BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF AGRICULTURE AND ENVIRONMENTAL SCIENCE

DEPARTMENT OF CROP SCIENCE

AN EVALUATION OF THE EFFECTIVENESS OF DIFFERENT APPLICATION RATES OF LIQUID PIG MANURE IN GROWTH AND YIELD OF RAPE (*Brassica napus)*

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A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF THE BACHELOR OF BSc HONOURS DEGREE IN CROP SCIENCE

December 2022

Approval Form

The undersigned certify that they have supervised and recommended to the University for Acceptance and exanimation of the research project entitled **An Evaluation Of The Effects Of Different Application Rates Of Pig Liquid Manure On Growth And Yield Of (Rape) Brassica Napus** submitted by **Mitchel Ruvimbo Lankeni** in partial fulfilment of the requirements for the award of the degree of Bachelor of Science Honors Degree in Crop Science.

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(Signature of supervisor) (Date)

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(Signature of student) (Date)

Dedication

I dedicate this project to my mother Mrs. Lankeni and my daughter Tanatswa Shalome Chimoto.

Acknowledgements

First and foremost, I give thanks to the Almighty God for his never-ending grace, mercy and provision throughout the entire project. Kudos to my fellow students who worked tirelessly and selfless in helping me. I would like to express my special thanks of gratitude to my supervisor Ms. Kamota for her guidance and support in completing my project

My sincere gratitude goes to Mr. P. Zabron and Mr S Mkwanda for reviewing the draft documents about organic vegetable production. Gratitude goes to N Chabikwa for helping in identification of pests in rape and controlling.

Abstract

Pig manure is a locally available source of manure which contains high nitrogen amounts and foliar applying it in rape increases growth and yield. The research was done with the objectives of determining leaf area index, plat height and dry weight of *Brassica napus L.* in relation to different application rates of pig liquid manure. All agronomic practices were merely done but not mentioned as they were not under the study. Lack of enough information on the application rate of liquid manure for a specific crop is still limited. So the main thrust of the project was to find the appropriate application rate of pig liquid manure on *Brassica napus* which will be used to supply the required nitrogen. Top dressing was done merely and recorded as it was done to determine application rate. It was done every fortnight every Monday with 40, 60 and 80mls used as application rates. Harvesting was done from the third week after transplanting to eighth week. The leaf area index, plant height and dry weight were significantly different ($p<0.05$) with the plants that received 80 mls having the highest recordings in all aspects. Rape plants respond very well in high nitrogen quantities so growth and yield were high. In a nutshell soil analysis should be a must before applying organic manure so as to know the nutrient status of the soil and thus helping farmers to make amends to reach the required quantities of nutrients needed by plants. So this project recommends farmers to undergo soil analysis test before applying organic matter.

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cm	centimeters
g	grams
kg	kilograms
mls	milliliters

m	meters

CHAPTER 1

1.1 Background

At present ever increasing population is exerting tremendous pressure on agriculture to meet their nutritional food requirement across the world. In order to achieve the current demand of food requirement, farmers are relying more on chemical fertilizers to achieve higher productivity per unit area. However, the efficiency of the chemical fertilizers already reached a plateau due to their indiscriminate use and resulted in poor soil fertility status of the agriculture fields in addition to accumulation of toxic substances in the harvested produces. Also the cost of inorganic fertilizers is increasing enormously to an extent that they are not affordable by the small and marginal farmers. In this regard there is a need to identify the suitable substitute in place of chemical fertilizers which are economically cheaper and ecofriendly. In this juncture, the use of organic fertilizers either bulky or liquid organic manures plays an important role to sustain the soil health as well as productivity of the crops (Verma et al., 2018). In particular the use of liquid organic pig manure not only helps to achieve higher yield but also a low-cost production approach, thus helps to realize higher returns by the farmers (Devakumar et al., 2014). The beneficial microorganisms will survive in the liquid organic manures and are helpful in phosphate solubilization, nitrogen fixation etc. Upon their application, they will enhance the soil microbial population and their activity to a larger extent in soil and inturn have positive effect on growth and development of crops (Boraiah et al., 2017). The liquid organic manures easily disperse in water and are readily available to plants compared to bulky organic manures and interestingly plants can absorb nutrients through the leaves about 20 times faster when applied as foliar spray than applied through the soil, thereby helps to overcome temporary and acute nutrient shortages in the crops (Dhanoji et al., 2018).

Rape has high nutrient requirements which can be met through mineral and/or organic fertilizer applications to attain optimum yield. Resultantly, continuous cropping without sufficient nutrient replenishment reduces productivity and poses a serious threat to the sustainable use of soil. There is need to find new efficient ways to meet growing food needs without undermining our futures

(Kunze and Drechsel. 2001). There are, however, opportunities to increasing agricultural output and profitability through promoting the use of improved and adaptable hybrids and through the application of site-specific rates of nutrient sources.

Rape (*Brassica napus*) has a high demand for water due to extensive leaf area and thus needs regular intervals of irrigation. The critical period for rape is the stem-elongation stage when the crop builds the branching structure and strong stems, then produce high yields. Rape is sown for later transplanting at the age of 4–6 weeks after sowing, but the crop can also be grown in situ. The crop has a short life span as compared to other leafy vegetables, making it the most preferred leaf vegetable grown by smallholder farmers in Zimbabwe (Katsvanga, 2010).

Interest on foliar fertilization has risen because of the many advantages of the methods of application of foliar nutrients, such as rapid and effective response to plant needs, regardless of soil conditions (Kerin and Berova, 2003). However, few studies have been conducted to compare the effects of both ground and foliar application of organic fertilizers. According to Tukey and Marczynski (1984), combined soil and foliar applications should be recommended to increase both plant productivity and yield quality. Kuepper (2003) also emphasized that foliar application of fertilizers is becoming more prevalent as practice in agricultural crop production because it is more directly targeted and potentially more friendly to the environment in contrast to soil fertilization. Zaniewiez-Bajkowska et al. (2010) cite that in horticultural practice, foliar fertilization of pig liquid manure is also recommended as the most effective method of supplying plants with nutrients under deficiency conditions.

