INFLUENCE OF NITROGEN AND PHOSPHORUS FERTILIZATION ON GROWTH PERFORMANCE AND SEED YIELD OF NIGER (*Guizotia abyssinica* (L.f) Cass)

M.Sc. THESIS

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As thesis advisors, we hereby certify that we have read and evaluated this thesis entitled 'Influence of Nitrogen and Phosphorus Fertilization on Growth Performance and Seed Yield of Niger (*Guizotia abyssinica* (L.f) Cass)' prepared under our guidance by Deresa Angasa. We recommend that it be submitted as fulfilling the thesis requirement.

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This thesis is dedicated to my brother Abdisa Angasa and my wife Hawi Tola for their love and moral support in my entire career through my education for the success of my life.

STATEMENT OF THE AUTHOR

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BIOGRAPHICAL SKETCH

Deresa Angasa was born in July 1984 at Gobu Kebele, Guduru District, Horo Guduru Wollega Zone of Oromia Regional State from his father *Obbo* Angasa Wakuma and his mother *Aadde* Zoditu Oljirra. He attended his Elementary school education at Loyya Kidame Primary school (1-8) and Secondary school education at Fincha Secondary school (9-10) and Preparatory School at Ambo Preparatory school. He joined Jimma University Ambo College and received his first degree (Bachelor of Science) in Biology in 2007. He also worked as a Biology Teacher at Jeldu District for 6 years. He joined Haramaya University in 2013 to pursue M.Sc. in Biology.

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ACRONYMS/ ABBREVIATIONS

ATP Adenosine Triphosphate

ANOVA	Analysis Of Variance
CRBD	Complete Randomized Block Design
DM	Dry matter
FA	Fatty Acid
GDAB	Guduru District Agricultural Bureau
ha	hectare
ICAR	India Council of Agricultural Research
LSD	Least Significant Difference
LA	Linoleic Acid
NPS	Nitrogen Phosphorus Sulfur
NMR	Nuclear Magnetic Resonance
NCP	Number of Capitula per Plant
PSAG	Penn State Agronomy Guide
SR	Seeding Rates
SY	Seed Yield per Hektar
SAS	Statistical Analysis Software
TB	Total Biomass
TSW	Thousand Seed Weight

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF TABLES

T a b l e

page

LIST OF FIGURE

LIST OF APPENDIX TABLE

LIST OF FIGURE IN APPENDEX

Influence of Nitrogen and Phosphorus Fertilization on Growth Performance and Seed Yields of Niger (*Guizotia abyssinica* (L.f) Cass)

ABSTRACT

Niger (Guizotia abyssinica) is an annual dicotyledonous oil crop and the only species cultivated in different countries throughout tropical and temperate zones. This study presents growth performance, seed yield and yield related traits of Guizotia abyssinica variety Kuyyu in different Nitrogen:Phosphorus fertilization rates of 0:0, 10.25:23, 20.5:23, 41:23 kg/ha and seeding rates of 7.5, 10 and 12.5 kg/ha in Gudane sirba Kebele of Guduru district, Horo Guduru Zone, Oromia regional state from June to November 2016 under rain-fed cultivation. The experiment was laid out in RCBD with three replications. Parameters such as plant height, number of branches/plant, number of capitula/plant, 1000 seeds weight (1000 SW), seed yield/ha, total biomass and oil content were measured at harvest. Except oil content which did not go in par with the rest of parameters measured, results showed that plant height, number of branches/plant, number of capitula/plant, 1000 SW, seed yeild/ha and total biomass increased with increasing level of N fertilization and decreased with increasing seeding rate. In all *cases, the best performance was observed when plants were fertilized with 41 kg of N/ha with seeding rate of 7.5 kg/ha and this values recommended for farmers to adopt.*

Key Words*: Fertilizer, Growth performance, Niger, Nitrogen, phosphoru*

1. INTRODUCTION

Niger (*Guizotia abyssinica* (L.f) Cass) belongs to the family Asteraceae and the genus *Guizotia*, which has only six species, of which five are native to Ethiopia (Baagoe, 1974). *Guizotia abyssinica* is the only species cultivated in different countries throughout tropical and temperate zones. Ethiopia and India are the chief niger producing countries of the world, but this annual herbaceous plant is also extensively cultivated in Sudan, Uganda, Zaire, Tanzania, Malawi, Zimbabwe, the West Indies, Nepal, Bangladesh, and Bhutan (Weiss, 1983).

Niger is an oilseed crop of commercial importance (Bhagya and Shamanthaka, 2003). Its seed contains about 40% oil with a fatty acid (FA) composition of 75-80% linoleic acid (LA, C18:2n-6) (Getinet and Tekelewold, 1995). In Europe and North America, niger seed is used as a birdseed. It is also used as a human food and today is particularly important to the economy of Ethiopia, where it accounts for 50-60% of its edible oil supply. Its oil is also used in the manufacture of soaps and paints and as a lubricant or lighting fuel (Shahidi et al., 2003).

The meal remaining after oil extraction is free from any toxic substance and contains approximately 30% protein and 23% crude fiber (Getinet and Sharma, 1996). It is used as feed, fertilizer or fuel. In particular, in tropical regions, with their poor quality of basal feed and lack of supplementation with locally available energy and protein sources, niger seed meal is an important supplement for sheep and goats demonstrated that supplementation of hay with niger seed meal improved dry matter (DM) intake, apparent digestibility coefficient and body weight performance of Farta sheep, presumably due to better availability and increased utilization of nutrients. Nawanyakpa *et al.* (1986) determined the effect of feeding *teff* straw and molasses-urea with and without niger cake on sheep growth rate, feed intake and nutrient utilization. They found that DM and N digestibility were higher in sheep fed niger cake than in those deprived of the meal. Butterworth and Mosi (1985) analyzed intake and digestibility by sheep of oat straw and maize stover fed with different levels of niger meal and found a strong positive relationship between increasing N intake and cellulose digestibility, intake of low quality roughage and bodyweight gain in young animals.

Nitrogen is a critical limiting element for plant growth and production. It is a major component of chlorophyll, the most important pigment needed for photosynthesis, as well as amino acids, the key building blocks of proteins. It is also found in other important biomolecules, such as ATP and nucleic acids. Even though it is one of the most abundant elements (predominately in the form of nitrogen gas (N_2) in the Earth's atmosphere), plants can only utilize reduced forms of this element. Plants acquire these forms of "combined" nitrogen by: 1) the addition of ammonia and/or nitrate fertilizer (from the Haber-Bosch process) or manure to soil, 2) the release of these compounds during organic matter decomposition, 3) the conversion of atmospheric nitrogen into the compounds by natural processes, such as lightning, and 4) biological nitrogen fixation (Vance, 2001).

