BIBLIOGRAPHY

COPAS, RAY P. APRIL 2008. Growth, Yield and Some Postharvest Characteristics of Romaine 'Xanadu' Applied With Varying Rates of Fish-Kelp-Guano Liquid Fertilizer. Benguet State University, La Trinidad, Benguet.

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ABSTRACT

The growth and yield and some postharvest characteristics of romaine 'Xanadu' as affected by the application of fish-kelp-guano liquid fertilizer were evaluated at the Balili experiment area and Horticulture Laboratory room of the Benguet State University, La Trinidad, Benguet from December 22, 2007 to February 2, 2008.

Methods of application. Although no significant difference was observed, applying fish-kelp-guano liquid fertilizer through drenching effected higher yield giving an 87.59% return on investment or Php 0.88 for every peso invested in the production compared to the 73.33% ROI from foliar application. All the data gathered differed slightly.

Rates of application. The farmers' practice of applying natural organic fertilizer and urea effected significantly higher marketable yield due to significantly lower non-marketable yield resulting to the highest return on investment of 128.08%.

Interaction of factors. There was no significant interaction effects of methods and rates of application in all the data gathered.

Based on the results, the farmers applying chicken manure as basal fertilizer and drenching urea one week after transplanting is still recommended for romaine 'Xanadu' production.

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INTRODUCTION

Nature of the Study

The vegetable industry in the Philippines plays an important role both in the economy of the country and the nutrition of the populace. Romaine lettuce (*Lactuca sativa L.*) is one of the salad vegetables being produced in the highlands of the Cordillera region, especially in Benguet which mature early. Aside from its early maturing characteristics, the price is as low as Php 20.00 to a high of Php 80.00 per kilo. This is due to the low volume of production at present although Benguet and Mountain Province have the best climatic condition for growing romaine lettuce.

The continues application of synthetic fertilizers from the introduction of "green revolution" up to this time created many problems in the ecology, economy and social dimensions. In ecological problems, Murakami (1991) mentioned the series of the problems to be experienced like the degradation of the soil, increasing pests, degradation of food quality, pollution of the soil and water, health hazard and disappearance of local varieties.

Chemical fertilizers are applied to the soil in the form of granule or to the plant leaves in the form of liquid solution. Soil application does not only make the soil acidic, but also have the problem of fixation, leaching and nitrification. These observations may be due to the fact that most of the fertilizers studied have nitrogen, phosphorous and potassium but do not have micronutrients. The latest introduction of foliar fertilizers guaranteed the inclusion of micronutrients which are commonly deficient in the soil. These foliar fertilizers are synthetically or biologically produced. To evaluate the efficacy of these foliar fertilizers, especially those formulations from organic origin compatible for organic production which is the trend, this study was proposed.

Importance of the Study

If the study on the varying rates of fish-kelp-guano liquid fertilizer show increase on the growth and yield of romaine 'Xanadu' lettuce and reduced cost, it will guide farmers to minimize their expenses on the fertilizers and to maximize their profit. If this happens, farmers will not only increase food production to meet the requirement of increasing population, but also raise their standard of living. This will lead to more developments in the community. It will also help the technicians of the Department of Agriculture promote their organic production program as well as the University whose mandate is to conduct research.

This study was conducted at This study was conducted at the Balili Experiment Area of Benguet State University, La Trinidad, Benguet from December 22, 2007 to February 2, 2008 aimed to evaluate the growth and yield performance of the romaine 'Tyrol' applied with the varying rates of fish-kelp-guano liquid fertilizer by foliar or drench method, to determine the best rates of fish-kelp-guano liquid fertilizer for romaine 'Xanadu' production, to determine the interaction between method of application and rate of application and to determine the level of profitability of using the varying rates of the fish-kelp-guano liquid fertilizer.

REVIEW OF LITERATURE

Description of the Crop

According to Groman, (1997), there are three main kinds of lettuce: (1) head, (2) leaf and (3) romaine. Head lettuce has leaves that curl around the center of the plant, forming a ball-shaped head. Crisp head lettuce or iceberg lettuce has tight head and brittle, juicy leaves. Leaf lettuce forms dense, leafy clumps instead of head. Gardeners grow more of it than any kind. Most leaf lettuce has a tight green leaves but a few red varieties have been developed for their taste and for the attractive color they give to salads. The waxy, crinkled leaves vary in shape among various type of leaf lettuce. On the other hand, romaine lettuce grows long and upright and its leaves are inward. The leaves are tender can be easily damaged in shipment. Romaine lettuce is the most nutritious among the lettuce crops.

Tied Jens (1964), stated that lettuce, a smooth annual plant of the family compositae is extremely favored for its crisp tender leaves as salads. Lettuce grown on well lime soil or sandy texture that permits adequate access to oxygen.

Moreover, McCollum (1924) said that after the leaf formation and leaf branching, flowering stem develop, these stems range in height from 3 to 4 ft. (90-120 cm) and bear clusters of small yellow flower heads.

Historically, Watts (1922) presents the following classification and description of the various types of lettuce recognized by most seeds men distinguished by their upright growth habit, long-leaf shaped heads and the spatulate leaves. There is no difficulty in identifying the romaine type, but certain crisp and the butter varieties are much alike, the latter are generally more delicately flavored, softer and with more pliable texture; while the crisp varieties are coarser veined and larger ribbed than the other parts of the leaf. On account of their much developed borders they are sometimes called frilled lettuce. Romaine is the most upright growing of the four major types of lettuce. Romaine has long, upright, crisp leaves with a distinctive midrib almost to the tip. The tip of the leaf is blunt. Leaves are somewhat folded (cupped) and grouped into loose heads. The interior leaves are more delicate and blanched than those toward the outside. This cylindrically-hearted lettuce known to the Romans as Cappadocian lettuce is now called Roman lettuce or more commonly, romaine. According to vegetable history, this dates from the time when the Popes moved from Rome to Avignon in the 14th century, bringing this type with them and having it grown in the palace gardens. It was therefore known as Avignon lettuce. In England, however, it is called cos lettuce after the Greek island that was the birthplace of Hippocrates. It was also grown and eaten raw or cooked in China in early history. Paintings in Egyptian tombs dating from about 4500 BC reveal a type of lettuce with long pointed leaves, not much different from romaine lettuce.

Soil and Climatic Adaptability

According to McCollum (1924), lettuce can be grown in a wide variety of soils, including muck and sandy or silt loam. Lettuce prefers a moist but well-drained soil type, rich in organic matter, sandy loam or loam with pH ranging from 6.55 to 7.50.

