

Cassava Soil Fertility Management Technology at Yen Binh District Yen Bai Province, Vietnam

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Abstract: *In both mother and baby trials, cassava starch yield of treatment # 5 (medium rate) is highest in compared with control 2 as farmer practice with values are 6.99 and 6.8 tons per ha, respectively. The NRoI of treatment # 3 as “300 kg NPK Lam Thao 12:5:10” is highest at value of 7.47, means that for every 100,000 VND invested in fertilizer, the farmer will receive 747,000 VND in increased yield (profit). The treatment # 2, a farmer practice (control 2) as “300 kg per ha of NPK Lam Thao 5:10:3” have highest NRoI of 5.41 and 5.34, indicating the reason why local farmers there used to apply that fertilizer rate. Balanced application with medium rate as “300 kg NPK (5:10:5) + 147 kg Urea+ 158 kg KCL” gained highest root yield, and application of “300 kg NPK Lam Thao 12:5:10” could gain highest NRoI, are considered as CSA technologies on soil fertility management for cassava production. Therefore, we would like to recommend the farmers applying this NPK compost for cassava production.*

Keywords: *Cassava fertilization; NPK compost; cassava fresh root yield; cassava starch yield; climate-smart agriculture technology.*

1. INTRODUCTION

Cassava is an important cash crop, contributing farmer's income at the research site, a Root-Tuber-Bananas CRP Post-harvest project (RTB project). The RTB project works on livestock feeding with cassava starch processing residues and crop management to increase cassava production at communes of Vinh Kien and Phuc An (Yen Binh district, Yen Bai province, Northern Vietnam). The crop is an economically important crop for local smallholder farmers at the mentioned research site, where cassava is more important than rice, field crops have no production competition and forestry production is dominant based on diversified topography and steep lands. In that condition, it is obvious that indigenous knowledge in cassava production and practice plays an important role in the development of a sustainable and adaptive agriculture. Cassava farmers there are selling fresh roots to not only small-scale wet starch processors based at the research site, but also for Yen Binh dried starch factory located on Vu Linh commune nearby. It looks that the research site has disadvantages in agricultural production, due to almost agricultural lands are now under the Thac Ba lake, a hydro-power reservoir constructed in 70-year of last 20th century. The total natural lands of research site are 5,300 ha, but agricultural land is small, only 760 ha, occupy 14.3%. Of which, cassava area is 400 ha, rice area is 305 ha, maize area is 140 ha. Forestry lands are 3,254 ha, occupy 61.4% of the total natural lands, lake area within research site is 1,332 ha. The research site comprises 2,220 households with 9,200 residents, including four ethnic groups such as Kinh, Cao Lan, Dao and Thai (Duong Van Son et al. 2016).

Local farmer practice in cassava intercropping with forest trees such as acacia and eucalyptus under agro-forestry system seems to be as an appropriate choice for the site, is climate-smart agriculture (CSA) practices and technologies (FAO, 2013). Under the agro-forestry system, forest trees (acacia, eucalyptus) and cassava are good friends, their relationship seems very good and the farming system is sustainable (Duong Van Son et al. 2016).

Integrated cassava CSA technologies and practices seem to be as smart choice for sustainable agricultural production. The paper describes cassava soil fertilizer management technology, an intervention of the RTB project for cassava production, is as one of the CSA technologies in small-scale farming. It would be nice if we have more cassava CSA options, focusing on the combination of indigenous knowledge and new technologies for integrated CSA technologies and practices to enhance adaptive capacity among local farmers and stakeholders in cassava production.

