Agronomical and financial feasibility of sweet corn intercropped under the coconut-based farming system in North Sulawesi

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Abstract. Research has been conducted in Pandu Experimental Garden, North Sulawesi. The research aimed to study the feasibility of sweet corn intercropping into a coconut-based farming system. The materials and methods used in this study were Khina-1 hybrid coconut monoculture plantations, planted in 1986 under RCBD design. The treatment used is: 6 treatments were: A: spacing 70 cm x 20 cm, under coconut; B: Spacing 70cm x 20 cm, under coconut; C: Spacing 70cm x 25cm, under coconut; D: Spacing 70cm x 30cm, under coconut; E: Spacing 70cm x 35cm, under coconut; and F: Spacing 70cm x 40cm unshaded. The Least Significant Difference Test (LSD) was then applied for mean separations. Significates were established at the 0.05 probability level. Financial analysis used RC Ratio, BEP, and sensitivity analysis. Financial analysis used an RC Ratio of 2.17, BEP Production determined 60,800 cobs/ha/3 seasons while BEB in price is IDR460.61/cob and sensitivity analysis. The best production in this research is treatment F, spacing 70cm x 20cm, unshaded, but for commercial purposes, it is recommended for treatment C, spacing 70cm x 30 cm to be implemented in the intercropping of the sweet corn within coconut plantation due to its financial analysis results.

1 Introduction

Sweet corn (*Zea mays* L. var. *saccharata* or var. rugosa Sturt) is one type of corn that is morphologically not different from corn for food or feed because it is a development of flint type and dent type, whereas the difference is only in higher sugar content when the grain stadia are immature/milk stage [1]. Corn belongs to the C4 plants [2]. Maize plants need light to carry out photosynthesis, but there is a maximum limit to the ideal light use which is about 2000 µmol.m-2·s-1 [3].

In North Sulawesi, sweet corn is one of the complementary foods and is always consumed daily by most families. A traditional menu called "tincture" is the major use of sweet corn. Tinutuan is porridge mixed with various vegetables, such as sweet corn, pumpkin, spinach,

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Abelmoschus, and Ipomea aquatica. Unless the other vegetables, sweet corn is needed, while others could be removed or replaced. Sweet corn also can be roasted, and it is popular with the youth. The nutrient content (K, Mg, P, Fe, and Zn) of sweet corn is higher than wheat and rice [4].

On the other hand, in suburban areas is difficult to find appropriate land areas to cultivate sweet corn. Therefore, farmers usually cultivate it in marginal areas, in the yards of houses, under fruit trees, and mostly under coconut. Although it belongs to C4 and requires lighter CO than the C3 plants sweet corn is still cultivated by farmers in this area under taller trees, especially coconut. It is important to evaluate the possibilities of any pattern that exists in local farming. The feasibility of the farming system and the tolerance limits of coconut shade are important points to be determined.

Coconut plantations are valuable to land that can be used for various purposes, such as implementing an intercropping system. However, in Indonesia, most coconut-growing land is cultivated using either monoculture or ad hoc mix cropping techniques. These methods result in low productivity, affecting farmer income and welfare.

The farmer's revenue is quite poor because they only have an average of 1 hectare and copra produces 1.1 t ha-1 annually. For instance, the price of copra in North Sulawesi, Indonesia's coconut production hub was an average of IDR 5,500,000 t-1 in 2019 USD 1= IDR 13,200), which means the farmer's revenue is only IDR 6,050,000. The farmer is considered poor or to be living below the poverty line if they only have one job and make less than US$ 1.9 per day [5]. Many farmers sell their properties or put them to other uses as a result of these issues. Rationally speaking, monoculture coconut plantations cannot ensure successful farming [6].

The majority of the coconut land in Indonesia (97%) is monoculturally farmed [7]. Monoculture management techniques are not lucrative even though they are used in high densities. On the other hand, it is thought that there is potential to maximize such an intercropping purpose with the monoculture coconut. For instance, a monoculture of coconuts only yields 100 nuts annually, or 17,1 tons/ha or 6,1% of the potential production of biomass [8]. In contrast to the canopy's covering, the transmission of light through the canopy changes with plant age. [9].