Temperature requirements, Groman (1997) wrote that most kinds of commercial lettuce grow well in 21 to 24 degree Celsius. In contrast, Wallace (1975) mentioned that the optimum high for lettuce is 10 to 15 Celsius with a day temperature of 15 to 20 Celsius. Seeds germinate in 6 to 10 day and can be directly planted.

Importance of the Crop

Ensminge *et al* (1986) said that romaine lettuce is guaranteed to be packed with nutrients. The vitamin and minerals found in romaine lettuce are especially good for alleviation or preservations of many health complaints due to its extremely low calorie amount and high water volume. Romaine lettuce while often over looked in the nutrition world actually a very nutritive food. Based on its nutrients density, the food ranking system qualified. It is source of vitamin A, C and foliate manganese.

Good source of dietary fiber. The fiber adds another plus in its collism of heart healthy effects. Folic acid (vitamin B), is needed by the body to covert a damaging chemical called "Homocytene" into another benign substances. In addition romaine lettuce is a very good source of potassium, which is in lowering high blood pressure.

Importance of Organic Fertilizer

Plants use nutrients at different rates and at different times during the growing season. For best results, ensure that the nutrients are available on a consistent basis. Organic fertilizers are like an insurance policy. Most contain rock powders and complex proteins that are not very water-soluble. This means organic fertilizers persist in the soil for many months or even years. They become part of the soil, improving its texture and long-term fertility.

Organic fertilizers (including compost) also feed the diverse food web of bacteria, fungi, earthworms and other beneficial soil life. These organisms convert soil minerals into available nutrients that can be absorbed by plant roots. These organisms also improve the texture of the soil by creating passageways for air and water and aggregating soil particles into "crumbs." Beneficial bacteria and fungi also release many disease-inhibiting substances.

Organic matter added to garden soil improves the soil structure and feeds the microorganisms and insects. The more beneficial microorganisms your soil can support, the less bad organisms will survive. The good guys feed on harmful microbes like nematodes and certain soil born diseases.

They also release their nutrients into the soil when they die. So the more beneficial microorganisms that are in the soil, the more nutrients will be in the soil. And many types of organic matter add still more soil nutrients to the mix.

Beneficial Effects of Organic Fertilizer

Incorporating moderate amounts of animal manure and other organic materials into the field is an established agricultural practice generally recognized to have beneficial effects on the soil's physical, chemical, and microbiological properties. For example, the use of properly composted organic soil amendments has been associated with desirable soil properties. These properties include greater plant water-holding and cation exchange capacity, lower bulk density of soils, and inducer of beneficial microorganisms (Lin et al. 1973; Parr et al. 1986; Chao *et al*. 1996).

One of the reasons for the unsustainability of cultivated soils is the decline in soil organic matter content. Adequate amount of soil organic matter also greatly reduces the difficulties of good crop production (Allison 1978). Therefore, restoring and maintaining a high soil organic matter content is the principal strategy for attaining economic progress and improving environmental quality. Increases in soil biomass, biological abundance, and diversity are directly related to increased levels of organic matter and good management practices, which, in turn, positively influence soil structure, nutrient cycling and availability, buffering capacity, and pest and disease control in cultivation systems.

There is also a close relationship between the nutrient status of soils and the organic matter content. Researches have shown that under long-term treatments, adding farmyard manure has raised soil fertility and yields to levels greater than those under synthetic fertilizer treatments. In addition to directly supplying nutrients from the mineralization of organic matter, the mechanisms of higher availability of nutrients with soil of higher organic matter contents are multiple. Parsa and Wallace (1979) showed that both dog manure and sewage sludge at lower rates were very effective in correcting the Fe deficiency of sorghum in calcareous soil by significantly increasing the dry matter yield and the uptake of Fe, Zn, Cu, and Mn. Benefits of compost amendments to soil also include pH stabilization and faster water infiltration rate due to enhanced soil aggregation (Stamatoados *et al*., 1999). Soils applied with compost initially had a lower soil pH than those applied with synthetic fertilizers, but over time soil pH increased to higher levels in soils with compost than those with synthetic fertilizers (Bulluck et al. 2002). The levels of mycorrhizal colonization were greater under organic treatments than under the conventional. Organic matter increased the available phosphorus in the soil through the organic anion, preventing P fixation and replacing the P bound to the soil (Swenson et al. 1949; Nagarajak *et al*., 1970; Kafkafi *et al*., 1998).

It has been shown that microbial activity and biomass are higher in fields with organic amendments than fields with conventional fertilizers (Drinkwater et al. 1995). Soils with compost application have higher propagule densities of Trichoderma species than soils amended with synthetic fertilizers regardless of their production system history (Bulluck et al. 2002). The supply of organic manure allows the direct uptake by plants of specific chemicals needed for the development of their immune system. Therefore, the application of organic manure also makes a direct contribution to the anti-phytopathogenic potential of soils . This is particularly important in the case of the fungal damping-off diseases such as Rhizotinia, Fusarium, and Pythium (Lampkin 1990). The most important mechanism is the antagonism of soil microorganisms toward each other, which may take the form of producing toxins and antibiotics, competing for nutrients and energy, and/or parasitism (Lampkin, 1990).

The buildup of soil organic matter and maintenance of a protective surface cover under organic and minimum tillage systems favor a reduction in soil loss and its associated problems.

Fish-kelp-guano Liquid Fertilizer

According to the brochure of the liquid fertilizer, fresh marine fish extracts contain substantial amount of protein, such as nitrogen, which is indispensable for plant growth due to its effect on chlorophyll, protein and amino acid production. Apart from being an important source of nitrogen, it also offers healthy balance of all 18 nutrients known to be significant for plants growth.

Moreover, fresh seaweeds Extracts contain more than 60 trace minerals and variety of amino acids, enzymes and alginates that feed and increase the necessary microorganisms in the soil. Includes plant growth hormones like Auxins, Cytokinins, and Giberilins responsible for cell elongation, division etc. A healthy, vigorous microbial population will divide organic materials and improve the quality and texture of the soil.

Furthermore, first class guano has so many agricultural uses, which guarantee efficient soil regeneration and abundant harvests of high quality, making it an invaluable agricultural fertilizer for producing organic food. It has a wide range of chelated material (natural organo-mineral compounds with high molecular weight), giving it greater structural stability and an extended residual effect on the soil.

The typical analysis printed on the container label are the following: Nitrogen – 0.42%, Phosphorous – 0.23%; Potassium – 5.31%; Magnesium – 0.16%, Calcium – 0.42%, Magnesium – trace; Copper – trace; Sodium – 0.21%; Iron – 50.46 ppm; and Zinc – 9.53 ppm.