Phosphorus (P) is an essential element for plant and animal growth and is necessary to maintain profitable crop and livestock production. Phosphorus is vital to plant growth and is found in every living plant cell. It is involved in several key plant functions, including energy transfer, photosynthesis, transformation of sugars and starches, nutrient movement within the plant and transfer of genetic characteristics from one generation to the next. Phosphorus content and availability vary with the soil parent material, texture, and pH, as well as with management factors such as the rate of application and tillage practices. Although P is relatively immobile in the soil, it is not non-mobile. It can move, especially where soils have become highly enriched with P (Johnston and Poulton, 1992).

Currently, Ethiopian soils are deteriorating in their essential nutrients contents and crop productivity is declining as a result. Although niger has been grown for long period of time in Ethiopia as major oil crop, no much emphasis has been given to determine the optimal level of NP fertilizers for a given seeding rate except for a Fogera variety done by Amare *et al*. (2015) in Ebnat district.

There is a lack of enough knowledge on the use of fertilizers with niger plants at Guduru district to increase the productivity of niger. Therefore, this experiment is designed to increase the knowledge of farmers on the use of fertilizer for niger plant to increase their productivity.

General Objective:

- To determine the influence of nitrogen and phosphorus fertilization on the growth performance and seed yields of niger (*Guizotia abyssinica*(L.f) Cass)

Specific Objectives

- To determine the optimal level of NP fertilizers for the given seeding rate of niger.
- To evaluate the response of yield and yield components of niger to NP fertilizers and seeding rates under rain fed condition.
- To evaluate the influence of nitrogen and phosphorus on the oil content of niger.

2. LITERATURE REVIEW

2.1. Botanical Description of Niger

Niger is an annual dicotyledonous herb. Germination is epigeal and seedlings have pale green to brownish hypocotyls and cotyledons (Seegeler, 1983). The cotyledons remain on the plant for a long time. The first leaf is paired and small and successive leaves are larger.

The leaves are arranged on opposite sides of the stem; at the top of the stem leaves are arranged in an alternate fashion. Leaves are 10-20 cm long and 3-5 cm wide. The leaf margin morphology varies from pointed to smooth and leaf color varies from light green to dark green, the leaf surface is smooth. The stem of niger is smooth to slightly rough and the plant is usually moderately to well branched. Niger stems are hollow and break easily. The number of branches per plant varies from five to twelve and in very dense plant stands fewer branches are formed. The color of the stem varies from dark purple to light green and the stem is about 1.5 cm in diameter at the base. The plant height of niger is an average of 1.4 m, but can vary considerably as a result of environmental influences and heights of up to 2 m have been reported from the Birr valley of Ethiopia.

2.2. Mode of Reproduction

Flower development, the extent of cross- and self-pollination, and the time at which fertilization occurs are important criteria for conducting breeding work. In Ethiopia capitulum buds open approximately 2 months after planting (Seegeler, 1983). Flower anthesis begins early in the morning at about 6.00 hours and dehiscence of pollen begins 2 hours later and continues up to 10.00 hours under conditions at Holetta, Ethiopia.

The style emerges covered with pollen but the receptive part rarely or never comes in contact with that pollen, a phenomenon that favors cross-pollination. A single head or capitulum takes 8 days and a field will require 6 weeks for completion of flowering (Seegeler, 1983).

Niger is a completely outcrossing species with a self-incompatibility mechanism (Chavan, 1961; Mohanty, 1964; Shrivastava and Shomwanshi, 1974; Sujatha, 1993) and insects, particularly bees, are the major agents of pollination (Ramachandran and Menon, 1979).

The self-incompatibility nature of niger complicates the production of selfed seed. At Holetta, 600 accessions were tested for their ability to produce selfed seed using muslin cloth bagging (Riley and Belayneh, 1989). Twenty-two out of the 600 accessions produced approximately 1 g of selfed seed per plant, indicating that niger germ plasm with some level of self-compatibility exists within the Ethiopian gene pool.

For crossing of niger, the disk florets which are hermaphroditic are removed from the capitulum, after 1-3 days of opening and the female ray florets are dusted with pollen from the selected second parent (Mohanty, 1964; Naik and Panda, 1968; Teklewold, unpublished). Pollination after the third day does not result in any seed set. After dusting, the capitulum is covered with a bag for 1 week to exclude any foreign pollen. This procedure produces a good quantity of crossed seed.

2.3. Origin and Center Of Diversity

Baagøe (1974) describes the distribution of the genus *Guizotia* in Africa. The distribution of *Guizotia* species in Africa as presented in the distribution map by Hiremath and Murthy (1988), in contrast to that reported by Baagøe (1974), is incorrect. In Africa, *G. abyssinica* is largely found in the Ethiopian highlands, particularly west of the Rift Valley. Niger is also found in some areas in Sudan, Uganda, Zaire, Tanzania, Malawi and Zimbabwe, and the West Indies, Nepal, Bangladesh, Bhutan and India (Weiss, 1983).

Baagøe (1974) raised four points about the origin of niger: first, the highest concentration of *Guizotia* species is in Ethiopia; second, *G. abyssinica* can also be collected from the natural habitat; third, the similarity of the distribution of niger with that of other cultivated crops, and fourth, the historical trade between Ethiopia and India. This would suggest that niger is not native to India and may have been taken from Ethiopia to India by traders.

2.4. Niger Seed

Niger seed resembles sunflower seeds in shape, but is smaller in size and black. It bears a fairly thick, adherent seed coat and can be stored for up to a year without deterioration. Niger seed contains proteins, oil and soluble sugars. Niger seeds are used as bird feed worldwide. Commercial niger seed is grown in Africa, India and other areas of south east Asia, and the seed is imported around the world as a popular type of birdseed. Before it is imported, however, niger seed is sterilized by intense heat to prevent germination of any additional seeds that may be part of the mix. Treated niger seed may germinate but would typically be stunted, limiting its spread and offering less of a threat to native plants.

