Effect of Intercropping with Mungbean on Growth, Yield and Seed Protein Of White And Black Waxy Maise

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Abstract. This study aims to determine the effect of intercropping on the growth, yield, and protein content of glutinous corn. This study used an experimental method with field trials in rainfed land in Rembitan village (Central Lombok) in December 2023-March 2024. The research design employed a Randomised Block Design (RBD) with two factors: White glutinous corn (J1) and purple glutinous corn (J2), with two treatments: without intercropping (T0) and with mung bean intercropping (T1). The researchers combined all factors to create four combinations, each replicated three times, resulting in a total of 12 experimental units. Observation variables include growth, yield and protein. Growth variables include plant height (TT) and the number of leaves (JD). Yield variables include the number of cob rows (JBT), the weight of 100 corn kernels per gram (BJ100/g), cob diameter (DT), weight of the cob without husk (BTTK), cob length (PT), and protein content (PrT).

The results showed that the interaction of intercropping treatment with glutinous corn significantly affected the parameters of JD 42 and 56 hst, cob length, cob diameter, number of rows, weight of 100 grains, and cob weight. The most significant number of leaves was observed in the T1J1 treatment at 56 hst, with 14.55 strands. The longest cob size was observed in the intercropping treatment with white glutinous corn, measuring 18.20 cm, while the diameter of the purple corn cob was 47.90 cm. The researchers found that the T1J1 treatment produced the highest number of rows, 14.45, and a 100-grain weight of 23.04 g, followed by a cob weight of 140.19 g and seed protein content of 4.89%. Based on their results, they concluded that applying intercropping planting patterns can significantly enhance the growth, yield, and protein content of glutinous corn. Specifically, intercropping green beans with white glutinous corn resulted in the highest growth and yield, while intercropping with purple glutinous corn neither contributed to nor affected growth and yield.

Keywords: intercropping of green beans; glutinous corn; growth; yield; protein.

INTRODUCTION

In 2020, the area planted with corn in Indonesia was 3.82 million hectares, while the area harvested for corn was 3.74 million hectares, resulting in a production of 2.81 million tons [1]. In 2023, the West Nusa Tenggara (NTB) region produced 1.28 tons of dry corn kernels with a water content of 14%. The area harvested for corn decreased to 8.69% compared to 2022 [2]. This decrease in yield and harvest area is very unfortunate if it continues to occur, even though corn has the potential to be a source of functional food, especially since the Indonesian indigenous functional market is increasingly open due to changes in people's lifestyles, changes in eating patterns that lead to healthy living [3, 4]. Corn comes in various types, one of which is glutinous corn (Zea mays ceratina), which consists of both purple and white glutinous corn [4, 5]. Purple glutinous corn, which is included in speciality corn, is one of the varieties widely developed in Thailand and the United States. This corn is unique due to its purple seeds, which are caused by the high anthocyanin content, ranging from 290 to 1323 mg/100 g dry weight [6]. Unlike purple glutinous corn, white glutinous corn has a lower anthocyanin content but contains 90% amylopectin, resulting in a delicious, savoury, and soft taste [6]. The characteristics of glutinous corn are that it is early maturing and physiologically ripe at the age of 80 days [4]. Glutinous corn is typically consumed, either grilled or boiled [7]. Glutinous corn has a lower starch digestibility compared to other corn. Therefore, glutinous corn is particularly suitable for consumption by people with diabetes who require carbohydrates but have low glucose levels. Glutinous corn also contains approximately 9.20 g of protein per 100 g. This indicates that glutinous corn has the potential to serve as a food diversification option or as an industrial material with a high economic value [3].

The disadvantages of glutinous corn are the small size of the cob, with a diameter of 10-12 mm and susceptibility to downy mildew, and the production level of glutinous corn is still relatively low, namely <2 tons/ha [8]. Genetic diversity studies on glutinous corn are also still relatively low [9]. Considering the advantages and disadvantages of glutinous corn, it is necessary to adopt cultivation techniques that aim to increase productivity and yield. One such planting method is intercropping. The intercropping system makes a significant contribution to crop production through the effective utilisation of resources, compared to monoculture [10–12]. In Indonesia, dryland farmers typically plant corn intercropped with legumes [13]. The advantage of the corn intercropping system with legumes is the increase in nitrogen (N) supply from legumes to corn (non-legumes) [6, 14]. The results of intercropping research between corn and various types of beans showed that corn plants intercropped with green beans had the highest grain yield and N absorption [15]. The amount of nitrogen is thought to affect the total protein content because nitrogen is an essential element in the formation of protein [16].