2. METHODS

The fertilizer trials were conducted at two communes of Vinh Kien and Phuc An, a RTB project site of Yen Binh district, Yen Bai province, Northern Vietnam, in cropping year of 2015. Cassava variety is used for the trial is Sa21-12, a best variety locally. Fertilizer treatments include: NPK Lam Thao 5:10:3, NPK Lam Thao 12:5:10, Urea: 46% N, KCL: 52% K. Trial treatments and amount of fertilizers per ha are (1) Treatment # 1: No fertilizer (Control 1), (2) Treatment # 2: 300 kg NPK Lam Thao 5:10:3 is as farmer practice - control 2), (3) Treatment # 3: 300 kg Lam Thao 12:5:10, a new NPK compost, (4) Treatment # 4: Low rate (aimed at cassava yield of 20 tons per ha) with balance 300 kg NPK Lam Thao 5:10:3 + 98 kg Urea + 105 kg KCL, (5) Treatment # 5: Medium rate (aimed at cassava yield of 30 tons per ha) with balance of 450 kg NPK Lam Thao 5:10:3 + 147 kg Urea+ 158 kg KCL, and (6) Treatment # 6: High rate (aimed at 40 tons of cassava fresh root per ha) with balance of 600 kg NPK Lam Thao 5:10:3 + 196 kg Urea + 211 kg KCL. Fertilizer application includes basal application, first top dressing and second top dressing. Basal application: 100% NPK Lam Thao. First top-dressing: apply 50% of Urea and KCL at 50 DAS. Second top-dressing: apply the remaining of Urea and KCL at 90-100 DAS.

In each commune, the experiment includes mother trials and baby trials. Each mother and baby trial comprises six mentioned fertilizer treatments. The mother trial was designed with four replicates, plot size = 5m x 6m = 30 m² (6 plants, 5 rows), total mother trial area is 6mx 4m x 30 m² = 720 m². There are at least four baby trials in each commune. Each treatment needs the plot size is 6m x 5m = 30 m² (6 plants, rows 5), so the area of each baby trial is 180 m², therefore, total area of 4 baby trials is 4 x 180 m² = 720 m², same size as mother trials. Planting space is 1m x 1m, or planting density is 10,000 plants/ha. In both mother trial and baby trial plants 30 plants per in each plot.

Fertilizer application: Basal application will be able to apply with NPK Lam Thao compost during planting time. All required P would be mobilized from the basal application. First application and second application will be used with single N and K. of which, ½ for first application and remainder (½) for second application.

Data does collect in both mother trial and baby trial for comparison, including fresh root yield, starch yield and net return on fertilizer investment (NRoI). Cost of fertilizers, fresh root price does collect for calculation of NRoI at cassava harvest. Formula for the NRoI calculation is following:

$$NRI = \frac{\text{Value increase from fertilizer} - \text{Total fertilizer cost}}{\text{Total fertilizer cost}}$$

3. RESULTS AND DISCUSSIONS

3.1. Fresh Root Yield

Data in the table 1 shown that fresh root yield of all proposed fertilizer treatments in both mentioned two communes looks to be equal, in Vinh Kien is 26.36 tons per ha and in Phuc An is 26.55 tons per ha, indicating that the trials were designed and controlled well. There are some differences on fresh root yields in mother and baby trials within two mentioned communes. For mother trials, it looks that, fresh root yield of all fertilizer treatments at Phuc An is 30.87 tons per ha, higher Vinh Kien (26.6 tons per ha). But baby trial is contrary, fresh root yield of all treatments in the baby trial conducted at Vinh Kien is 26.13 tons per ha, higher its yield at Phuc An (only 22.59 tons per ha). It implies that it is necessary to conduct both mother and baby trials at the research site, where have diversified topography and soil, ensuring the accuracy of measurement.

Data in the table 1 shown that, all of the fertilizer treatments tested at both mother and baby trials, and both two communes did increase cassava fresh root yields compared to the control 1 (no fertilizer treatment) at least significant difference 95% (LSD.05), indicating that nutrient depletion is already a problem in relatively cassava fields in research sites at Yen Binh district, Yen Bai province.

Note that, it would be good to group the sites by soil and land characteristics before doing more detailed statistical analysis. Actually, for this, we do not have data about soil analysis, simply that it maybe does not mean within the research sites characterized by diversified topography and steep lands.

