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Research on Sustainable Cassava Cultivation Methods on Gray Soil in Gia Lai Province, Vietnam

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***Abstract*— Cassava is popular crop in many countries in over the world, and each area has particular cultivation method that suit with natural and socioeconomic conditions, special with properties of soil resources. The results from field experiments on gray soil at Gia Lai province, Vietnam, show that the formula of combination between chemical and organic fertilizer (manure or microbial fertilizer) are the most suitable and the measurement about height of plant, root diameter, weight and size of tubers, productivity, starch content are high. The cultivation methods to fight against erosion and to project of soil also show that the intercropping formula between cassava and legumes is the optimal choice for gray soil. After two years, soil physical and chemical properties are improved and weight of soil was lose by erosion decreased.**

***Key Words*— Cassava, Vietnam, Cultivation Method, Gray Soil, Intercropping.**

I. INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a food crop, food, animal feed, starch processing and is the main raw material for processing biofuels which have competitive advantage for many countries in the world [1]. In Vietnam, cassava is an important food crop, production of cassava ranks third after rice, corn and it is considered as the main fuel for bioethanol production. Cassava is also a choice of many poor households, people in infertility soil, many processing and business companies, because of cassava is easy to plant, less care, low cost, easy to harvest and processing [2], and cassava cultivation can achieve high profits.

Gia Lai province has about 60,000 ha for planting cassava is practiced mainly on the extensive, monoculture for many years, only material regions of plants are investment intensive. Gia Lai terrain is mainly hilly, steep slopes, large annual rainfall and high intensity level, therefore can cause soil erosion, degradation and bad effects on growth, development and productivity of crops, special is cassava.

Study on application of cultivation methods to fight against infertility and degradation of soil, as well as to protect fertility of soil for cassava has been perform very effective in the world as well as in many local of Vietnam, but is still relatively new at region of Tay Nguyen, Vietnam. Therefore, in order to contribute for sustainable development, the research on protection of fertility for gray soil in Gia Lai province is very necessary.

II. METHODS

This research performs study on effects of cultivation methods on growth of cassava, as well as economic effective and soil security. Formulas were set on gray soil in Ia Le commune, Chu Puh district, Gia Lai province, Vietnam in two years 2012 and 2013. Experiment was repeated four times under the type of random block fully. Cassava species VN 21-12 is used to study.

1. Setup of formula

Experiment 1: Study on fertilizer regime for cassava

- Formula 1 (C1): Unfertilizer
- Formula 2 (C2): Chemical fertilizer (80 N - 40 P_2O_5 - 80 K_2O)
- Formula 3 (C3): 5 tonnes manure (22,3% OM; N-P-K = 0,37 - 0,12 - 0,42)
- Formulaiton 4 (C4): 5 tonnes manure and chemical fertilizer (80 N - 40 P_2O_5 - 80 K_2O)
- Formula 5 (C5): 1 ton microbial compounds (15% OM; N-P-K = 1-1-1; Nitrogen-fixing and phosphate-solubilizing bacteria > 10^6 CFU/g)
- Formula 6 (C6): 1 ton microbial compounds and chemical fertilizer (80 N - 40 P_2O_5 - 80 K_2O)

Experiment 2: Study on solution to soil protection

- Formula 1 (E1): Only grow cassava
- Formula 2 (E2): Cassava + band of Muong plant has yellow flowers large nuts (Crotalaria striala DC)
- Formula 3 (E3): Cassava + band of Muong plant has yellow flowers small nuts (Crolataria usaramoensis)
- Formula 4 (E4): Cassava + band of Dau san (Cajanus indicus Spreng)

2. Measurement

- Height of plant; Root diameter; Weight and size of tubers; Productivity; Starch content.
- Weight of land erosion; Soil fertility before and after the experiment.

III. RESULT AND DISCUSSION

1. Effect of fertilizer on cassava growth

Fertilizer, is an important factor, has decided to growth, development and productivity of cassava [3]. The C1

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formula show that cassava is less growth, after 6 months average height of cassava is 170.45 cm, average root diameter is 18.1 mm. The C3, C5 formula are only use manure leads to average height of cassava is 178.2 – 179.3 cm, average root diameter is 18.2 – 18.3 mm after 6 months, and they are better than C1 formula, but still are low level. Cassava in C2 formula with chemical fertilizer is growth better than it in C1, C3, C5 formula, and the height of cassava is 187.3 cm, root diameter is 18.4 mm. After 6 months, growth and development of cassava are the best in C4 and C6 formula with average height of cassava is 191.8 – 193.5 cm, average root diameter is 19.3 – 19.5 mm, because we mix balanced between manure and chemical fertilizer.