The improvement and maintenance of soil fertility is the major constraint to sustainable crop production in the communal smallholder farming areas of Zimbabwe. It was revealed that over 40% of the soils had phosphorus deficiency, while 82% had very low nitrogen (Muchecheti, et al 2012). In addition, communal area fields show wide ranges in the values of soil properties, and this coupled with continuous cropping has led to the deficiency in nitrogen (N), phosphorus (P), or both. The implications are that sustainable crop yield can only be achieved through determination of site-specific variety and nutrient requirements instead of the generalized crop and fertilizer recommendations, an approach that is currently used in Zimbabwe.

In a recent review, Fernández and Brown (2013) stated that foliar fertilization is an agricultural practice of increasing importance. In theory, application of nutrient sprays may indeed be an environmentally friendly fertilization method since the nutrients are directly delivered to the plant in limited amounts, thereby helping to reduce the environmental impact associated with soil fertilization. However, response to foliar sprays is often variable and not reproducible due to the existing lack of knowledge of many factors related to the penetration of the leaf-applied solution.

According to Szewczuk, (2003), it is particularly beneficial to provide the plant with micronutrients in pig liquid manure in the foliar form. This form allows the supply of nutrients under difficult soil uptake and in the phases of the greatest demand for them.

1.2 Problem Statement

There is limited knowledge and information of liquid manure in vegetable production and low production of rape in Zimbabwe yet it's one of the main source of food. Pig manure is readily available in Zimbabwe, both large and small scale farmers due to piggery production. Pig manure comes up with high nitrogen and phosphorus content, so foliar application of liquid pig manure will boost vegetable production. Due to limited information about the use of liquid pig manure in vegetable production, there is need to identify the best application rate specifically on rape production to attain a better use of pig manure.

1.3 Justification

The study helps to have a clear picture of the best application rate of liquid manure on rape according to its yields performance as it requires more nitrogen in its growth period. This also helps farmers to know the best application rate to apply on rape. Farmers who grow vegetables (*brassica napus)* also earn currency due to an increase in yields because they will not have to buy synthetic fertilizers, they will use locally available resources. The health status of people is improved as there is no use of synthetic fertilizers. Stakeholders will also obtain record keeping and determine the application rate of pig liquid manure on rape.

1.4 Main Objective

To identify the optimum application rate of pig liquid manure that can be foliar applied to supply more nitrogen in *Brassica napus* production.

1.5 Specific Objectives

1. To measure leaf area index of rape grown on different pig liquid manure application rates.
2. To measure dry weight and plant height of rape on different pig liquid manure application rates.

1.6 Hypotheses

$H_{o:}$ Application rates of pig liquid manure cannot affect leaf area index of rape

$H_{0:}$ Application rates of pig liquid manure has no effect on leaf dry weight and plant height of rape.

CHAPTER 2

Literature Review

2.1 Origin of *Brassica napus*

B*rassica napus* is an important oilseed crop, worldwide, and includes both tuberous (swede or rutabaga) and leafy (fodder rape and kale) forms used for animal fodder and human consumption

(Allender and King, 2010). During *B. napus* breeding, the undesirable oil components, erucic acid and aliphatic glucosinolate, in the seeds have undergone a dramatic reduction, whereas oil content, seed yield, and disease resistance have been significantly improved (Snowdon R., Lühs W. & Friedt W., 2007). As described by the Triangle of U (Nagaharu U., 1935), three allopolyploid species, *Brassica napus* (AACC, $2n = 38$), *Brassica juncea* (AABB, $2n = 36$), and *Brassica carinata* (BBCC, $2n = 34$) each originated from hybridization between two of three ancestral diploid species, *Brassica rapa* (AA, $2n = 20$), *Brassica oleracea* (CC, $2n = 18$), and *Brassica nigra* (BB, $2n = 16$). The three *Brassica* diploid progenitors are themselves ancient polyploids that experienced a lineage-specific whole-genome triplication, making the allopolyploid descendant *B. napus* an excellent model for investigating processes of polyploid speciation, evolution, and selection.

2.2 Importance of *Brassica napus*

Rapeseed or canola (B. napus) is the second most important oilseed crop of the world. It is also a favourite plant for basic and breeding research. Due to its origin and evolution, rapeseed has a complex polyploid genome (Friedt and Snowdon. 2010). Recent sequencing of the corresponding genomes provides the basis for a better understanding and exploitation of the genetic diversity involved in major rapeseed traits. However, directed selection for major quality characteristics, i.e. minimal erucic acid content and low glucosinolate level, has caused genetic bottlenecks limiting genetic variation in the current gene pools of cultivated oilseed rape (OSR) (Zhou et al 2016). Therefore, broadening genetic diversity is an important aim of research and a necessary prerequisite for further progress by OSR breeding (Oldham, 2006). . In agricultural production, rapeseed is nowadays an indispensable component of crop rotations in major growing areas such as Australia, Western Canada, Central China and many countries of the European Union. In many cases, OSR is the only leaf crop among dominating cereal species. Therefore, OSR as a component of crop rotations helps to maintain soil fertility and contributes to sustainable production therefore.

