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Growth and economic potential of newly established Cacao (*Theobrama cacao*) plantation intercropped with glutinous Corn (Zea *mays*) and Mungbean (*Vigna radiata* L.)

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Key words: Grafted, Mungbean, Leaf area index, Glutinous corn, Economic potential

Abstract

The research was conducted at the Cagayan State University at Lal-lo from June 2017 to March 2018 to establish a CSU demonstration farm for cacao-based integrated multi- story cropping system by intercropping *mungbean* (*Vigna radiata L.*) and glutinous corn (Zea *mays*) during establishment stage of cacao farming and to showcase its economic potential. Specifically, it aimed to determine the following: the plant height, number of leaves, survival rate, leaf area index, plant height of glutinous corn and mungbean, pods of mungbean, length of corn ear, yield per plot(kg) and return of investment. It was laid out in Randomized Complete Block Design (RCBD) with three treatments and replicated three times. The treatments were: T1- cacao as control, T2- cacao + glutinous corn and T3- cacao + *mungbean*. No significant differences among the treatments on the plant height, number of leaves, and leaf area index. However, there are significant differences in terms of survival rate, plant height of glutinous corn and *mungbean*, pods of *mungbean,* length of corn ear, yield/plot (kg). Grafted cacao seedlings intercropped with glutinous corn produced highest net income and return on investment compared to *mungbean*. Therefore, planting cacao intercropped with glutinous corn is recommended to the Lal-lo farmers to obtain higher income during the establishment stage. Another trial must be conducted to give more conclusive results and another research must be conducted using other intercropped.

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Introduction

In cacao producing countries, it is grown mainly for its beans, processed into cacao powder, cake and cocoa butter (Beg *et al.*, 2017). These products are largely used in the manufacture of chocolates, soaps, cosmetics, shampoo and other pharmaceutical products (Aya, 2017). In the country, cacao is considered as high value crop but the economic potential is still to be explored (Sumalde, & Quilloy, 2015). The Cagayan Valley area does not have an agricultural data that shows an extensive area suitable for cacao growing either as monocrop or intercrop. Its cultivation could promote an agro-industrial development for value-adding export products, as well as reduction of importation of cacao beans from countries like Indonesia, Papua New Guinea, and Malaysia (PCAARRD, 2000; Bertoldi *et al.*, 2017). Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (Aya, 2017) mentioned that to date, more than 75% of the cacao beans requirement of the country is imported from major producing countries.

Cacao, a popular, stable and marketable long-term beverage crop is widely planted under and between stands of coconut trees. To be a compatible and productive intercrop, cacao tree is best planted not closer than two (2) meters from the base of mango trees, at three (3) meters between hills and three (3) meters between rows.

The growth of two of more crop species simultaneously in the same field during a growing season, defined as intercropping has many advantages over sole cropping. Intercropping is receiving increasing attention as it offers potential advantages for increasing sustainability in crop production. Thus, greater yield stability and land use efficiency including better use of growth resources are derived from intercropping. Moreover, intercropping increased competition between crops and weeds for nutrients and light. In some cases, the output of one crop may be increased through a decline in the production of the other (Dimitrios *et al.,* 2010; Stagnari *et al.*, 2017) As cited by Requita (2003); Parvez *et al.*, agricultural land appears to be no longer viable with fast growing population unless intercropping is adapted. Intercropping system appears to a productive and useful approach to small and subsistence farmers (Pros and Cons; 2015; HAMBURDA, MUNTEANU & TELIBAN, 2015; Gebru, 2015). It provides the farm with variety of returns from the land, often increases the efficiency of resources utilization, increase productivity, yield stability and reduce the risk from total crop failure of the farmer. It can also help reduce erosion and maintain soil fertility especially when legumes are grown in association with the cereal crops.

Growing of intercrops in cacao (*Theobrama cacao*) based areas produces more food and agricultural products, ensuring food security of the people in rural and urban areas. The intercropping practice generates jobs and livelihood, enhancing farm incomes and the purchasing power of people, thus alleviating poverty in farming communities (Magat, 2004; Mango *et al.*, 2018; Singh, 2018).

In Cagayan Valley Region, Lal-lo, in particular no study has been conducted to determine the economic importance of intercropping high value crops to fruit trees like specifically in mango and cacao. Thus, this study was conceived.

Thus, this study was conducted to establish demonstration farm for cacao integrated multi-story cropping system and to show case its economic potential. Specifically, it aimed to determine the following: the plant height (cm), number of leaves, survival rate (%), leaf area indeces of glutinous corn and *mungbean,* pods of *mungbean,* length of corn ear, yield per plot (kg) and return of investment (ROI).

Materials and methods

The study was conducted from June 2017 to March 2018 at Cagayan State University Lal-lo, Cagayan.