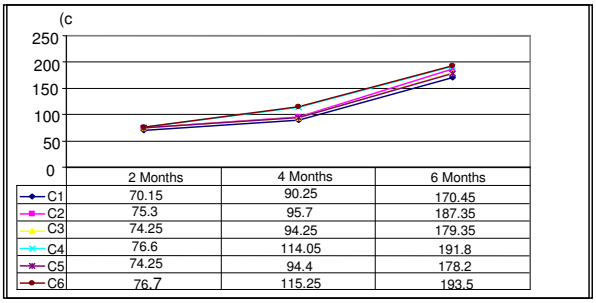

Chart 1. Effect of fertilizers on cassava height (cm)

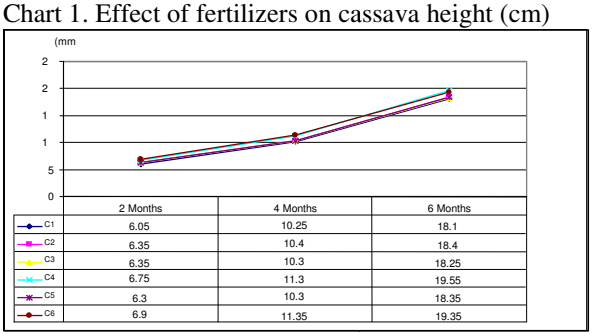

Chart 2. Effect of fertilizers on root diameter (mm)

2. Effect of fertilizer on weight and size of cassava tubers

Result of Table 1 and Table 2 show that: Weight and size of cassava tubers are the lowest in C1 formula with 254.6 g/tuber and diameter 30.1 cm. Fertilization has an efficiency to improve the quality of cassava tubers, make bigger and heavier, whereby the effect of chemical fertilizer is higher than manure or microbial fertilizer. The formula of combination between chemical and organic fertilizer (manure or microbial fertilizer) have increased weight and size of tubers with 279.8 – 280.7 g/tuber and diameter 33.9 – 34.0 cm.

Table 1. Effect of fertilizer on weight of tubers (g/tuber)

Formula	Year 2012	Year 2013	Average
C1	256.2	252.9	254.6
C2	271.8	272.4	272.1
C3	263.3	263.4	263.4
C4	279.4	280.1	279.8
C5	263.2	263.6	263.4
C6	280.2	281.1	280.7
$LSD_{0.05}$	0.33	2.33	0.73
CV%	3.4	3.9	3.6

Table 1. Effect of fertilizer on diameter of tubers (cm)

Formula	Year 2012	Year 2013	Average
C1	30.2	30.0	30.10
C2	32.2	33.0	32.60
C3	31.3	31.8	31.55
C4	33.8	34.1	33.95
C5	31.3	31.4	31.35
C6	33.9	34.2	34.05
$LSD_{0.05}$	0.22	0.52	0.43
CV%	4.4	4.8	4.6

3. Effect of fertilizer on productivity and quality of tubers

The study results show that, after 2 years, the average highest productivity of fresh cassava tubers is 34.35 tonnes/ha in C6 formula, followed is respectively in the C4 formula (34.20 tonnes/ha), C2 formula (33.75 tonnes/ha). The productivity of fresh cassava tubers in C3 formula and C5 formula are equal with 31.40 tonnes/ha. The lowest average productivity of fresh cassava tubers is 26.55 tonnes/ha in C1 fomula because this is unfertilizer formula.

Fertilizer in different formulas can increase productivity of fresh cassava tubers from 19.8 to 30.8% compared with control formula - C1. Therein, in the C3 and C5 formula, the productivity can increase 4.85 tonnes/ha corresponding 19.8%; in the C2 formula that use chemical fertilizer can increase 7.2 tonnes/ha corresponding 27.2%. In mix formula of manure - chemical fertilizer can help cassava gets the best productivity with 34.2 – 34.4 tonnes/ha and 27.2 – 30.8% higher than control formula.

Table 2. Effect of fertilizer on productivity of fresh cassava tubers

Formula	2012 (ton/ ha)	2013 (ton/ ha)	Average	
			(ton/ha)	(%)
C1	26.8	26.3	26.55	100.0
C2	33.5	34.0	33.75	127.1
C3	31.3	31.5	31.40	119.8
C4	34.0	34.4	34.20	130.8
C5	31.3	31.5	31.40	119.8
C6	34.1	34.6	34.35	127.2
$LSD_{0.05}$	0.24	0.50	0.347	
CV%	8.3	9.2	8.7	

If only use chemical fertilizer, starch content is not improved, even also has decreased trend compared with control formula. Starch content increased on 1.2 – 1.6% by using organic fertilizer. Special, the use of chemical fertilizer combination with manure or organic fertilizer can ameliorate starch content which is higher 2.6 – 2.8 % than control formula.