As a major cash crop OSR substantially contributes to farmers' incomes and therefore helps to stabilize rural populations. Beyond that, as major globally traded agricultural commodities rapeseed/canola and rapeseed/canola oil and meal significantly input the national products of a number of countries e.g. Canada. Rapeseed/canola is a raw material for vegetable oil and extraction meal as feed, food and fuel. The oil is mainly used as a high-value salad oil for dressings etc. due to its high contents of oleic acid (ca. 60%) and poly-unsaturated linolenic acid (omega-3, ca. 10%). Nevertheless, a large part is also used as a mobility fuel for diesel cars and tractors, particularly in Germany and Europe (Renard et al. 2006). The extraction meal (and protein) from oil processing is now recognized as a highly valuable animal feed, particularly for ruminants (cattle) but also for monogastric farm animals (pigs, poultry). Furthermore, the interest in rapeseed protein for the purpose of human nutrition is increasing. Optimal contents of the major compounds mentioned before represent the main requirements for rapeseed/canola varieties today. Consequently, quality characteristics are major criteria for variety testing and registration therefore. Other major requirements for modern rapeseed varieties are yield and various agronomic traits securing seed yield, i.e. resistance against fungal diseases and insect pests. Because of the environmental concerns and the rejection of agrochemicals such as insecticides (e.g. ban of neonicotinoids in the EU), genetic approaches of establishing resistant crop cultivars constantly gain importance (Zhou, Hua, Sharpe, Paterson, Guan and Wincker 2014). OSR breeding has long been a relatively ordinary process of repeated selection for resistance, quality and yield, the propagation of improved populations and their release as new open pollinated (OP) varieties (Delourme, Falentin, Huteau, Clouet, Horvais, Gandon, Specel, Hanneton, Dheu, Deschamps, Margale, Vincourt and Renard. 2006). Since this approach is not very effective, breeders have been interested in breeding hybrids instead. Today, F1 hybrids represent the major variety type. They are produced with genetic male sterility systems, most of which are based on cytoplasmic mutations causing male sterility (cms). The higher performance of hybrids is caused by “heterotic effect” which largely depends on the genetic distance between the parents. Therefore, distant genetic pools need to be generated for the development of female and male parents. The future potential of variety design is consequently determined by the usefulness of the genetic pools and the performance of hybrid parents extracted from them.

2.3 *Brassica napus* in Zimbabwe

Vegetable production in Zimbabwe is a fast expanding enterprise because of the increasing demand resulting from the rapid increasing urban populations (Kuntashula, Mafongoya, Sileshi, and Lungu, 2004) . Diversification in crop production by small holder farmers in Southern Africa has the capability of creating employment and increase in income. This, in turn, allows for the purchase of food to increase food security (Drechsel and Kunze, 2001). Vegetables provide nutrients such as vitamins, minerals, and roughage which are essential for a balanced diet. *Brassica napus* and other leaf vegetables are a profitable agricultural enterprise in both local and export markets (Kuntashula, Mafongoya, Sileshi, and Lungu. 2004), (Loehr, Seif, and Nyambo, 1998).

Rape is one of the primary vegetable crops in Zimbabwe, grown for its leaves (Nyakudya, et al. 2010), which are rich in vitamin A, thiamine, and ascorbic acid. Rape seed oil is used for baking bread, illumination, lubrication, and the manufacture of soaps (Ware and McCollum, (1975). The vegetable is grown all year round in Zimbabwe and is used as a source of income through the selling of the leaf produce (Shumba, 2018).

Rape (*Brassica napus*) has a high demand for water due to extensive leaf area and thus needs regular intervals of irrigation. The critical period for rape is the stem-elongation stage when the crop builds the branching structure and strong stems, then produce high yields (Xiao-bo, Yuan-nong, Ya-dan, and Min-hua, , 2016). Rape is sown for later transplanting at the age of 4–6 weeks after sowing, but the crop can also be grown in situ (Ware and McCollum, (1975). The crop has a short life span as compared to other leafy vegetables, making it the most preferred leaf vegetable grown by smallholder farmers in Zimbabwe (Muchecheti, Madakadze, and Soundy 2012).

According to Musara and Chitamba (2015), there are many rape cultivars available in Zimbabwe but the most popular ones are English Giant rape and Hobson cultivars. The characteristics of the two cultivars were summarized by (Muchecheti et al. 2012). The English Giant rape cultivar has dark green leaves and medium branches and has an immense growth rate. The English Giant rape has large broad leaves, with a yield potential of the cultivar of 25–40 tons/ha. The cultivar has large broad leaves and is normally preferred for its hardness. The cultivar cooks quicker than its competitor, Hobson. The English Giant rape germination takes 5–10 days and also takes 90 days to mature (Tweedie and Mullins, 1962).

Another variety is Hobson rape, which is an improvement of the English Giant rape variety. This variety can be grown throughout the year and is reported to be a high yielding, with the potential of producing 25–40 tons/ha during its production period (Oldham, 2006). The Hobson rape cultivar has a rapid growth and responds well to regular cuttings. The cultivar has pale green leaves and is a very palatable vegetable. It is an excellent variety with a wide sowing window.

Either Hobson and English Giant rape varieties are heavy feeders and respond well to applications of farm yard manure or mature compost, which should, however, be supplemented with either a compound or straight fertilizer (Baliyan, Baliyan, and Madhava Rao, 2012). A recommended good practice is to collect soil samples from the land and send for analysis before planting in order to apply the exact amount of fertilizer and manure required by the crop (Washington University Extension (WSUE), 2014). The condition of the crop will dictate whether further top dressings are needed (Tweedie and Mullins, 1962).

The production of leaf vegetables all year round requires land use intensification, and the enterprise is only viable and profitable when nutrients from the soils which are depleted during crop production are replenished (Losak, Hluseki, Kracmar, and Varga, 2008). Continuous cropping in most soils in sub-Saharan Africa has led to the deficiency in nitrogen (N), phosphorus (P), or both (Mafongoya, Giller, and Palm, 1998). The negative nutrient balances have been attributed by the removal of crop residues from the fields, coupled with lower rates of macronutrients applications compared to losses (Bedada, 2015).

