Weed growth and sweet corn yield as affected by planting patterns and mulch types in organic farming practice

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Abstract. Weed is the main problem in organic agriculture. Intercropping is an agricultural practice to control weeds. The study intended to compare weed growth and sweet corn yield in intercropping and monoculture patterns with different mulch types and to determine the best planting pattern and mulch type for crop growth and yield. A field experiment was conducted at the CAPS Research Station situated in Air Duku Village, Rejang Lebong, Bengkulu, at 1054 m above sea level. The experiment used Completely Randomized Block Design (RCBD) with two factors. There were no interactions between planting patterns and organic mulch types on weed growth and sweet corn yield. Intercropping sweet corn-kidney bean and sweet corn-string bean suppressed the growth of weeds. Also, intercropping of sweet corn-kidney bean or sweet corn-string bean had similar sweet corn yield with monoculture. Rice straw and rice husk mulch suppressed weeds growth better than coffee husk mulch.

1. Introduction
Organic agriculture is a farming system to maintain soil health, ecosystem, and human. It is highly dependent on the ecological process, biodiversity, and cycles adaptable to local conditions instead of adverse external input [1]. Organic farming’s primary purpose is to provide healthy and safe agricultural products both for producers and consumers and environmentally friendly crop cultivation. More international communities desire a healthy lifestyle by consuming guaranteed safe, high nutritional content, and environmentally friendly agricultural products. Improved economic development and consumer preferences have led to increased demand for organic farm products worldwide [2].

However, the cultivation of organic agriculture faces several obstacles, including weed problems. The presence of weeds in organic agricultural cultivation leads to a decrease in plant growth and yield. Weed control in organic farming done without using herbicides. Some weed control methods in an organic farming system include using cover crops, biological control, bioherbicides, mechanical, non-living mulch, thermal, soil solarisation, and cultural weed control.

One of cultural weed control practices is by combining crops intercropping and the use of organic mulch. As reported by [3], cultural weed control, i.e., intercropping and using mulch, suppressed weed growth. A farming method that involves more than one crop at the growing season on the same land is called intercropping. It means that the cultivation simultaneously has more than one crop at the same space [4]. Intercropping optimizes land-use efficiency compared to monoculture [5].
Improvements in land-use efficiency and suppression of weed growth rates in intercropping systems with different spacing resulted in additional crop yield [6]. Intercropping corn with legume crop influenced plant height, the number of leaves, and corn cobs' fresh weight. The corn population per plot in the intercropping system also affects cobs fresh weight, cob dry weight, and corn yields per plot [7]. In addition to cropping patterns, mulch use may also suppress weed growth and affect plant growth and yield. There are two types of mulch, namely plastic mulch and organic mulch.

Organic mulch inhibits weeds growth due to decreasing the intensity of direct sunlight reaching the soil surface. Mulch maintains optimal soil temperature to develop roots and beneficial microorganisms to increase in the soil [8][9]. A field experiment conducted by [10] showed that organic mulch affected the growth of three sweet corn varieties tested but did not affect the yield. Rice straw mulch application reduced weed dry weight compared to that of with no mulch in corn cultivation.

Several other research results showed that the dosage and type of organic mulch affected the effectiveness of weed control and soybean crop yields [11]. Five centimeters thickness of rice husks and rice straw mulch suppressed weeds' growth as indicated by the lower dry weight of weeds, 17.80 g, and 24.00 g, respectively, compared to that without mulch (93.83 g) [12]. Cornstalk mulching, paddy straw, and Crotalaria juncea can improve red pepper yield compared to control [13]. The experiment of [14] indicated that the application of rice straw and plant residues mulches did not affect the yield of hot pepper but increased the fruit number. Using red bean and ground peanut as cover crops could increase hot pepper yield.

This research aimed to determine the best cropping pattern and type of organic mulch for weed growth and the growth and yield of sweet corn in the organic farming system.