Niger seed yields about 30-35% of its weight in oil which is clear, slow-drying, and edible. Niger seed oil is polyunsaturated semi-drying oil. It has pale yellow or orange color with a nutty taste and sweet odor. Raw oil has low acidity and can be used directly for cooking. Normally it has a poor shelf life and will become rancid when stored for a long period. Its fatty acid composition is similar to sunflower oil and has high content of linoleic acid. It is used substitute for olive oil and can be mixed with linseed oil. The presence of linoleic acid varies from 45.0-65.0% depending on harvested soil conditions and seed variety.

2.5. Ecology of Niger

Niger is a crop of the cooler parts of the tropics. The major niger-producing areas in Ethiopia are characterized by a moderate temperature ranging between 15°C and 23°C during the growing season. Prinz (1976) studied the effect of temperature and day length of Ethiopian and Indian niger in the field and phytotron at Göttingen, Germany. Ethiopian niger showed best flower induction at 18/13ºC day/night temperature and 12 hours day length. Flowering was very delayed at day lengths of more than 12 hours and temperature of 23ºC. The Ethiopian types may not be induced at day lengths of more than 14.5 hours. Once flowering is induced it remains induced, even at longer photoperiods (Yantasath, 1975). The Ethiopian types can be induced to flower at 11- 12 hours day length 7 weeks after planting.

The influence of temperature on the flower induction of Indian niger was not observed. Longer day lengths increased vegetative growth and plant height in Ethiopian and Indian types, but more so in Ethiopian than in Indian. In summary, the Ethiopian types are short-day and the Indian types are quantitative short-day types.

In Ethiopia, niger is grown mainly in mid-altitude and highland areas (1600-2200 m). It is also cultivated in lower (500-1600 m) and higher (2500-2980 m) altitudes with enough rainfall. Niger is adapted to areas where rainfall does not exceed 1000 mm per year. A higher precipitation (1000-1200 mm and lower levels of about 500 mm may be suitable, depending upon the variety and the distribution of rainfall. In India, a rainfall between 1000 and 1300 mm is optimum but a well distributed rainfall of 800 mm can produce a reasonable yield (Sharma, 1990b). The growth may be depressed with rainfall of over 2000 mm, but the plants can withstand high rainfall during the vegetative phase. For this reason, niger is the most suitable crop for hill regions of high rainfall and humidity in India. Niger will grow on almost any soil as long as it is not coarse-textured or extremely heavy. It is usually sown in areas with a rather poor soil or on heavy clay soil under poor cultural conditions. It grows well at pH values between 5.2 and 7.3. Niger tolerates waterlogged soils since it grows equally well on either drained soils or waterlogged clays. Niger is extraordinarily resistant to poor oxygen supply in soil because of its ability to develop aerenchymas under these conditions. The aerenchymas develop only when niger plants are grown under high waterlogging condition and transport oxygen within the cormus into the root system (Prinz, 1976).

Rainfall during seed-setting and maturity leads to seed shattering and hence, low yield. Niger is salt tolerant (Abebe, 1975) but flowering is delayed with increasing salinity. It has been observed that crops following niger grow well and inoculation of soil with soil in which niger was grown resulted in increased growth of the crop following niger (Yantasath, 1975). A microorganism involved in mycorrhiza association, *Glomusmacro carpus*, has been identified.

2.6. Agronomy of Niger

Farmers in Ethiopia plant 'abat' niger in mid-May to early June and harvest in December, 'bungne' niger is planted in July and harvested in October and the growing season for '*mesno*' niger is from September to February. Systematic research at the Holetta Research Centre showed that mid-June to mid-July was the optimum time of planting for the 'abat' niger (Belayneh *et al.,* 1986). Planting too early should be avoided as rain in October can cause shattering and reduce seed yield.

In India niger is planted as a rain-fed crop in '*kharif*' and '*rabi*' seasons (ICAR, 1992). Generally it is planted from mid-June to early August for *'kharif'*, in September for the semi-*rabi* season and in December for *'rabi'* season. The optimum sowing period varies from state to state. Niger is a small-seeded crop and seed rates vary from 5 to10 kg/ha in Ethiopia and from 5 to 8 kg/ha in India. The crop compensates for lower seeding rates through increasing branching. In Ethiopia lower seed rate is preferred during early planting. In India the seed is treated with Thiram at a rate of 3 g/kg of seed to prevent soil borne diseases. In both countries it is often broadcast but it can also be sown in rows. In Ethiopia niger is mainly sown as a sole crop, usually in rotation with *teff* and maize. In some areas, particularly in Wello and Hararghe in Ethiopia and Maharashtra in India, niger is planted as a border crop around a cereal field to prevent animals from damaging the cereal crop. In Ethiopia farmers often report that niger is a good precursor for cereals and that crops following niger have less weed infestation. This was confirmed in crop rotation trials where high yields of cereals were obtained following niger. Preliminary investigations at Holetta showed that a water-extract substance from niger inhibited the germination of monocotyledonous weeds. In India, niger is sown as a sole or mixed crop with finger millet, castor, groundnut, soybean, sorghum, mungbean, chickpea and even sunflower.

Niger has a low response to nitrogen and phosphorus fertilizer. However, a rate of 23 kg N/ha and 23 kg P_2O_5/ha is necessary for stand establishment. In India, both nitrogen and phosphorus and farm yard manure are applied. Correct timing of harvesting of niger is an important practice in reducing shattering. Traditionally, niger is harvested while the buds are still yellow and stacked dry. Then the stack is taken up right over to the threshing ground. As niger seeds are loosely held in the head, threshing is easy. Research has shown that harvesting niger at a bud moisture content of 45-50% or when the buds turn from yellow to brown yellow is the optimum stage (Belayneh, 1987). In India it is harvested when the leaves dry up and the head turns black (ICAR, 1992). During harvesting, plants are kept in stacks and when dried they are taken to the threshing ground in an upright position to reduce shattering. The crop is then threshed using sticks.

The effects of cultural practices –sowing date, seed rate, fertilizer rate, weeding, improved variety – on seed yield of niger were studied. In Ethiopia, the plant developmental stage at harvest and the variety planted were found to be important factors contributing to high seed yields. In India, fertilizer application and variety contributed 68 and 51%, respectively, to increased yield (Sharma, 1990a). Adoption of improved technology increased seed yield of niger by 40%.

2.7. Uses of Niger

The niger plant is consumed by sheep but not by cattle, to which only niger silage can be fed (Chavan, 1961). Niger is also used as a green manure for increasing soil organic matter.