Rape grows on a wide range of soils, provided the inherent drainage and fertility problems associated with clays and sandy soils are alleviated (Shumba, 2018). The improvement and maintenance of soil fertility is the major constraint to sustainable crop production in the communal smallholder farming areas of Zimbabwe. From a regional assessment carried out in the Chinamhora and Mhondoro communal areas of Zimbabwe, it was revealed that over 40% of the soils had phosphorus deficiency, while 82% had very low nitrogen (Nyamangara, Mugwira, and Mpofu, 2000). In addition, communal area fields show wide ranges in the values of soil properties, and this coupled with continuous cropping has led to the deficiency in nitrogen (N), phosphorus (P), or both (Mafongoya, Giller, and Palm 1998). The implications are that sustainable crop yield can only be achieved through determination of site-specific variety and nutrient requirements instead of the generalized crop and fertilizer recommendations, an approach that is currently used in Zimbabwe.

The nutritional requirements of the crop are considered to be the most important factor. Nitrogen fertilizer plays a vital role in enhancing crop yield (Rathke et al., 2005). Compared to cereals, winter rapeseed requires a higher amount of nutrients, and available N frequently limits seed yield. Hocking et al. (2001) said that rapeseed requires about 25% more N than wheat. Yield response of rapeseed to increasing N doses varies with different environmental variables, including weather, soil type, residual fertility (especially nitrate), soil water content, and cultivar. Many studies have shown that both growth and yield of rapeseed are enhanced significantly by high doses of applied N (Kumar et al., 2001; Cheema et al., 2001). Nitrogen increases yield by influencing a number of growth parameters. Choosing the correct dose, source and timing of N fertilizer application is therefore an important aspect of successful rapeseed production (Chamorro et al., 2002).

2.4 Pig Liquid Manure

Top dressing liquid manure containing high nitrogen content should be applied to cereal crops at the five to six leaf stages or when plants are at knee-height or 30cm tall, soon after the first weeding (referred from soil fertility management) and are good source of top dressing. Liquid manure is prepared and applied in bands where 250ml are applied per planting station weekly of fortnightly from week 3 up to week 10 or 12 depending on availability of resources for liquid manure preparation and moisture. Liquid manure is applied onto moist soils with precision: this will ensure the nutrients are available where they are needed. Apply the liquid manure around (5-10cm from the plant) and not on the plants to avoid burning and ensure each plant in the basin have equal access to the topdressing (Fambidzanai Permaculture Centre (2009) Manual on Organic Dry land Conservation Farming Unpublished).

Davies et al (2000) states that liquid manure teas are prepared by soaking various manures, suitable plants or a mixture of the two in water for 10 to 15 days. The nutrients are dissolved in water. The fresh plants or manure should be collects in a sack and tied securely. The sack is then suspended from a stick so that it hangs freely into the drum. The quantity ranges between 30 to 50kg manure in 200 liters of water. Move the stick up and down every three days to stir the mixture and quicken the release of nutrients. The smell will be very strong when only using manure, as excess N turns into Ammonia NH4+. Therefore cover on the drum to reduce volatilization and the stingy smell. Once the smell vanishes, the liquid would be ready to use and the mixture would be brown.

The solution is extremely variable, depending on the quality of the manure or plants used. The mixture is a concentrate and needs to be diluted before application in order to avoid scorching the crop being manured (Davies et al 2000). As a rough guide the diluted liquid should be a weak tea colour but experience judgment is needed to decide on the correct dilution. For example one drum chicken liquid manure concentrate as to 3 drums of water for pigs is 1:2, cow 1:1, bat gunner is 1:4.

Then application rate depends on the size and rate of growth of the targeted crop. Seedlings and maturing crops benefits from applications once a week or every two weeks. Regular applications of small quantities are more effective and helps reduce leaching. Any manure is suitable for use, if more than one type of manure is available, they can be mixed. Various plants with dark green leaves such as comfrey or amaranth can be substituted with manure if scarce. In liquid form, nutrients are less likely to burn roots or foliage, though extreme caution is still advised. Nutrients in plants has been decomposed and reduced to humus. Soaking out these nutrients in liquid manure makes them available soon and is the most efficient way of applying nutrients and especially of applying manure if quantities available at limited. P. Zabron at Fambidzanai Permaculture Training Centre said, "Pig liquid manure application rate for vegetables such as rape, kale mustard is 300ml per 5 plants." At this organization liquid manure, compost, vermicomposting and manure are widely used to improve soil fertility.

Pig manure contains all 13 of the essential plant nutrients that are used by plants. These include nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), manganese (Mn), copper (Cu), zinc (Zn), chlorine (Cl), boron (B), iron (Fe), and molybdenum (Mo). Plant nutrients originate from the feed, supplements, medications, and water consumed by the animals. Using pig manure as a fertilizer for crops or trees may provide a portion, or all, of the plant requirements. The amount of nutrients provided depends on the nutrient content of the manure (lb of nutrient / 1,000 gal of manure) and the amount of manure applied (gal of manure / acre). The amount of manure applied per acre (called the application rate) is typically based on the nitrogen needs of the plants. However, phosphorous requirement can also be used to determine the application rate.

CHAPTER 3 MATERIALS AND METHODOLOGY

3.1 Study Site

The research was carried out at Fambidzanai Permaculture Centre [from January to June] 2022. The center is located in Mt Hampden which is in Zvimba district, Mashonaland West Province (17° 44' 30" South, 30° 56' 20" West). This area is in agro ecological zone 2A where there is intensive farming. Crops and livestock production are both practiced in this region. The area receives rainfall which ranges from 750-1000mm per annum with eighteen rainy pentads per season but rarely experiencing severe dry spells in summer.