2. Materials and methods

2.1. Time and location
This experiment was conducted in the Closed Agriculture Production System Field Laboratory of UNIB, in Air Duku Village, Selupu Rejang District, Rejang Lebong Regency, at an altitude of ± 1054 m above sea level from September 2018 to December 2018 in organic dry land for organic vegetable cultivation since 2009.

2.2. Research design
This experiment used a randomized complete block design (RCBD), two factors and replicated three times. The first factor was the cropping pattern, which was consists of 3 levels of treatment, namely M1 = Monoculture sweet corn, M2 = Intercropping sweet corn + string bean, and M3 = Intercropping sweet corn + kidney bean. The second factor was the type of organic mulch with four treatment levels: P1 = rice straw, P2 = rice husk, P3 = coffee husk, and P4 = control / without mulch. Each treatment combination was repeated three times.

2.3. Fieldworks
Before planting, the soil was plowed twice. Furthermore, the land was divided into three blocks with a distance between blocks of 1 m. The experimental plot size for each block was 3cm x 3cm. The distance between the plots in the blocks was 50 cm. The application of vermicompost at a dose of 30 tonnes/ha was carried out at the plotting time.

Sweet corn, string bean, and kidney bean were planted at a depth of approximately 2 cm - 3cm. Sweet corn plant spacing was 25 cm x 75 cm, while string bean and kidney bean were planted between sweet corn rows with a 25 cm x 37.5 cm plant spacing. An organic mulch of rice straw, rice husk, and coffee husk were applied two weeks after planting, approximately 5 cm thickness. Insect and disease control was carried out using plant-based pesticides of weeds goatweed (Ageratum conyzoides L.) Corn harvest was carried out at 95 days after planting. Samples of five plants were taken randomly from each experimental plot.
2.4. Variables observed
Corn growth and yield, as well as weeds growth, were evaluated. Sweet corn variables observed were plant height (cm), shoot dry weight (g), husk corn weight per plant (g), cob weight per plant (g), husk corn weight per plot, and total dry weight of weeds (g).

2.5. Statistical analysis
Data were analyzed statistically using analysis of variance with an α level of 5%. Significantly data was further tested using the LSD test.

3. Results and discussion
Table 1 showed no interaction between cropping patterns and types of mulch in all variables observed. Weeds' total dry weight was significantly affected by the cropping pattern, and total weeds dry weight and corn shoot dry weight was significantly affected by organic mulch treatment as well.

Table 1. F-value (5%) of the effect of cropping patterns and types of organic mulch on weed growth and growth and yield of sweet corn.

| Variables                              | Cropping patterns | Organic mulch | Interaction | CV% |
|----------------------------------------|-------------------|---------------|-------------|-----|
| Total weed dry weight                  | 7.95 **           | 7.66 **       | 1.01 ns     | 2.90|
| Plant height                           | 1.14 ns           | 0.37 ns       | 0.28 ns     | 5.81|
| Shoot dry weight                       | 0.70 ns           | 4.11 *        | 0.62 ns     | 22.96|
| Husk corn weight per plant             | 0.21 ns           | 0.16 ns       | 1.80 ns     | 18.05|
| Cob weight per plant                   | 0.13 ns           | 1.12 ns       | 3.12 ns     | 14.84|
| Husk corn weight per plot              | 0.004 ns          | 0.22 ns       | 2.17 ns     | 15.61|

Note: *: significantly different, **: highly significantly different, ns: non-significantly different; CV = Coefficient of Variation

3.1. Effect of planting patterns and organic mulch on weed growth

Table 2. Effect of cropping patterns on total weeds dry weight

| Cropping patterns                          | Total weed dry weight (g/0.5 m²) |
|--------------------------------------------|----------------------------------|
| Corn monoculture                          | 225.91 a                         |
| Intercropping sweet corn + string bean     | 162.97 b                         |
| Intercropping sweet corn + kidney bean     | 123.03 b                         |

Note: numbers followed by different letters in the same column were significantly different at the 5% level.