Analyzed by commune, it looks that, in Vinh Kien, all proposed fertilizer treatments in both mother and baby trials have fresh root yield higher than farmer practice (control 2) at LSD (.05). However, in Phuc An, it is the same rule as data in Vinh Kien with treatment # 4, # 5 and # 6, but treatment # 3 in

mother trial is 29.15 tons per ha, lower than the farmer practice as control 2 at -0.38 tons per ha. Especially, treatments # 3 and # 4 have fresh root yield is 23.88 and 22.24 tons per ha, respectively, the same yield as farmer practice at LSD (.05). In both two communes, the fresh root highest yield is treatment # 5 (medium rate) at Vinh Kien is 32.05 tons per ha, Phuc An is 33.73 tons per ha, and average two communes is 32.89 tons per ha (table 1).

Table1. Cassava fresh root yield (t/ha) by fertilizer treatments

Fertilizer treatments	Vinh Kien			Phuc An			Average (treatments)
	Mother	Baby	Average	Mother	Baby	Average	
(1) No fertilizer (Control 1)	15.35	17.19	16.27	21.15	14.67	17.91	17.09
(2) 300 kg/ha NPK 5:10:3 (Farmer practice - Control 2)	22.67	23.04	22.86	29.53	19.61	24.57	23.71
(3) 300 kg NPK 12:5:10	29.65	27.92	28.79	29.15	23.88	26.51	27.65
(4) Low rate + balance	30.00	28.17	29.08	33.76	22.24	28.00	28.54
(5) Medium rate + balance	32.10	32.00	32.05	37.93	29.53	33.73	32.89
(6) High rate + balance	29.80	28.47	29.14	33.68	25.63	29.66	29.40
Average (sites)	26.60	26.13	26.36	30.87	22.59	26.73	26.55
<i>P</i>	< 0.05	< 0.05		< 0.05	< 0.05		
<i>CV%</i>	9.1	10.7		8.3	16.1		
<i>LSD(.05)</i>	3.63	2.97		3.86	4.33		

In sum, balanced application with medium rate as “300 kg (NPK 5:10:5) + 147 kg Urea+ 158 kg KCL” gained highest root yield, is one of the cassava CSA technology on soil fertility management for cassava production.

3.2. Starch Yield

High fresh root yield does not mean high price for selling, due to it depends on starch content. The cassava processing factories are often paid fresh roots by starch content. In proposed fertilizer treatments, we would like to use the NPK Lam Thao compost (with NPK=12:5:10), a new NPK compost from a chemical fertilizer company produced in Viet Tri city, Phu Tho province. Actually, local farmers did apply NPK Lam Thao compost (with NPK=5:10:3) instead of single fertilizer like Nitrogen, Potassium or Phosphate for labour save and efficient use, even although the NPK ratio of NPK Lam Thao 5:10:3 currently still do not meet the nutrient requirement of cassava plant (due to low rate of K content). However, the use of NPK compost is a technology on soil fertility management. It was said that Potassium (K) is limiting, application of adequate levels of K fertilizer can increase starch content. Potassium is an essential plant nutrient and is required in large amounts for proper growth and reproduction of cassava plant. If cassava-processing factories are not getting enough fresh roots to run at full capacity, they could have incentive to provide credit for farmers to apply K fertilizer for their cassava production.

Table2. Cassava starch yield (t/ha) by fertilizer treatments

Fertilizer treatments	Vinh Kien			Phuc An			Average (treatments)
	Mother	Baby	Average	Mother	Baby	Average	
(1) No fertilizer (Control 1)	3.30	4.45	3.87	5.69	4.38	5.04	4.46
(2) 300 kg/ha NPK 5:10:3 (Farmer practice - Control 2)	4.89	5.67	5.28	8.80	5.92	7.36	6.32
(3) 300 kg NPK 12:5:10	5.61	6.67	6.14	8.34	7.24	7.79	6.97
(4) Low rate + balance	6.45	6.08	6.26	9.02	6.21	7.62	6.94
(5) Medium rate + balance	6.99	6.80	6.90	9.29	8.52	8.91	7.90
(6) High rate + balance	5.76	6.12	5.94	7.38	7.40	7.39	6.66
Average (sites)	5.50	5.96	5.73	8.09	6.61	7.35	6.54
<i>P</i>	< 0.05	<0.05		< 0.05	<0.05		
<i>CV%</i>	13.3	9.4		10.6	16.0		
<i>LSD(.05)</i>	1.10	0.76		1.29	1.26		