Green beans are classified as C3 plants with low stomatal density, which causes the rate of photosynthesis to occur at relatively low light intensities and temperatures compared to C4 plants (such as corn), making green bean plants resistant to shade [17]. The results of research by authors [18] demonstrated that corn and green bean varieties in the intercropping system had a significant impact on the growth and yield components of both plants. The combination of treatments resulted in corn seed yields of 7.63 tons/ha and green bean yields of 0.73 tons/ha. However, research has never been conducted to determine the effect of intercropping and mycorrhizal application on increasing the protein content of glutinous corn seeds.

METHOD

The researchers conducted this study from December 2023 to March 2024 in Rambitan Village, Pujut District, Central Lombok Regency. The experimental design used was a Randomised Block Design (RBD) with two treatment factors: intercropping and glutinous corn. Each treatment has two levels: T0, without intercropping, and T1, with intercropping. The intercropping varieties are J1, White Glutinous Corn, and J2, Purple Glutinous Corn. The researchers combined each treatment factor to produce four treatment combinations, repeated each combination three times, and assigned unique codes (T0J1, T0J2, T1J1, and T2J2), resulting in a total of 12 treatment combinations.

The materials used in this experiment include red arrow brand glutinous corn seeds, Vima 4 variety green bean seeds, 16:16:16 urea fertiliser, neem leaf extract, and Bessazinon 750 EC insecticide. In contrast, the tools used include hoes, wooden sticks, measuring tapes, rulers, ropes, sickles, buckets, plastic, paper, markers, stakes, wooden boards, and laboratory analysis tools.

The researchers prepared the land by creating four experimental plots, repeating each plot three times, and established a total of 12 experimental plots on a single plot of land. The size of the land plot used was 9.3 m x 20 m, with a height of 20 m. The researchers planted local varieties of glutinous corn with a row spacing of 75 cm and an intra-row spacing of 20 cm. Likewise, with green beans, we planted two rows between 2 rows of corn, with a distance of 25 cm between rows and 20 cm within rows. Green beans were grown first, followed by glutinous corn, after 10 days.

The researchers conducted this study during the rainy season, which allowed them to use rainwater for irrigation. Fertilisation was carried out by making holes in the planting area, spaced 3-5 cm apart, and then covering them with soil. The researchers fertilised the green beans at 15 and 35 days after planting, while they fertilised the corn at 10, 35, and 49 days after sowing. The fertiliser used was urea at a dose of 50 kg/ha and NPK at a dose of 200 kg/ha. Weeding was carried out twice, namely at the ages of 8-9 hst and 27-28 hst. Pest and disease control was carried out before planting. The researchers first watered the land using neem leaf extract. They controlled insect pests by applying Bassazinon 750 EC to the corn and Curracron 500 EC to the green beans. The researchers harvested the green beans at 65 days after planting and the corn at 80 days after planting.

The parameters observed were growth parameters including plant height, number, length and width of leaves. At the same time, the yield parameters included the weight of the cob without husk, the diameter and length of the cob, the weight of 100 grains, and seed protein. The samples observed were three per plot. Data analysis used Analysis of Variance (ANOVA). The study's results, showing significant differences, were further tested using a 5% Bonferroni correction.

RESULTS AND DISCUSSION

Legal Protection Against Consumer Losses Due Based on the results of data analysis using Analysis of Variance (ANOVA), it can be seen that the interaction between intercropping of green beans and glutinous corn has an insignificant effect on the observation variables of plant height and number of leaves at the age of 28 hst, but has a significant impact on the number of leaves at the age of 42 and 56 hst. The interaction of these two factors also has a substantial effect on the yield of corn plants, including the variables of cob length, cob diameter, number of seed rows, cob weight, weight of 100 grains, and protein content.

Table 1 – Effect of mung bean intercropping on the growth of glutinous corn plants

Treatments	TT14A		TT28		TT42A		TT56		JD14A		JD28		JD42		JD56A	
J1	12.82	a	41.84	a	77.23	a	105.87	a	5.22	a	7.45	b	9.84	b	12.78	b
J2	12.42	a	42.69	a	76.50	a	106.67	a	5.17	a	8.06	a	10.61	a	13.00	a
HSD0.05	1.22		1.22		1.88		3.94		0.22		0.16		0.15		0.22	
T0	12.13	a	42.43	a	77.69	a	106.07	a	5.22	a	7.28	b	9.28	b	11.78	b
T1	13.11	a	42.10	a	76.04	a	106.47	a	5.17	a	8.22	a	11.17	a	14.00	a
HSD0.05	8.18		3.64		5.33		5.50		0.87		0.24		0.24		0.85	
Interaction	ns		ns		ns		ns		ns		ns		*		***	

Note: J1 – white glutinous corn, J2 – purple glutinous corn, TT – plant height, JD – number of leaves, ns – non-significant, * – significant. Numbers followed by the same letter in the same column indicate no significant difference in the treatments according to the 5% BNJ test.