Experimental design and treatments

The Randomized Complete Block Design (RCBD) was used in the study. A field with an area of 1,820sq.

meters (70m x 26m) including spaces between blocks and plots was divided into three (3) equal blocks with two (2) meters space between blocks to represent the three (3) replications. Each block was divided into three (3) equal plots with one (1) meter space between plots to represent the three (3) treatments. The treatments were labelled as: T1-Control (without intercropped), T2- Cacao + Glutinous corn; and T3-Cacao + Mungbean.

The area was cleaned, measured and boundaries were established. After the final harrowing, the area was laid out following the desired measurement and design per treatment.

Cacao Farm Establishment

Planting points were marked with sticks using suitable size and length of wire or guide from straight line planting. The right time to plant is during early morning or late afternoon. The grafted cacao seedlings were planted in the area with a distance of three (3) meters between rows x four (4) meters between hills. It is plant seedlings with young and soft flush leaves were for transplanting susceptible to sunburn, planting shocks or stress. A hole of 30cm wide x 30cm long x 30cm deep was prepared enough to accommodate the ball of the soil mass. The surface of soil should be separated from the sub-soil.

For glutinous corn and mungbean, the seeds were planted at recommended rate per hill at a distance of between hills and rows and the depth of and covered with fine soil and fertilization was based on the result of soil analysis. Cacao plants and intercrops were maintained by watering (if needed), by manual ring weeding; and by managing pest and diseases.

Data gathered

The data on the plant height (cm), number of leaves, survival rate (%), leaf area indeces of glutinous corn and *mungbean,* pods of *mungbean,* length of corn ear, yield per plot (kg) and return of investment (ROI) were gathered, analyzed and analysed using the Analysis of Variance (ANOVA) of Randomized Complete Block Design (RCBD).

Results and discussions

Table 1 shows the Cacao Plant height (cm), number of cacao leaves and survival rate (%) of cacao seedlings intercropped with glutinous corn and *mungbean* production at 30, 60, 90, 120, 150 and 18180 days after transplanting (DAT).

The tallest cacao plants (37cm, 42cm, 45cm, and 51cm) were registered at 30, 60 90 to 120 days after transplanting (DAT) when intercropped with mungbean, however at 150 to 180 DAT, cacao seedlings intercropped with glutinous corn and mungbean gave comparable plant height.

Consistently, results revealed that the most number of leaves were obtained by cacao seedlings intercropped with glutinous corn, followed by cacao seedlings intercropped with mungbean and cacao seedling without intercropped with a means of 22, 25, 26, 26, 28 and 29, respectively. The number of leaves of cacao plants without any intercropped was ranging from only from 11 to 20 leaves at increasing trend from 30-180 days, respectively. Ultimately, the number of leaves of grafted cacao seedlings at 180 DAT revealed that the most number of leaves were obtained by cacao intercropped with glutinous corn, followed by cacao seedlings intercropped with mungbean and cacao seedlings without intercropped with a means of 27.93, 22.03 and 19.70, respectively. However, numerical differences among treatments on this parameter did not prove any significant result as evidence in the Analysis of Variance. According to Adeyemi, A. *et al.* (1999) the number of leaves in cacao with intercropped was also higher than or similar to that in pure stands. According to Ebenezer Mensah *et al.* (2013) and Ogunrinde 2006 this might have facilitated the green pigment of seedlings which is the primary absorber of light energy responsible for photosynthesis, thud helps in stimulation of rapid and vigorous vegetative growth, increasing seedlings height, leaf area and dark green color of seedling leaves.

Interesting to note that the result of survival rate of transplanted cacao seedlings from 30 to 120 days after transplanting (DAT) was consistently significantly

highest in cacao intercropped with glutinous corn followed by cacao intercropped with mungbean. From 30 to 120 DAT, intercropping, regardless of the crop provided a significantly good effect on the plant recovery as shown by 91 to 100% survival rate when compare to 52-55% survival rate of cacao plants without any intercropped. This is supported by the ANOVA at 5% level, thus supported with the least significant difference test among treatments indicated that cacao was not significantly different from cacao seedlings intercropped with glutinous corn and cacao seedlings intercropped with mungbean.

A very good data on survival rate of transplanted cacao plants at 180 DAT intercropped with glutinous corn gave highest survival rate mean of 94.44% followed by transplanted cacao plants intercropped with mungbean with a mean of 77.77% and by transplanted cacao plants without intercropped with mean of 53.70%.

According to Adeyemi, A., *et al.* (1999) the survival rate of intercropped cacao was as good as or better than without any intercropping. Thus, the various crops are encouraged to be accompanied by the cacao plants in early stage of its establishment (Belel, M.D. *et al.,* 2014 and However, numerical differences among treatments on this parameter did not prove any significant result (ANOVA)

According to Adeyemi, A (1999) and Dunmola, Omobowale, & Iyabo (2015) the number of leaves in intercropped cocoa was also higher than or similar to that in pure stands. According to Arthur, Acquaye & Dogbatse (2019) and Isaac *et al.* (2007) which might have facilitated the green pigment of seedlings which is the primary absorber of light energy responsible for photosynthesis, helps in stimulation of rapid and vigorous vegetetative growth, increasing seedlings height, leaf area and dark green color of seedling leaves.