The area have red soils, a reflection that they are weathered due to oxidation process. It has loamy sand soils. It is sticky when wet and difficult to work with but it is easily washed. The slop is generally flat 0-5%.

3.2 Experimental Design and Field Layout

A Randomized Complete Block Design (RCBD) was used with 4 treatments (control, 40ml, 60ml and 80ml) and each treatment had 4 replications and the blocks were of equal size (10m x 3.3m). The layout will be presented on the table below.

Plot number	Block1	Block2	Block3	Block4
Plot number	control	80ml	40ml	60ml
Plot number	60ml	control	80ml	40ml
Plot number	80ml	40ml	60ml	control
Plot number	40ml	60ml	control	80ml

3.3 Experimental Procedure

3.3.1 Land Preparation

Land preparation commenced on 20 June 2022. Every plant debris was removed so as to avoid seasonal carry-over of pests and diseases from the previous plants. The soil was tilled till a finer tilth was produced and followed by the making of raised beds. The tape measure was used to measure the beds 1m wide and 10m long. Lastly the beds were levelled.

3.3.2 Basal Dressing

Basal dressing was done after holes were made for planting. At basal dressing the beds were treated with same application amount of manure per hole. 9 -15kgs of manure for every 9.29m^2.

9.072kg=9.29m^2

More 100m^2

100÷9.29m^2× 9.072kgs= 97.65kg

97.65kg for 480 plants or for 100m^2

For 1 plant or hole= 1÷480 (97.65kg)

= 0.203kgs

=203grams per planting station.

By so doing pig manure was applied and planting phase began.

Plant spacing of 0.25m and spacing between rows is 0.4m and the Hobson variety seedlings were used from SeedCo.

3.3.3 Liquid Manure Preparation

Prior to land preparation liquid manure was made to ensure complete fermentation before application.

3.3.4 Materials Used for Liquid Manure Preparation

- 200l drum,
- Empty 50kg sack,
- Shovel,
- 1.5m stick and 3m string and
- 1.5m wide and black polythene plastic.

Step 1

- Collect pig manure using a shovel and fill the sack (50kg empty) using a shovel.

Step 2

- Fill a 200l drum with water up to 3/4 full.

Step 3

- Tighten the sack well using a string and leave a string long enough.

Step 4

- Hang the sack freely in water suspended from the stick with that string on the sack on the mouth of a drum.

NB make sure the 50kg sack with manure has drawn in water.

Step 5

- Cover the drum with a black plastic or any plastic and tighten it around the drum to reduce the strong smell from the drum and to reduce loss of Nitrogen (N) through volatilization and denitrification.

Step 6

- After every 4 days move the stick up and down around the circumference of a drum to stir the mixture and quickening the release of nutrients.

NB. During stirring wear a mask as the strong smell comes out of the mixture which assembles that nitrogen was being converted into ammonia. Hence, the mixture was ready to use when the strong smell disappears, and the liquid water turns brown. Therefore the mixture was a concentrate it needed to be diluted before application in order to avoid scorching the crops. The concentrate of liquid manure depends on the type of manure used.

Step 7

Pig liquid manure was diluted as follows:

- One drum of pig liquid manure as to 2 parts of water. And it's ready to use. The application rate depends on crop N requirement.

The suspending stick at the top of the drum via the sack makes it easier to turn the sack for mixing. Rather than stirring manure in the drum with a stick, the pressure of water forced them to be rigid and difficult to turn and the strong smell will suffocate a person as one would take a lot of time turning manure.

The pig liquid manure was prepared 2weeks prior to planting to allow for complete fermentation. Pig manure was compound applied 10 days prior to planting in all beds to allow decomposition before planting, then foliar application comes in 2 weeks after planting of seedlings.

3.3.5 Pest and Disease Control

Bio fumigants (intercropping with garlic) and natural plant extracts were used to prevent diseases and also to control the attack of pests. Rape is more prone to cut worms and crabs so they need to be controlled before they reduce yield.

At week 2 just after planting, signs and symptoms of cutworms and grabs attack were noticed on rape plant. Fortunately the researcher sprayed them and cutworms were successfully controlled but crabs were resistant to almost all the remedies that the researcher applied.

For cut worms *cacti barks* (mukonde), *tephrosia* and garden rue were used, and the infestation of cutworms was reduced. Thereafter remedies were changed simultaneously but there was no change in crab's infestation. Mechanical control was done by uprooting the affected plants for visual inspection of crabs. The crabs were crushed by hands and herb solution was sprayed to rape plants, giving time for herb action on crabs and the solution was to be applied again after another infestation occurs.

Crabs reduced the overall yields as wrong diagnosis was given for nematodes, as a result marigold was used for nematodes as a remedy but there was no effect as it was used for crab's control. The danger possessed by unidentified and unexpected pests is very destructive.

Some other pests that were observed are aphids. *Cacti, tephrosia* and chili were successfully used control them, however I continuously used different remedies and the aphids were successfully controlled.

3.3.6 Weeding

Weeds are competitors of nutrients, water, sunlight and space with the plant so the weeds has to be removed before they reduce yield and harbor pests. Minimum tillage based control of weeds (hoeing and hand pulling) were used.

Weeds are fast field invaders which plays a big role in yield reduction if not controlled at early growth stages. Mechanical weed control inform of hoeing and uprooting was used as it has little disturbance to plant roots and aerating the soil to improve drainage. Weeding was done on all the 12 beds under normal circumstances and on the same day.

Weeding was done after forty night but due to the crab infestation uprooting was done and leaving some weeds to act as a trap crop for crabs. After repeated series of weeding and uprooting process, there was reduction in crabs' infestation rate.