Niger seed is used as a human food. The seed is warmed in a kettle over an open fire, crushed with a pestle in a mortar and then mixed with crushed pulse seeds to prepare '*wot'* in Ethiopia (Seegeler, 1983). *'Chibto*' and *'litlit'* are prepared from crushed niger seed mixed with roasted cereals, and is the preferred food for young boys. In Ethiopia, niger is mainly cultivated for its edible oil. The pale yellow oil of niger seed has a nutty taste and a pleasant odour. The traditional method for extraction of oil from niger in Ethiopia is through a combination of warming, grinding and mixing with hot water followed by centrifugation in an '*okkotee*' (a container made of clay). After an hour of centrifugation by hand on a smooth soft surface the pale yellow oil settles over the meal.

Niger is also crushed in small cottage expellers and large oil mills. The small, electrically powered cottage expellers are manufactured as different brands with varying capacities in Addis Abeba and Adama in Ethiopia. The meal remaining after extraction of the oil using Ethiopian expellers contains 6-12% oil depending on the expeller. Many expellers are found in the provinces of Arsi, Bale, Gojam, Gonder, Shoa and Wellega of Ethiopia.

In India the oil is extracted by bullock-powered local '*ghanis*' and rotary mills(Cottage expellers) or in mechanized expellers and hydraulic presses in large industrial areas. The niger oil is used for cooking, lighting, anointing, painting and cleaning of machinery (Chavan, 1961; Patil and Joshi, 1978; Patil and Patil, 1981). Niger oil also is a substitute for sesame oil for pharmaceutical purposes and can be used for soap-making.

The meal remaining after the oil extraction contains about 24% protein and 24% crude fibre (Seegeler, 1983). Niger meal from India contains higher protein (30%) and lower crude fibre (17%) levels than meal from Ethiopia. Niger cake replacing linseed cake at levels of 0, 50 and 100% was fed as a nitrogen supplement for growing calves (Singh *et al*., 1983). No significant differences in growth rate, feed efficiency and dry matter digestibility were noticed between niger and linseed cake and it was concluded that niger cake can replace linseed cake in calf rations (Singh *et al.* 1983). Similarly, four levels of niger cake (0, 50, 75 and 100%) replacing groundnut cake were fed to large White Yorkshire pigs for 9 weeks.

There was no significant difference in weight gain between rations containing either niger or groundnut cake. Niger lipoprotein concentrate was fed to growing rats as a sole protein source for 90 days and no negative effects on growth rate were observed (Eklund, 1971b). A niger-based agar medium can be used to distinguish *Cryptococcus neoformans* (Sant) Vaill, a fungus that causes a serious brain ailment, from other fungi (Paliwal and Randhawa, 1978). There are reports that niger oil is used for birth control and for the treatment of syphilis (Belayneh, 1991). Niger sprouts mixed with garlic and '*tej*' are used to treat coughs

2.8. Nitrogen Fertilizers

Nitrogen fertilizer is one of the key drivers producing high yields in modern agriculture and its use has grown substantially over the past 40 years. Plants, however, are able to use only about half of the nitrogen fertilizer applied. The remainder moves through the soil and enters ground and surface water systems, or volatilizes into the air as a greenhouse gas 300 times more potent than carbon dioxide.

Many different chemical and physical forms of nitrogen (N) fertilizers exist. Some of the more common fertilizer nitrogen sources are Anhydrous ammonia—NH_3, Urea—NH_2-CO-NH_2, Ammonium nitrate—NH_4NO_3, Nitrogen solutions (UAN)—Urea+NH_4NO_3+Water, Ammonium sulfate—$(NH_4)_2SO_4$, Diammonium phosphate (DAP)—$(NH_4)_2HPO_4$,Monoammonium phosphate (MAP)—$NH_4H_2PO_4$, and so on. The nitrogen in most farm-grade fertilizers is readily available. When different nitrogen fertilizer materials are applied properly, they give the same results per unit of nitrogen applied. Some fertilizers, such as "turf-grade" fertilizers, release nitrogen very slowly. Plants can use nitrogen in one of two forms: ammonium nitrogen (NH_4^+) or nitrate nitrogen (NO_3^-).A long-term effect of all ammonium-based nitrogen fertilizers is to lower soil PH. Anhydrous ammonia, urea, diammonium phosphate, and nitrogen solutions, when first applied, greatly but temporarily increase soil pH in the zone of application. Ammonia is released and can "burn" germinating seeds or seedling roots in the area of fertilizer placement. In the eventual conversion of NH_4^+ to NO_3^-, however, an acid residue is formed.

2.9. Phosphorus Fertilizer

Phosphorus (P) is an essential plant nutrient required for optimum crop production. Phosphorus deficiencies can be corrected with phosphate fertilizer (P_20_5). Generally, P is the second most limiting soil nutrient in crop production in Alberta. With respect to fertilizer use, it is second only to nitrogen (N) in Alberta. Phosphorus fertilizer is immobile in soil; therefore, plant uptake of fertilizer P may be low in the first year after application. However, alfalfa and grasses do have feeder roots very near the soil surface and can take up some broadcast P fertilizer when surface soil moisture conditions are good (Johnston and Poulton, 1992).

Plants need phosphorus for growth, utilization of sugar and starch, photosynthesis, nucleus formation and cell division. Phosphorus compounds are involved in the transfer and storage of energy within plants. Energy from photosynthesis and the metabolism of carbohydrates is stored in phosphate compounds for later use in growth and reproduction. The phosphorus content of a fertilizer is specified as the amount of P2O5 because this is the anhydrous form of phosphoric acid. In this sense it is the most concentrated form of phosphate, which is the form of phosphorus required by plants (Johnston and Poulton, 1992).

