Effect of Chicken Manure, *Tithonia diversifolia* and *Albizzia spp* on Maize Plant Height and Dry Matter Production – Lessons Learnt in the Eastern Highlands of PNG.

by

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Abstract

A pot trial was carried out to evaluate the effect of Chicken manure, Tithonia diversifolia and Albizzia spp on maize plant height and dry matter production at the University of Goroka in the Eastern Highlands Province of Papua New Guinea (PNG). Increasing levels of organic inputs (5, 10 & 20 t/ha) plus a control (0 t/ha) were used as treatments (10) replicated 3 times in completely randomized design. Experimental soil was analyzed for water soluble anions and cations.

Application of organic inputs resulted in positive responses. All chicken manure levels and 20 t/ha level of Tithonia diversifolia resulted in highly significant maize plant heights and dry matter production compared to all other treatments. . Mean maize plant heights ranged from 34 cm (control) to 54 cm (20 t/ha chicken manure). Dry matter production followed a similar trend with figures ranging from 0.19 t/ha (control) to 0.63 t/ha (chicken manure 20 t/ha). The effectiveness of organic input followed the order: Chicken manure > Tithonia diversifolia > Albizzia > Control.

Keywords: Organic, Chicken manure, Tithonia diversifolia, Albizzia spp, soil fertility, plant height, Dry matter production. Water soluble anions and cations.

Introduction

Shifting cultivation was traditionally practiced in PNG with long fallow periods due to low population. Continuous cultivation is now evident in highly populated areas of PNG, resulting in rapid fertility decline. Subsistence farmers are forced to replenish soil fertility more regularly than ever before, due to population increase. The use of organic inputs as fertilizer is cheaper and environmentally friendly.

This study investigated effect of chicken manure, *Tithonia diversifolia*, and *Albizzia spp* on maize plant height and dry matter production (DMP). The selection of organic input was based on availability.

Organic manure research in PNG include pig manure (Kimber, 1982), coffee pulp (Siki, 1980), chicken manure (Thiagalingam & Bourke, 1982; Mesa, 1983; Igua, 2000). Mesa (1983) reported significant increase in maize plant height due to chicken manure. Igua (2000) reported that plant height, grain yield and selected yield components of maize gave positive responses to chicken manure application.

The use of *Tithonia diversifolia* as fertilizer is unknown in PNG. In Kenya and South East Asia small holder farmers use *T. diversifolia* for fertility improvement. *Tithonia* leaves contain 3.5, 0.37 and 4.1 % N, P and K respectively and decomposes quickly after incorporation into the soil and is an effective source of fertility (Gaghenco et al., 1999). Soil fertility benefits are greater for green biomass rather than dried (Otuma et al., 1998).

Olabode et al., (2000) concluded that *Tithonia* with its high nutrient status is a potential soil improver for productivity and recommended it as a green manure or as a major component of compost manure.

Tithonia improved available soil P and P uptake by maize on acid soils of Northern Zambia (Malama, 2001). *Tithonia* appeared to enhance P availability on these P-fixing soils. Stover and grain yields were improved by the incorporation of *Tithonia* (Malama, 2001). *Tithonia* improved soil fertility and maize yield, alone or in combination with single superphosphate or ground rock phosphate. It is a cheap effective method of ameliorating soil acidity in Northern Zambia (Malama, 2001).

Other uses of tithonia include fodder (Rooethart and Patterson, 1997; Rooethaet et al., 1977), fuel wood (Ng'inja et al., 1998), compost (Dreschel & Reck, 1998; Ng'inja et al., 1998), land demarcation, soil erosion control (Ng'inja et al., 1998), building material, shelter for poultry (Otuma et al., 1998). Extracts from *Tithonia* plant parts contain chemicals that inhibit plant growth (Baruah et al., 1994; Tongma et al., 1997) and control insects (Carino & Rejestes, 1982; Dutta et al., 1993) and is of medical value in the treatment of hepatitis (Lin et al., 1993; Kuo & Chen, 1997).

The use of *Albizzia* as a fertilizer is unknown in PNG and its potential is unexploited. *Albizzia* is a leguminous plant and has beneficial effects through nitrogen fixation. Botanical description *Albizzia* is adequately detailed by Hanum and Van Der Maesen (1997).