Table 2 – Effect of mung bean intercropping on glutinous corn yields

Treatments	Ptongkol1		Dtongkol2		JbarisBj1		B100Kr2		BtongNoKlo		Protein3	
J1	17.75	b	47.50	a	13.72	a	22.52	a	126.72	b	4.79	a
J2	17.96	a	47.85	a	13.94	a	22.56	a	130.30	a	4.52	b
HSD0.05	0.20		0.36		0.56		0.46		2.91		0.20	
T0	17.54	a	47.53	a	13.50	a	22.26	a	121.07	b	4.56	b
T1	18.17	a	47.82	a	14.17	a	22.82	a	135.95	a	4.75	a
HSD0.05	0.66		0.98		1.10		0.86		3.78		0.15	
Interaction	*		*		*		*		***		ns	

Note: J1 – white glutinous corn, J2 – purple glutinous corn, Ptongkol – cob length, Dtongkol – cob diameter, Jbaris – number of rows of seeds, B100kr – the dry weight of 100 grains, Btongnoklo – the weight of the cob without husk, ns – non-significant, * – significant. Numbers followed by the same letter in the same column indicate no significant difference in treatment according to the 5% BNJ test.

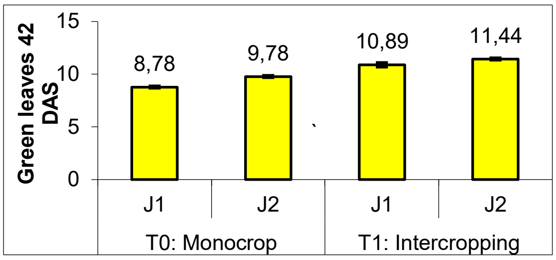

Figure 1 – Green leaves of waxy corn (Mean ± SE) as affected by the interaction effect of the treatment factors

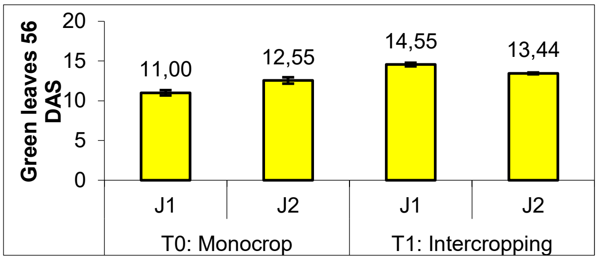

Figure 2 – Green leaves of waxy corn (Mean ± SE) as affected by the interaction effect of the treatment factors

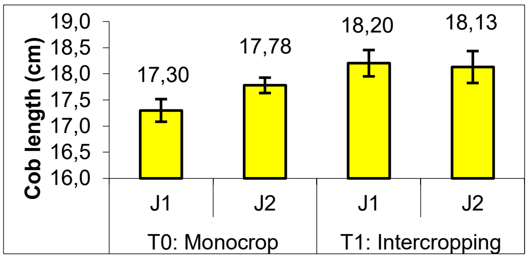

Figure 3 – Cob length of waxy corn (Mean ± SE) as affected by the interaction effect of the treatment factors

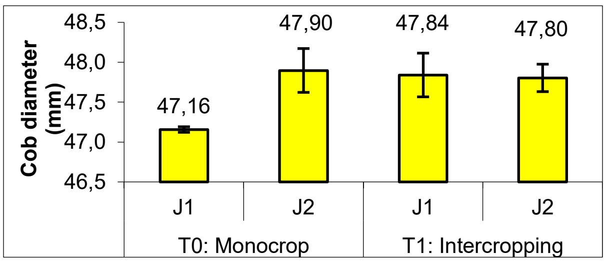

Figure 4 – Cob diameter of waxy corn (Mean ± SE) as affected by the interaction effect of the treatment factors

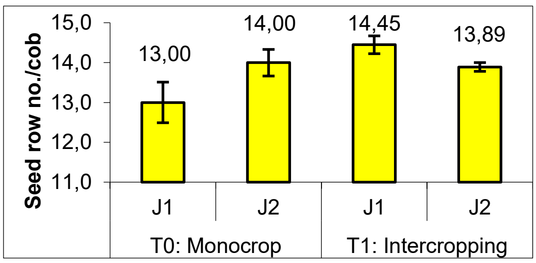

Figure 5 – Seed rows of waxy corn (Mean ± SE) as affected by the interaction effect of the treatment factors

