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Growth and yield performance of cassava *(Manihot esculenta)* intercropped with leguminous crops

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Abstract

The study was conducted to determine the effect of intercropping leguminous crops to growth and yield of Cassava (*Manihot esculenta*). The Randomized Complete Block Design was used in the study and treatments were randomly assigned with three experimental blocks. Data gathered were: plant height, number of stem, stem diameter, survival rate, number of roots, weight of roots and return on investment. The treatments used are the following: Treatment 1 (sole cassava); Treatment 2 (cassava + mungbean) and Treatment 3 (cassava + bush sitao). The results show that intercropping leguminous crops has no significant effect on the growth of cassava in terms of plant height at first and second months, number of stem and survival rate. Moreover, the highest net income was obtained by the cassava plants intercropped with bush sitao (T3) with an amount of Php. 814.13 with an ROI of 62.96% followed by cassava plants intercropped with mungbean (T_2) with an amount of Php. 755.57 and ROI of 58.42%. The lowest net income was obtained by cassava plant without any intercropping or companion crop with an amount of 491.18% and an ROI of 45. 61%. Thus bush sitao is recommended as intercrop to cassava plants for additional income per unit area.

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Introduction

Cassava is a perennial plant that grows best under well-drained, damp, acidic and tropical soils (Cock, 2019). The fully grown plant achieves an elevation of about 2-4m. In the forest, the cut-stem parts were planted in the earth to become just as with sugarcanes. After about 8-10 months of planting; thick, globular roots or tubers develop in a circular pattern down deep into the soil from the bottom end of the stem to 2-4 feet deep. (Edhirej *et al.,* 2017)

Depending on the type of cultivar, each tuber weights one to multiple pounds, and features gray-brown, rough, woody textured skin. Its internal flesh contains dry, sweet-flavored starch-rich beef, which should only be consumed after frying. (Puoza, Opoku & Aboagye, 2016)

Cassava, scientifically known as *Manihot esculenta,* locally known as *kamoteng kahoy* or *balinghoy* ranks second next to sweet potato in hectarage among root crops produced in the country (Tacio, HD, 2015; Balagopalan, 2018 Herawati, Kamsiati & Bachtiar). It is mainly grown for its tubers which are a rich source of carbohydrates which contain 38 grams of carbohydrates per 100-gram serving (Wenjun *et al.*, 2016). Unknowingly, it is a good source of calcium and ascorbic acid. Principal products of the processing industry are food, dried chips, starch and good supplemented feed for livestock and cassava contributes about 2% to gross value adding in agriculture. Although not the staple of Filipinos, cassava is planted in our country about 223,000 hectares producing 580,817 metric ton and Cagayan Valley rank second producing 101,997 metric ton. (Philippine Statistic Authority, 2016). Cassava is considered as a long-season crop, due to its slow growth at the initial stages, it does not efficiently use the availability of light, water and nutrients during these early growth stages (Debra, 2017). Thus, short-duration crops may be intercropped to make more efficient use of these growing factors (Chiona *et al.,* 2016). Among all, legumes can be considered for use in intercropping systems with cassava because of their fast growing and the ability to improve soil fertility through nitrogen fixation. (Gyau & Jnr 2015)

Farmers tend to select crops on the basis of differences in growth habits and growth duration. The selection is highly site-specific, depending on the soil and climatic conditions, as well as on local tastes and traditions. Having a slow initial growth, cassava can be best intercropped with cowpea (*Vigna unguiculata*), peanut (*Arachis hypogaea*), and mungbean (*Vigna radiata*) having a rapid growth and early to medium growth duration (Reinhardt Howeler, 2011 & 2008). The advantage that the grain legumes are harvested before the cassava closes its canopy and neither crop suffers too much from interspecific competition (Cock, 2019; Etany *et al.,* 2016). In this case, the association of a long-duration crop (cassava) with a short-duration crop results in a higher total yield due to better utilization of both space and time (Salau *et al.,* 2015; Delaquis, Haan & Wyckhuys, 2018).

Thus, intercropping cassava with legumes is important to cassava farmers since it would provide additional crop yield during the early cassava growth stage with the same piece of land. Obtaining additional food grain is an attractive option for the farmers having land shortage to plant cassava and legume separately. The benefit of obtaining additional legume grain would have positive advantage on food security and land use efficiency (Uzokwe *et al.,* 2006).