3.4 Data Collection

Measurement of leaf area index and plant height using a ruler and a string was done after every forty night after application of liquid manure. Dry weight was weighed using a measuring scale, 4 plants were used as data collection representations for each treatment.

3.5 Data Analysis

The data collected was subjected to the analysis of variance (ANOVA) to determine the leaf area index and to determine if application rates had an effects on plant stem circumference and leaf weight in *Brassica napus* using GENSTAT (version 2018). The fisher's least significant difference (LSD) test at 0.05 probability level was used where the means were significantly different.

CHAPTER 4

4.1 Results

4.1.1 Leaf Area Index

The leaf area index from week 1 to week 7 were significantly different (P<0.05) in all treatments as application rate was increased. The means amongst the treatments were statistically different. The lowest mean was recorded in the control treatment and the highest mean was recorded in the highest treatment (80ml)

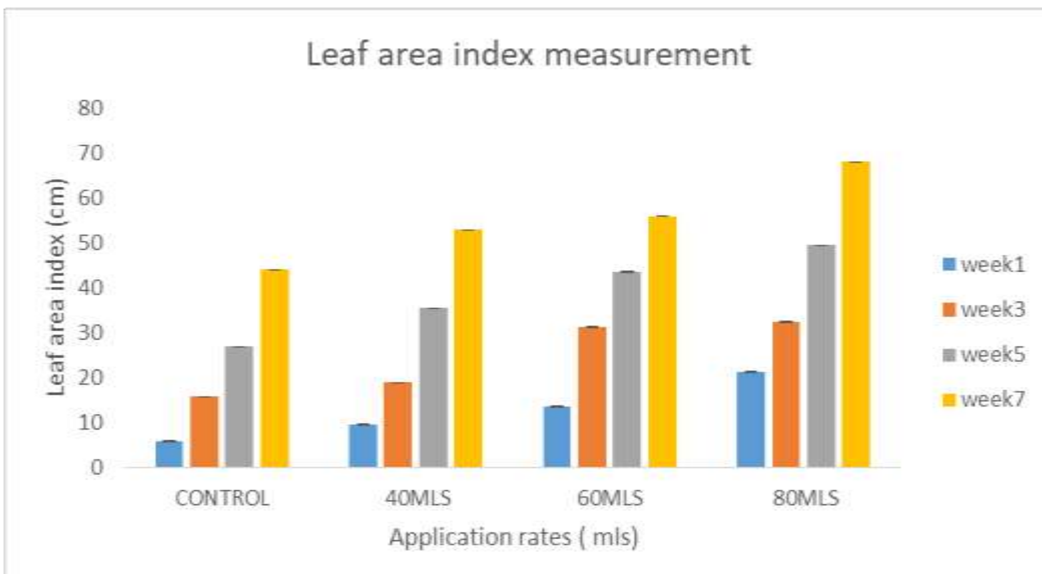

Figure 1 Response of Brassica napus to different application rates from week 1 to week 7

4.1.2 Dry Weight

Application rates had an effect on dry matter weight as the means were significantly different (P<0.05) from week 1 to 7. The treatment which weighed the highest 80ml was applied to it and the control treatment weighed the least. The mean weights increased after every forty night of data collection.

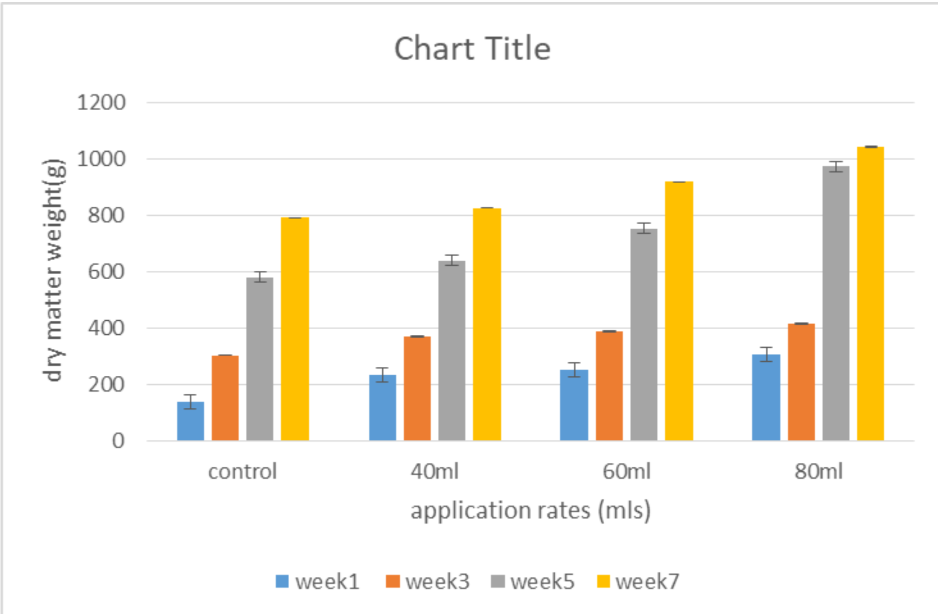

Figure 2 Response of Brassica napus weight to increase in application rates

4.1.3 Plant Height

Significant differences in the rape plant height ($p \leq 0.05$) were identified between treatments (Figure 3). Plant height from week one to week seven consistently increased with increasing application rates of liquid pig manure. Highest plant height recordings were observed in the plots subjected to 80mls.

