

Full Length Research Paper

Use of cultured indigenous micro-organism (IMO) decomposed liquid chicken manure on the growth and yield of onions (*Allium cepa*)

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This study was conducted to determine the effect of indigenous micro-organism (IMO) decomposed liquid chicken manure on the growth and yield of onions set up at Africa University, Mutare, Zimbabwe. There were five treatments arranged in a Randomized Complete Block Design with three replicates. Treatments were: 1 (Onions grown with IMO decomposed liquid chicken manure only), 2 (IMO decomposed liquid chicken manure only), 3 (half recommended in organic fertilizer and half IMO decomposed liquid chicken manure), 4 (half recommended inorganic fertilizer and half non-IMO decomposed liquid chicken manure) and 5 (inorganic fertilizers only) using Red creole onion variety. Data on average plant height and number of leaves per plant at physiological maturity, average onion bulb width, onion fresh and cured weights was collected and analysed using Genstat. Growth and yield parameters of treatment 3 had the best results ($P<0.05$). Treatments 2, 3 and 5 were not significantly different at 5% level. It was also concluded that the use of IMO decomposed liquid chicken manure in combination with half the recommended in organic fertilizers had the best returns of 14.3% on investment.

Key words: Chicken manure, indigenous micro-organism (IMO), growth, yield, onion, return on investment.

INTRODUCTION

Onion (*Allium cepa*) is a spicy vegetable which belong to the family Alliaceae. Onions originated in middle Asia between Turkmenistan and Afghanistan where some of its relatives still grow as wild plants. Onions are used as a spice for the different food dishes all over the world.

According to George et al. (2009), addition of chicken manure to garden onion plants increases the concentration of organic sulfur compounds in the onion. Natalie et al. (2020) reported that plant-derived sulfur compounds are beneficial in cancer prevention and

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therapy. The authors revealed that the main source of plant-derived sulfur compounds is alliaceous and cruciferous vegetables. Onions belonging to Alliaceae family are therefore rich in these compounds. Griffiths et al. (2002) further revealed that onions have anti-bacterial and anti-inflammatory properties. The authors suggested that due to this property, onions can be used to treat heart disease and asthma.

Proper fertility is important in onion production. For proper plant growth, onions require three main elements, namely: nitrogen, phosphorus and potassium. Nearly all animal wastes particularly faeces contain these three elements (Arcangelo et al., 2019). What is more is that when animal manure goes into the garden, the nitrogen content in it does not immediately get released into the soil. Instead composite manure acts as a time release capsule. Some of the nitrogen gets to the plant upon first application, over weeks, months and years. This is so mainly due to the population and diversity of IMO breaking down the dead organic matter. The greater the population and diversity of these IMOs, the faster the rate of decomposition and vice versa. For example, Jiaying et al. (2022) reported that litter mixing promotes decomposition rate through increased diversities of phyllosphere microbial communities. The authors further revealed that there is a relationship between nutrient release and microbial diversity structure.

In order to increase the rate of decomposition, the population and diversity of micro-organism has to be increased. Umair et al. (2020) in their review paper suggested that humus and indigenous micro-organisms (IMOs) could be a useful resource for sustainable agriculture. IMOs are a group of innate microbial consortium that inhabits the soil and surfaces of all living things having the potential in biodegradation, bioleaching, bio-compositing, nitrogen fixation, improving soil fertility and production of plant growth hormones. This therefore means that addition of IMOs on a decomposing dead organic matter will enhance the process hence nutrient recycling can occur faster. The use of IMOs to get economic, social and environmental benefit is inherently attractive and is an evolution from traditional technologies to modern technologies to provide an efficient way to protect the environment and new methods of environmental monitoring (Umair et al., 2020).

According to Agricura (2019), Zimbabwe onion farmers guide, cultivation of onions requires application of large amounts of fertilizers for example Compound C fertilizer (NPK) should be applied at a rate of 600 kg/ha, ammonium nitrate at a rate of 100 kg/ha and MOP at a rate of 100 kg/ha. These make the cost of fertilizer per hectare to be at least 300.00 US dollars. The Borgen report (2021) revealed that poverty affects 76.4% of rural Zimbabweans. This therefore becomes prohibitive for small scale onion farmers to afford inorganic fertilizers or even expand their onion production to big commercial

gardens.

