Soil management and crop nutrition for tomato in acid soil of Claveria, Philippines

Agustin Mercado, Jr[A], Annabelle Tulin[B] and Christopher Dorahy[C]

[A] World Agroforestry Centre, MOSCAT Campus, Claveria, Misamis Oriental, 9004 Philippines, Email agustin9146@yahoo.com
[B]Visayas State University, Leyte, Philippines.
[C]Ableblue Pty Ltd., 450 Haydens Rd, Nareen VIC 3315.

Abstract
Integrated soil management and crop nutrition need to be developed for vegetable based production system in the upland areas in Claveria, Philippines, being a "tomato bowl" of the country. A study was conducted to find alternative fertility management options for tomato production. As a result of participatory assessment and soil survey and analysis, 3 alternative treatments were being compared against farmer's fertility level, which was normally 3-5 times more than what the crop needs. The results indicated that growth of tomato was more influenced by the level of N when P and K were not limiting. This was partly influenced by the mobility of N during intense rainfall. The better yield in farmer's fertility level was attributed to the addition of organic matter which reduced N loss during intense rainfall. Under intense rainfall, diseases severity was not influenced by the different fertility levels. Although farmer had intensive pesticides application, occurrence of diseases still persisted. Marketable and non-marketable yields were still superior under farmer's fertility level than the alternative treatments. Farmer's fertility level still provided better income against alternative treatments. Tomato fertility levels and management regimes should revolve around climatic conditions that would enhance better nutrient use efficiency.

Key Words
Integrated, N efficiency, farmer's fertility management

Introduction
Vegetable is one of the primary crops in Mindanao. Its production is extensive in the highlands of Misamis Oriental particularly the municipality of Claveria which is considered to be the "tomato bowl" of Northern Mindanao providing table tomatoes in big cities, like Manila, Cebu, Iloilo, Davao, Cagayan de Oro and other smaller cities and towns in the in the Philippines. Appropriate fertility management for tomato is very important in order to attain high economic return to investment as well as reducing environmental hazard associated with improper fertilizer application. Tomato farmers in Claveria tend to apply 3-5 times more fertilizers than what are required affecting efficiency and income. Vegetable farmers tend to over-fertilize vegetables in order to secure optimum yield (Morris 1996). During our participatory assessment, farmers indicated that lack of capital is the main constraint to tomato production. Thus, the objectives of this research activity were: i.) to examine different rates of fertilizer application in tomato production; and ii) to increase N-use efficiency. These objectives were formulated to address the key production issues of: i) reducing N losses in the tomato production system; and ii) reduce N inputs to the tomato production system.

Materials and methods
Site description
The study was conducted at Claveria, Philippines (8º38'39" N, 124º 55'49"). The site was located at 980 meters above sea level (masl). The soil is derived from pyroclastic materials (Mts Mat-i, Balatukan, Sumagaya), deep and well drained. The soil chemical analysis is given in Table 1. Claveria soils represent most of acid uplands in Southeast Asia physically (Mercado 2007) and socio-economically (Bertumeu 2005). After the experiment, there was slight increase in soil pH particularly in T1 (farmer's fertility level). Other treatments were relatively unchanged (Table 1). There was also a slight increase in total N particularly in T2 and T3. Extractable P (Bray P-2) has more than doubled after the experiment particularly T1 and T3. Exchangeable K did change significantly across all treatments. Exchangeable Ca had more than doubled after the experiment as well as the Exchangeable Mg. But there was a decline in exchangeable Na after the experiment.

Treatments
Nutrient concentration of fertilizer inputs, formulation, rates, cost per bag including chicken manure is given in Table 2.

Table 1. Soil test results from field experiment Claveria, Philippines.

Soil parameter (units)	Pre-plant	Post-harvest			
		T1 (FP)	T2	T3	T4
pH	5.49	6.01	5.67	5.72	5.76
Total Org. C (%)	2.16	-	-	-	-
Total N (%)	0.13	0.19	0.21	0.21	0.19
Extractable P (Bray P-2) (mg/kg)	8.73	19.04	15.84	19.89	18.74
Exchangeable K (cmol(+)/kg)	0.28	0.28	0.22	0.16	0.19
Exchangeable Ca (cmol(+)/kg)	1.60	3.79	3.24	3.30	3.75
Exchangeable Mg (cmol(+)/kg)	0.16	0.36	0.20	0.19	0.19
Exchangeable Na (cmol(+)/kg)	0.17	0.08	0.03	0.04	0.04
Cation Exchange Capacity (cmol(+)/kg)	2.28	-	-	-	-

Table 2. Nutrient concentration of fertiliser inputs (N:P:K) including chicken manure. Claveria, Philippines.