Table 3. Effect of fertilizer on starch content (%)

Formula	Year 2012	Year 2013	Average
C1	23.4	22.8	23.1
C2	22.9	22.2	22.6
C3	25.7	23.6	24.7
C4	26.8	25.0	25.9
C5	25.1	23.5	24.3

C6	26.6	24.8	25.7

4. Study on cultivation methods to fight against erosion and to protect of soil for cassava

4.1. Effect of cultivation methods on soil erosion

Result of monitoring show that: If practice without methods to fight against erosion (E1 formula) on slope 7°, weight of soil was washed is quite large with 19 tonnes/ha.

The intercropping formula between cassava and legumes such as: Muong plant has yellow flowers large nuts, Muong plant has yellow flowers small nuts, Dau san limited weight of soil was washed because of erosion occur on cassava terrace field. With E2, E3, E4 formulas the weight of washed soil were decreased from 34.2 – 35.3% compared with control formula.

Table 4. Effect of cultivation methods on soil erosion

Formula	Slope (°)	Year 2012 (ton/ha)	Year 2013 (ton/ha)	Average	
				(ton/ha)	(%)
E1	7	18.5	19.5	19.0	100.0
E2	7	12.5	12.1	12.3	64.7
E3	7	12.6	12.3	12.5	65.8
E4	7	12.5	12.4	12.5	65.8

4.2. Effect of cultivation methods to fight against erosion on cassava growth

In E1 formula, growth of cassava is the worst, after 6 months, the average height of plant is 135.5 cm and average root diameter is 16.1 mm. In E2, E3, E4, the average height of plant is from 160.3 cm to 169.4 cm, average root diameter is 17.3 mm.

There are not large difference in intercropping formulas.

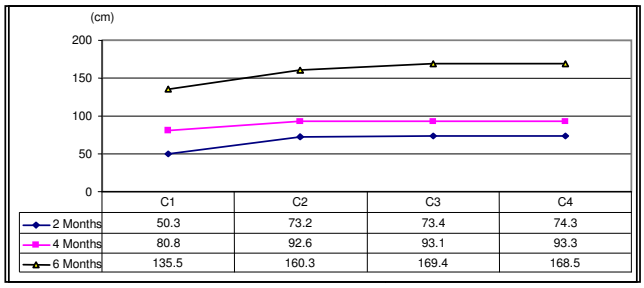

Chart 3. Effect of cultivation methods to fight against erosion on cassava height (cm)

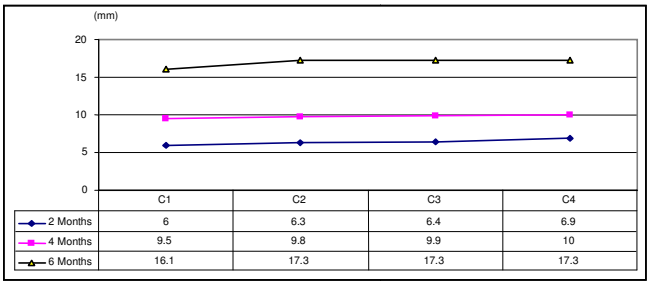

Chart 4. Effect of cultivation methods to fight against erosion on root diameter (mm)

4.3. Effect of cultivation methods to fight against erosion on weight and size of tubers

The methods of intercropping between cassava and legumes limited soil erosion and nutrition leaching, helped to create cassava tubers more favorably. Therefore, weight and size of tubers in E2, E3, E4 formula are higher than in control formula - E1.

Table 5. Effect of cultivation methods to fight against erosion on weight of tubers (g/tuber)

Formula	Year 2012	Year 2013	Average
E1	262.2	261.9	262.1
E2	267.2	268.4	267.8
E3	265.2	267.4	266.3
E4	268.4	269.9	269.2
$LSD_{0,05}$	0.05	1.57	0.24
CV%	0.9	1.2	0.9

Table 6. Effect of cultivation methods to fight against erosion on root diameter (cm)

Formula	Year 2012	Year 2013	Average
E1	31.1	30.7	30.9
E2	32.2	32.5	32.4
E3	32.3	32.6	32.5
E4	32.4	32.6	32.5
$LSD_{0,05}$	0.01	0.73	0.27
CV%	1.8	2.8	2.3

4.4. Effect of cultivation methods to fight against erosion on cassava productivity and quality of tubers

In cultivation formula without soil protection methods, cassava productivity is only 30 tonnes/ha. Although against erosion plant bands take a place in area for cassava, the growth and productivity of cassava are relative high, so total of production is higher than control formula. Productivity of cassava in E2, E3, E4 formula is from 32.0 to 32.5 tonnes/ha, and 7 – 8% higher than E1 formula.