Because organic manure in form of animal droppings or decomposing plant residues is cheaper and can be used as an alternative to inorganic fertilizers, their decomposition rate is often very slow and nitrogen mineralisation mainly depends on agro-ecological zone with areas of high rainfall and average temperatures standing to benefit more than arid area (Kabasiita et al., 2022). Because onions in Zimbabwe are grown in winter when temperatures are low and with little or no rainfall, addition of solid manure will have a low rate of nitrogen mineralisation therefore nutrient release does not synchronise with onion growth period hence low yields. Similarly, that type of manure emits bad smelling gases during the process of decomposition that may be a source of conflict between the farmer and the neighbours. There is therefore urgent need to come up with an organic fertilizer that is cheap, eco-friendly and has a high nutrient release pattern that synchronises with the growth period of onions.

Mirjana et al. (2018) reported that, application of liquid manure into the soil increases nematode diversity and the stability of the soil ecosystems as well as nutrient content in the soil. The authors elaborated that this results into a reduced economic investment primarily in the use of mineral fertilizers.

This study was therefore aimed at assessing the effects of IMO decomposed liquid chicken manure on the growth and yield of onions as a substitute to inorganic fertilizers.

MATERIALS AND METHODS

The experiment was conducted at Africa University farm, Mutare, Eastern Zimbabwe at a location of 18.8968°S and 32.6013°E. During the experiment, 936 mm of rainfall was received and the bulk of it was between December and February as shown in the Figure 1. The soils at the experiment site are heavy red clay soils with a pH of 6.04.

Red creole onion variety was used in this study. The chicken manure used was collected from the Layer's section of Africa University farm. The IMOs were harvested from soils that were 100 m away from the experimental site. The process of indigenous micro-organism harvesting was conducted as explained by Hoon and Dupont (2010). The process involves use of 2 kg of steamed rice that was buried in soil for 5 days. The rice was removed, smashed, brown sugar added and then cultured in 200 L of water where 5 kg of maize bran was added. The alcoholic smell was used as an indicator of the presence of the IMOs.

The seedlings used in this experiment were raised from the nursery at the horticulture department of Africa University. The seedlings were transplanted to the experiment site after 10 weeks in the nursery.

The experiment had 5 treatments arranged in a Randomized Complete Block Design (RCBD) and replicated 3 times. The treatments were blocked for soil fertility. Treatment 1 (Onions grown with IMO decomposed liquid chicken manure only), Treatment 2 (Onion grown with non-IMO decomposed liquid chicken manure only), Treatment 3 (Onions grown with half recommended inorganic fertilizers and IMO decomposed liquid chicken manure), Treatment 4 (Onions grown with half recommended inorganic fertilizers and

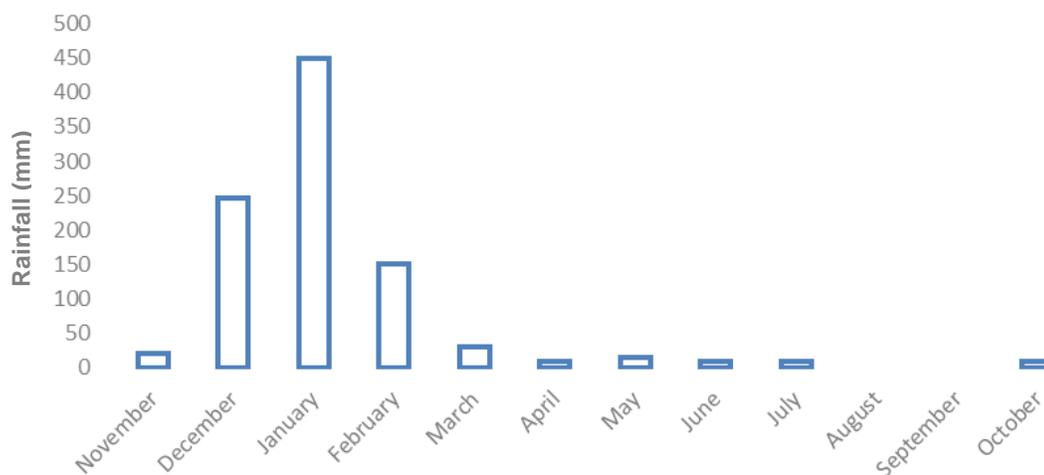


Figure 1. A bar graph showing rainfall received at Africa University farm from November 2020 to October 2021.