Table 1. Plant height (cm), number of cacao leaves and survival rate (%) of cacao seedlings intercropped with glutinous corn and *mungbean* production at 30, 60, 90, 120, 150 and 180 days after transplanting (DAT).

Treatment	Days after transplanting																	
	30	60	90	120	150	180	30	60	90	120	150	180	30	60	90	120	150	180
	Cacao Plant height (cm)						Number of cacao leaves						Survival rate of cacao seedlings					
T1- cacao without intercropped	33	37	42	47	51	56	11	14	16	17	18	20	55b	52b	52b	72	59	53.7b
T2- cacao + glutinous corn	34	38	44	49	54	57	22	25	26	26	28	29	100a	100a	99a	98	94	94.4a
T3- cacao + mungbean	37	42	45	51	54	57	13	16	18	18	20	22	100a	93a	91a	79	79	77.7ab
Statistical inference	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	*	*	*	ns	ns	*
CV (%)	9.3	7.3	7.4	5.5	5.7	5.1	58.4	48.6	51.5	55.5	50.8	32.4	6.5	8.8	9.6	19.	16.2	14.3

Means in a column with the same letter are not significantly different at 5% level, LSD.

Table 2. Leaf area index (LAI) of cacao seedlings, yield and rReturn on investment (ROI) income on newly established cacao plantation intercropped with glutinous corn and mungbean. Cagayan State University, Lal-lo, Cagayan. August 2017- March 2018.

Treatment	leaf area index (LAI)	Yield (kg)	ROI(%)			
			Gross Income (P)	Total Cost of Production (P)	Net Income (P)	ROI (%)
T1- cacao without intercropped	143.74	0	0	9349.2	0	0
T2- cacao + glutinous corn	193.20	3947.16a	177622.0a	43080.2	134541.1a	312.3a
T3- cacao + mungbean	159.12	372.16b	89318.4 b	41648.8	47669.5b	114.1b
Statistical inference	ns	ns	*	*	*	*

Means in a column with the same letter are not significantly different at 5% level, LSD.

Table 2 shows the result of leaf area index (LAI) yield and return on investment (ROI) income on newly established cacao plantation intercropped with glutinous corn and mungbean.

Results revealed that cacao seedlings intercropped with glutinous corn obtained the highest LAI with a mean 193.20cm² followed by cacao seedlings intercropped with mungbean with a mean 159.12cm² and cacao seedlings without intercropped with a mean 143.74cm². However, numerical differences among treatments on this parameter did not prove any significant result as evidence in the Analysis of Variance (ANOVA).

Based on the study of Addo-Quaye, A. *et al.* (2011) and Dwivedi *et al.* (2015) under non drought conditions, each leaf has a well-define growth rate, which is a function of temperature and maximum leaf area. Competition for resources e.g., water could possibly be the most important growth resources in this trial that limited LAI. In addition, according to Agbeniyi *et al.* (2010) and Ibiremo *et al.* (2017) high nitrogen concentration found in the leaves of hybrid cacao seedlings stimulate rapid vegetative growth and give a bigger leaf area, but the leaf area of intercropped was comparable with or superior to the control in all cases (Adeyemi, A. 1999; Weerarathne, Marambe & Chauhan, 2017).

The average yield (kg) of glutinous corn and mungbean per plot produced the highest yield among the varieties with a mean of 3947.16kg per plot and *mungbean* with a mean of 372.16kg per plot. Analysis of variance revealed significant differences among treatments. The Least Significant Difference Test among treatments indicated that cacao seedlings intercropped with glutinous corn was significantly different to grafted cacao seedlings intercropped with mungbean.

For the return on investment (ROI), an area of 1,820 square meter CSU land, the highest net income of Php 13451.67 was obtained by cacao seedlings intercropped with glutinous corn (T_2) with a return on investment (ROI) of 312.30 percent and the lowest net income was obtained by cacao seedlings intercropped with mungbean (T_3) with Php 46669.55 and return of investment (ROI) 112.05%. This corroborates with the study of Dasgupta, P. (2016) that growing cacao as an intercrop increases yield and farmers profitability per unit area.

Conclusion

Generally the study aimed to determine the growth and economic potential of grafted cacao seedlings intercropped with glutinous corn and mungbean in terms of plant height, number of leaves, survival rate, leaf area index, plant height of glutinous corn and mungbean, pods of mungbean, length of corn ear, yield per plot (kg) and gross margin analysis. Based on the result of the study, it is concluded that cacao + glutinous corn had the tallest cacao plants, the highest number of leaves and leaf area index, most survived plants, highest net income, and return of investment (ROI).

Recommendation

Based on the result of the study, a newly established cacao farms can be intercropped with glutinous corn in the locality to obtain immediate income in its first six months of establishment. It is further recommended that another trial must be conducted to give more conclusive results; another research and observations must be conducted using other higher value crops as intercrops.

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