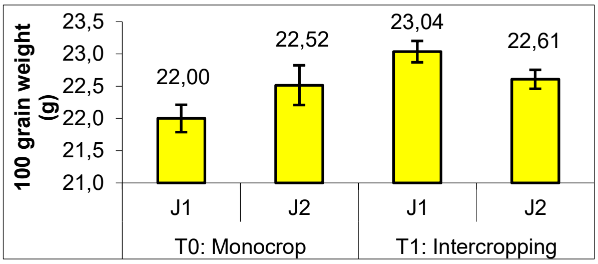

Figure 6 – 100-grain weight seeds of waxy corn (Mean ± SE) as affected by the interaction effect of the treatment factors

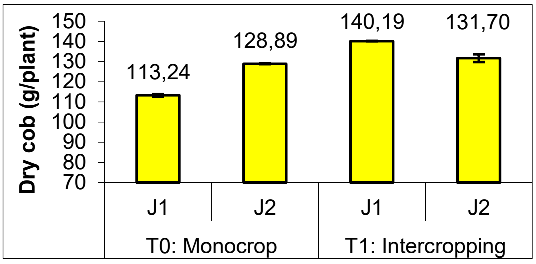

Figure 7 – Dry cob of waxy corn (Mean ± SE) as affected by the interaction effect of the treatment factors

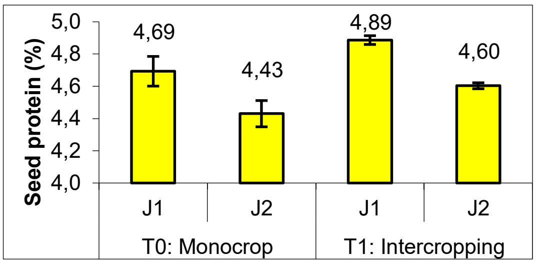

Figure 8 – Seeds Protein of waxy corn (Mean ± SE) as affected by the interaction effect of the treatment factors

Based on Figures 1 and 2, it is evident that the intercropping pattern treatment yields a greater number of glutinous corn leaves compared to the monocrop system. At 42 hst, the highest number of leaves is purple glutinous corn at 11.44 strands, while at 56 hst, the highest number of leaves is in white glutinous corn at 14.55 strands. Likewise, the length of the corn cob is larger when planted with intercropping than when planted without intercropping. White glutinous corn has the longest cobs, measuring 18.20 cm (Figure 3). The researchers observed that purple glutinous corn without intercropping treatment had the widest cob diameter, measuring 47.90 cm (Figure 4). The observation results on the variable number of rows of seeds showed that white glutinous corn with intercropping treatment had the most significant number of rows, which was 14.45 (Figure 5). Figure 6 shows that white glutinous corn with intercropping treatment produced the highest 100-seed weight, measuring 23.04 g.

Additionally, the cob weight variable indicates that the intercropping treatment yields better results, as evidenced by the increase in cob weight compared to the treatment without intercropping. The heaviest cobs were in the T1J1 treatment of 120.19 (Figure 7). Figure 8 also demonstrates that intercropping increases corn seed protein content, with the T1J1 treatment yielding the highest protein value of 4.89%.

It is known that with the intercropping treatment, the number of leaves increases from 45 days after sowing to 56 days after sowing, indicating that intercropping green beans can provide sufficient nitrogen nutrients for the growth of glutinous corn. As is known, green beans are legume plants that have root nodules symbiotic with the bacteria Rhizobium sp., which can bind nitrogen from the atmosphere and fix it, allowing the plants to absorb it. Nitrogen nutrients are the nutrients that most influence the growth and development of leaves [19]. The number of leaves is an indicator of growth parameters that describe a plant's ability to photosynthesise [20]. The results of photosynthesis can be used as a source of energy for the formation of new leaves and other plant organs. The results of photosynthesis are distributed to the upper part of the plant, which helps the growth of the canopy (leaf tips and stems), allowing the plants to become taller and increasing the number of leaves [21]. The plant's increasing age leads to an increase in the number of its leaves [18]. The number of leaves has a close relationship with the planting results. Based on the correlation data, the number of leaves shows a positive correlation with the result parameter, with an R-squared value of 0.00.