3. MATERIALS AND METHODS

3.1. Description of the Study Area

Field experiment was conducted under rain fed condition (June to November) of 2016 at a site called Gudane Sirba Kebele of Guduru District in Horo GuduruWollega zone. The District is located between 09^{o}29’ North latitude and 37^{o}26’ East longitude. The mean annual rainfall of the District is 1400 mm, of which 90% occurs in the months of June to September. The monthly mean temperature of the District varies from 14.9ºC to 27.5ºC and the elevation of the experimental site is 2296 m.a.s.l. (GDAB, unpublished)

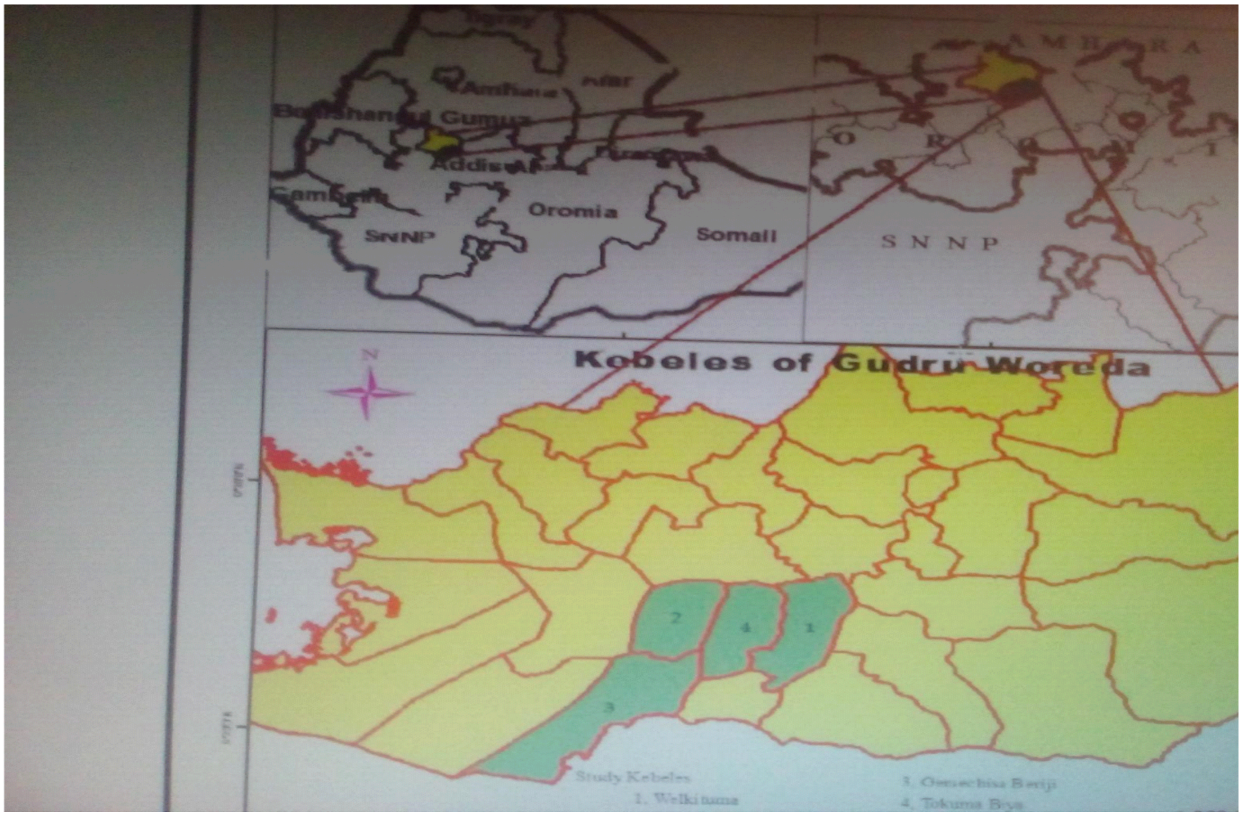

Figure 1. Location of the study area in Guduru distinct

3.2. Planting Materials Used for the Study

Kuyyu variety of Niger from Holetta Agriculture Research Centre, which was commonly grown by farmers in the district, was used as a planting material.

3.3. Pre Planting Soil Sampling and Analysis

Eight soil samples were systematically sampled from depth of 0-30 cm from all directions of the experimental plot and made into composite for physico-chemical properties study. The collected soil samples were air-dried and sieved through a 2mm diameter sieve. Soil texture was determined by Hydrometer method (Bouyoucos, 1962). The soil pH at 1:2.5 soil-water ratios was determined by KCl method using a digital pH meter (Thomas, 1996). The organic matter content of the soil was determined by Walkley and Black method (Walkley and Black, 1934). Total nitrogen was determined by micro-Kjeldahl method (Miller and Houghton, 1945). The available P was estimated following standard procedure of Bray II methods (Bray and Kurtz, 1945).

3.4. Experimental Design and Treatments

Factorial experiment of four levels of NP fertilizers and three levels of seeding rate under broadcast planting method were laid under randomized complete block design (RCBD) with three replications. The effect of N on the growth and yield parameters of *G. abyssinica* was evaluated by varying the amount of N and keeping P constant. Nitrogen is a critical limiting element for plant growth and production. When different nitrogen fertilizer materials are applied properly, they give the same results per unit of nitrogen applied. While P is vital to plant growth and found in every living cell and Phosphorus fertilizer is immobile in soil; therefore, plant uptake of fertilizer P may be low in the first year after application. The four levels of NP fertilizers were 0-0, 10.25-23, 20.5-23,and 41-23 kg/ ha of N and P_2O_5, respectively, while the three levels of seeding rates (SR) were 7.5, 10 and 12.5 kg /ha (Amare *et al.,* 2015) . The experimental land was oxen plowed three times before laying the experimental plots on the field. A 3 m × 1.8 m (5.4 m^2) plot size was used as an experimental unit. The blocks were separated by 1 m wide open space, whereas the plots within a block were separated by 0.5 m wide space. Nitrogen fertilizer was applied in two equal splits where 50% of the N was evenly scattered during the sowing time while the remaining 50% applied 30 days after germination. Urea fertilizer (46% N) was used as a source of N. $P_2 O_5$ was used as a source of Phosphorus and applied during planting time. The amount of urea fertilizers used as a source of N representing the above mentioned treatments per plot 5.535 gm, 11.07 gm and 22.14 gm and that of phosphorus was 12.42 gm.

3.5. Determination of seed oil content

Extraction of oil is the first step in the refining process. Oil is extracted from its original source (the seeds, oil-bearing raw materials) using a variety of different methods. Modern oil mills extract oil by using a combination of pressing, cooking and solvent extraction. For this, 5 gm of dry sample was taken and placed in the extraction thimble, which was placed in the extraction unit. The flask containing petroleum ether at 2 or 3 of total volume was connected to the extractor containing extractor unit. Then the flask containing the sample was boiled by adjusting heat at 40^0c-60^0c to obtain about 10 refluxes per hour. The length of extraction depends on the lipid content of the sample. When finished, the ether was evaporated in the rotary evaporator. The flask containing oil was cooled in a dryer and then, the oil content was estimated by Nuclear Magnetic Resonance in Holetta Agricultural Research Centre oil laboratory and expressed in percentage.

