Fertilizer Management for Passion Fruit (*Passiflora edulis)* on Alaminos Clay Soil

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Abstract *- Soils in rolling to hilly are strongly acidic and deficient in N, P and K – characteristics that are major constraints to high fruit yield like passion fruit. The importance of the macronutrient to passion fruit production showed that best yield was obtained with fertilization of 250-50-80 kg N-P_2O_5-K_2Oha^{-1}. The degree of importance of N, P and K followed the order N > P > K. Yield reductions due to the absence of these nutrients from the complete treatment were 60%, 39% and 7%, respectively. Furthermore, best value per fruit was observed with fertilization 250-50-80 kg N-P_2O_5-K_2O ha^{-1}.Mean value per fruit reductions due to non-application of N or P or K from the complete treatment were 29.74%, 17.75% and 11.19%, respectively. Higher juice characteristic (pH) was observed from treatments with K compared from treatments without K. Performance of passion fruit from combined inorganic and organic fertilizers showed that highest yield and average value per fruit were produced by fertilization with 75% IF + 25% OF. Yield per hectare and average value per fruit reductions due to decreasing of percentage inorganic fertilizer (IF) but increasing of percentage organic fertilizer (OF) like 50% IF + 50% OF, 25% IF + 75% OF, and 100% OF were 26%, 37%, and 56% the former and 6%, 13%, and 41% the later, respectively.*

Keywords*: Passion fruit, Alaminos clay, Inorganic and organic fertilizers*

INTRODUCTION

The fruit of American vine *Passiflora edulis*is commonly called Passion fruit**.** Its production is not restricted to tropical areas since it can be found in many parts of the world. It possesses exquisite aroma and high nutritive value (as an excellent source of vitamin C). It is mainly used for juice production. Its juice is utilized as refreshing drink, flavoring sherbets, and for making jams and jellies [1].

The soil properties, climate, genetic composition and cultural management practices are broad factors that affect the yield and quality of passion fruit. The variation of these factors is more specific component variables that influence yield and quality of crop under site or soil specific conditions [2], [3].

In West Central Luzon, there are wide areas of rolling topography that could be used for the production of passion fruit. However, for this particular region, there is practically no information about the production constraints and their management to enable more efficient passion fruit production, thus this study.

Organic and inorganic fertilization was evaluated through production of passion fruit. Earthworms vermicompost was considered as one of organic fertilizer used. Vermicompost is considered to be highly nutritive 'organic fertilizer' and more powerful 'growth promoter' over the conventional composts and a 'protective' farm input (increasing the physical, chemical and biological properties of soil, restoring & improving its natural fertility) against the 'destructive' chemical fertilizers which has destroyed the soil properties and decreased its natural fertility over the years [4], [5], and [6].

OBJECTIVES OF THE STUDY

Generally, the research aimed to produce yellow passion fruit on Alaminos Clay of better quality and in large quantity. Specifically, it was conducted to quantify the influence of inorganic and organic fertilizers on fruit yield, fruit value and juice characteristics of the crop.

MATERIALS AND METHOD

The research involved two studies with the same methodology as described below:

Experimental Area/Site

The study was conducted at Pangasinan State University-Infanta Campus experimental area located at Barangay Bamban, Infanta, Pangasinan from January 2012 to May 2013. The soil is classified as Alaminos clay (fine clayey, kaolinitic, isohyperthermicTropudult) based on soil taxonomy and classification [7, 8 and 9].

Soil samples were collected consisting ten random boring, 0-15 cm depth, in study area. An area of 1,000 $m^2$was prepared by removing the grasses and other unwanted plantswhich were damaging to the test crop.

Land Preparation and Planting

Zerotillage was employed in the study. Holes were dug manually using grab hoe and shovel to loosen the soil. The distance of planting was 1.5m between row and 3.0m between vines with 5 plants per plot. The depth of planting was 30 cm deep.

Trellis Construction

Prior to planting of passion fruit seedlings, trellis was constructed for the vines to grow using bamboo (native kawayan and bulo species).

Irrigation

Watering the plants was done every other day after planting for two months and month of November onward till the last harvest.

Harvesting

Harvesting was done when fruit was fully mature. Fruit was picked after full color development when the whole fruit was canary yellow [10], [11]. It was collected every second day.