In this study, it is evident that there are differences in the results between the two types of glutinous corn. White glutinous corn tends to yield optimal results in an intercropping system compared to a monocropping system. The longer cob size resulting from this intercropping treatment suggests that the nitrogen absorbed by the plant is sufficient to meet the nutrient needs in both the vegetative and generative phases. The availability of nitrogen at the beginning of growth significantly affects subsequent development phases, such as pollination, seed filling, and increasing cob weight [22]. Nitrogen is a component of protein synthesis. Plants will then utilise the protein produced to form essential organs, such as cobs and seeds [23]. Experts reiterate that nitrogen stimulates the formation of cobalamin (vitamin B12) [24]. Figure 4 shows that the diameter of the white glutinous corn cob is larger than that of the cob without intercropping. The number of rows of seeds also influences the diameter of the cob. The more rows there are, the wider the cob diameter will be. Conversely, if the number of rows of seeds in the cob is small, the diameter of the cob will also be small. The results of this study show that intercropping increases the number of rows of white glutinous corn seeds compared to monoculture. The researchers attribute this to nitrogen nutrients that enhance the photosynthesis process, producing photosynthate that the plant then distributes to its various parts. Thus, metabolism will take place actively, resulting in the processes of cell division and elongation in corn plant organs, such as cobs and seeds [25, 26], as evidenced by the observations on the weight of 100 grains.

In Figure 6, it can be seen that white glutinous corn with intercropping has the highest 100-grain weight value, indicating that the results of photosynthesis are allocated maximally to the parts of the corn plant. The increase in dry seed weight is related to the amount of photosynthate transferred into the seed [27]. The substantial translocation of photosynthate to the reproductive organs enables the formation of cobs and facilitates seed filling, resulting in seeds that are full and larger. Likewise, the study's results on the weight of white glutinous corn cobs showed that intercropping treatment produced heavier cobs. The results of this study align with those of previous research conducted by authors [28], which found that intercropping sweet corn with peanuts can increase the number of leaves, fresh cob weight, and dry stalk weight. Intercropping corn with peanuts also yields a higher dry corn weight, specifically 4,727.95 kg/ha, compared to the 2,852.46 kg/ha obtained without intercropping [29]. Researchers have also reported that corn intercropped with peanuts produces a higher dry weight than corn planted alone (monoculture) [30].

Intercropping mung beans with glutinous corn also increases seed protein; this is thought to be due to the availability of nitrogen nutrients that support the growth and productivity of corn plants. In line with what was conveyed by the author [31], nitrogen is a key component in the formation of amino acids and proteins. As observed in this study, the intercropping of mung beans can increase the number of leaves and yield of glutinous corn, which is correlated with the protein content of the corn. The characteristics and biomass of plants influence the protein content of corn [32]. Numerous studies have demonstrated the benefits of intercropping, including increased corn seed yields. The results of this study align with those of a survey conducted by authors [32], which found that intercropping corn with faba beans can increase protein content from 42% to 39%. Likewise, research by authors [33] reported that intercropping corn with the legume Vicia villosa can increase corn protein by 180% compared to monoculture. Authors [34] also reported the results of research showing that intercropping corn with faba beans can increase protein content by 7-39%. Likewise, the results of research by authors [35] indicate that intercropping corn with soybeans can increase corn protein by 22% compared to monoculture. The results of research by authors [36] also showed that intercropping corn with alfalfa plants can increase corn protein from 31% to 59%.

The increase in results observed in this study, supported by previous studies, was due to the positive response between the two types of plants. Corn is a C4 plant that requires large amounts of nitrogen nutrients for its growth and productivity. At the same time, legumes (mung beans) are plants that can bind nitrogen and contribute to corn plants, on the other hand, corn plants can protect mung beans from high light intensity considering that mung beans are plants that are tolerant to shade, but on the other hand, purple glutinous corn tends to have less than optimal results when compared to white glutinous corn. The difference in results in this study is attributed to variations in the response of purple glutinous corn plants to the presence of mung beans. Not all intercropping can increase corn yields. Some research results also show that intercropping has no contribution to corn crops. The research results from Worku [37] also indicate that intercropping green beans does not impact the yield of corn crops. In line with the research results of Trelogames [38], intercropping of corn with green beans does not contribute to corn yields. Similarly, the research results from the author [38] indicated that intercropping corn with green beans did not yield optimal results.

However, all the research results on intercropping green beans with glutinous corn indicate a significant impact on increasing the growth and yield of glutinous corn plants compared to monoculture.

CONCLUSIONS

The implementation of intercropping patterns can significantly contribute to and increase the growth, yield, and protein content of glutinous corn. Intercropping green beans with white glutinous corn yields the maximum growth and yield. In terms of growth, white glutinous corn has the most significant number of leaves at 56 days after planting, with 14.55 strands, as well as a protein content of 4.89%. However, intercropping with purple glutinous corn has no contribution, so it does not affect its growth and yield.

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