MATERIALS AND METHOD

Materials

The materials used in the study are the seeds of Romaine ‘Xanadu’, garden tools, water pumps, knapsack sprayer, measuring tools, watering cans, labeling materials, compost, urea (46-0-0), and fish-kelp-guano liquid fertilizer (organic).

Methods

The study was laid out in Split-plot design with three replications. The treatment combinations are represented as follows.

Methods of Application – Factor A

A_1 – Foliar application

A_2 – Drench application

Rate of Application – Factor B

R_1 – 10 ml Fish-Kelp-Guano/gallon of water

R2 – 15 ml Fish-Kelp-Guano/gallon of water

R3 – 20 ml Fish-Kelp-Guano/gallon of water

R4 – Farmer’s practice

Seedling Production

Seeds of romaine ‘Xanadu’ were sown on seedling trays. The media used was coconut coir dust. Proper care was done in order to produce healthy and vigorous seedlings. The seedlings were transplanted 3 weeks after sowing the seeds.

Land preparation

An area of 120 sq m was prepared for the study. The area was prepared into 24 plots measuring 1 m x 5 m and these plots were grouped into three blocks representing the three replications and each replication contained eight plots to represent the eight treatment plot combinations. Each plot was applied with 1 can coconut coir dust compost and mixed thoroughly with the soil. The plant spacing was marked by pressing the tip of the finger on the plot surface at a distance of 15 cm x 15 cm before transplanting the seedlings.

Transplanting

Three weeks old seedlings were transplanted to their assigned plots in a triple row with triangle arrangement at 15 cm marked during land preparation. These mean 33 seedlings per row or 99 seedlings per plot.

Fertilizer Application

The application of foliar fertilizer followed the rate specified in the treatments, which was applied 9:00 in the morning. The treatments were implemented five days after transplanting the seedlings at seven days interval. The farmers practice was drenched with 200 grams urea in 16 liters water seven days after transplanting.

Care and Maintenance

Irrigation was done every three days from transplanting to a day before harvest. Pest control was done manually when insects were observed for the area is under transition for conversion to organic crop production.

Harvesting

Harvesting the plants was done 36 days after transplanting or when the leaves of the plants are erect and are capping. The crop was harvested by cutting the base with sharp knife then packed in cartoon and sold to buyers.

Data Gathered

The data gathered, tabulated, computed and means subjected to separation test by the Duncan's Multiple Range Test (DMRT) were the following:

1. Number of days from transplanting to harvest. This was the number of days from transplanting the seedlings to the day the plants were harvested.
2. Plant height at harvest (cm). This was obtained from ten samples plants by measuring the leaves from the base to the tip of the leaves at harvest time.
3. Non-marketable yield (kg/plot). The weight of non-marketable plant with defects such as diseased and rotten that were not sold in the market.
4. Marketable yield (kg/plot). This was the weight of marketable plants without defects that were sold in the market.
5. Total Yield (kg/plot). The total weight of marketable and non marketable plants per plot was recorded.

6. Weight of individual plant (g). This was taken using the formula:

   Plant weight (g) = Total plant weight/number of harvested plants per plot

7. Computed yield per hectare (tons). The yield per plot was converted to tons per hectare by multiplying the yield per plot by 2000 then divided by 1000. Two thousand is the number of plots per hectare based on the plot size of 1 m x 5 m used in the study while 1000 is the weight of 1 ton.

8. Cost and Return Analysis. All expenses that were incurred in the study were recorded and the Return on Investment (ROI) was computed using the formula:

$$\text{ROI (\%)} = \frac{\text{Gross sales per plot} - \text{Total expenses per plot}}{\text{Total expenses per plot}} \times 100$$

9. Phytotoxicity. The plants in each plot were observed if there were burning effects, discoloration and other abnormalities as an effect of the foliar fertilizer applied.

10. Incidence of Insect Pest and Diseases.

    A. Disease Incidence. This was evaluated on a per plot basis using the following scale:

Rating Scale	Description
1	No disease (no plant infested)
2	Slight Incidence (1-19% of plant is infested per plot)
3	Moderate Incidence (20- 39% of plant is infected per plot)
4	Severe Incidence (40% or more of the plants is infected per plot)

B. Insect Pest Incidence. This was evaluated on a per plot using the following scale description:

Rating Scale	Description
1	No disease (no damaged by insect)
2	Slight Incidence (1-19% of the plants is damaged by insect)
3	Moderate Incidence (20- 39% of plant is damaged by insects)
4	Severe Incidence (40% or more of plants is damaged by insects).

11. Refractive index of crop juice (°Brix). Leaves were taken from each plot and crushed and squeezed three drops of juice onto the prism of the hand refractometer and the reading was recorded during harvest. This gave an idea of the quality of the vegetable produce.

12. Post harvest

a.) Shelf life. This was the number of days from the day the plants were harvested and displayed in the storage room to the day they were not fit for consumption.

b.) Weight loss. The initial weight of the three plant samples in each plot was recorded and the weight during the termination was also recorded and the difference was the loss of weight.

c.) Days to 100% wilting. This was the number of days from the day the sample were displayed under ambient storage room to the day all the leaves of sample plants wilted.

13. Other Observations. Other observation that cannot be measured was recorded by means of photographs.

RESULTS AND DISCUSSION

Days from Transplanting to Harvest

Effect of application methods. The plants were harvested at the same time as they attained the same maturity period (Table 1). This means that foliar and drench application have similar effect.

Effect of application rates. The varying rates of fish-kelp-guano liquid fertilizer and the farmer's practice of drenching inorganic fertilizer have similar number of days from transplanting to crop harvest (Table 1). Apparently, the application rates did not significantly affect the number of days from transplanting to harvest in romaine 'Xanadu'.

Interaction effect. There were no significant effects between application methods and rates of application on plant height at harvest.

Plant Height at Harvest

Effect of application methods. Table 1 shows the similar height of romaine 'Xanadu' applied with fish-kelp-guano liquid fertilizer through foliar or drench method at harvest.

Effect of application rates. The application of 20 ml fish-kelp-guano liquid fertilizer per gallon of water produced the tallest plants, but did not significantly differ from the other rates and from the farmers practice as shown in Table 1. This means that the varying rates did not have marked influence on romaine 'Xanadu' height at harvest.

Interaction effect. There were no significant interaction effects between application methods and rates of application on plant height at harvest.