Treatments and Experimental Design

Study 1.Macronutrient Requirements of Passion Fruit

The treatments involved were levels of N-P_2O_5-K_2O (0-0-0, 250-0-0, 0-50-0, 0-0-80, 250-50-0, 250-0-80, 0-50-80, and 250-50-80). These treatments were arranged following a Randomized Complete Block Design with three replications. The area per plot was 22.5 m^2.Urea (46-0-0), solophos (0-20-0) and muriate of potash (0-0-60) were used as fertilizer materials. Fertilizer application was done each plant every four (4) weeks throughout the growing season. For N recommendation, 30 g of urea was applied per m^2at each application.

Study 2.Performance of passion fruit from combined inorganic and organic fertilizer

An area of 500 m^2 was prepared and cleaned following the zero tillage operation. The treatments involved were percentage inorganic fertilizer (IF) and organic fertilizer (OF): 100% IF; 75% IF + 25% OF; 50% IF + 50 OF; 25% IF + 75% OF; and 100% OF. These treatments were arranged following the Randomized Complete Block Design (RCBD) with three replications. The area per plot was 22.5 m^2.The recommended rate for inorganic fertilizer was 250-50-80 kg N-P_2O_5-K_2Oha^{-1} and for organic fertilizer was $20tha^{-1}$. Inorganic fertilizer application was done each plant every 4 weeks throughout the growing season. The organic fertilizer (vermicompost) was applied basally.

Data Gathered

The number of fruits per hectare. This was taken by counting the number of fruits per plot (from first to last harvest) and computedto per hectare basis.

Weight(t) of fruits per hectare. This was done by weighing the harvested fruits per plot (from first to last harvest) using the weighing scale and computedto per hectare basis.

Average value per fruit. This was done based on the weight (g) per fruit which was taken by weighing ten (10) fruits per plot then divided by the number of fruits sampled.

Volume (ml) of juice per fruit. This was measuredand taken from ten (10) passion fruit samples per plot. Fruits were sliced on two halves,seeds with pulp were scraped by spoon to cheese cloth and squeezed well to juice jar and the juice was measured using the graduated cylinder then divided by the number of fruits sampled.

Number of seeds per fruit. Seeds per fruitwere counted of ten (10) samples fruits per plot then the mean was calculated.

Percent (%) rind and pulp per fruit. This was done by weighing the rind and pulp of ten (10) fruits per plot after extracting the juice and seeds with the used of weighing scale then divided by the total weight of ten (10) fruits sampled and multiplied by 100.

Juice characteristic (pH).This was done by reading/recording the acidity of the juice with the use of a glass electrode potentiometer (pH meter).

RESULT AND DISCUSSION

Properties of the Soil in the Experimental Area

The taxonomic name of Alaminos clay is fine clayey, kaolinitic, isohyperthermic Tropudult. The physical and chemical properties of the soil shown in Table 1.

Table 1. Properties of the soil in the field experimental area

Properties	Mean
Bulk density (g/cc)	1.50
pH (1:1 soil water)	4.90
Organic matter (%)	2.48
Total N (%)	0.10
Available P (ppm-Bray)	5.30
Exchangeable K (meq/100 g soil)	0.08
Cation exchange capacity (meq/100 g soil	15.00

Characteristics of the Yellow Passion Fruit

The passion fruit vine is a shallow-rooted, woody, perennial, and climbing by means of tendrils. The alternate, evergreen leaves, deeply 3-lobed when mature. Its fruit is round to oval with yellow skin at maturity with a soft to firm, juicy interior filled with numerous seeds. It is generally propagated from seeds, although cuttings and grafting can be used. Within 5-7 weeks after transplanting, each plant will have up to four healthy laterals. From then on the vine grows very rapidly; the first flowers are produced 5-7 months after transplanting. If a plantation is cropped for three years; of the total crop, yield roughly 50% is produced in the first year, 35% in the second year and 15% in the third year. An average yield is from 20 to 25t ha^{-1} yr^{-1}.

Study 1. Macronutrient Requirements of Passion Fruit

Number of fruits per hectare (ha^{-1}).The passion fruit differed significantly in its capacity to respond to fertilization and produce number of fruits. The need for N by passion fruit in this soil was greater than its need for P and K since there were no significant responses to P and K alone. Addition of N and P together significantly increased the number of fruits compared to treatments of N and P alone. Highest number of fruits was obtained from the applied 250-50-80 $kgha^{-1}N$-P_2O_5-K_2O (Table 2). Evidently, the removal of N from the NPK treatment reduced the fruits by 57% to as low as that of the control. The reduction in fruits without P and K were 38% and 7%, respectively.