Additionally, it has been noted that the largest coconut canopy coverage was 8 to 30 years ago; currently, in a triangle pattern with a normal spacing of 9 m by 9 m, only 60% of the canopy is covered, and after 30 years, that number could drop to 20% [10]. According to another study carried out in Indonesia, only 12.57 to 25.14 percent of the effective land was utilized when estimating plant densities of 100 to 200 plants per hectare [11]. The remaining effective land was therefore between 87.43 and 74.86%. Additionally, according to a report from 2010 [10], only 30-130 cm of coconut root could be found. As a result, only a 2 m radius can utilize land to its maximum potential [9].

In a study conducted by [11], it was found that about 75% of the land planted with coconuts was not used by coconut plants. Therefore, planting interstitial crops among coconut plants can improve the effectiveness of agricultural land utilization and farm productivity. In addition, planting interstitial crops can also increase farming and farmers' incomes, as explained [10]. Utilizing land between coconut plants by planting interstitial crops is the right choice to increase benefits for farmers. By planting interstitial crops, farmers can obtain several benefits, such as increasing land productivity and farmer income, efficient use of labor, and efficiency of land resources.

2 Materials and Methods

The study was conducted from March to June 2018 using coconut-based plants in 1986 32 years) in the Pandu Experimental Garden, North Sulawesi. The coconut variety used was

Khina-1, a hybrid created by crossing the local Indonesian variety Tenga Tall and Nias Dwarf. Bonanza F1 sweet corn variety with 70 days maturity was used in the experiment.

2.1 Agronomical Feasibilities

The study was laid out in three equal blocks, equally spaced by 25m2 (5m x 5m). There were six treatments replicated three times, then it was allocated using the Randomized Complete Block Design's randomization process (RCBD). The treatments were: A: spacing 70 cm x 20 cm under coconut; B: Spacing 70 cm x 25 cm, under coconut; C: Spacing 70 cm x 30 cm, under coconut; D: Spacing 70 cm x 35 cm, under coconuts, E: Spacing 70 cm x 40 cm, under coconut; and F: Spacing 70 cm x 20 cm, unshaded. Moreover, the Duncan Multiple Range test was used to compare means and an analysis of variance was used to test for statistical differences. Using letter designations, statistics demonstrate considerable differences. Significant variances between data points with different letters can be seen ($P < 0.05$).

Direct planting of corn was conducted into a 7 cm hole depth, 2 seeds. hole 1. Then, the hole was covered by 30 g of manure equal to about 1,500 kg. ha-1 The plants were fertilized after 7 days (*the day after planting*), at a dose suggested by [13]:160-80-60 kg N-P2O5-K2O.ha-1, except N, applied 3 times, at 7, 28, and 42 daps respectively. The yield harvested was about 20 days after pollination, in the "milk stage," when the kernels have a high moisture content (>70%) [14].

The parameters tested were: (1) plant height at early generative stage; (2) stem gird just before harvesting, measurement of stem gird is easier method to measure stem diameter (by using mathematical equation); (3) cob height was measured from the ground to the base of the cob, (4) cob gird, cob weight, peeled cob weight, number of the row of seed, number of seeds in row and weight of 100 seeds just after harvesting.

2.2 Economic Parameters

Economic parameters are (1) the number of cobs harvested, (2) the cobs' pricing at collector traders, and (3) the daily market rates for farmers and traditional markets (data series from 2016 to 2019).

2.3 Financial Analysis

2.3.1 Cost Analysis

Cost analysis includes all farm costs, including fixed and variable costs. Fixed costs are start-up costs such as land rent, debt interest, equipment, and building taxes. In addition, variable costs are the total costs required in the production process. Variable costs can be changed due to the changeable nature of their output in the production process [6]. In this study, materials used once in the production process, worker payments, and marketing were calculated as variable costs. Total costs can be calculated by combining fixed and variable costs, which can be calculated using the following formula [7].