Table 2 showed total weed dry weight in the monoculture cropping pattern was higher (225.91 g) than that of the intercropping of sweet corn + string bean and sweet corn + kidney bean. Thus, string bean or kidney bean as intercrops in sweet corn plants suppressed weed growth space and resulted in weed growth inhibition. Also, weeds lack direct sunlight as taller plants shaded them. As a result, weed growth in the intercropping was slower as compared to that of monoculture. This result was in line with [15] research report that the intercropping system resulted in lower weeds dry weight than that of the monoculture cropping system. Besides the cropping pattern, the mulch type also affected the weeds dry weight in organic farming systems.

Rice straw mulch suppressed weed growth better than that of rice husk or coffee husk mulch. The total weed dry weight of rice straw mulch treatment was smaller than the other treatments (Table 3).
Table 3. Effect of mulch type on total weed dry weight on sweet corn plants

| Mulch treatments     | Total weed dry weight (g/0.5 m²) |
|----------------------|----------------------------------|
| Rice straw           | 161.48 a                         |
| Rice husk            | 190.66 b                         |
| Coffee husk          | 197.05 b                         |
| Control (no mulch)   | 226.79 b                         |

Note: numbers followed by different letters in the same column were significantly different at the 5% level

Thus, rice straw mulch was more effective in covering crop plots’ soil surface than rice husk or coffee husk mulch. This due to straw mulch decomposition was slower than that of rice husks and coffee husks. Therefore, rice straw mulch covered the soil surface for a longer time than the other two. The experiment of [16] also showed that the application of rice straw mulch had a significant effect on the dry weight of weeds. Although not significantly different, the mulch of rice husk and coffee husk produced a lower average weeds dry weight than the control treatment. Rice husk mulch treatment resulted in lower weed dry weight than coffee husk mulch (Table 3).

Besides reducing the growth rate of weeds, rice husk mulch also affects soil physical, soil chemical, and soil biological properties. The rice husk mulch function was reducing soil crust, increasing soil infiltration, soil moisture, soil aeration, soil temperature, microbial activity, and root penetration [17]. Rice husk mulch could also increase the water content in the soil [18]. On the other hand, the coffee husk mulch used in this studied had already decomposed, resulted in less effective in suppressing the growth rate of weeds. The decomposed coffee husks then become compost, which contributed to increased nutrients in the soil. Increasing nutrient content in the soil has a positive effect on the growth rate of weeds. Therefore, rice straw, rice husks, and coffee husk mulch effectively controlled weed in organic farming practices.

Similar results were reported by [19]; cultural weed control techniques using organic mulch effectively suppressed weed growth. Also, organic mulch may inhibit weeds in obtaining the growth factors needed for their growth and development [20]. Besides, organic mulch also inhibits further weed growth [21][22].

3.2. Effect of planting patterns and organic mulch on the growth and yield of sweet corn

The cropping pattern treatment had no significant effect on the growth and yield of sweet corn (Table 1). Table 4 showed the influence of cropping patterns on plant height, shoot dry weight, husk corn weight per plant, cob weight per plant, and husk corn weight per plot of sweet corn.

Table 4. Effect of cropping patterns on the growth and yield of sweet corn

| Cropping Patterns | PH (cm) | SDW (g) | CHWT (g) | CWT (g) | CHWP (kg) |
|-------------------|---------|---------|----------|---------|-----------|
| Monoculture corn  | 214.36  | 149.68  | 364.65   | 285.53  | 7.50      |
| Intercropping corn+ | 213.71  | 148.86  | 333.85   | 268.90  | 6.90      |
| string bean       |         |         |          |         |           |
| Intercropping corn+ | 219.88  | 138.36  | 377.13   | 291.95  | 7.53      |
| kidney bean       |         |         |          |         |           |