Materials and Methods

Location and climate

A pot trial was carried out at the University of Goroka, Papua New Guinea (PNG). Goroka is in the highlands of PNG with an altitude of 1600 masl. Goroka has mean annual rainfall figures of 1800-1900 mm with rainfall maxima occurring between November and March. Goroka has a mean annual maximum temperature of 25^{o}C and minimum temperature of 14^{o}C (McAlpine et al., 1983).

pH measurements

10 grams of soil, chicken manure, *tithonia* and *albizzia* leaves were weighed into a beaker, 25 ml of distilled water added, shaken and left for 30 minutes to stabilize and read using a pH meter.

Electrical conductivity

10 grams of soil, chicken manure, *Tithonia* and *Albizzia* leaves were weighed into containers and 50 ml of distilled water added (1:5 ratio). These were placed in reciprocating shaker at 139 rpm for an hour and read using the EC meter.

Water soluble anions and cations

Samples read for EC were preserved for the measurements of water soluble anions and cations. Prior to the measurements, samples were subjected to two sets of filtrations. The first filtration was through coffee filter paper. 10 ml of the filtrate was obtained and pipette into a centrifuge tube and centrifuged at 2000 rpm for 5 minutes. 2 ml of the supernatant was then pipette into another container to which 10 ml of distilled water was added and then using a syringe, the sample was filtered through a hydrophilic membrane (second filtration) for final purification before injecting into the ion analyzer for measurements of water soluble anions and cations.

Experimental design and layout.
A completely randomized design was used with 10 treatments (Table 2) replicated 3 times giving a total of 30 pots..

Table 2. Experimental protocols for organic input

Treatments	Type of Organic Input	Rate of Input (t/ha)
1	Control	0
2	Chicken Manure	5
3	Chicken Manure	10
4	Chicken Manure	20
5	Tithonia diversifolia	5
6	Tithonia diversifolia	10
7	Tithonia diversifolia	20
8	Albizzia spp	5
9	Albizzia spp	10
10	Albizzia spp	20

The pots had a surface area of 1.6 x 10^{-6} ha. Field capacity of soils in the pots was determined for before planting. After the determination of field capacity, plastic bags were placed into each pot and filled with 2 kg of soil and organic inputs incorporated

Chicken manure was sieved (2 mm) before incorporation into the soil. Chicken manure was obtained from eight week old broiler birds. Leaves of *Tithonia diversifolia* and *Albizzia* were dried for 2 days before incorporation into the soil, maize seeds were planted four days later. Seeds were soaked in water overnight before planting. A local maize variety (Suwan), an open pollinated, with good yielding ability, was used in the study. Four maize seeds were planted on June 22nd 2008. Field capacity was maintained throughout the duration of the experiment. Weeds were controlled manually.

Plant Height and Dry Matter Production

Plant height measurements were obtained upon termination of the experiment. Upon termination of the experiment, fresh above ground biomass was recorded and total dry matter production (DMP) calculated from an oven–dried sample.

Data processing

Analysis of variance was used to analyze data and Duncan Multiple Range Test (DMRT) was used to separate the means.

Results.

Soil Analysis

Soil pH was slightly acidic (6.15), falling into the category preferred by most plants. The soil had an EC reading of 25 μS, indicative of a strongly saline soil with values > 15 μS.

Water soluble anions and cations are given in Table 3. Analysis showed that some of the nutrients were absent in the soil, or undetected. Of the anions, PO_4^-, NO_2^- , and Br^- were undetected, whilst of the cations, L^+, and Na^+ were undetected or absent.

pH and EC readings of organic input

pH of all organic inputs were slightly alkaline (7.38 -7.6) and EC of 25 (μS) indicative of strongly saline (Table 4). Analysis of water soluble anions and cations of the inputs was not done.

Table 3. Concentration of soil water soluble anions and cations

Anions	**Concentrations mg/kg**	**Cations**	**Concentrations mg/kg**
PO_4^-	0.0	L^+	0.0
Cl^-	7.57	Na^+	0.0
NO_2^-	0.0	NH_4^+	0.634
Br^-	0.0	K^+	0.1
NO_3^-	0.288	Mg^{+2}	0.573
SO_4^{-2}	8.09	Ca^{+2}	0.27

Table 4. pH and EC of organic input

Organic Input	pH	EC (μS)
Chicken manure	7.38	25
Tithonia	7.60	25
Albizzia	7.39	25

Maize

A highly significant difference was observed between the types of organic inputs and level of application (Table 5). Response followed the order: Chicken manure > *Tithonia diversifolia* > *Albizzia spp* > Control. Mean plant height ranged from 34 cm (control) to 54 cm (20 t/ha chicken manure). Dry matter production followed a similar trend with figures ranging from 0.19 t/ha to 0.63 t/ha observed in the control and 20 t/ha chicken manure respectively.