$$TC = TFC + TVC \tag{1}$$

2.3.2 Farming system revenue

Production value acquired in an agribusiness is the source of farming system revenue. The following formula could increase overall revenue:

$$TR = P \times TP \quad (2)$$

2.3.3 Farming system incomes

Farming system income was calculated based on the cost and revenue counted, as follows:

$$\pi = TR - TC \quad (3)$$

2.3.4 Return Cost Ratio Analysis (RC Ratio)

Cost ratios were calculated with the following formula suggested by [13]: Gross return = Monetary value of crop produced Net return = Gross return – Cost of cultivation

The net returns and B/C ratio were calculated as follows: B/C ratio = Net return ($^{ha^{-1}}$) x 100 cost of cultivation (ha $^{-1}$)

The revenue/cost ratio is known as the R/C ratio, and the formula is as follows:

$$RC\ ratio = TR/TC \quad (4)$$

As stated by [8], commodity agribusiness can only be carried out if the net income is at least 20% of the total cost. Therefore, the feasibility category is calculated by RC ratio analysis as follows notifications:

1. R/C ratio > 1.2: indicates that agribusiness is generating decent and efficient profits.
2. R/C ratio < 1.2: indicates that agribusiness is neither efficient nor profitable, but profits are not worth it.
3. R/C ratio < 1: indicates that agribusiness is not viable.
4. R/C ratio = 1: indicates that agribusiness gets a break-event point.

2.3.5 Break Event Point

Two factors: (a) break-event in output and (b) break-even in price, were examined to determine the even Point. The study is intended to establish the production or product price tolerance at which the company can remain profitable. The break-event points are determined as follows: [10]:

$$BEP\ Production = Cp/Pc \quad (5)$$

$$BEP\ price = Cp/Pt \quad (6)$$

2.4 Sensitivity Analysis

Two main factors affect agribusiness income: price and total physical output. In addition, environmental factors such as pests, diseases, and climate generally change the total output. However, prices may change due to fruit season, stock availability, or competition with various other types of fruit. For this reason, sensitivity analysis is carried out by two methods: (a) by modification of significant factors, and (b) by measuring how much change caused the project to become unviable [11].

3 Results and Discussion

3.1 Agronomical Performance

The results of observations on plant height, stem gird, cob height, cob gird, cob weight peeled cob weight, number of rows of seeds, number of seeds in a row, and weight of 100 seeds are shown in Table 1 and Table 2.

Table 1. Agronomy component analysis of sweet corn intercropped under coconut-based farming system.

Treatments	Plant height	Stem gird	Cob height (cm)
A	164.3a	5.12c	62.8a
B	164.1a	5.08c	62.0a
C	161.0ab	5.68b	60.7a
D	157.19b	5.72b	61.9a
E	157.21b	5.92b	61.1a
F	152.32c	6.42a	60.3a

Notes: The mean followed by the same letter in each column is the same at 5%

Plant height is a crucial factor in the cultivation of sweet corn because it affects the ability to transmit nutrients, resistance to lying, and maintenance. There are different plant heights among the treatments, the highest is shown in treatments A (70 cm x 20 cm) and B (70 cm x 25 cm). These are statistically different with the treatment F, the unshaded field. Naturally, shade causes plants to grow higher as their shoots expand in search of light, showing the activation of some phototropism responses [16,17,18].

Other researchers also stated that plants when compared to plants raised in high light, those that were low light-grown displayed stronger epical dominance environments, resulting in higher plants growing in shaded It's therefore called etiolation [23]. Etiolation is the process of extended growth without light, which leads to the production of etioplasts in tissue that would otherwise have chloroplast [16].

Table 2. Production component analysis of sweet corn intercropped under a coconut-based farming system.