Table 1. Number of days to harvest and plant height at harvest

TREATMENT	DAYS TO HARVEST (days)	PLANT HEIGHT (cm)
Methods of Application		
Foliar	36[a]	26.55[a]
Drench	36[a]	26.51[a]
Rates of Application		
10 ml	36[a]	26.70[a]
15 ml	36[a]	25.80[a]
20 ml	36[a]	27.09[a]
Farmer's practice	36[a]	26.52[a]

Means in a column with the same letter are not significantly different at 5% level by DMRT

Marketable Yield

Effect of application methods. Drenching the fish-kelp-guano liquid fertilizer produced slightly heavier marketable yield than foliar application as shown in table 2. This means that the application may be either drenching or by foliar spraying.

Effect of application rates. The marketable yield from the farmer's practice significantly surpassed the yield obtained from the plants applied with varying rates of fish-kelp-guano liquid fertilizers, which did not show marked differences among the 10 to 20 ml liquid fertilizer per gallon of water (Table 2). The higher marketable yield from the farmer's practice maybe due to the significantly lighter non-marketable yield shown from the same table.

The application of 46-0-0 (urea) in the farmers practice produced the heaviest marketable romaine due to the higher percentage of nitrogen than from the liquid fertilizer which has only 0.42 %.

Interaction effect. There were no significant interaction effect between the methods of application and the rate of application.

Non-marketable Yield

Effect of application methods. The weight of non-marketable yield is shown in Table 2. Statistical analysis shows that there was no significant difference between foliar and drench methods of applying fish-kelp-guano liquid fertilizer.

Effect of application rates. As presented in Table 2, the weight of non-marketable yield from the farmers practice was significantly lighter compared to those plants applied with fish-kelp-guano liquid fertilizer. The application of 46-0-0 may have promoted more marketable with lesser non-marketable plants.

Interaction effect. There was no significant interaction effect observed between methods and rates of application on the non-marketable yield of romaine 'Xanadu'.

Total Yield

Effect of application methods. There were no significant differences observed between the two methods of applying the liquid fertilizer (Table 2). However, drenching the fish-kelp-guano liquid has a slight advantage of 1.01 kg per 5 sq. m, which when expanded to a hectare area will mean great economic benefit for the grower.

Effect of application rates. As shown in Table 2, plants applied with 10 ml fish-kelp-guano liquid fertilizer per gallon of water has significantly lower total yield than 15-20 ml per gallon of water and farmer's practice with similar total yield. This observation confirms the instruction in the container that 15 ml concentrate solution is to one gallon of water. The application of 10 ml may suggest that it is not enough to promote significant increase in yield of a crop to be applied.

Fish-kelp-guano liquid fertilizer at the rate of 15 – 20 ml per gallon of water and farmers practice did not show significant difference.

Interaction effect. There were no significant interaction effect between the methods and the rate of application.

Table 2. Marketable yield, non-marketable yield and total yield

TREATMENT	MARKETABLE YIELD (kg)	NON-MARKETABLE YIELD (kg)	TOTAL YIELD (kg)
Methods of Application			
Foliar	13.26[a]	1.55[a]	14.81[a]
Drench	14.42[a]	1.40[a]	15.82[a]
Rates of Application			
10 ml	12.73[b]	1.63[a]	14.36[b]
15 ml	13.55[b]	1.63[a]	15.18[a]
20 ml	13.72[b]	1.48[a]	15.20[a]
Farmer's practice	15.35[a]	1.15[b]	16.50[a]

Means in a column with a common letter are not significantly different at 5% level by DMRT

Weight of Individual Plant

Effect of application methods. Table 3 shows the similar weights of the individual romaine 'Xanadu' applied with fish-kelp-guano liquid fertilizer through foliar and drench.

Effect of application rates. The weight of individual romaine 'Xanadu' from the farmer's practice and applied with 15 to 20 ml per gallon of water significantly outweighed the 10 ml per gallon of water (Table 3).

As mentioned earlier the application of 46-0-0 in the farmer's practice and 15 to 20 ml per gallon of water may have provided the nutrient elements that enhanced growth and yield.

Interaction effect. There were no significant interaction effect between the methods and the rate of application.

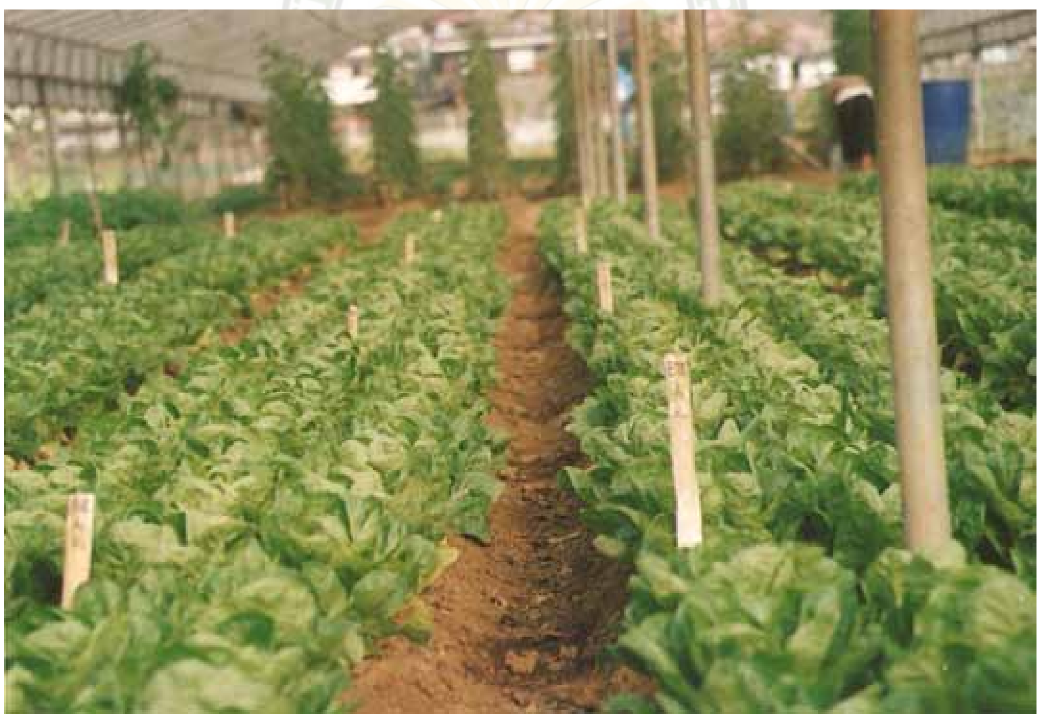
Computed Yield per Hectare

Effect of application methods. Consistent with all the other data, the computed yield per hectare shows similar yield of romaine 'Xanadu' applied with fish-kelp-guano liquid fertilizer through foliar and drench (Table 3).