3.6. Data Collected

Plant height, number of branches per plant, number of capitula per plant, seed yield per hectare (in gm), thousand seed weight (in gm), total biomass (in gm) and oil content were the data collected at harvest time.

3.7. Data Analysis

Data were subjected to the analysis of variance (one-way ANOVA) using SAS version 9.0 statistical soft ware and means were separated by using least significant difference (LSD) at 0.05 probability level.

4. RESULTS AND DISCUSSION

4.1 Soil Physico-chemical properties of the study site

The results of soil laboratory analysis of some selected physico-chemical properties of the soil of experimental site are presented below (Table 1).

Results of the soil analysis before planting showed that the soil of the site is sandy loam in texture with acidic (pH 4.92) reaction. The soil had 0.161% total nitrogen, 8.721ppm of available phosphorus and 2.10% of organic carbon. According to the limit suggested by Walkley and Black (1934), soil with the organic carbon (1.43%) organic matter content (2.46%) of the soil was rated as very low. According to the rating suggested by London (1991), soil with the nitrogen content of about 0.15% is considered to be low. Also, according to the rating suggested by Olsen et al. (1954), soils with phosphorus content of less than 15.5 ppm are said to be low in phosphorus. Overall the results of the current study showed that soil of the study area is poor in the examined nutrient elements so that fertilization is crucial to increase crop productivity.

Table 1.The physico-chemical analysis of the soil of the study area

No.	Soil characteristics	Analytical value	Remark
1	Texture class	Sandy loam	
2	Soil pH	4.92	Acidic
3	Organic Carbon (%)	2.10%	Low
4	Total N (%)	0.161%	Low
5	Available P(ppm)	8.721ppm	Very low

4.2 Growth, Yield and Yield related Parameters

Plant height was recorded at the time of harvest. It was observed that different levels of nitrogen exhibited significant effect on the plant height at ($p < 0.05$) (Table 2). Height of plants grown without any dose of nitrogen and phosphorus in all seeding rates were found to be significantly shorter than those that were grown on plots fertilized with N and P. Plant height was found to increase with decreasing seeding rate in all levels of Nitrogen fertilization and was maximum at 41 kg/ha N and 7.5 kg/ha of seeding rate (Table 2) and declined when seeding rate was increasing. This suggests that even if seeding rate is 7.5 kg/ha, plants will attain maximum height as far as Nitrogen fertilization is increased up to 41 kg/ha.

The result shows that increased availability of N leads to increased plant heights, and this result is in agreement with that of Robin et al. (2001) who reported higher plant heights due to increased rate of N. Similarly, Fisseha (1982) and Yohannes (1994), working on wheat and Ensete, respectively observed significant increments in height of the respective crop plants as the rates of N and P were increased. Again the same result was found by Tadele (2009) on Carrot. The increase of plant height at higher rates of NP fertilizers would likely be associated with the effects of N and P on vegetative growth promotion and stem strengthening, respectively. These results are in conformity with the findings of Amsale *et al*. (2000) reported on wheat crop.

The highest mean value (13.667) of number of branch was obtained at the highest (41 kg) application of N and at the lowest (7.5 kg) seeding rate and the lowest mean number of branches per plant (8.33) was observed when plants were fertilized with 10.25 kg N/ha at 12.5 kg seeding rate, but no significant difference was observed with 0 kg application of N/ha at 12.5 kg seeding rate (Table 2). At 7.5 kg seeding rate, number of branches found to be increased due to increased application of N from 0kg to 20.5 kg N/ha, but no significant difference was observed at ($P<0.05$). The same result was observed at 10 kg seeding rate as application of N increased (Table 2). At 12.5 kg seeding rate as application rate of N increased the number of branches increased, but significant difference was observed between the lower (0 and 10.25 kg N/ha) application of N rate and the higher (20.5 kg and 41 kg/ha) application of N rate (Table 2). Increased number of branches per plant with increased levels of NP rates might be due to the vegetative growth promoting effect of nitrogen as well as branch development effect of phosphorous. These results are in agreement with those documented by ICAR (1992).

Table 2. Mean plant height and number of branches per *G. abyssinica* plant. (Values are means, n=3)

NP rate	Seeding rate	Height (cm)	Number branches/plant
N=0	7.5	153.67^{f}	11.00^{ab}

P=0	10	150.33^{f}	10.33^{ab}
	12.5	146.67^{f}	9.00^{b}
N=10.25 P=23	7.5	198.00^{de}	12.33^{ab}
	10	191.67^{e}	11.00_{ab}
	12.5	189.23^{e}	8.33^{b}
N=20.5 P=23	7.5	233.00^{bc}	12.33^{ab}
	10	220.00^{bcd}	11.667^{ab}
	12.5	210.33^{cde}	11.00^{ab}
N=41 P=23	7.5	260.67^{a}	13.667^{a}
	10	243.00^{ab}	11.667^{ab}
	12.5	230.33^{bc}	11.667^{ab}

Means with the same letter in a column are not significantly different at $p<0.05$.

4.3 Yield and Yield Related Parameters

Compared to the non-fertilized plants, number of capitula/plant was significantly higher in fertilized plants at all rates of N fertilization and seeding rate/ha (Table 3). Under a given seeding rate, number of capitula/plant increased with increasing rate of N fertilization, but found to decrease with increasing seeding rate for each rate of N fertilization (Table 3). That is, number of capitula was found to be highest at 7.5 kg seeding rate when fertilized with 10.25 kg of N/ha, but values decreased with increasing seeding rate. Also, when fertilized with 20.5 kg of N/ha, number of capitula found to be higher at 7.5 kg seeding rate, but values declined with increasing seeding rate. At 41 kg of N, number of capitula/plant peaked compared to all other seeding rate and fertilization combinations, but values declined with increasing seeding rate (Table 3). In agreement with this investigation, Graham *et al*. (2007) reported that the maximum number of tillers was recorded at the highest dose of N fertilizer. Similarly, Puri *et al*. (1988) reported that with increasing N fertilizer rate triticale tiller number increased.