Data in table 2 shown that, generally starch yield of all fertilizer treatments conducted at Vinh Kien commue is lower than Phuc An not only in mother trial, but also in baby trial with values per ha are 5.5, 5.96, 8.09 and 6.61 tons per ha, respectively. Starch yield averagely of all fertilizer treatments at Vinh Kien is 5.73 tons per ha, lower than in Phuc An (7.35 tons per ha), indicating the complexity of

soil nutrient in cassava fields at research sites. Notes that in 2015 season, it met drought in mid cropping season, but in late season it is rainy, an unusual climate, so it could effect to starch movement within the cassava plant, causing the low of starch content, is as an obvious evidence of climate change, even cassava is considered as a resilient crop (Duong Van Son et al. 2016). It means that it would be nice if we do harvest later, about 1 month behind, mostly for higher starch yield.

Starch yield analyzed by commune, data in table 2 shown that, at Vinh Kien commune, both mother and baby trials, starch yield of treatment # 5 (medium rate) is highest in compared with control 2 (farmer practice) with values are 6.99 and 6.8 tons per ha, respectively at LSD (.05). Data in Phuc An is the same rule as treatment # 5 (medium rate) is highest starch yield with values respectively are 9.29 and 8.52 tons per ha.

In addition, when increasing different application rates from low, medium and high rate as proposed treatment # 4, 5 and 6, expecting starch yield increases, but in the contrast, the starch yield averagely within two mentioned communes is 6.94, 7.90 and 6.66 tons per ha respectively, indicating that the role of Potassium element in increasing starch content particularly, and fresh root yield generally.

3.3. Net Return on Fertilizer Investment

Before making recommendations to farmers about fertilizer application rates, we will need to get prices for fertilizers and manure and the selling price for roots so that we can calculate the net return (net income) on investment for the various fertilizer treatments. This is how much profit farmers get from more root sales after the cost of the fertilizer is paid back. The net return on investment is higher if the root price is higher. Since farmers do not know when they buy the fertilizer what the root price will be, there is risk in applying high rates of fertilizer. This is an area where good linkages between producers and processors (or traders) and arrangements that include minimum root prices or access to credit to buy fertilizers can help increase yields and benefit both farmers and factories.

Fertilizer application with difference rates can be able to analyze on economical aspect as net return on fertilizer investment (NRoI), indicating how about the profit the cassava farmer receive from their investment on fertilizer for their cassava production. Data in table 3 shown that value increase from fertilizer gained highest value at fertilizer treatment # 5 (medium rate) in both communes of Vinh Kien and Phuc An as values are respectively 20,512.7 and 20,565.7 thousands VND (1 USD = 22,200 VND), indicating that the higher fresh root yields, the higher value increase from fertilizer.

The NRoI of treatment # 6 as “high rate” is lowest, in Vinh Kien is 1.54, and Phuc An is 1.32, indicating that if the cassava farmers invested every 100,000 VND for cassava, they will receive 154,000 VND and 132,000 VND respectively (1 USD = 22,200 VND). Obviously the NRoI of treatment # 3 as “300 kg NPK Lam Thao 12:5:10” is highest at value of 7.47 for Vinh Kien commune, means that for every 100,000 VND invested in fertilizer, the farmer will receive 747,000 VND in increased yield (profit). The treatment # 2 as farmer practice (control 2) with 300 kg per ha of NPK Lam Thao 5:10:3 have highest NRoI of 5.41 in Phuc An, and second highest NRoI in Vinh Kien (with value of 5.34), indicating the reason why local farmers there used to apply that fertilizer rate (Duong Van Son et al. 2016). The high values of NRoI in the trials imply that the high competition of cassava production at research sites.