non-IMO decomposed liquid chicken manure) and Treatment 5 (Onions grown with inorganic fertilizers only).

Data collection focused on the following parameters: growth, yield and yield components. Five plants were picked at random from each plot. Each treatment was placed in a plot which had an area of 2 m². The growth parameters were measured after every 2 weeks until the crop reached the senescence stage. The average values were then recorded.

Growth parameters

Number of leaves

Data for growth parameters included counting the number of leaves per plant from 5 randomly selected plants in the middle row of a net plot which were physiologically mature and the average number was computed.

Plant height

Plant height was measured from the ground level up to the tip of the longest leaf using a measuring tape. Five randomly selected plants from the central row of each plot at physiological maturity of the crop were measured and the average value was computed.

Yield components measured

Bulb diameter

The bulb diameter was measured at right angle to longitudinal axis at the widest circumference of the bulb of five randomly selected plants in each plot using a vernier calliper.

Average fresh bulb weight

The average weight of 5 freshly and randomly selected plants from the net plot was measured within the first 15 min of harvesting.

Average cured onion weight

The onion bulbs whose fresh weight was measured were tagged and cured weight was measured after 3 weeks of curing. Curing involved windrowing, topping and hanging of onions in a cool dry place inside the laboratory.

Yield in tons per hectare of cured onions

In computing this, a standard formula of 1 kg/m² = 10 tons/ha was used.

Data analysis

All the measurements were checked for normality before analysis and they were subjected to analysis of variance (ANOVA) using GENSTAT where least significant difference LSD test was used to separate the means at 5% probability level.

RESULTS AND DISCUSSION

Data on growth productivity is presented in Table 1.

Number of leaves

There was a significant difference ($P < 0.05$) in the number of leaves at physiological maturity depending on treatment. Treatments 1, 3, and 5 had more leaves at physiological maturity. Treatments 2 and 4 where non-IMO decomposed liquid chicken manure was applied solely or in conjunction with half the recommended inorganic fertilizers, respectively had significantly a smaller number of leaves and this could be attributed to less nutrients available to onions and a smaller number of micro-organisms that were available to decompose the

Table 1. Growth parameters measured.

Treatment	Number of leaves at physiological maturity	Plant height (cm)	Bulb diameter (cm)	Fresh onion weights (g)	Cured onion weights (g)
1	7.75 ^c	54.33 ^c	3.1000 ^c	0.320 ^d	0.1470 ^c
2	11.33 ^a	61.00 ^b	5.5530 ^b	0.880 ^b	0.6100 ^b
3	11.20 ^a	64.33 ^a	6.3300 ^a	0.990 ^a	0.7630 ^a
4	7.91 ^b	55.00 ^c	3.4400 ^c	0.403 ^c	0.2330 ^c
5	10.13 ^a	63.67 ^{ab}	5.8500 ^{ab}	0.927 ^{ab}	0.6400 ^{ab}
LSD	1.947	2.698	0.5504	0.0783	0.1245
CV (%)	11.1	2.5	3.1	6.1	14.3

LSD 5%=Least significant difference P=0.05, CV (%) is coefficient of variation expressed as a percentage; means with the same superscript letter within a column are not significantly different at 5% level. Treatment means with in a column with a different superscript differ significantly at P<0.05.

chicken manure, respectively. Therefore, during the period of plant growth, there might have been less nutrients availed to the plant for proper growth

Plant height

Application of IMO decomposed liquid chicken manure had a significant effect on onion height. Treatments 2, 3 and 5 where IMO decomposed liquid chicken manure was applied solely or in combination with half the recommended in organic fertilizers had the highest values and did not show significant difference at P<0.05. Treatment 1 and 4 where Non-IMO decomposed liquid chicken manure was applied had significantly shorter onions plants and this could be attributed to a smaller number of micro-organisms that were available to decompose the chicken manure. This implies that during the period of plant growth, there were fewer nutrients availed to the plant for proper growth.