Treatments	Cob gird (cm)	Unpeeled cob weight(g)	Peeled cob weight(g)	No. row	No. seed in row	Weight of 100 seeds
A	10.7b	148.3d	132.9c	41.2b	13.56b	244.3d
B	10.9b	149.7cd	133.9c	41.7b	13.78b	250.7d
C	12.0ab	158.3bc	139.2b	43.2ab	14.67a	270.3c
D	12.7ab	160.2ab	143.3ab	43.4ab	14.67a	283.7bc
E	13.5a	160.7ab	144.5ab	44.2ab	14.58a	285.5b
F	13.6a	164.5a	145.8a	44.4a	14.85a	294.3a

Notes: The mean followed by the same letter in each column is the same at 5%

Meanwhile, the treatments, A, B, C, D, E, and F are various responses to the shade condition. The tolerant growth responses were expressed by treatments D (70 cm x 35 cm), E (70 cm x 40 cm), and F unshaded field. Treatments D and E were not different from treatment F, meaning the treatments were not different with the unshaded (open) field. Among the shaded treatments, treatment C (70 cm x 30 cm) was not different from treatments D and E, therefore for commercial purposes, in certain places such as North Sulawesi Market, treatment C is considered to be recommended. In general, the marketable sweet corn production determined is cob. The cob component sold in the market in North Sulawesi mostly in unpeeled form.

The plant height characters, the stem gird expressed the highest gained by treatment F, and the lowest in treatment A, meaning that the higher exposure to the light, the shorter plant growth. It is necessary for maintaining the plant. Moreover, the cob position especially the height from the floor is necessary to identify due to its strengthened facing wing or other site risk of falling. Fortunately, the results show that there is no difference among the treatments, indicating that the light intensity does not significantly influence the height of the sweet corn cob. In maintaining plants, the height of the cob from the ground is quite important, where farmers usually difficult to maintain if the cob is too short, but if the cob is located too high, it is sensitive to fall, especially in the windy season.

Measurement of the cob characters, such as cob gird, cob weight, and peeled cob weight show the influences of coconut shade on these characters. The cob gird is not different between open fields and those cultivated under coconut shade until a certain spacing, treatment C (70 cm x 30 cm), while the closer space, treatments A and B are different. Finally, both the unpeeled cob weight and peeled cob weight characters were similar in response to the shade effect, whereas these are only not different with the open field treatments until the spacing 70cm x 35cm (treatment D), while the next closer space was different. The results expressed the marketable aspect, especially in the Capital of Manado City, where in local marketable product is an unpeeled cob.

Furthermore, the seed components measured were quite different from the cob components, mainly on 100 seed weight. All shaded treatments are significantly different from the control treatment, open field (treatment F). The weight of 100 seeds of treatment F is 294.3 g, while the shaded treatments are 285.5g; 283.7g; 270.3g; 250.7g, and 244.3g, respectively for treatments E, D, C, B, and A. The difference is related to the grain filling metabolism, where corn as a C4 plant metabolism type, will not be saturated for high light exposure. Fortunately, the market demand for sweet corn in this area is unpeeled or peeled cob. Then for these purposes, the different seed weight is not necessary since the marketable cob characters are not different from the unshaded treatments. For any case where the seed weight is an important form, it could be concluded that the treatment of cultivating sweet corn within a coconut plantation is not recommended.

3.2 Financial Analysis

3.2.1 Cost Analysis

Intercropping of sweet corn within the coconut-based farming system is generally costly in the suburban area of Manado. The cost analysis was directed into two aspects: Costs are both fixed and variable.

3.2.2 Fixed Costs

Land rent IDR 4,000,000 dominates fixed costs a year. The existing coconut land is space in the area, mostly cultivated in a monoculture system. Therefore, in implementing an agribusiness in this arranged farming system is available by leasing. The farmers rent their land relatively cheaper than the other compatible open fields earning IDR 6,000,000 a year. Moreover, cultivation tools such as goes, knives, shovels, and sprayers are available in several agricultural stores in Manado City.

3.2.3 Variable cost

The majority of cost components needed in this agribusiness is variable cost. Variable costs include material expenditures and labor charges. Because the materials purchased are consumables, they are not included in fixed expenses. The materials used in this farming amounted to IDR 14,280,000 or 25.92% of the total variable cost. Meanwhile, the largest cost component of variable costs is labor costs IDR 40,800,000 or 74.07%. In three seasons in a year, IDR 15,000,000. It is similarly costly to general maintenance, needs 150 manpower, total cost of IDR 15,000,000 consisting of fertilizing, irrigating, weeding, and pesticide spraying. Moreover, planting and harvesting costs respectively IDR 4,800 (48 manpower) and IDR6,000 (60 manpower).

