grains per panicle, and the weight of one thousand grains [29].

Table 2. The production variables of several rice varieties.

Variety	Number of tillers hill	Straw weight (ton/ha)	The ratio of straw weight and grain weight	Percentage of straw weight and plant weight
Inpari 30	23.07 ± 5.25^{BC}	$18{,}361.38 \pm 4{,}210.04^{AB}$	2.63 ± 0.79^{AB}	70.95 ± 6.25^{A}
Inpari 32	21.70 ± 3.60^{C}	$9{,}064.53 \pm 1{,}954.52^{B}$	1.25 ± 0.14^{B}	56.28 ± 2.47^{C}
Inpari 33	26.87 ± 6.78^{AB}	$21{,}440.00 \pm 2{,}042.74^{AB}$	2.55 ± 0.28^{AB}	71.97 ± 0.83^{A}
Inpari 35	27.30 ± 7.28^{AB}	$19{,}423.59 \pm 661.43^{AB}$	2.61 ± 0.25^{AB}	71.92 ± 2.37^{A}
Ciherang	21.30 ± 4.69^{C}	$10{,}852.27 \pm 1{,}065.92^{B}$	1.59 ± 0.15^{AB}	58.08 ± 2.10^{BC}
Bestari	22.83 ± 4.07^{BC}	$15.956.10 \pm 3{,}754.28^{AB}$	2.23 ± 0.38^{AB}	67.76 ± 3.35^{AB}
Cilamaya	28.93 ± 4.70^{A}	$24{,}625.85 \pm 6{,}159.18^{A}$	3.52 ± 0.99^{A}	77.18 ± 5.42^{A}

Note: Different letters in the superscript in the same column indicate that values are significantly different by the Duncan's test ($P < 0.01$).

Cilamaya Muncul has the highest straw weight per hectare ($P<0.01$), while the lowest was the Inpari 32 and Ciherang varieties (Table 2). Straw weight was affected by the length of the cut. The longer the cutting length, the higher the straw weight will be. Several studies reported different rice straw production per hectare, such as 7.5 to 8 tons/ha [2], 12-15 tons/ha [30], 11.0 tons/ha [31], 18.58 tons/ha [32] and 22.0 tons/ha [33]. Several factors must be considered to obtain high straw production, such as the proper cropping pattern, reducing the number of straws left in the field, low cutting height, and choosing the appropriate variety [34].

The results of the ANOVA showed that the Cilamaya Muncul variety had the highest value of the ratio of straw weight and grain weight ($P<0.01$). The straw and grain weight ratio ranged from 1.25 to 3.52. These results are in the range of Zafar [35] study, which was 1.0 to 4.3. However, it is higher than other results, which were 0.7-1.5 [34].

The rice varieties with the highest percentage of straw and plant weight ($P<0.01$) are Inpari 30, Inpari 33, Inpari 35, and Cilamaya Muncul, while the lowest is the Inpari 32 variety (Table 2). The difference in yield depends on the method used at harvest. Logeswaran et al. [36] stated that variations in rice straw production occurred due to harvesting methods. The results of the percentage of straw weight and plant weight in this study ranged from 56.28-77.18%. This result is higher than the range of the [36] study, which reported 40-60%.

4 Conclusion

The Cilamaya Muncul variety is the most potential rice variety because it produces higher straw for ruminant feed sources, especially the number of tillers per hill and the weight of straw, than other varieties.

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