Bulb diameter

Bulb diameter was significantly influenced by application of IMO decomposed liquid chicken manure and half the recommended in organic fertilizers (P<0.05). Treatment 3 gave the highest value (6.33 cm) bulb diameter. This highest value was found from onions grown under application of both IMO decomposed liquid chicken manure and half recommended inorganic fertilizers. Treatments 5 and 2 where inorganic fertilizer only and IMO decomposed liquid chicken manure only were applied, respectively did not differ significantly at P<0.05. This non-difference could be due to the fact that non-IMO decomposed liquid chicken manure was still in the process of decomposing therefore less nutrients being availed to the onions during their growth time.

Bulb fresh and cured weights

The average fresh bulb weight was influenced by application of IMO decomposed liquid chicken manure (Table 1). Treatment 3 produced the highest value 0.99 kg followed by treatment 5 with 0.927 kg and treatment 2 with 0.88 kg. Like in the parameters of growth, treatments 4 and 1 where non-IMO decomposed liquid chicken manure was used in combination with inorganic fertilizers and zero fertilizer application, respectively had significantly low value. This is mainly attributed to the fact that the non-IMO decomposed liquid chicken manure was slow in decomposing therefore did not avail required plant nutrients during the growing time of onion.

Yield in tons/ha of cured onions

From the graph, treatment 3 (IMO decomposed liquid chicken manure and half recommended in organic fertilizers) had the best yield of 25.44 tons/ha. This might be due to the fact that the IMO decomposed liquid chicken manure was fully decomposed so released essential nutrients to top up the deficit of half the inorganic fertilizers applied needed for proper growth of onions. Treatment 1 (non-IMO decomposed liquid chicken manure only) had the least value of yield of 18.9 tons/ha. This might be due to the slow rate of decomposing the liquid chicken manure which deprived onions the vital nutrients during the growing season hence low yield (Figure 2).

Economic analysis

Data for economic analysis of the five different treatments is summarized in Table 2. According to Corporate Finance Institute Financial Ratio eBook, gross margin is

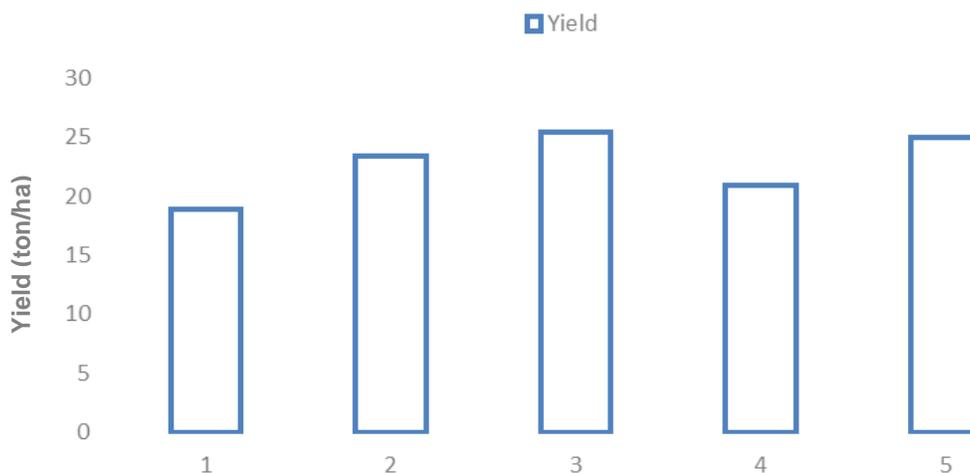


Figure 2. A column graph showing the yield of onions in ton/ha under different treatments.

Table 2. The economic analysis of the different fertilizer treatments inputs versus returns in US dollars.