3.2.4 Total Cost Analysis

For a sweet corn farming system superimposed on the outskirts of Manado City, the total cost is IDR 60,800,000 for three seasons a year, consisting of these two costs [7].

3.2.5 Revenue, Income Return Cost Ratio Analysis (R/C ratio)

The production value obtained by agribusiness is known as the income of the agricultural system. Two factors, price and production, affect total revenue. There were significant differences in revenues gained between the two treatments. The revenue gained by sweet corn planted within a coconut-based farming system (IDR132.000.000) was lower than those planted in open fields (IDR145.200.000). These are caused by the price difference between the two products. The cob price of sweet corn planted within coconut shade in the collecting trader was only IDR1000 due to the physical characteristics (Table 3), such as weight, and length. Meanwhile, the price of those planted in the opened area was IDR1.100.

Table 3. Financials analysis of sweet corn intercropped under the coconut-based farming system.

Subject	Volume	Unit	Unit Cost	Amount
A. Fixed Cost				
Hoe	2	piece	80,000	160,000
Knife	2	piece	150,000	300,000
Shovel	2	piece	80,000	160,000
Electric sprayer	1	piece	1,100,000	1,100,000
Land rent	1	Ha	4,000,000	4,000,000
B. Variable Cost				
Labor				
Tillage (3 seasons)	3	packages	5,000,000	15,000,000
Planting	48	man	100,000	4,800,000
Maintenance	150	man	100,000	15,000,000
Harvesting	60	man	100,000	6,000,000
Materials				0
Seeds	60	sachet	90,000	5,400,000
Fertilizer				0
'-NPK (@20 kg)	18	sack	240,000	4,320,000
'-UREA	300	Kg	7,200	2,160,000
Pesticides	3	package	800,000	2,400,000
C. Total Cost				60,800,000
Revenue	132000	cobs	1,000	**132,000,000**
Income				**71,200,000**
R/C RATIO				**2.17**

The annual income of the sweet corn planted within coconut-based was IDR 71.200.000, while in the opened field was IDR 84.400.000. Despite the two patterns being different, based on the R/C Ratio analysis, both patterns where it is feasible to apply, namely B/C Ratio respectively 2.17 and 2.39 for shaded un unshaded patterns. The condition leads to the management pattern choice, where the first choice is to apply agribusiness of sweet corn in an unshaded or open field where the farmer will gain an ideal income. For example, they have 1 ha of land arranged for this business, therefore they can gain a monthly income of about IDR 7,033,333. It is much higher than the Official Regional Minimum Wage of IDR3,310.723. On the other hand, the certain open field available in the area is limited. Therefore, the farmer needs alternative land. Since the analysis results showed the feasibility, indicating an opportunity to develop the commodity.

This directed scale agribusiness produces 320,000 cobs annually, with market transactions generally per cob in Manado City. The products produced in a shaded area smaller than those produced in an unshaded area were cheaper, namely, IDR 1.000 per cob, while the unshaded products were IDR1.100. These brought about the differences in revenue and income between the two patterns. The annual revenue gained by the shaded area was IDR320,000,00 compared to IDR145,200,000 gained by the unshaded pattern. Moreover, the feasibility was shown by the R/C Ratio. Despite the R/C Ratio of certain agribusiness practices of sweet corn under coconut shade (2.69) being lower than those conducted in unshaded fields (2.39), it is still significantly feasible leading to an opportunity to be developed in certain areas. The R/C ratio of more than 1.2 indicates an effective and viable agribusiness [8].

3.2.6 Break Event Point (BEP)

The production aspect and the price of the break event are analyzed to determine the Point Break Event. This analysis is used to determine the production tolerance or decrease in the price of products in which the company remains profitable. As follows is the calculated break-even point [10]: BEP production determined in this research is 60,800 cobs/ha/3 seasons, meaning that the cultivation of sweet corn under certain coconut plantations will not be lost if the declining in production does not reach 60,800 cobs/ha/3 seasons. In addition, the break-even price analysis result is IDR460.61/cob, which shows that the company will not lose if the price drops no more than IDR460.61/cob.