Table 7. Effect of cultivation methods to fight against erosion on cassava productivity

Formula	2012 (ton/ha)	2013 (ton/ha)	Average	
			(ton/ha)	(%)
E1	30.0	30.0	30.0	100
E2	32.0	32.0	32.0	107
E3	32.3	32.3	32.3	108
E4	32.5	32.5	32.5	108
$LSD_{0,05}$	0.01	0.16	0.23	
CV%	3.3	3.3	3.3	

There are not significant change of starch content among intercropping formulas.

Table 8. Effect of cultivation methods to fight against erosion on starch content (%)

Formula	Year 2012	Year 2013	Average
E1	25.6	24.7	25.2
E2	25.5	24.5	25.0
E3	25.8	24.7	25.3
E4	25.5	24.8	25.2

4.5. Effect of cultivation methods to fight against erosion on soil fertility

Feralic gray soil (Feralic Acrisols) was utilized in this study, which has acidity reaction, medium organic and nitrogen content, less dissolved phosphate and potassium, low CEC, less Ca^{2+}, Mg^{2+} [4]. After two years, general, acidity of soil has increase trend and Ca^{2+}, Mg^{2+} content have decrease trend in all of formula. Content of organic matter, nitrogen, phosphate, potassium and CEC are decrease in control formula, but are quite stabilized in intercropping formulas.

Table 9. Soil chemical properties before and after the experiment

Formula		pH_{KCl}	Total (%)		Dissolved (mg/100g)		Exchange (me/100g)		
			OM	N	P_2O_5	K_2O	Ca^{2+}	Mg^{2+}	CEC
E	Before	4.3	2.18	0.116	3.1	11.5	2.1	1.8	8.9
	After	4.3	2.11	0.112	2.9	10.9	1.8	1.6	8.2
E	Before	4.3	2.19	0.114	3.0	11.3	2.1	1.6	9.1
	After	4.2	2.24	0.118	3.2	11.6	1.8	1.5	9.3
E	Before	4.4	2.16	0.115	3.1	11.4	2.1	1.6	9.0
	After	4.3	2.25	0.118	3.2	11.8	1.9	1.3	9.3
E	Before	4.4	2.18	0.116	3.2	11.4	2.1	1.7	8.8
	After	4.4	2.24	0.119	3.5	11.7	1.9	1.7	9.2

In physical properties of soil, soil has high bulk density and density, and medium porosity. After two years, physical properties in control formula are change direction unfavorable to the growth of crops, such as: increased bulk density and density, porosity reduction. The intercropping between cassava and legumes can stabilize and improve soil properties [5].

Table 10. Soil physical properties before and after the experiment

Formula		Bulk density (g/cm^3)	Density	Porosity (%)
E1	Before	1.24	2.73	54.6
	After	1.28	2.75	55.3
E2	Before	1.25	2.72	54.0
	After	1.22	2.71	55.0
E3	Before	1.24	2.74	54.7
	After	1.22	2.72	55.1
E4	Before	1.26	2.74	54.0
	After	1.23	2.71	54.6

IV. CONCLUSION

In gray soil at Chu Puh district, Gia Lai province, Vietnam, the use of fertilizer worked improvement on cassaca productivity quite clever. Therein, the combination between chemical and organic fertilizers (manure or microbial fertilizer) has more efficient than use of each fertilizer individual. The suitable formula is C4: 5 tons manure + (80 N - 40 P_2O_5 - 80 K_2O).

In the gray soil, bands of Muong plant has yellow flowers large nuts, Muong plant has yellow flowers small nuts, Dau san have an efficiency to protect fertility of soil, fight against erosion, decrease weight of washed soil from 19.5 tonnes/ha down to 12.3 – 12.5 tonnes/ha. Thence, soil was stabilized fertility and the growth and development of cassava are very well, as well as productivity of cassava is high and stabilized in next years.

REFERENCES

[1] Fermont A.M., Van Asten P.J.A., Giller K.E.(2008), *Increasing land pressure in East Africa: The changing role of cassava and consequences for sustainability of farming systems*, Agriculture, Ecosystems&Environment, Volume 128, Issue 4/2008, pp 239 -250.

[2] Duong Hong Da (2004), *Cassava - food crops has been a change in industrial crops*, Publishing House of Labor and Society.

[3] Trinh Cong Tu (2007), *Study on cassava cultivation methods in Dak Lak and Dak Nong*, Journal of Agricultural Science and Technology, Vol.4 (5)/2007.

[4] Trinh Cong Tu (2006), *Study on building of application model of methods to prevent degradation, unfertility, erosion and to ensure that intensive cassava is suitable development in Dak Lak province*, Final report of of research project level province.

[5] Nguyen Cong Vinh, Mai Thach Hoanh, Tran Thi Tam (2002), *General management soil fertility for intensive farming,* Publishing House of Agricultural.

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