Treatment	Fertilizer	Formulation ($N:P_2O_5:K_2O$)	Rate (bags*/ha)	Cost per bag (PHP/bag)	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)	Cost (PHP/ha)
T1 Farmers practice	Chicken dung	(1.4-0.83-0.63)	100	100	56	33.2	25.2	10000
	Ammophos	(16:20:0)	3	920	24	30	0	2760
	Urea	(46-0-0)	2	920	46	0	0	1840
	Complete	(14-14-14)	4	1100	28	28	9	4400
	Potash	(0-0-60)	1	1700	0	0	30	1700
				Total	**154**	**91**	**64**	**20,700**
T2	Ammophos	(16-20-0)	3	1100	24	30	0	3300
	Urea	(46-0-0)	3	920	69	0	0	2760
	Potash	(0-0-60)	5	1700	0	0	150	8500
				Total	**93**	**30**	**150**	**14,020**
T3	Ammophos	(16-20-0)	6	1100	48	60	0	6600
	Urea	(46-0-0)	6	920	138	0	0	5520
	Potash	(0-0-60)	5	1700	0	0	150	8500
				Total	**186**	**60**	**150**	**19,540**
T4	Solophos	(0-18-0)	4	1050	0	36	0	4200
	Urea	(46-0-0)	4	920	92	0	0	3680
	Potash	(0-0-60)	5	1700	0	0	150	8500
				Total	**92**	**36**	**150**	**16,380**

* weight per bag is 50 kgs except for chicken manure which has 40 kgs only

Chicken manure was applied as basal in T1, and all Ammophos, Muriate of Potash and Solophos in T2, T3 and T4 in 13 June 2009. Seven days after transplanting (DAP) Ammophos in T1, and 1/3 split of Urea in T2, T3 and T4 were sidedressed. Second week after planting ½ split of Urea, Complete fertilizer and Muriate of Potash were applied in T1, and 1/3 split of Urea was applied in T2, T3 and T4. At hilling up which was 25 days after planting, ½ split of Urea and Muriate of Potash were applied in T1, and another 1/3 split of Urea was applied in T2, T3 and T4.

Cultural management

The experimental field was prepared last May through June 2009 by having 3 passes of animal drawn plough with harrowing interval between plough passes. The tomato seeds, Imelda Redeemer variety developed by Seminis, Inc which is a tomato leaf curl virus tolerant, was sown in whorled banana leaves in May 29, and were transplanted in June 13, and replanting was done in June 18, 2009. Planting distance was was 1.5m between rows and 0.4 between plants. Trellising and tying of tomato vines was done 35 days after transplanting by staking bamboo stakes in double rows using local materials. Spraying was done right after planting to prevent cut worms damaging the seedlings, and weekly thereafter using combination of insecticides (Cypermethrin) and fungicides (Mancozeb) to control pests and diseases

Data collection

Plant population at 14 DAP, and plant height at 30, 45 and 60 DAP were taken. Plant biomass and tissue analysis was taken at 50 DAP, and different plant parts were separated such as leaves, fruits, stems and roots. Harvesting started 60 DAP and went up to the total of 3 harvests, fruits were separated by marketable and non-marketable sizes and quality, and within these categories sizes of large, big, medium and small were segregated. Market prices of these different sizes vary from 10 to 50% difference. Diseases occurrence was also monitored by counting the number on infected plants particularly the intense rainfall was occurring at the site during the conduct of the experiment. Rainfall was collected from the installed rainguage at the experimental plot.

Results and discussions

Plant height, yield and total dry matter yield

During the early stage of tomato growth at 30 (DAP), T2 showed better except for T3, while T4 had lower plant height of 46 cm (Table 3). At 45 DAP, farmer's fertility level (T1) had significantly higher plant height except for T2. At 60 DAP, T1 had 105 cm significantly higher than T2, but not significantly higher than T3 and T4. Tomato yields were classified into marketable and non-marketable (Table 3). Farmer's fertility level (T1) had significant marketable yield of 15.82 t/ha compared with other treatments. For non-marketable yield, T1 still had significantly higher yield than other treatments except for T2. For total yield, T1 had the highest yield of 22.6 t/ha, significantly better than the alternative treatments. T3, which had the highest nutrient load among the alternative treatments, was the 2nd highest total yield of 16.76 t/ha but not significantly better than T2 and T4.