The main effects of N fertilizer levels and seeding rates on 1000 seed weight (TSW) were highly significant at $P<0.05$ (Table 3). The present study showed that the highest
TSW of niger (3.67 gm) was obtained from the sample of niger grown with 41 kg N/ha at 7.5 kg/ha seeding rate, but the values declined with increasing seeding rate (table 3). And the lowest TSW (2.64 gm) was obtained from the sample of niger grown with 0 kg N/ha at 12.5 kg seeding rate but the values increased with decreasing seeding rate (Table 3).The

TSW of the niger fertilized with 10.25 kg and 20.5 kg of N/ha was found to be higher at 7.5 kg seeding rate, but the value declined with increasing seeding rate (Table 3). At the same seeding rate, the TSW was gradually increased with increasing N application. Thousand seed weight increased with N application rate. Amsale *et al.* (2000) reported that a positive and linear response of thousand seed weight to N fertilizer rates. Similarly, Puri *et al*. (1988) found on triticale the highest kernels number and kernels weight at the highest rates of N fertilizer.

The main effects of N application levels, significantly influenced ($P<0.05$) seed yield of niger (Table 3). Seed yield gradually increased with increasing N rate from 0 to 41 kg/ha and the seed yield at the maximum rate of N application (41 kg/ha) at 7.5 kg seeding rate was significantly higher (473.34 kg) than other N application levels (Table 3). In the same seeding rate, the seed yield/ha increased with increasing N application. Similarly, Sayre *et al*. (1996), Lack *et al*. (2000) and Graham (2007) reported that the highest grain yield of triticale was produced at the highest application rate of N fertilizer.

The main effects of N fertilizer on the total biomass yield (TB) was highly significant ($P<0.05$) (Table 3). Compared to the non-fertilized plants, total biomass yield was significantly higher in fertilized plants at all rates of N fertilization and seeding rate/ha (Table 3). Total biomass increased with increasing of N fertilizer within the same seeding rate. Total biomass was found to be highest (1246.12 kg) at 7.5 kg seeding rate when fertilized with 41 kg of N/ha, but the values declined with increasing seeding rate (Table3) and the lowest TB (792.59 kg) was observed at 0 kg N/ha application rate at 12.5 kg seeding rate. Gooding and Davies, (1997) reported that increase in total biomass as N increases might be due to increases in tillering. The declining of biomass at higher plant densities (higher seeding rate) was attributed to greater inter-plant competition for growth factors such as nutrients, sunlight, and moisture that do not allow the individual plants to achieve their maximum potential.

Table 3. Mean results of yield components of *G. abyssinica* in response to different levels of NP fertilization and seeding rate (values are means, n=3)

NP rate	Seeding rate	NCP	TSW(gm)	SY(in kg)	TB(in kg)
N=0	7.5	58.00^{d}	2.85^{i}	390.3^{f}	814.81^{j}

P=0	10	54.00^{d}	2.74^{j}	353.59^{i}	803.59^{k}
	12.5	40.33^{d}	2.64^{k}	337.98^{j}	792.59^{l}
N=10.25 P=23	7.5	105.00^{abc}	3.44^{c}	417.04^{e}	1047.22^{g}
	10	70.33^{cd}	3.23^{fg}	377.11^{g}	1027.78^{h}
	12.5	56.33^{d}	3.05^{h}	365.13^{h}	1009.26^{i}
N=20.5 P=23	7.5	113.00^{abc}	3.52^{b}	445.61^{bc}	1156.17^{d}
	10	101.33^{abc}	3.25^{f}	432.11^{d}	1138.28^{e}
	12.5	80.67^{bcd}	3.20^{g}	429.44^{d}	1120.37^{f}
N=41 P=23	7.5	139.00^{a}	3.67^{a}	473.34^{a}	1246.12^{a}
	10	117.00^{ab}	3.40^{d}	455.28^{b}	1200.09^{b}
	12.5	113.33^{abc}	3.34^{e}	436.89^{cd}	1182.07^{c}

NCP=Number of Capitula/Plant, TSW=Thousand Seed Weight, SY=Seed Yield/hectare, TB=Total Biomass .

Means with the same letter in a column are not significantly different at $p<0.05$

Niger *(Guizotia abyssinica*) is an annual dicotyledonous oil crop and the only species cultivated in different countries throughout tropical and temperate zones. From the present study, Oil content tested from seeds of different N fertilization rate and seeding rate showed that oil content appeared to be higher in seeds from unfertilized plots than in seeds from fertilized plots, and found to decrease with increasing seeding rate in un-fertilized plots (Table 4).

The oil content of niger was found to be higher at 7.5 kg seeding rate when fertilized with 10.25 kg of N/ha, but the value also declined with increasing seeding rate. When niger plants fertilized with 20.5 kg of N/ha the oil content of niger found to be lowest at 7.5kg seeding rate, but the value increased with increasing seeding rate and similar result was obtained from niger plants fertilized with 41kg of N/ha with increasing seeding rate (Table 4). Compared to the fertilized plants, the oil content of niger was significantly higher in non-fertilized plants at all seeding rate (Table 4). In this case as the amount of nitrogen fertilizer increased from 0, 10.25, 20.5 to 41 kg N/ha the oil content of niger found to decline. This result is in agreement with that of Ozer et al. (1999) who observed similar response in Canola plant. According to Chamorro *et al*. (2002), excessive N fertilization may decrease oil content of seeds in oil crops. The possible reason for the decrease in oil content with increasing N may be due to the fact that N is the major constituent of protein so it might increase the percentage of seed protein, as a result there might be decrease in the percentage of oil content. The result agrees with those documented by Jan *et al*. (2002) and Özer (2003).

Table 4. Mean results of oil contents *G. abyssinica* in the response to NP fertilizers in different seeding rate (values are means, n=3)

NP rate(kg/ha)	Seeding rate(kg/ha)	Oil content (%)
N=0 P=0	7.5	39.867a
	10	39.9a
	12.5	37.7b
N=10.25 P=23	7.5	36.7c
	10	33.7f
	12.5	32.8h
N=20.5 P=23	7.5	32.5i
	10	34.53d
	12.5	33.5g
N=41 P=23	7.5	33.567fg
	10	34.2e
	12.5	33.6fg

Means with the same letter in a column are not significantly different at $p<0.05$.