Careful planning is required when selecting the component crops of a mixture, taking into account the environmental conditions of an area and the available crops or varieties (Mashhadi, NAKHZARI & Sabouri, 2015; Barot *et al.,* 2017). Intercropping systems must be designed to maximize the total net income of the system, to increase the various advantages and decrease the disadvantages. This will require the careful selection of the various crops to be planted. (Esiape, 2015; Jones, 2016)

Generally, the study was conducted to determine the growth and yield performance of cassava intercropped with different leguminous crops. Specifically, the study aimed to find out what treatment can give the best performance of cassava in

terms of the following parameters: (a) monthly plant height (cm); (b) stem diameter (cm); (c) number of stem; (d) survival rate (%); (e) number of roots, and (f) weight of roots.

Materials and methods

Experimental Design and Treatments

The Randomized Complete Block Design (RCBD) was used in the study, with a total area of 900 sq.m which was divided into three (3) equal blocks to represent the three (3) replications. Each block was further sub-divided into three (3) equal plots with a size of 8m x 8m to represent the three (3) treatments having a distance of 1.5 m between blocks and treatments. The treatments were as follows: (a) T_1- Control (sole cassava); (b) T_2- Cassava + Mungbean, and (c) T_3- Cassava + Bush sitao.

Securing the Planting Materials

The planting materials of cassava (Lakan 4) and mungbean (Tri-star) needed in the study were secured at the Department of Agriculture, Regional Field Office 02. The planting materials used were selected from vigorous plants with no nutritional deficiencies, suitable age and are free of diseases and pests. While the bush sitao seeds (Sumilang) were secured at Aljay farm supply, Dugo, Camalaniugan, Cagayan.

Preparing the Field

The land area of 900 sq.m was thoroughly prepared by alternate plowing and harrowing to ensure uniform germination and maximum stand of crops in the field. After the final harrowing, the area was laid out following the desired design and treatments.

Planting and replanting

Before planting, the cassava planting materials was stored at environmental condition which promotes pre-sprouting. The cassava planting materials were sown at the same time at a distance of one meter between furrows and 80cm between hills. The mungbean and bush sitao was directly planted in between furrows of cassava at the rate of three seeds per hill at 40cm apart in between hills to attain equal population density. Replanting of cassava was done two weeks after planting.

Cultivating, weeding the plants and Controlling of insect and diseases

Cultivation was done three times after planting and hilling-up was done one month after planting to loosen the base of the plants for better aeration and to facilitate nutrient absorption. Weeding was done 20 days after planting (DAP) and one month interval thereafter. The insect pests that attacked and caused damage to the plants during their growing period were controlled by insecticide spray. Physical method was done also to remove the insect such as cutworm.

Applying Fertilizer

The fertilizer applied into the plants was based in the results of soil analysis (50-60-0) were adjusted based on experimental unit (17.58kg. of Ammonium Phosphate, 0.25kg of Urea and 28.8kg. of organic fertilizer). Foliar fertilizers were sprayed when 50% of the leguminous crops were on the flowering stage.

Priming and Marketing

First priming of *mungbean* was done 27 days after blooming. This was done seven times until the plant senescence at four days interval. Likewise, *bush sitao* pods were harvested ten (10) days after blooming. Harvesting was done nine times at four days interval. All the harvested green pods of bush *sitao* and dried seeds of *mungbean* were sold to the market.

Data Gathered and Analysis

The following data was gathered from the experiment: (1) Monthly plant height (cm); (2) Number of stem/plant; (3) Stem diameter (cm); (4) Survival rate (%); (5) Number of roots; and (6) Weight of roots. The data gathered were analyzed using the analysis of variance (ANOVA) in Randomized Complete Block Design (RCBD).

Results and discussion

Plant Height (cm)

The result on average plant height at 30 to 90 days after planting (DAP) is presented in Table 1. Results revealed that the consistently, cassava plants without intercropped (T_1) are the tallest among the treatments with a mean of 45.60cm, 80cm and 105.43cm, respectively.

While plants intercropped with mungbean (T_2) are the shortest with a mean of 37.43cm, 68.57cm and 88.33cm. However, the analysis of variance shows no significant difference among the treatments. However, after 90 days, significant difference was observed among treatment means. Results revealed that the plants without intercropped (T_1) are the tallest among the treatments with a mean of 105.43cm, followed by plants intercropped with mungbean (T_2) with a mean of 92.33cm.

Plants intercropped with bush sitao .The results revealed that there is a significant difference among the treatment means. In terms of the average plant height after three months, plants without intercropped (T_1) are significantly different from the plants intercropped with bush sitao (T_3) but not significantly different with plants intercropped with mungbean (T_2).