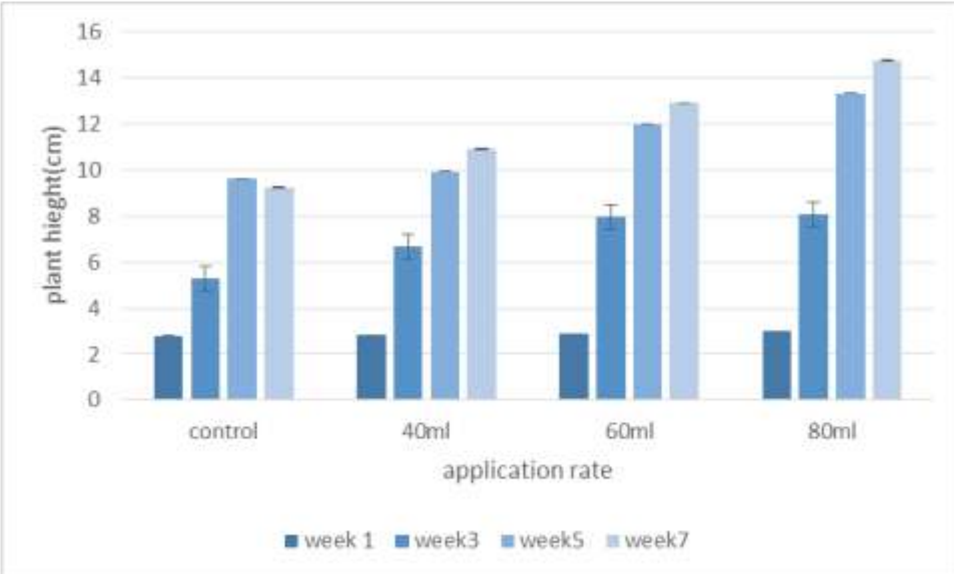

Figure 3 response of Brassica napus height to increasing application rates

CHAPTER 5

5.1 Effects of Different Application Rates on *Brassica napus* Leaf Area Index

The findings from this study showed that different application rates had an effect on the leaf area index of *B. napus*. Mean separations between treatments for LAI at every harvesting event were significantly ($p \leq 0.05$) different from week 1 to week 7. Increasing the application from 40, 60 to 80mls also increase the overall leaf area respectively because the will be an increment on the nutrients to be supplies to the plants as application rates increases. With the assumption that rape leaf yields increases with an increase in the amount of N availed by liquid manure Ghanti et al. (1982) attributed the increases in leaf yield with increasing N availability to the fact that N favored more vegetative growth producing plants with a higher leaf count and subsequently higher total green leaf area per plant. Increases in the growth parameters in turn synthesized more plant metabolites thereby increasing leaf yields (Kumar and Rawat, 2002). The application of higher rates of N were accompanied by rapid leaf area growth and improved overall crop nitrogen assimilation and thus contributing to increased fresh leaf yield (Li et al., 2016). The supply of N is a limiting factor in leaf rape production as it influences the growth of leaf area which impacts on yield if sustained throughout the growing season (Roggatz et al., 1999; Reid, 2002; Nyakudya et al., 2010). In a study on rape plant development response to N fertilizer application the researchers recorded increasing rape leaf area growth with increasing N fertilizer application rate.

5.2 Effects of Different Application Rates on *Brassica napus* Height.

The increase in application rates of pig liquid manure increased the plant height from week 1 to week 7 with the highest plant height from 80mls. The highest height on week 1 was 9.2325(cm) and on week 7 the height was 14.7550(cm). The means were significantly different ($p>0,001$) in all treatment. There were significant differences statistical in plant height among treatments from weeks 1 to 7 (fig 2), but application rate of 80mls had taller plants than their counterparts across the treatments. The increase in height of plants amended with 40, 60 and 80mls of organic liquid pig manure is probably due to release of nutrients which promoted vigorous plant growth through efficient photosynthesis (Iqtidar, Ayyaz, and Ahmad, (2006). Plant height is an important component that helps to determine plant growth (Murányi and Pepó, 2013). Findings of the present study are in agreement with studies conducted on other crops which reported that organic fertilizers (e.g. farm yard manure) enhance plant growth (Ismael, Abusuwar and El Naim, 2012). Since organic fertilizer constitutes a slow release source of plant nutrients (Pace, Miller and Farrel-Poe, 1995), so foliar application of pig liquid manure will ensure that the nutrients are utilized sooner by the plant as the manure will be applied on the leaves.

5.3 Effects of Different Application Rates of Pig Liquid Manure on Dry Weight of *Brassica napus* L.

Overall dry weight of rape as affected by application of liquid pig manure showed that plants amended with 40, 60 and 80 (mls) of organic fertilizer significantly ($p<0.05$) increased in weight as compared to the rest (fig 3). This implies that the higher the application rate of liquid pig manure the higher the yield of rape. The higher increase in yield parameters such as fresh weight, plant height, leaf number and leaf area of rape could be attributed to the nutrient contents of the organic fertilizer used which encouraged better plant growth. The findings of the present study are supported by Adebayo and Akou (2000) and Moyin-Jesu (2007) who reported that organic pig liquid fertilizers supported crop performance and increased crop yield. Due to the high nitrogen content in pig liquid manure and the nitrogen is readily available for plant uptake the plant produced big leaves which in turn produced high values of dry weight. Application of organic fertilizers probably increased nitrogen in the soil which positively affected leaf fresh weight and quality of the leaves because nitrogen stimulates plant vegetative growth and increases leaf area; as a result increment in the leaf area increases the rate of plant photosynthesis and thus higher leaf quality and leaf weight. This is in line with the findings of different studies elsewhere on spinach (Guiser, 2005). Since pig liquid manure contains N in the form of Ammonium (Barker, 1990) it might be possible that the ammonium was actively used by the plants because it is readily used by the plants. In addition, the present study confirmed the importance of fertilization on the fresh and dry weights of the garden cress plant. The application of high rates of pig liquid manure might have enhanced nitrogen supply thus increased vegetative growth and so grown dry values. These results are in agreement with Mojeremane, Motlad, Mathowa and Legwaila, 2015), who found that the application of organic pig liquid fertilizer on rape (*Brassica napus* L.) greatly enhanced fresh and dry weights. Supplying plants with sufficient nitrogen makes its leaves dark green, and the photosynthesis process can proceed more effectively. Therefore, supplying the plant with high rates of pig liquid manure (because high rates contains more ammonium which will be readily used by the plants) will increase the amount of protein, chlorophyll formed, and protoplasm. Thus, it increases cell size, leaves production, leaf area, and photosynthetic activity as well as stimulating root growth, which will reflect in high net assimilation rate, consequently high vegetative growth, high plant fresh and dry weights, and high yield and enhance quality (Leghari, Wahocho, Laghari, HafeezLaghari, MustafaBhabhan, Talpu, Bhutto, Wahocho and Lashari 2016).