Effect of application rates. Table 3 shows that the application of farmer's practice and 15 to 20 ml fish-kelp-guano liquid fertilizer per gallon of water produced more yield than 10 ml fish-kelp-guano liquid fertilizer per gallon of water. This may suggest that 10 ml is not enough to provide the nutrient for optimum growth and yield.

Interaction effect. There were no significant interaction effect between the methods and the rate of application.

a.) Overview of the experiment



b.) Close – up view

Figure 1. Photographs of showing the overview of the experiment (a) and close-up without pest damage and liquid fertilizer toxicity

Table 3. Weight of individual plant and computed yield per hectare

TREATMENT	WEIGHT OF INDIVIDUAL PLANT (g)	COMPUTED YIELD PER HECTARE (ton)
Methods of Application		
Foliar	255.17[a]	29.60 [a]
Drench	260.80 [a]	30.35 [a]
Rates of Application		
10 ml	243.39[b]	28.67 [b]
15 ml	259.48 [a]	30.10 [a]
20 ml	262.07 [a]	30.40 [a]
Farmer's practice	267.01 [a]	30.73 [a]

Means in a column with a common letter are not significantly different at 5% level of DMRT

<u>Phytotoxicity.</u>

<u>Effect of application methods</u>. The plants did not show any burning effects, discoloration and other abnormalities. This means that foliar and drench application do not have any toxicity to romaine 'Xanadu' as shown in Table 4.

<u>Effect of application rates</u>. The varying rates of fish-kelp-guano liquid fertilizer and the farmer's practice of drenching inorganic fertilizer did not show any burning effects, discoloration and abnormalities on the plants (Table 4).

Interaction effect. There were no significant effect between application method and rates of applications in terms of phytotoxicity.

Disease Incidence

Effect of application methods. Table 4 shows the similar roting of disease incidence in romaine 'Xanadu' applied with fish-kelp-guano liquid fertilizer through foliar or drench method.

Effect of application rates. As presented in Table 4, the disease incidence from different rates of applying fish-kelp-guano liquid fertilizer and farmer's practice did not differ significantly.

Interaction effect. There were no significant interaction effect between the methods and the rate of application in terms of disease incidence.

Insect Pest Incidence

Effect of application methods. Table 4 shows the similar rating on insect pest incidence in romaine 'Xanadu' applied with varying rates of fish-kelp-guano liquid fertilizer through foliar and drench methods.

Effect of application rates. As presented in Table 4, insect pest incidence from the different rates of applying fish-kelp-guano liquid fertilizer and farmer's practice did not show significant differences. This means that the varying rates studied did not influence the insect incidence to romaine 'Xanadu'

Interaction effect. There was no interaction effect observed between application methods and rates of application.

Table 4. Phytotoxicity, and incidence of insect pest and diseases

TREATMENT	PHYTOTOXICITY	INSECT PEST INCIDENCE	DISEASE INCIDENCE
Methods of Application			
Foliar	None	2.17[a]	2.00[a]
Drench	None	2.17[a]	1.92[a]
Rates of Application			
10 ml	None	2.33[a]	2.00[a]
15 ml	None	2.33[a]	2.00[a]
20 ml	None	2.00[a]	2.00[a]
Farmer's practice	None	2.00[a]	1.83[a]

Means in a column with the same letter are not significantly different at 5% level by DMRT

Refractive Index of Crop Juice

Effect of application methods. The sugar content of romaine 'Xanadu' is shown in Table 5. Statistical analysis shows that there was no significant difference between foliar and drench methods of applying fish-kelp-guano liquid fertilizer.

Effect of application rates. As presented in Table 5, the sugar content of romaine 'Xanadu' was not affected by the different rates of applying fish-kelp-guano-liquid fertilizer.

Interaction effect. There was no significant interaction effect observed between application methods and rates of applying fish-kelp-guano liquid fertilizer.

Shelf-life

Effect of application methods. The plants were displayed in the storage room at ambient condition has the same shelf-life. This means that foliar and drench applications did not influence the shelf-life of the romaine ‘Xanadu’ (Table 5).

Effect of application rates. The varying rates of fish-kelp-guano liquid fertilizer and the farmer’s practice have similar number of days from harvest from to the day it is still fit for consumption.

Interaction effect. There were no significant effect between application method and rates of application on shelf-life of romaine ‘Xanadu’.

Weight Loss

Effect of application. The weight loss is shown in Table 5. Statistical analysis shows that there was no significant difference between foliar and drench methods of applying fish-kelp-guano-liquid fertilizer

Effect of application rates. As shown in Table 5. Statistical analysis shows that no significant differences among the rates of applying fish-kelp-guano liquid fertilizer and the farmer’s practice on the weight loss during storage of romaine ‘Xanadu’.

Interaction effect. There was no significant interaction effect observed between methods and the rates of application on the weight loss of displayed crops.

Figure 2. Photograph of the different samples set-up inside the horticulture service laboratory room

Table 5. Refractive index of crop juice, shelf-life, and weight loss

TREATMENT	REFRACTIVE INDEX OF CROP JUICE (^{0}brix)	SHELF-LIFE (days)	WEIGHT LOSS (g)
Methods of Application			
Foliar	3.52 [a]	5.58 [a]	248.93 [a]
Drench	3.45 [a]	5.83 [a]	246.64 [a]
Rate of Application			
10 ml	3.30 [a]	5.67 [a]	254.50 [a]
15 ml	3.37 [a]	5.67 [a]	280.80 [a]
20 ml	3.60 [a]	5.67 [a]	225.97 [a]
Farmer's practice	3.67 [a]	5.83 [a]	232.87 [a]

Means in a column with the same letter are not significantly different at 5% level by DMRT

Days to 100% Wilting

Effect of application method. The plants displayed in the storage room wilted at the same time as shown in Table 6. This means that foliar and drench application have similar effect on the duration of wilting.

Effect of application rate. As shown in Table 6, the varying rates of fish-kelp-guano liquid fertilizer and the farmers practice have similar days from harvest to storage to attain 100 % wilting.

Interaction effect. There were no significant effect between application method and rates of application on the days to 100% wilting.