3.3. Sensitivity Analysis

A sensitivity analysis of a 0% decrease in sweet corn prices was conducted in this study (Table 4).

Then, the decline is simulated gradually at a rate of decline of 10%, 20%, 30%, 40%, and 50%, with an R/C ratio of less than 1.2. Inflation sensitivity, overproduction, and price fluctuations are also the basis of this category. Farming can also experience decreased production, which can be caused by weather, disease, pests, or theft. However, the potential decrease in productivity is not as large as price fluctuations, so the sensitivity of such decreases is 0%, 10%, 15%, and 25%. With good management, it is estimated that there will no longer be a decrease in productivity of more than 25%

Table 4 shows that if the output price and productivity of sweet corn change, the value of the R/C ratio will change significantly. To some degree of rice, there will be a decrease in productivity. According to useful and efficient rules with an R/C ratio of 1.2 and above, the findings show that sweet corn farming in the Manado Suburban area is feasible and efficient despite the decline. At an R/C ratio of 1.0, there is still a break-event point, whereas agriculture does not lose money, but is inefficient because the R/C ratio is more than or less than 1.2 [8].

Table 4. Sensitivity analysis of the agribusiness value of sweet corn farmed within a coconut-based plantation in the suburban area of Manado City

Decrease in Output price. (IDR)	Decrease in Productivity			
	0%	5%	15%	25%
0%	132,000,000	125.400,000	112,200,000	99,00.000
	R/C 2.17	R/C 2.06	R/C 1.85	R/C 1.63
-10%	118,800,000	112,200,000	99,000,000	85,800,000
	R/C 1.95	R/C 1.85	R/C 1.63	R/C 1.41
-20%	10,560,0000	99,000,000	85,800,000	72,600,000
	R/C 1.74	R/C 1.63	R/C 1.41	R/C 1.19
-30%	92,400,000	85,800,000	72,600,000	59,400,000
	R/C 1.51	R/C 1.41	R/C 1.19	R/C 0.97
-40%	79,200,000	72,600,000	-	-
	R/C 1.30	R/C 1.19	-	
-50%	66,000,000	-	-	-
	R/C 1.09	-		

Scenarios of decline in value due to decreased production are set with a value of up to 25% which is determined purposively on the possibility of external disturbances such as pest and disease attacks, climate change, and so on. The scenario of a maximum production decrease of 25% was also determined because sweet corn is a short-harvest crop, which is around 70 daps, so abiotic and biotic disturbances can be minimized. If the most extreme condition is a decrease in production of up to 25%, then sweet corn farming can still be feasible if there decrease in price is not more than 10% (R/C ratio 1.41). Furthermore, the price decrease is tolerated up to 40% (R/C ratio 1.30) as long as there is no decrease in production. The combination of a decrease in product price by 20% and a decrease in production by 15% is also feasible (R/C Ratio 1.41).

4 Conclusion

1. Optimization of coconut-based plantations in North Sulawesi can be implemented by applying intercropping practices such as sweet corn inappropriate spacing.
2. The best production gotten in this research is treatment F, unshaded, spacing 70 cm x 20cm, where both the unpeeled and peeled cob were higher than other treatments, but these not significantly different from treatment D and E, but the treatments D and E is not different with treatment C, therefore, for the commercial purposes where the marketable product such as unpeeled or peeled cob, it is recommended for treatment C, spacing 70 cm x 30 cm to be implemented in the intercropping of sweet corn within coconut plantation.
3. Financial viability is indicated by an RC ratio of 2.17. If the decline in production is not more than 60,800 cobs/ha per season, sweet corn cultivation in certain coconut plantations will not disappear. This is because BEP production is 60,800 cobs/ha per

season. Thus, the price of BEB is IDR 460.61/cob, which indicates that the company will not incur a loss if the price drops no more than IDR 460.61/cob.

4. The tolerable sensitivity determined was a 15% decrease in production if the price decrease is not above 20%, as well as, a decrease in the price of 30% since the decrease in production does not more than 15%.

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