CHAPTER 6

6.1 Conclusion

By observation and not detailed as they were not under objectives, the pests affected mainly the plants which received 80mls (high treatment), this is because the plants were highly nutrious, also weeds were more concentrated on these beds as compare to other treatments. And concluded that for pest resistance the beds which received lower treatments (control treatment and 40mls) were resistant to pests and pests didn't favor it because of small leaves.

The beds which received high treatment (80mls) showed the highest growth rate, big leaves and stems and a dark colour. It illustrates that increasing the amount of liquid manure by 20ml increases yields and growth rate, reducing it by 20ml also reduces yield. In terms of plant logging, the beds which received 80mls easily breaks as they tend to be turgid and flaccid, any disturbance breaks the plant.

Yields from plots ameliorated with different application rates reflected differences in growth rate of *Brassica napus*. Due to high nitrogen content in beds with 80mls, there were plants were of high quality. Overally high yields were obtained from second to third harvest. Therefore l conclude that the beds which received 60mls showed more preferable features (medium leaves, number of leaves and weight.

6.2 Recommendations

1. The researcher hereby recommend farmer to use 60mls as application for pig manure in
2. *Brassica napus,* as it shows more special attribute (resistant to pests mainly) though the plant vigor is not that high.
3. Under circumstances of resistance to pest and diseases, the researcher recommend farmers to grow rape under 40ml or 60ml depending on soil nitrogen content because of their high resistance to pests.
4. It is recommended that farmers should go for soil analysis before planting so as to know the nutrient status which will help the farmers in decision making for the best application rate to use.

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Appendix

Appendix 1 Analysis of variance for the effects of different application rates on the leaf area index of *Brassica napus* on week 1.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	3	518.94610	172.98203	3773.47	<.001

Residual	12	0.55010	0.04584
Total	15	519.49620	

Appendix 2 Analysis of variance for the effects of different application rates on leaf area index of *Brassica napus* on week 3.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	3	868.643850	289.547950	55371.72	<.001
Residual	12	0.062750	0.005229		
Total	15	868.706600			

Appendix 3 Analysis of variance for the effects of different application rates on leaf area index of *Brassica napus* on week 5.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	3	1.153E+03	3.843E+02	1.724E+06	<.001
Residual	12	2.675E-03	2.229E-04		
Total	15	1.153E+03			

Appendix 4 Analysis of variance for the effects of different application rates on leaf area index of *Brassica napus* on week 7.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	3	1.171E+03	3.904E+02	6.693E+06	<.001
Residual	12	7.000E-04	5.833E-05		
Total	15	1.171E+03			

Appendix 5 Analysis of variance for the effects of different application rates of pig liquid manure on dry weight of *Brassica napus* on week 1.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	3	59405.	19802.	15.05	<.001
Residual	12	15794.	1316.		
Total	15	75199.			

Appendix 6 Analysis of variance for the effects of different pig liquid manure application rates on dry weight of *Brassica napus* on week 3.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	3	27146.000	9048.667	2525.21	<.001
Residual	12	43.000	3.583		
Total	15	27189.000			

Appendix 7 Analysis of variance for the effects of different application rates of pig liquid manure on dry weight of *Brassica napus* on week 5.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	3	358829.5	119609.	180.69	<.001
Residual	12	7943.5	662.0		
Total	15	366773.0			

Appendix 8 Analysis of variance for the effects of different application rates of pig liquid manure on dry weight of *Brassica napus* on week 7.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT	3	1.531E+05	5.105E+04	72070.35	<.001

Residual	12	8.500E+00	7.083E-01
Total	15	1.532E+05	

Appendix 9 Analysis of variance for the effects of different application rates of pig liquid manure on plant height of *Brassica napus* on week 1.

Source	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK	3	0.0007500	0.0002500	1.49	0.288
TREATMENT	4	0.0931111	0.0232778	139.09	< 0.001
Residual	8	0.0013389	0.0001674		
Total	15	0.0952000	0.0063467		

Appendix 10 Analysis of variance for effects of different application rates of pig liquid manure on plant height of *Brassica napus* on week 3.

Source	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK	3	0.0006250	0.0002083	1.36	0.322
TREATMENT	4	37.5145278	9.3786319	61387.41	< 0.001
Residual	8	0.0012222	0.0001528		
Total	15	37.5163750	2.5010917		

Appendix 11 Analysis of variance for the effects of different application rates of pig liquid manure on plant height of *Brassica napus* on week 5.

Source	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK	3	0.0016687	0.0005562	1.09	0.409
TREATMENT	4	68.9848750	17.2462188	33651.16	< 0.001
Residual	8	0.0041000	0.0005125		
Total	15	68.9906437	4.5993762		

Appendix 12 Analysis of variance for the effects of different application rates of pig liquid manure on plant height of *Brassica napus* on week 7.

Source	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK	3	0.0016687	0.0005562	1.09	0.409
TREATMENT	4	68.9848750	17.2462188	33651.16	< 0.001
Residual	8	0.0041000	0.0005125		
Total	15	68.9906437	4.5993762		