Table 6. Days to 100% wilting

TREATMENT	DAYS TO WILTING (days)
Methods of Application	
Foliar	3[a]
Drench	3 [a]
Rate of Application	3 [a]
10 ml	3 [a]
15 ml	3 [a]
20 ml	3 [a]
Farmer's practice	3 [a]

Means with a common letter are not significantly different at 5% level by DMRT

Cost and Return Analysis

Methods of application. As shown in Table 7, drenching the fish-kelp-guano lquid fertilizer obtained 83.03% return on investment in the production of romaine 'Xanadu' compared to the 73.33% ROI of spraying the foliage of the crop. While the statistical analysis on the yield shows slight difference of Php 0.10 advantage from drenching may provide tremendous economic contribution to the farmer in a hectare basis.

Rates of application. Table 8 show's that the farmer's practice obtained the highest return on investment of 128.08% or Php 1.28 for every peso spent in the production. This was followed by the application of 15 ml fish-kelp-guano liquid fertilizer per gallon of water with 87.49% and 85.99%, respectively.

Table 7. Cost and return analysis of rates from the methods of applying the liquid fertilizer

ITEM	FOLIAR	DRENCH
YIELD (kg)	159.10	168.00
SALES (PhP)	2863.80	3024.00
INPUTS:		
1. Compost	135.00	135.00
2. Seedlings	270.00	270.00
3. Fish-kelp-guano liquid Fertilizer	141.50	141.50
LABOR:		
1. Land preparation	140.64	140.64
2. Transplanting	84.39	84.39
3. Irrigation	323.46	323.46
4. Fertilizer application	168.75	168.75
5. Harvesting	196.89	196.89
DEPRECIATION COST	191.59	191.59
TOTAL EXPENSES	1652.22	1652.22
NET INCOME	1211.58	1371.78
ROI (%)	73.33	87.59

Note: Selling price was Php 18/kg

Table 8. Cost and return analysis of the method of liquid fertilizer application

ITEM	RATES OF APLICATION 10 ml	15 ml	20 ml	FARMER'S PRACTICE
YIELD (kg)	76.40	81.30	82.30	87.10
SALES (Php)	1375.20	1463.40	1481.40	1567.80
INPUTS:				
1. Compost	90.00	90.00	90.00	90.00
2. Seedlings	180.00	180.00	180.00	180.00
3. Insecticides	---	---	---	21
4. Urea	---	---	---	24
5. Fish-kelp-guano liquid fertilizer	63.00	94.50	126.00	---
LABOR:				
1. Land Preparation	46.88	46.88	46.88	46.88
2. Transplanting	28.13	28.13	28.13	28.13
3. Irrigation	107.82	107.82	107.82	107.82
4. Fertilizer application	56.25	56.25	56.25	18.75
5. Spraying	---	---	---	9.38
6. Harvesting	733.50	65.63	65.63	65.63
DEPRECIATION COST	191.59	191.59	191.59	191.59
TOTAL EXPENSES	733.50	765.00	796.50	687.38
NET INCOME	641.70	698.00	684.90	880.42
ROI (%)	87.49	91.29	85.99	128.08

Note: The selling price was Php 18.00/kg

SUMMARY, CONCLUSION AND RECOMMENDATION

Summary

The study was conducted at the Balili expereiment area and Agriculture laboratory room of Benguet State University, La Trinidad, Benguet from December 22, 2007 to February 2, 2008 to evaluate the growth and yield and some postharvest characteristics of romaine 'Xanadu' as affected by the application of fish-kelp-guano liquid fertilizer , determine the best method of applying the fertilizer, determine the effective rate of application, determine the interaction effect of the factors and asses the profitability of using the said fertilizer.

The following are the findings:

Methods of application. Foliar and drench application did differ in their effect on the growth, yield and some postharvest characteristics of romaine 'Xanadu'. However, drenching effected slightly higher yield in than the foliar application resulting to higher return on investment.

Rates of application. The farmers' practice of applying natural organic fertilizer and urea effected significantly higher marketable yield due to a significant lower non-marketable yield obtaining the highest return on investment of 128.08%. This was followed by 15 ml, 10 ml and 20 ml fish-kelp-guano liquid fertilizer per gallon of water with return on investment of 91.29%, 87.49% and 85.99%. Slight differences were observed in the incidence of pest and disease, sugar content, and no burning effect or phytotoxicity was observed.

Interaction between the two factors. There were no significant interaction effect of methods and rates of application in all the data gathered.

Conclusion

Based on the results, the farmers' practice applying natural organic fertilizer and urea effected higher marketable yield of romaine 'Xanadu' and with lower cost of production giving higher return on investment without marked differences on some post harvest characteristics.

Recommendation

It is therefore recommended that farmers' practice of applying chicken manure as basal and drenching of urea one week after transplanting is still recommended for romaine 'Xanadu' production.

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APPENDICES

Appendix Table 1. Plant height at harvest (cm)

TREATMENT		REPLICATION			TOTAL	MEAN
		I	II	III		
A_1	R_1	26.99	24.99	24.73	76.71	25.57
	R_2	24.97	26.68	24.99	76.64	25.55
	R_3	27.26	25.69	28.76	81.71	27.24
	R_4	26.96	27.04	26.48	80.48	26.83
A_2	R_1	26.71	26.65	27.14	80.50	26.83
	R_2	26.16	26.54	25.46	78.16	26.05
	R_3	25.50	26.54	28.76	80.80	26.93
	R_4	26.08	24.64	27.42	78.14	26.05

TWO WAY TABLE

TREATMENT	REPLICATION				TOTAL	MEAN
	R1	R2	R3	R4		
A_1	25.57	25.55	27.24	26.83	105.18	26.30
A_2	26.83	26.05	26.93	26.05	105.87	26.47

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Mean Square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Replication	2	0.85	0.43			
Factor A	1	0.01	0.01	0.04[ns]	18.51	98.49
Error	2	3.85	1.92			
Factor B	3	5.22	1.74	1.08[ns]	3.49	5.95
AB	3	1.18	0.39	0.24[sn]	3.49	5.95
Error	12	19.40	1.62			
Total	23	30.51				

ns= Not significant
sn= Significant

Coefficient of Variation: 4.79%

Appendix Table 2. Non-marketable yield (kg)

TREATMENT		REPLICATION			TOTAL	MEAN
		I	II	III		
A_1	R_1	1.80	1.80	2.10	5.70	1.90
	R_2	1.70	2.00	1.20	4.90	1.63
	R_3	1.60	1.80	1.30	4.70	1.57
	R_4	1.00	1.00	1.30	3.30	1.10
A_2	R_1	1.70	1.10	1.30	18.60	1.37
	R_2	1.90	2.00	1.00	4.10	1.63
	R_3	1.60	1.50	1.10	4.90	1.40
	R_4	1.20	1.60	0.80	4.20	1.20