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

A field experiment was conducted under rain-fed condition during 2016 at Gudane Sirba, Guduru district of Horo Guduru Wollega zone, Oromia Regional state, to investigate the influence of nitrogen and phosphorus fertilization on the growth performance and seed yield of niger (*Guizotia abyssinica* (L.f) Cass). Kuyyu variety of Niger from Holetta Agriculture Research Centre which was commonly grown by farmers in the district was used as a planting material. Factorial experiment of four levels of NP fertilizers and three levels of seeding rate under broadcast planting method were laid under randomized complete block design (RCBD) with three replications. The effect of N on the growth and yield parameters of *G. abyssinica* was evaluated by varying the amount of N and keeping

P constant. The four levels of NP fertilizers were 0-0, 10.25-23, 20.5-23,and 41-23 kg/ ha of N and P_2O_5, respectively, while the three levels of seeding rates (SR) were 7.5, 10 and 12.5 kg /ha . The experimental land was oxen plowed three times before laying the experimental plots on the field. A 3 m × 1.8 m (5.4 m^2) plot size was used as an experimental unit. Nitrogen fertilizer was applied in two equal splits where 50% of the N was evenly scattered during the sowing time while the remaining 50% applied 30 days after germination. Urea fertilizer (46% N) was used as a source of N. P_2O_5 was used as a source of Phosphorus and the full rate of P fertilizer was applied during planting time.

Soil samples, 0-30 cm depth, were collected from experimental field before planting. Analysis of composite soil sample revealed that the soil of experimental field was sandy loam in texture, and acidic (pH=4.92). It had 0.161% total N, 2.10% organic carbon, and 8.721 ppm available phosphorus.

Nitrogen fertilizer rate exhibited notable effects on yield and yield components of niger. The levels of N significantly influenced all growth parameters and some yield and yield components. Plant height and number of branches increased with N application at 41kg/ha recorded significantly higher values than other treatments. Similarly, the number of capitula per plant, thousand seed weight of niger seed, seed yield/ha and total biomass yield were increased when the levels of N increased to 41 kg/ha. However, the oil content of niger decreased when the levels of N increased**.**

5.2 Conclusion

From the results of this investigation, it can be concluded that N application at the rate of 41 kg N /ha combined with phosphorus at the rate of 23 kg P/ha is optimum for the increment of plant height, number of branches/plant, number of capitula/plant, thousand-seed weight, seed yield/ha and biomass yield of niger at 7.5 kg seeding rate under rain fed condition and no need of any dose of fertilizers to improve the oil content of niger, , it is best to use 7.5 kg/ha of seeding rate for niger.

5.3 Recommendation

- This finding being the result of one location, it is recommended that the experiment should be repeated in different agro-climatic zones

- Since the finding of this work is a single year result, it should be repeated consecutive years.
- Further work is again necessary to look at the composition of other organic matter (carbohydrate and protein) of niger.

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7. APPENDEXES

Appendix Table 1. Data collected on the growth parameters

N p level(kg/hek)	Seed level (Kg/hek)	No. trials	Height(cm)	Number of branches / plant
N=0 p=0	7.5	1	157	9
		2	148	13
		3	156	11
	10	1	139	9
		2	155	9
		3	157	13
	12.5	1	147	9
		2	145	11
		3	148	7
N=10.25 P=23	7.5	1	212	13
		2	180	9
		3	202	15
	10	1	202	9
		2	163	13
		3	210	11
	12.5	1	185.7	7
		2	187	11
		3	195	7
N=20.5 P=23	7.5	1	240	13
		2	207	15
		3	252	9
	10	1	216	11
		2	204	13
		3	240	11
	12.5	1	204	11
		2	207	13
		3	220	9
N=41 P=23	7.5	1	251	17
		2	281	13
		3	250	11
	10	1	231	11
		2	250	11

		3	248	13
	12.5	1	218	13
		2	245	11
		3	228	11

Appendix Table 2. Raw data of yield parameters of niger (*G.abyssinca* (L f) Cass)

NP level (kg/ha)	**SR**	**No. trials**	**Oil Content(%)**	NCP	TSW (gm)	SY(in kg)	TB (in kg)
N=0 P=0	7.5	1	39.9	63	2.85	390.0	814.82
		2	39.8	51	2.83	390.1	814.82
		3	39.9	60	2.87	390.8	814.79
	10	1	39.9	24	2.74	353.62	803.59
		2	39.9	67	2.73	353.57	803.57
		3	39.9	71	2.75	353.58	803.61
	12.5	1	37.8	34	2.63	338.00	792.58
		2	37.7	37	2.64	337.98	792.62
		3	37.6	50	2.65	337.96	792.57
N=10.25 P=23	7.5	1	36.7	148	3.44	417.02	1047.27
		2	36.8	55	3.42	417.07	1047.20
		3	36.6	112	3.46	417.03	1047.19
	10	1	33.7	97	3.23	377.11	1027.67
		2	33.7	47	3.22	377.10	1027.88
		3	33.7	67	3.24	377.12	1027.79
	12.5	1	32.7	55	3.05	365.13	1009.23
		2	32.8	53	3.02	365.12	1009.27
		3	32.9	61	3.08	365.14	1009.18
N=20.5 P=23	7.5	1	32.6	104	3.52	445.59	1156.14
		2	32.5	110	3.5	445.60	1156.15
		3	32.4	125	3.54	445.64	1156.22
	10	1	34.6	109	3.25	432.10	1138.31
		2	34.4	127	3.27	432.09	1138.26
		3	34.6	68	3.23	432.14	1138.27
	12.5	1	33.5	112	3.25	429.34	1120.38
		2	33.6	80	3.15	429.44	1120.36
		3	33.4	50	3.20	429.54	1120.37
N=41 P=23	7.5	1	33.6	137	3.67	473.33	1246.16
		2	33.5	130	3.65	473.33	1246.11
		3	33.6	150	3.69	473.36	1246.09

	10	1	34.2	123	3.4	455.27	1200.08
		2	34.2	133	3.4	455.25	1200.14
		3	34.2	95	3.4	455.32	1200.05
	12.5	1	33.5	99	3.34	436.86	1182.08
		2	33.7	126	3.36	436.90	1182.05
		3	33.6	115	3.32	436.91	1182.08

Figures In The Appendix

Figure 1. Vegetative growth of G. abyssinica plant

Figure 2 Capitula of the G. abyssinica plant

Figure 3. Flowers of the G. abyssinica from the study area

Figure 4 Seed yields of G. abyssinica

Figure 5. The prepared samples of niger in test tube for oil content determination

Figure 6. The nuclear magnetic resonance (NMR), the oil content reading instrument of oilseeds