Table 4. Agronomic results from field experiment on tomato. Claveria, Philippines . Wet season (WS) 2009.

Treatment	Plant height (cm)			Dry matter at (t/ha)	Marketable yield (t/ha)	Non-Marketable yield (t/ha)	Total yield (t/ha)
	30 DAP	45 DAP	60 DAP	50 DAP			
T1(FP) (154:91:64)	48.26^{bc}	94.92^{a}	105.38^{a}	1.34^{a}	15.82^{a}	6.78^{a}	22.6^{a}
T2 (93:30:150)	53.07^{a}	89.90^{ab}	96.12^{b}	1.13^{ab}	11.72^{b}	4.76^{ab}	16.48^{b}
T3 (186:60:150)	50.97^{ab}	88.30^{b}	98.08^{ab}	1.22^{ab}	12.26^{b}	4.50^{b}	16.76^{b}
T4 (92:36:150)	46.00^{c}	87.18^{b}	97.26^{ab}	1.04^{b}	12.22^{b}	4.40^{b}	16.62^{b}
Mean	49.57	89.82	99.21	1.18	13.0	5.11	18.13
LSD (5%)	3.59	6.46	8.27	0.27	2.96	2.08	4.22

In a column, means having the same letters are not significantly different by tukey's test at 5% level

Partial nutrient budget

Nutrient loading, uptake, removal and balance of N, P (P_2O_5), and K (K_2O) are presented in Table 5. Total N loading was highest at T3 of 186 N kg/ha, followed by farmer's fertility level of 143 N kg/ha. T2 and T4 had 93 and 92 N kg/ha., respectively. P loading was highest at farmer's fertility level (T1) of 143 P_2O_5 kg/ha, followed by T3 of 60 P_2O_5 kg/ha. T4 and T2 had 36 and 30 P_2O_5 kg/ha, respectively. K nutrient loading was lowest in T1 of only 64 K_2O kg/ha and the other treatments have similar loading of 150 K_2O kg/ha. N uptake was highest at T1 and T3 of 44.68 and 44.28 N kg/ha, respectively, followed by T4 and T2 which were significantly lower. T1 had significantly higher P uptake of 7.34 P_2O_5 kg/ha, followed by T3 with 6.21 P_2O_5 kg/ha. T2 had the lowest P uptake of 4.93 P_2O_5 kg/ha. T1 had the highest K uptake of 88.22 K_2O kg/ha, followed by T3 and T4 of 61.48 and 56.11 K_2O kg/ha. T2 had significantly lower K uptake of 45.05 K_2O kg/ha. Hedge (1996) found out a ton of fresh tomato fruits need to absorb 3:0.3:3.5 kgs NPK, respectively. Nutrient removal was significantly higher in T1 with 58.32 N kg/ha, followed by T3 with 44 N kg/ha which was not significantly higher compared to T4 and T2 with 40.86 and 33.80 N kg/ha, respectively. P removal was significantly higher in T1 with 8.34 P_2O_5 kg/ha, followed by T3, which was significantly higher than T4 and T2. K removal was highest in T1 of 74.76 K_2O kg/ha, followed by T3 which was significantly lower. T2 had the lowest K removal, but was not significantly different from T4 and T3. Hedge (1996) also found out that 38 t fruit/ha removes 104 kg N, 9.5 kg P and 116 kg K. Nutrients remaining in the soil including the ones in the tomato residues are presented in Table 5. T3 had the highest remaining N with 141.88 kg/ha significantly higher compared with T1 (farmer's fertility level) of 84.68 kg/ha. T4 had the lowest remaining N of 51 kg/ha comparable to T2 of 59.20 kg/ha. P remaining was significantly higher in T1 with 82.86 P_2O_5 kg/ha, followed by T3 of 53.94 P_2O_5 kg/ha which was significantly lower. The significantly lowest P remaining was in T2 with 25.31 P_2O_5 kg/ha, and was significantly lower than T4 with 31.02 P_2O_5 kg/ha. K remaining was highest in T2 with 105.55 K_2O kg/ha and followed by T4 with 102.01 K_2O kg/ha. T1 had the lowest and negative K_2O balance of -10.56 K_2O kg/ha.