TWO WAY TABLE

TREATMENT	REPLICATION				TOTAL	MEAN
	R1	R2	R3	R4		
A_1	1.90	1.63	1.57	1.10	6.20	1.55
A_2	1.37	1.63	1.40	1.20	5.60	1.40

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Mean Square	Computed F	TABULAR F	
					0.05	0.01
Replication	2	0.55	0.27			
Factor A	1	0.14	0.14	1.05^{ns}	18.51	98.49
Error	2	0.26	0.13			
Factor B	3	0.94	0.31	3.66*	3.49	5.95
AB	3	0.35	0.12	1.36^{ns}	3.49	5.95
Error	12	1.02	0.09			
Total	23	3.25				

ns- Not significant
* - Significant

Coefficient of Variation: 19.78%

Appendix Table 3. Marketable yield (kg)

TREATMENT		REPLICATION			TOTAL	MEAN
		I	II	III		
A_1	R_1	11.00	13.20	11.70	35.90	11.97
	R_2	13.20	12.70	13.50	39.40	13.13
	R_3	12.50	14.30	13.90	40.70	13.57
	R_4	14.00	14.60	14.50	43.10	14.37
A_2	R_1	14.60	12.40	53.60	40.50	13.05
	R_2	14.30	13.40	13.50	41.90	13.97
	R_3	13.80	13.40	14.20	41.60	13.87
	R_4	14.60	14.20	14.40	44.00	14.60

TWO WAY TABLE

TREATMENT	REPLICATION				TOTAL	MEAN
	R1	R2	R3	R4		
A_1	11.97	13.13	13.57	14.37	53.03	13.26
A_2	13.50	13.97	13.87	14.60	56.00	14.00

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Mean Square	Computed F	TABULAR F	
					0.05	0.01
Replication	2	1.45	0.72			
Factor A	1	8.05	8.05	1.50^{ns}	18.51	98.49
Error	2	10.73	5.36			
Factor B	3	21.63	7.21	6.87**	3.49	5.95
AB	3	2.46	0.82	0.78^{ns}	3.49	5.95
Error	12	12.59	1.05			
Total	23	56.90				

ns-Not significant
**- Highly significant

Coefficient of Variation: 7.40%

Appendix Table 4. Total yield (kg)

TREATMENT		REPLICATION			TOTAL	MEAN
		I	II	III		
A_1	R_1	12.80	15.00	13.80	41.60	13.87
	R_2	14.90	14.70	14.60	44.20	14.73
	R_3	14.10	16.10	15.20	45.40	15.13
	R_4	15.00	15.60	15.80	46.40	15.47
A_2	R_1	14.30	14.0	14.80	43.1	14.37
	R_2	16.20	14.70	15.20	46.10	15.37
	R_3	15.40	14.90	15.50	45.80	15.27
	R_4	15.8	15.30	16.00	47.10	15.70

TWO WAY TABLE

TREATMENT	REPLICATION				TOTAL	MEAN
	R1	R2	R3	R4		
A_1	13.87	14.73	15.13	15.47	59.20	14.80
A_2	14.37	15.37	15.27	15.70	60.53	15.13

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Mean Square	Computed F	TABULAR F	
					0.05	0.01
Replication	2	0.390	0.195			
Factor A	1	0.844	0.844	0.48[ns]	18.51	98.49
Error	2	3.490	1.745			
Factor B	3	6.975	2.325	9.60**	3.49	5.95
AB	3	0.241	0.080	0.33[ns]	3.49	5.95
Error	12	2.907	0.242			
Total	23	14.846				

ns-Not significant
** - Highly significant

Coefficient of Variation: 3.28%

Appendix Table 5. Weight of individual plant (g)

TREATMENT		REPLICATION			TOTAL	MEAN
		I	II	III		
A_1	R_1	220.69	258.62	237.93	717.24	239.08
	R_2	256.90	253.45	251.72	762.07	254.02
	R_3	243.10	277.59	262.07	782.76	260.92
	R_4	258.62	268.97	272.41	800.00	266.67
A_2	R_1	246.55	241.38	255.17	743.1	247.70
	R_2	279.31	253.45	262.07	794.83	264.94
	R_3	265.52	256.89	267.24	789.65	263.22
	R_4	272.41	263.79	275.86	812.06	270.69

TWO WAY TABLE

TREATMENT	REPLICATION				TOTAL	MEAN
	R1	R2	R3	R4		
A_1	239.08	254.02	260.92	266.67	1020.69	255.17
A_2	247.70	264.94	263.22	270.69	1046.55	261.64

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Mean Square	Computed F	TABULAR F	
					0.05	0.01
Replication	2	106.98	53.49			
Factor A	1	190.24	190.24	0.31[ns]	18.51	98.49
Error	2	1218.48	609.24			
Factor B	3	1880.30	626.77	8.39**	3.49	5.95
AB	3	108.71	36.24	0.48[ns]	3.49	5.95
Error	12	896.81	74.73			
Total	23	4401.52				

ns- Not significant
** - Highly significant

Coefficient of Variation: 3.35%

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Appendix Table 6. Computed yield per hectare (ton)

TREATMENT		REPLICATION			TOTAL	MEAN
		I	II	III		
A_1	R_1	25.60	30.00	27.60	83.20	27.73
	R_2	29.80	29.40	29.20	88.40	29.47
	R_3	28.20	32.20	30.40	90.80	30.27
	R_4	30.00	31.20	31.60	92.80	30.93
A_2	R_1	28.60	30.60	29.60	88.80	29.60
	R_2	32.40	29.40	30.40	92.20	30.73
	R_3	30.80	29.80	31.00	91.60	30.53
	R_4	31.60	28.00	32.00	91.60	30.53

TWO WAY TABLE

TREATMENT	REPLICATION				TOTAL	MEAN
	R1	R2	R3	R4		
A_1	27.73	29.47	30.27	30.93	118.40	29.6
A_2	29.60	30.73	30.53	30.53	121.40	30.35