The results of the study on plant height support with the observation of Mrema, P. (2009) and Mdyente, (2016) that cassava mono crop showed significantly ($p<0.05$) taller plants among cassava + groundnut and in cassava + cowpea. This might due to the competition of nutrients and sunlight as explained by the study of Prabhakar and Nair (1992) that the setback in cassava growth during its early stage was due to competition with associated groundnut for light and applied nutrients.

Table 1. Plant height of cassava intercropped with different leguminous crops after one month.

Treatments	Plant Height (CM)		
	30 DAP[1]	30 DAP	30 DAP
T_1- Cassava (Control)	45.60	80	105.43 a
T_2- Cassava + Mungbean	37.43	69.63	92.33 ab
T_3- Cassava + Bush sitao	40.33	68.57	88.33 b
Statistical inference	ns		*
CV	9.47%	7.77%	6.12%

*Means with the same letter are not significantly different at 5% level.

[1]Days after Planting

Table 2. Stem diameter of Cassava intercropped with different leguminous crops.

Treatments	Stem diameter (cm)	Number (#) of stem	Survival rate	Net income	ROI
T_1- Cassava (Control)	1.37 a	3.43	81.67	76746.88	45.61%
T_2- Cassava + Mungbean	0.92 b	3.80	86.33	118057.81	58.42%
T_3- Cassava + Bush sitao	1.11 ab	3.70	85.33	127207.81	62.96%
Statistical inference	*				
cv	10.25	8.05%	2.25%		

*Means with the same letter are not significantly different at 5% level.

Stem Diameter (cm)

The result on average stem diameter is presented in Table 2. Results revealed that the plants without intercropped (T_1) obtained the bigger stem diameter compared to the other treatments with a mean of 1.37cm, followed by plants intercropped with bush sitao (T_3) and mungbean (T_2) with a mean of 1.13cm and 0.92cm, respectively. The Least Significant Difference (LSD) revealed that there is a significant difference among the treatment means. The average stem diameter of plants without intercropped (T_1) is significantly different from the stem diameter of plants intercropped with mungbean (T_2) but not significantly different with the stem diameter of plants intercropped with bush sitao (T_3). This might due to the population density per experimental unit. Plants intercropped with bush sitao and mungbean has more number of hills as compared to the plants without intercropped.

This is supported by the study of Silva *et al.* (2013) that planting density had an effect on the above-ground part (stem diameter + branches + leaves). Above the soil surface, the competition between plants occurs for light and space. Higher plant densities would result in mutual shading, with reductions in photosynthesis rates, which would in turn result in smaller plant.

Number of Stem

Results revealed that the plants intercropped with mungbean (T_2) produced the highest number of stem with a mean of 3.80, followed by plants intercropped

with bush sitao (T_3) with a mean of 3.70, and the least number of stem are the plants without intercropped (T_1) with a mean of 3.43, respectively. However the analysis of variance shows no significant difference among the treatments (Table 2).

Survival Rate (%)

Results revealed that the plants intercropped with mungbean (T_2) obtained the highest survival rate with a mean of 86.33%, followed by plants intercropped with bush sitao (T_3) and plants without intercropped (T_1) with a mean of 85.33% and 81.67%, respectively. However the analysis of variance shows no significant difference among the treatments (Table 2).

During the germination stage of the plants, a partial drought occurs as shown in Table 7 which consequently affects the growth of cassava. According to Esiape, C. (2015), cassava finds the most favorable growing conditions in tropical and sub-tropical at temperatures of between 25 to 32^{0}C and the crop can be successfully grown in areas with rainfall ranging from 50 to 250cm.

Gross margin analysis

The cassava intercropped with different leguminous crops gave the highest net income was obtained by the plants intercropped with bush sitao (T_3) with an amount of Php. 127207.81per ha^{-1} followed by plants intercropped with mungbean (T_3) with an amount of Php. 118057.81per ha^{-1} and sole cassava with an amount of Php. 76746.88per ha^{-1}. The study gave a ROI of 62.96%, 58.42% and 45.61%, respectively. This is in consonance with the study of Giller, (2001) cited by Pieter *et al.* (2010), stating that productivity is increased through integrated soil fertility management in cassava-legume intercropping system in highlands.

Conclusion

Based on the results obtained in the study, it shows that there is no significant effect of intercropping different leguminous crops on the plant height on the first and second month, stem number and survival rate. However, cassava intercropped with different leguminous crops differs significantly in terms of diameter of stem and plant height on the third month. As the number of stem increases, the stem diameter and plant height decreases except for the survival rate.

Recommendation

Since intercropping of bush sitao with cassava gain the highest net income and ROI. It is recommended to do intercropping with bush sitao to maximize the utilization of the resources.

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