Partial cost benefit analysis

Partial cost benefit analysis of the different treatments is presented on Table 6. Farmer's fertility level (T1) had the highest investment costs of P24,666, followed by T3 with P20,350, and T2 with P14,800. Being the highest yielder, T1 had the highest income of P189,840 with a partial gross margin benefit (GMB) of

P165,174. This was followed by T3 with P147,120 with a partial GMB of P126,770. T2 had the lowest fertilizer costs of P14,800, and also had the lowest value of the marketable yield of P140,120 as well as having the lowest partial GMB of P125,840.

Table 5. Partial nutrient budget on tomato from field experiment. Claveria, Philippines . WS 2009.

Treatment	Nutrient loading			Nutrient uptake			Nutrient removal			Nutrient balance		
	N	P_2O_5 (kg/ha)	K_2O	N	P_2O_5 (kg/ha)	K_2O	N	P_2O_5 (kg/ha)	K_2O	N	P_2O_5 (kg/ha)	K_2O
T1 (FP)	143	91	64	44.68a	7.34a	88.22a	58.32^a	8.34^a	74.76^a	84.68b	82.86a	-10.56b
T2	93	30	150	28.77b	4.93c	45.05c	33.80^b	4.69^b	44.45^b	59.20c	25.31d	105.55a
T3	186	60	150	44.28a	6.21b	61.48b	44.12^b	6.06^b	56.46^b	141.88a	53.94b	93.54a
T4	92	36	150	29.46b	5.02c	56.11b	40.86^b	4.98^b	47.99^b	51.14c	31.02c	102.01a
Mean	129	67	151	36.80	5.58	62.72	44.28	6.02	55.91	84.22	48.28	95.92
LSD (5%)				4.87	0.78	8.45	11.62	1.75	24.75	11.61	1.75	16.72

In a column, means having the same letters are not significantly different by tukey's test at 5% level

Table 6. Partial cost-benefit analysis of treatments used in the field experiment tomato. Claveria, Philippines. WS 2009.

Treatment ($N:P_2O_5:K_2O$)	Fertiliser cost (PHP/ha)	Value of Marketable Yield* (PHP/ha)	Partial GMB (PHP/ha)
T1 (FP) (154:91:64)	24, 666	189,840	165,174
T2(93:30:150	14,800	140,120	125,840
T3(186:60:150)	20,350	147,120	126,770
T4(92:36:150)	15,830	146,640	130,810

* Note: P300 per box at 25 kgs a box

Conclusion

The growth of tomato was more influenced by the level of N when P and K were not limiting. This was partly influenced by the mobility of N during intense rainfall particularly if the organic matter was not applied. The better yield in farmer's fertility level was attributed to the addition of organic matter which reduced N losses during intense rainfall. Under intense rainfall, diseases severity was not influenced by the different fertility levels. Although farmer had intensive pesticides application, occurrence of diseases still persisted. Marketable and non-marketable yields were still superior under farmer's fertility level than the alternative treatments. Farmer's fertility level still provided the better income against alternative treatments, but not the highest return to investment (700%), than the lowest fertility level (T2) which had 850%. Tomato fertility levels and management regimes should revolve around climatic conditions that would enhance better N-use efficiency. There is a need for better N management during high rainfall period in order to reduce N losses and better understanding on the role of organic matter in N management such will increase N use-efficiency.

References

Bertomeu M (2005) 'Smallholder Timber Production on Sloping Lands in the Philippines: A System Approach'. (World Agroforestry Centre: Los Banos, Philippines).

Mercado AR Jr (2007) 'Potential of timber based hedgerow intercropping for smallholder on degraded soils in humid tropics of Southeast Asia'. (World Agroforestry Centre: Los Banos, Philippines).

Morris RA (1996) Vegetables, nutrient rates and management. In 'Managing soil fertility for intensive vegetable production systems in Asia. (Ed RA Morris) pp 5-24. (AVRDC: Taiwan).

Hedge DM (1996) Nutrient requirements for solanaceous crops. In 'Managing soil fertility for intensive vegetable production systems in Asia. (Ed RA Morris) pp 58-71. (AVRDC: Taiwan).