Maize plants exhibited dark blue-green and purpling of stems on older leaves, typical of P deficiency symptoms. P is mobile in plants and symptoms will appear on older leaves. No other deficiency symptoms were observed.

Table 5. Summary of Statistics

Treatment	Mean height (cm)	DMP (g/pot)	DMP t/ha
Chicken manure 20 t/ha	54.6 a	1.0 a	0.63 a
Chicken Manure 10 t/ha	53.1 a	0.8 a	0.50 a
Chicken Manure 5 t/ha	51.1 a	0.6 ab	0.38 ab
Tithonia diversifolia 20 t/ha	44.8 ab	0.6 ab	0.38 ab
Tithonia diversifolia 10 t/ha	42.1 b	0.6 ab	0.38 ab
Tithonia diversifolia 5 t/ha	39.7 b	0.3 b	0.19 b
Albizzia spp 20 t/ha	37.9 b	0.3 b	0.19 b
Albizzia spp 10 t/ha	35.7 b	0.3 b	0.19 b
Albizzia spp 5 t/ha	35.6 b	0.3 b	0.19 b
Control	34.7 b	0.3 b	0.19 b
Statistics	**	**	
LSD	8.461381	0.417	

Means with the same subscripts denotes non significant differences by DMRT (p=0.05)

Discussions

Nitrite, Nitrate and Ammonia

NO_2^- was undetected in the soil while NO_3^- and NH_4^+ ions were present. NO_2^- is mobile in the soil and hardly adsorbed by soil particles, and this may explain it's absence. On the other hand, NH_4^+ ions are strongly adsorbed to negatively charged clay minerals because of its cationic properties (Mengel and Kirkby, 1982) and hence available for plant uptake. Maize plants showed no N deficiency symptoms, indicative of adequate supply of N in the form of NH_4^+ ions as evident in Table 3.

Phosphorus

P is deficient in highland soils particularly on volcanic ash-derived soils where the amorphous allophane renders P unavailable. As expected, laboratory analysis showed an absence of PO_4^-. Substantial amount of total P is associated with soil organic matter (Williams, 1959) and in mineral soils the proportion of organic P lies between 20-80 % of total P (Mengel and Kirkby, 1982). Deficiency symptoms typical of phosphorus were distinct in the control plants. Treatments receiving *Albizzia* also exhibited P deficiency symptoms indicative of low P content. It appears that all chicken manure levels and 20 t/ha level of *Tithonia* contained adequate P, showing no P deficiency symptoms.

Chlorine

Chloride in the soil is not adsorbed by minerals and most mobile ion, easily leached under freely drained conditions. The area where the experimental soil was obtained sits in a valley floor, with poor drainage and receives runoff from the surrounding slopes, resulting in high Cl^-.

Sulphate

In most soils organically bound S provides reservoir (Reisenauer *et al.,*1973). In the humid regions the inorganic forms of sulphate are usually found in the subsoil and organic forms in the top soil. The current study shows a relatively high value (8.09 mg/kg of soil) of SO_4^{-2}. Work by Chapman (1966) on diagnostic criteria for plants and soils reported that SO_4^{-2} concentration < 3 mg/kg of soil is indicative of a likely deficiency.

Bromine & Lithium

Br^- was absent or undetected in the soil. Levels of Br^- in soils are generally very low, so low that toxicity does not occur and the current study confirms this. Normal Br^- levels in plants are usually in the range of 0-260 ppm, concentrations at the lower end are more common (Martin, 1966). Observations of Li^+ concentration was similar to that made with Br^-, Li^+ was absent in the soil.

Sodium, Potassium, Magnesium and Calcium,

Na^+ was absent in the experimental soil. Igua et al., (2008) reported that Na^+ concentration generally decreased with decrease in slope gradient and the current study confirms that suggestion.
K^+ content of the experimental soil measured 0.1 mg/kg of soil. K^+ is mostly bounded in primary minerals or present in the secondary clay minerals which largely makes up the clay fraction of soil particle size less than 2 μm. Thus, soils rich in clay are also generally rich in K^+. The experimental soil had a clay loam texture and is not as rich in K^+ as heavy clays. There is a general decrease in K^+ concentrations with decrease in slope gradient (Igua et al., 2008).

Low Mg^{+2} content is due to the clay loam soil texture. Higher levels are often present in heavy clay soils compared lighter textured soils, due to relatively easily weatherable ferromagnesium minerals, such as biotite, serpentine, hornblende, and olivine. In addition it occurs in secondary clay minerals including chlorite, vermiculite, illite and montmorillonite.