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Mean Square	Computed F	TABULAR F	
					0.05	0.01
Replication	2	1.56	0.78			
Factor A	1	3.38	3.38	0.48 ns	18.51	98.49
Error	2	13.96	6.98			
Factor B	3	14.90	4.97	2.84 ns	3.49	5.95
AB	3	4.61	1.54	0.88 ns	3.49	5.95
Error	12	20.99	1.75			
Total	23	59.39				

ns- Not significant

Coefficient of Variation: 4.41%

Appendix Table 7. Disease Incidence

TREATMENT		REPLICATION			TOTAL	MEAN
		I	II	III		
A_1	R_1	2	2	2	6	2
	R_2	2	2	2	6	2
	R_3	2	2	2	6	2
	R_4	2	2	2	6	2
A_2	R_1	2	2	2	6	2
	R_2	2	2	2	6	2
	R_3	2	2	2	6	2
	R_4	2	1	2	5	1.5

TWO WAY TABLE

TREATMENT	REPLICATION				TOTAL	MEAN
	R1	R2	R3	R4		
A_1	2	2	2	2	8	2
A_2	2	2	2	1.50	7.50	1.88

Analysis of Variance

Source	Degrees of Freedom	Sum of Squares	Mean Square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Replication	2	0.08	0.42			
Factor A	1	0.04	0.42	1.00 ns	18.51	98.49
Error	2	0.08	0.42			
Factor B	3	0.13	0.42	1.00 ns	3.49	5.95
AB	3	0.13	0.42	1.00 ns	3.49	5.95
Error	12	0.50	0.42			
Total	23	0.96				

ns- Not significant

Coefficient of Variation:10.42 %

Appendix Table 8. Insect pest Incidence

TREATMENT		REPLICATION			TOTAL	MEAN
		I	II	III		
A_1	R_1	2	2	3	7	2.33
	R_2	2	3	2	7	2.33
	R_3	2	2	2	6	2
	R_4	2	2	2	6	2
A_2	R_1	3	2	2	7	2.33
	R_2	2	3	2	6	2
	R_3	2	2	2	6	2
	R_4	2	2	2	6	2

TWO WAY TABLE

TREATMENT	REPLICATION				TOTAL	MEAN
	R1	R2	R3	R4		
A_1	2.33	2.33	2	2	8.66	2.17
A_2	2.33	2	2	2	8.33	2.08

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Mean Square	Computed F	TABULAR F	
					0.05	0.01
Replication	2	0.08	0.04			
Factor A	1	0.00	0.00	0.00ns	18.51	98.49
Error	2	0.25	0.13			
Factor B	3	0.67	0.22	1.14ns	3.49	5.95
AB	3	0.00	0.00	0.00ns	3.49	5.95
Error	12	2.33	0.19			
Total	23	3.33				

ns- Not significant

Coefficient of Variation:20.35 %

Appendix Table 9. Sugar content (^{0}brix)

TREATMENT		REPLICATION			TOTAL	MEAN
		I	II	III		
A_1	R_1	3.2	3.6	4.0	10.8	5.4
	R_2	4.0	3.8	2.0	9.8	4.9
	R_3	2.8	4.0	3.8	10.6	5.3
	R_4	3.2	4.0	3.8	11	5.5
A_2	R_1	3.0	3.0	3.0	9	3
	R_2	4.0	4.0	2.4	10.4	3.47
	R_3	3.0	4.0	4.0	11	3.67
	R_4	4.0	4.0	3.0	11	3.67

TWO WAY TABLE

TREATMENT	REPLICATION				TOTAL	MEAN
	R1	R2	R3	R4		
A_1	5.4	4.9	5.3	5.5	21.10	5.26
A_2	3.0	3.47	3.67	3.67	13.80	3.45

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Mean Square	Computed F	TABULAR F	
					0.05	0.01
Replication	2	1.29	0.65			
Factor A	1	0.03	0.03	0.21 ns	18.51	98.49
Error	2	0.25	0.13			
Factor B	3	0.57	0.19	0.42 ns	3.49	5.95
AB	3	0.60	0.20	0.44 ns	3.49	5.95
Error	12	5.41	0.45			
Total	23	8.15				

ns- Not significant

Coefficient of Variation:19.28 %

Appendix Table 10. Shelf-life (days)

TREATMENT		REPLICATION			TOTAL	MEAN
		I	II	III		
A_1	R_1	6	6	6	18	6
	R_2	5	5	6	16	5.33
	R_3	5	6	5	16	5.33
	R_4	6	5	6	17	5.67
A_2	R_1	6	5	5	16	5.33
	R_2	6	6	6	18	6
	R_3	6	6	6	18	6
	R_4	6	6	6	18	6

TWO WAY TABLE

TREATMENT	REPLICATION				TOTAL	MEAN
	R1	R2	R3	R4		
A_1	6	5.33	5.33	5.67	22.33	5.58
A_2	5.33	6	6	6	23.33	5.83

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Mean Square	Computed F	TABULAR F	
					0.05	0.01
Replication	2	0.08	0.04			
Factor A	1	0.38	0.38	3.00 ns	18.51	98.49
Error	2	0.25	0.13			
Factor B	3	0.13	0.04	3.49 ns	3.49	5.95
AB	3	1.79	0.60	3.49 ns	3.49	5.95
Error	12	2.33	0.19			
Total	23	4.96				

ns- Not significant

Coefficient of Variation:7.72 %

Appendix 11. Weight loss (g)

TREATMENT		REPLICATION I	II	III	TOTAL	MEAN
A_1	R_1	275.80	298.00	220.00	793.80	264.60
	R_2	260.00	302.00	225.70	817.70	272.56
	R_3	256.50	215.60	156.90	625.00	208.33
	R_4	265.90	299.30	181.40	746.60	248.86
A_2	R_1	199.20	216.30	814.00	715.20	238.40
	R_2	453.20	193.00	220.90	867.10	289.03
	R_3	267.20	195.00	264.60	726.80	242.26
	R_4	281.1	220.40	149.10	650.60	216.86

TWO WAY TABLE

TREATMENT	REPLICATION R1	R2	R3	R4	TOTAL	MEAN
A_1	264.60	272.56	208.33	248.86	995.70	248.93
A_2	238.40	289.03	242.26	216.86	986.56	246.64

Analysis of Variance

Source	Degrees of Freedom	Sum of Squares	Mean Square	Computed F	TABULAR F	
					0.05	0.01
Replication	2	16635.86	8317.93			
Factor A	1	31.28	31.28 7	0.04 ns	18.51	98.49
Error	2	4843.02	421.51			
Factor B	3	10814.33	3604.78	0.98 ns	3.49	5.95
AB	3	4535.24	1511.75	0.41 ns	3.49	5.95
Error	12	44141.61	3678.47			
Total	23	91001.34				

ns- Not significant

Coefficient of Variation:24.48%