Weight (t) of fruits per hectare (ha^{-1}).The response of passion fruit to single elements N, P_2O_5 and K_2O applications had been observed the same pattern for weight (t ha^{-1}) of fruits. The treatment that produced the best fruit weight was from 250-50-80 $kgha^{-1}$ N-P_2O_5-K_2O(Table 2). Fruit weight reductions due to non-application of N, P_2O_5 and K_2O were 63%, 40% and 6%, respectively

Table 2. Yield per hectare of passion fruit with NPK application

Treatment kg ha^{-1}N-P_2O_5-K_2O	Number of fruits (ha^{-1})	Weight (t) of fruits (ha^{-1})
0-0-0	11`8,888c	10.12bc
250-0-0	158,055b	12.44b
0-50-0	129,444bc	10.41bc
0-0-80	131,111bc	11.55bc
250-50-0	237,499a	21.08a
250-0-80	157,777b	13.40b
0-50-80	110,555c	8.21c
250-50-80	256,111a	22.43a
F-test	21.26**	22.08**
c.v. (%)	12.69	14.04

Means of the same letter are not significantly different at 0.5 level DMRT

Average Value per Fruit

Table 3. Average value per fruit and juice characteristic (pH) of passion fruit with NPK application

Treatment kg ha^{-1}N-P_2O_5-K_2O	Average value per fruit				Juice characteristic (pH)
	Weight per fruit (g)	Volume (ml) of juice	Number of seeds	% rind and pulp	
0-0-0	93.53b	29.33b	165b	52.03	2.56b
250-0-0	93.93b	31.00b	177b	49.89	2.66b
0-50-0	94.20b	30.66b	159b	52.15	2.63b
0-0-80	94.00b	31.33b	169b	50.15	2.90a
250-50-0	96.93b	36.00a	200b	54.50	2.66b
250-0-80	95.86b	33.00ab	174b	50.96	2.83a
0-50-80	85.20c	28.66b	139c	51.32	2.93a
250-50-80	114.00a	37.00a	238a	48.48	2.96a
F-test	12.56**	3.81*	2.97*	0.68ns	11.71**
CV (%)	4.12	8.30	18.31	7.36	2.82

Means of the same letter are not significantly different at 0.5 level DMRT

Weight (g) per fruit. Insignificant differences in weight (g) per fruit were obtained from separate application of any single element (N, P and K) or combination of two elements (NP and NK) except PK

combination which was significantly differed among the other treatments. The highest weight per fruit of 114.00 g was obtained from the 250-50-80 treatment plot (Table 3). Per fruit weight reductions due to omission of either N, P or K but with the presence of the other two elements were 25%, 16% and 15%, respectively.

Volume (ml) of Juice per Fruit.Significant responses in volume of juice per fruit were observed from addition of N with other elements compared to treatments of N, P and K alone and PK combination. Highest volume of juice per fruit of 37 ml was obtained from treatment applied with 250-50-80 kg ha^{-1} N-P_2O_5-K_2O(Table 3). The removal of N, P and K from the NPK treatment reduced the volume of juice by 23%, 11% and 3%.

Number of Seeds per Fruit**.**Like the weight (g) per fruit, the same trend of responses to individual N, P_2O_5 and K_2O application had been observed for number of seeds per fruit. The treatment that produced the highest number of seeds per fruit was at 250-50-80 kg ha^{-1} N-P_2O_5-K_2O (Table 3). Number of seeds reductions due to non-application of N, P_2O_5 and K_2O were 41%, 27% and 16%.

Percent (%) Rind and Pulp per Fruit**.**As noted from Table 3, the per cent rind and pulp per fruit was not significantly affected by the treatment used in the study.

Juice Characteristic (pH).It can be noted from Table 3, that treatments with application either alone or in combination with other elements significantly differed from treatments without K application with regards to pH value of the fruit juice. Higher value of pH was obtained from treatments with K than from treatments without K application.

Study 2.Performance of passion fruit from combined inorganic and organic fertilizer

Number of fruit (ha^{-1}).Apparently, the number of fruits per hectare was largely reduced by increasing the percentage of organic fertilizer in the treatment. The highest number of fruits of 108,148.14 was obtained from the 75% IF + 25% OF treatment plot (Table 4). Number of fruit reductions due to increasing the percentage OF but decreasing the percentage IF were 26%, 33% and 54%, respectively.