Table3. Value increase from fertilizer and NRoI by fertilizer treatments

Fertilizer treatments	Value increase from fertilizer (000 VND)			Net return on fertilizer investment (NRoI)		
	Vinh Kien	Phuc An	Average (2 communes)	Vinh Kien	Phuc An	Average (2 communes)
No fertilizer (Control 1)	0	0	0	-	-	-
300 kg/ha NPK 5:10:3 (Farmer practice - Control 2)	8,561.4	8,658.5	8,609.9	5.34	5.41	5.38
300 kg NPK 12:5:10	16,269.5	11,183.3	13,726.4	7.47	4.82	6.15
Low rate + balance	16,656.4	13,116.3	14,886.4	4.08	3.00	3.54
Medium rate + balance	20,512.7	20,565.7	20,539.2	3.16	3.17	3.17
High rate + balance	16,727.3	15,271.1	15,999.2	1.54	1.32	1.43

In addition, data in table 3 said that when increasing different application rates from low, medium and high rate (treatment # 4, 5 and 6), hoping fresh root and starch yield increases, but NRoI is contrary, decreasing averagely within mentioned 2 communes from 3.54 to 3.17 and 1.43, respectively, indicating economical aspect of 3 mentioned fertilizer treatments.

Shortly, application as “300 kg NPK Lam Thao 12:5:10” could gain highest NRoI, is as a CSA technology on soil fertility management for cassava production.

CONCLUSION AND RECOMMENDATION

All of the fertilizer treatments tested at both mother and baby trials, and both two communes did increase cassava fresh root yields compared to the control 1 (no fertilizer treatment), indicating that nutrient depletion is already a problem in relatively cassava fields in research sites at Yen Binh district, Yen Bai province. In both two communes, the highest fresh root yield is treatment # 5 (as medium rate), at Vinh Kien is 32.05 tons per ha, Phuc An is 33.73 tons per ha, and averagely two communes is 32.89 tons per ha.

In all mother and baby trials, starch yield of treatment # 5, medium rate as “300 kg NPK (5:10:5) + 147 kg Urea+ 158 kg KCL” is highest in compared with control 2 as “farmer practice” with values are 6.99 and 6.8 tons per ha, respectively. The application of balanced fertilizers, with adequate rate of Potassium in particular, seems to be necessary for high yields. Adequate levels of Potassium increase both root yields and starch contents, thus increasing starch yields (tons of starch per hectare). The consultation meeting between project team and the Chemical fertilizer Company in Phu Tho province (close-in Yen Bai province) will be worthwhile for production of the NPK compost with suitable NPK ratio for cassava plant.

The NRoI of treatment # 3 as “300 kg NPK Lam Thao 12:5:10” is highest at value of 7.47 for Vinh Kien commune, means that for every 100,000 VND invested in fertilizer (1 USD = 22,200 VND), the farmer will receive 747,000 VND in increased yield (profit). The treatment # 2 as farmer practice (control 2) with “300 kg per ha of NPK Lam Thao 5:10:3” could gain highest NRoI of 5.41 in Phuc An, and second highest NRoI in Vinh Kien (with value of 5.34), indicating the reason why local farmers there used to apply that fertilizer rate. The high values of NRoI in the trials imply that the high competition of cassava production at research sites.

Balanced application with medium rate as “300 kg NPK (5:10:5) + 147 kg Urea+ 158 kg KCL” gained highest root yield, and application of “300 kg NPK Lam Thao 12:5:10” could gain highest NRoI, are considered as CSA technologies on soil fertility management for cassava production. Due to high economical effect of new NPK Lam Thao 12:5:10 tested, we would like to recommend the farmers applying this NPK compost for cassava production. It would be nice if we have further researches on the use of new NPK Lam Thao 12:5:10 (e.g. application rate, or/and trace elements...) for cassava production at the research site and other sites at Northern Vietnam.

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