Calcium deficiency is very rare except in sandy and highly leached acid soils. For a majority of soils which are neutral or only slightly acidic, calcium ions occupy most of the exchange sites on clays and organic matter (Russell, 1988). Most soils also contain enough calcium for crop growth if the crop is not affected by acidity.

Manurial Properties

The nutrient content of organic inputs were not analyzed, however extrapolation is based on data obtained elsewhere (Table 5). From data presented it appears that *Tithonia* is relatively high in N and K, however low in P.

Table 5. Data of manurial properties obtained elsewhere

Organic source	**N%**	**P %**	**K %**	**Source**
Chicken manure	2.31	2.27	1.44	Igua, 2000
Chicken manure	1.78	2.00	1.80	Togun & Akambi 2002
Tithonia	3.5	0.37	4.1	Gachengo et al.,1999
Tithonia	2.7	0.14	4.2	Malama, 2001
Tithonia	1.76	0.82	3.92	Olabode et al., 2007
Albizzia	-	-	-	Literature unavailable

Plant Height Measurements and Dry Matter Production

All levels of chicken manure application resulted in highly significant growth in terms of plant height and dry matter production. This indicates that chicken manure and *Tithonia* level of 20 t/ha are relatively high in nutrients compared with lower levels of *Tithonia* and all *Albizzia* treatments.

The current study confirms significant response to chicken manure application as observed by others (Thiagalingam & Bourke, 1982; Mesa, 1983; Igua, 2000).

The study suggests that, the highly significant difference in response to the organic input is largely due to P. Water soluble PO_4^- was absent in the experimental soil (Table 3). Stunted plant growth is due to the limiting nutrient and it is P in this case. Data obtained from other studies (Table 5) show that P content in *Tithonia* is relatively lower than chicken manure and hence the highly significant response to chicken manure. However, larger responses to *Tithonia* is possible if it applied as green or fresh biomass rather dried as demonstrated by Otuma et al.,1998.

Conclusion

The effectiveness as soil ameliorants followed the order: Chicken Manure > *Tithonia* > *Albizzia* > Control . It is most likely that the response is largely due to P. Application of chicken manure and 20 t/ha of *Tithonia diversifolia* improved available soil P and hence P uptake by maize as confirmed by the current data. Of all the nutrients, P is most deficient in the highlands soil. Application of soil ameliorants high in P will certainly result in a response.

Recommendations

Chicken manure is the preferred form of organic input at a rate of 5 t/ha and 20 t/ha since they were statistically the same. However, with issues of availability and cost, *Tithonia* is a better option than chicken manure at rates of 40-50 t/ha and applied as fresh biomass rather than dried.

Acknowledgements

Grateful thanks to the University of Goroka for providing experimental and laboratory facility. Mr. Kanehito Sasai, Mr. Jeffrey Binifa and Mr. Mathias Ewande are duly acknowledged for their assistance in the field and the laboratory.

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ADDITIONAL INFORMATION

Title:	Effect of Chicken Manure, *Tithonia diversifolia* and *Albizzia spp* on Maize Plant Height and Dry Matter Production – Lessons Learnt in the Eastern Highlands Province of PNG
Authors:	Passinghan Igua and Lisa Huasi
Topic/Theme:	2 - Farm management of Food, Fiber and Energy
Peer Review or Non Peer Review:	Peer Review Paper
Word count:	3497
Affirmation:	I affirm and declare all work in this paper is original and is not published elsewhere. Information obtain from other sources are duly acknowledged in the references.
Short Biography of Lead Author:	Passinghan Igua is a Soil Science lecturer at the University of Goroka in the Eastern Highlands Province of Papua New Guinea. Work experiences include land use planning and evaluation for crop suitability, soil fertility, soil erosion and agronomy. Has provided consultancy for a World Bank funded project – Rabaul Ashbed Revegetation Project, Land Evaluation for Ramu Sugar Ltd Diversification Program, and Mine Rehabilitation work for OK Tedi mine. Author of "Food Security Strategies for PNG" published under CGPRT (UN) in Bogor, Indonesia. Holds a Bachelor of Agriculture (Hons), University of PNG and Masters of Agricultural Science from Lincoln University, New Zealand.
Comments:	Please be informed that the water soluble anions and cations of chicken manure, *Tithonia* and *Albizzia* were not measured due delays in the supply of reagents from Japan. Discussion is solely based on plant height and DMP data.