Weight (t) of Fruits (ha^{-1}).The same trend like the number of fruits in response to the combined inorganic and organic fertilizers had been observed. The treatment that produced the best fruit weight was obtained from combined 75% IF and 25% OF (Table 4). Fruit weight reductions due to increasing percentage OF but decreasing the percentage IF were 26%, 42% and 58%.

Table 4. Yield of passion fruit with inorganic and organic fertilizer application

Treatment	Number of fruits (ha^{-1})	Weight (t) of fruits (ha^{-1})
100 % IF	106,666a	6.93a
75% IF + 25% OF	108,148a	7.17a
50% IF + 50% OF	80,370b	5.30b
25% IF + 75% OF	72,222c	4.16c
100% OF	49,629d	3.02d
F-test	31.94**	66.18**
c.v. (%)	2.88	7.08

Means of the same letter are not significantly different at 0.5 level DMRT

Average Value per Fruit

Weight (g) per Fruit. Corresponding percentage of OF applied, it is observed that the weight (g) per fruit decreased with increasing amount of OF. Highest weight per fruit was 88.00 g from applied 75%IF + 25%OF (Table 5) higher than that with the combined 50% IF + 50% OF, 25% IF + 75% OF and 100% OF by 4.70%, 6.95%, 39.39%, respectively. The increased in weight per fruit could be attributed to availability of nutrient elements supplied by inorganic fertilizer when combined with 25% organic fertilizer.

Volume (ml) of Juice per Fruit. Decreasing the amount of IF and increasing the amount of OF were significantly reduced the volume (ml) of juice per fruit (Table 5). Production of juice was better from treatments of 100% IF, 75% IF + 25% OF and 50% IF + 50% OF compared to treatments of 25% + 75%OF and 100% OF.

Number of seeds per fruit**.**Significant differences in number of seeds per fruit were obtained from separate application of inorganic plus organic fertilizers combinations. The highest number of seeds per fruit with 189 was observed from combined 75% IF + 25% OF fertilizers. Similarly, high number of seeds per fruit was also observed with treatment of 50% IF + 50% OF application. The lowest number of seeds per fruit of 72.11 was observed from applied 100% organic fertilizer (Table 5).

Percent (%) rind and pulp per fruit.The highest percent rind and pulp was observed from applied 75% IF + 25% OF (41.93%) which was not significantly different from 100% IF (40.44%). The percent rind and pulp from treatments of 50% IF + 50% OF, 25% + 75% OF and 100% OF applications were not significantly different from each other.

Table 5. Average value per fruit and juice characteristics (pH) of passion fruit applied with inorganic and organic fertilizers

Treatment	Average value per fruit				Juice characteristic (pH)
	Weight (g)	Volume (ml) of juice	Number of seeds	Per cent (%) rind and pulp	
100% IF	82.99b	32.83a	158c	40.44a	2.60
75% IF + 25% OF	88.00a	33.77a	189a	41.93a	2.66
50% If + 50% OF	83.88b	33.00a	186a	36.12b	2.76
25% If + 75% OF	81.88b	29.88b	168b	33.07b	2.76
100% OF	53.33c	18.37c	72d	35.19b	2.90
F-test	14.79**	12.42**	29.82**	8.71**	3.54ns
CV (%)	2.55	3.36	3.09	5.83	3.82

Means of the same letter are not significantly different at 0.5 level DMRT

Juice Characteristic (pH).The pH of passion fruit juice was not significantly affected by the different amount of inorganic and organic fertilizers applied. The pH ranges from 2.6 to 2.9 corresponding to applications of 100% IF and 100% OF, respectively (Table 5).

CONCLUSION AND RECOMMENDATION

The relative importance of the macronutrient to passion fruit production showed that best yield (number and weight (t) of fruits per hectare) was obtained with fertilization of 250-50-80 kg N-P_2O_5-K_2Oha^{-1} rate. The best value per fruit (weight (g), volume (ml) of juice, and number of seeds) were obtained with fertilizer rate of 250-50-80 kg ha^{-1}N-P_2O_5-K_2O. The macronutrient constraints followed the order N > P > K.

The performance of passion fruit from applications of combined inorganic and organic fertilizers was observed from 75% IF and 25% OF.

The application of 250-50-80 kg ha^{-1}N-P_2O_5-K_2O is recommended in a rolling to hilly areas to supplement the nutrient requirements of yellow passion fruit.

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APPENDICES

Appendix 1: One month-old passion fruit after planting

Appendix 3: Flowering stage of passion fruit

Appendix 2: Two-month old passion fruitafter planting

Appendix 4: Flowering and fruiting stages of passion fruit – commence harvestinng