Economic assessment	Treatment				
	1	2	3	4	5
Seedling costs	1.350	1.350	1.350	1.350	1.350
IMO	00.000	0.865	0.433	00.000	00.000
SSP	00.000	0.000	0.275	0.275	0.550
AN	00.000	0.000	0.185	0.185	0.370
KNO ₃	00.000	0.000	0.145	0.145	0.290
Management costs	4.200	4.200	4.200	4.200	4.200
Quantity in kg of cured onion per treatment	3.780	4.680	5.088	4.170	5.000
Total input costs	5.550	6.415	6.588	6.155	6.760
Price per kg of cured onion	1.481	1.481	1.481	1.481	1.481
Total Returns	5.598	6.931	7.535	6.176	7.405
Gross Margin	0.048	0.516	0.947	0.021	0.645
Return on Investment %	0.9	8.1	14.3	0.3	9.5

Treatment 1 (Non-IMO decomposed liquid chicken manure only), treatment 2 (IMO decomposed liquid chicken manure only), treatment 3 (half recommended inorganic fertilizer and IMO decomposed liquid chicken manure), treatment 4 (half recommended inorganic manure and non-IMO decomposed liquid chicken manure) and treatment 5 (Inorganic fertilizers only). IMO- Indigenous Micro-organisms; SSP- Single Super Phosphate; AN- Ammonium Nitrate; KNO₃- Potassium Nitrate.

calculated using the formula:

Net sales - Cost of goods sold (COGS)

Return on investment was calculated using the formula as explained in the Corporate Finance Institute Financial Ratio eBook:

$$\frac{(\text{Return from investment} - \text{Initial cost of investment})}{\text{Initial cost of investment}} \times 100$$

From the growth and yield parameters measured for the

5 treatments under different fertilizer arrangements, treatment 3 had the best results. The IMO decomposed liquid chicken manure managed to top up the nitrogen and other essential nutrient deficit which was not supplied by the less inorganic fertilizers applied. This agrees with Mohanty et al. (2015) who reported that application of organic inputs and chemical fertilizers gave better results than application of organic or chemical fertilizers alone.

The significant difference of treatment 2 from treatments 1 and 4 where non-IMO decomposed liquid chicken manure was applied could be due to action of the higher number of IMOs that ensured a faster decomposition

of the chicken manure; hence more nutrients were released to the onions in their growth period. This agrees with Khalib et al. (2019) who found out that composting wastes using IMO increases nitrogen content until the end of composting period of over 60 days.

The economic assessment of the 5 treatments under different fertilizer arrangements revealed that treatment 3 (IMO decomposed liquid chicken manure and half recommended inorganic fertilizers) had the highest return on investment of 14.8%. This could be due to less amount of money incurred in buying the fertilizers since only half of the recommended fertilizer was applied and the cheap IMO decomposed liquid chicken manure managed to bridge the gap of the remaining half of the inorganic fertilizer. This agrees with Mohanty et al. (2015) who reported that application of organic inputs in combination with chemical fertilizers had better economic returns and revenue generation to the farmer.

CONCLUSION AND RECOMMENDATIONS

From the results obtained, the growth and yield parameter measured indicated that treatment 3 (onion grown using half recommended inorganic fertilizers and IMO decomposed liquid chicken manure) gave the best result overall followed by treatment 5 (onion grown using inorganic fertilizers only) and treatment 2 (onions grown using IMO decomposed liquid chicken manure). However, these 3 treatments were not significantly different at 5% level.

From calculation of returns on investment (ROI), treatment 3 had the highest returns on investment of 14.3%; hence, more profitable. The results from this study show that fertilizers applied in treatments 2, 3 and 5 can easily substitute each other therefore the farmers should go for a fertilizer with a high return on investment because it is much profitable than the rest.

From the study, the following recommendations are derived:

- (1) Small scale Onion farmers should adopt the use of Indigenous Microorganism (IMO) decomposed liquid chicken manure for increased profits.
- (2) More research about the use of IMOs in crop production needs to be done in order to have a wide range of knowledge on their use in crop growing.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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