Ket: PH = plant height, SDW = shoot dry weight, CHWT = husk corn weight per plant, CWT = cob weight per plant, CHWP = husk corn weight per plot

Monoculture and cropping patterns showed similar results on the growth and yield of sweet corn (Table 4). Therefore, the sweet corn plant is appropriate for intercropping with either string bean and kidney bean. This result was due to the sweet corn plant is easily adapt to the existing environment. A previous study by [23] reported crops may grow well, both in intercropping and monoculture systems. As [24] reported, intercropping of maize with legumes had a positive effect on maize production.
Legumes contributed to providing nutrients, especially N, in the soil for plants. Sweet corn also grows well while intercropped with string bean or kidney bean. The result was due to the corn plant is a C4 plant. C4 plants are more adaptive in hot and dry areas than C3 plants. Besides, the CO$_2$ bound by PEP (CO$_2$ binding enzyme in C4 plants) does not bind O$_2$, so there is no competition between CO$_2$ and O$_2$ in C4 plants [25].

Type of mulch has no effect on the growth and yield of sweet corn except for shoot dry weight (Table 5).

**Table 5. Effects of organic mulch on the growth and yield of sweet corn**

| Mulch treatments   | PH (cm)   | SDW (g)  | CHWT (g) | CWT (g)  | CHWP (kg) |
|--------------------|----------|----------|----------|----------|-----------|
| Rice straw         | 217.00   | 172.09 a | 387.46   | 305.61   | 7.64      |
| Rice husk          | 216.45   | 161.84 ab| 365.90   | 280.98   | 7.21      |
| Coffee husk        | 218.25   | 138.61 b | 365.76   | 285.36   | 7.68      |
| Control (no mulch) | 210.62   | 117.05 c | 364.43   | 260.26   | 6.86      |

Note: PH = plant height, SDW = shoot dry weight, CHWT = husk corn weight per plant, CWT = cob weight per plant, CHWP = husk corn weight per plot

These results indicated that sweet corn plants adapted well to various growing environments either in rice straw, rice husk, and coffee husk mulch. Although not significantly different, generally, the average growth and yield of sweet corn increased in the presence of organic mulch. Plant height, shoot dry weight, husk corn weight, cob weight, and husk corn weight per plot in the control treatment was 210.62 cm, 117.05 g, 364.43 g, 260.26 g, and 6.86 kg, respectively. Table 5 showed the growth and yield of sweet corn in all mulch treatments were above the average of control plants. These results indicate that mulch retained soil moisture and suppressed weed growth, as shown in Table 3. Inhibition of weed growth may lower competition between weeds and cultivated plants. Less competition of weeds and crops resulted in better plant growth and higher yield. As [26] reported, the use of organic mulch has a positive effect on soil environmental conditions for soil microorganisms, increased soil water content, and better roots development. Also, decomposed and mineralized organic mulch provides additional nutrients to the soil.

Organic mulch rice straw yielded a higher sweet corn shoot dry weight than coffee husk mulch and control treatment (with no-mulch). Rice straw is an organic material with high lignin content making it difficult to decompose. This experiment showed that straw mulch was more effective in suppressing the growth rate of weeds (Table 3). Rice straw mulch increased crop yields compared to control treatment [27], and the slow decomposition of rice straw mulch may protect soil surface for a longer time [28].

### 4. Conclusion

The intercropping pattern suppressed weed growth in organic farming systems. Weeds dry weight in the intercropping of sweet corn with string bean and kidney bean were lower than those in sweet corn monocultures. Rice straw mulch was effective in controlling weeds on organically cultivated sweet corn plants. Sweet corn intercropped with string bean and kidney bean resulted in similar growth and yield compared to monoculture. There was no interaction between intercropping and organic mulch cropping patterns on the weed growth and sweet corn yield.

Further research is necessary to evaluate integrated weed control in intercropping sweet corn with beans in highlands organic farming systems.

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