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The effect of organic and inorganic fertilizers on the growth and yield of irrigated potato (*Solanum tuberosum*) at Woflek Kebele, Gishe District, North Shewa Zone, Amhara Regional State, North East Ethiopia

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List of abbreviations

DBARC	DebreBirhan Agricultural Research Center
meq	mill equivalent
NPSB	Nitrogen, Phosphorus, Sulfur Boron fertilizer

Table of Contents

List of Tables

List of figures

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Abstract

Globally, it has been understood that there is a significant contribution of potato both as food security as well as a source of income. Soil fertility is one of the limiting factors that affect potato production. Therefore, the aim of this study was to determine the effect of inorganic and organic fertilizers on potato growth and yield under irrigated condition. The Woflek peasant participants were selected using purposive sampling techniques to get relevant information and a plot for the experiment in a randomized complete block experimental design with eight treatments replicated three times within the farm. A potato seed/tuber variety ''Jalene cultivar'' was grown. The data were collected through field observations, questionnaires and field experiments. A field experiment was carried out on growth and yield components of potato by identifying the soil physio-chemical characteristics. Soil analysis results before planting revealed that the experimental soil contained organic carbon (1.14%), available phosphorus (3.6 ppm), total nitrogen (0.112%), potassium (1.16 cmol (+) kg soil), electrical conductivity (0.053 Ms/cm) and pH (7.54) with clay in texture. The experimental results show that maximum values of shoot length (64.9 cm/plant), stem diameter (5.7cm/plant), number of branches (13.0/plant), number of leaves (40.5/plant), fresh tuber weight (904.5g/plant), shoot fresh weight (201.3 g/plant), number of tubers (13.7/plant) and marketable tuber yield (36.9 t/ha) were recorded from the combined application of inorganic and organic fertilizers (compost) at a rate of 18.9g/m^2 of Urea, 16.2g/m^2 of NPSB and 720g/m^2 of compost. However, the minimum value of shoot length (44.8 cm/plant), stem diameter (4.5 cm/plant), number of branches (3.9/plant), number of leaves (16.4/plant), fresh tuber weight (305 g/plant), shoot fresh weight (124.0 g/plant), number of tubers (9.8/plant) and marketable tuber yield (9.1 t/ha) were recorded from the control treatment. This study indicated that the combined use of inorganic and organic fertilizers can significantly increase the potato growth and yield. Therefore, it can be recommended that the soil requires the mixed use of inorganic and organic fertilizers for the potato growth and yield in the study area. Therefore, the Wolflek local community should use the integrated fertilizers.

Key words: *fertilizer, soil character, tuber yield, combined application*

1. Introduction

Potato (*Solanum tuberosum*) belongs to the Solanaceae family of flowering plants and it is an herbaceous annual plant grown for edible tubers in the world (Rykaczewska, 2013). Tubers are underground stems and are high in carbohydrates, exceedingly low in sodium and relatively rich in potassium and vitamin B, C, making it a good dietary complement to meats and pulses (Nand *et al.,* 2011). Potato is one of the most important field crops not only to its local consumption, but also to increase income through its exportation among different countries in the world (Sriom *et al*., 2017).

Globally, annual the largest potato producing countries include China (99,065,724t), India (43,770,000t), Russia (31,107,777t), Egypt (5,029,022t), Algeria (4,782,690t), Kenya (1,335,883t). However, potato is production in Ethiopia is 921,403t, which is relatively the lowest compared to the world yield (FAOSTAT, 2018) regardless of suitable conditions for potato cultivation of altitude of 1500 to 3000 meters above sea level and annual rainfall between 600mm and 1200 mm. Generally, there is a high potential to expand the cultivation area of the potato crops since there is 70% of the country is arable land, although currently only 2% of the potential area in Ethiopia is under potato production and the average productivity of potato is less than 10t/ha this means that still far below attainable yields of potato (Helen, 2016). The major production constraints that account for such low yields are biotic factors (weed, animal pest, diseases, quality of potato seed tubers, lack of well adapted potato cultivars), abiotic factors (soil fertility, temperature, rainfall, pH, poor agronomic practices, inadequate storage, transportation and marketing facilities: Chanie *et al*., 2017).

Synthetic fertilizers are one of the most important inputs of increasing the productivity of potato crops (Ali *et al*., 2010) despite their cost and environmental health impact is discouraging the small holder farmers and needs for urgent production options. Accordingly, integrated approach (synthetic and organic fertilizers) has useful effects on the quality, growth and yield of potato (Boke, 2014). Hence, applications of both fertilizer types are useful in improving the fertility of nutrient deficient Ethiopian soils for potato production (Girma *et al*., 2017). According to Kumar *et al.* (2011) addition of organic (composts) and inorganic fertilizers increase the growth and yield of potato plants. Recent studies confirmed that a number of bacterial species, mostly associated with the plant rhizosphere soil are found to be beneficial to plant growth, yield and quality, including potato and some soil microbes have proven the importance in plant growth promotion (Henry *et al.*, 2015). Thus, the mechanisms by which the plant growth promotion effect on the ability to produce plant hormones, a symbiotic N_2-fixation, production of enzymes (Suprata *et al.*, 2014). Even though organic and inorganic fertilizers are necessary for sustainable crop production, studies on the effect of organic and inorganic fertilizers on the production of potato are so limited in the study area. This knowledge gap necessitated to conduct the current study with the major purpose increasing potato growth and yield at the Woflek area under irrigated condition. Therefore, this effect of organic and inorganic fertilizers was initiated to determine growth and yield of potato plants in nutrient deficient soil of Woflek area. In addition, the present study was also designed to determine the physio-chemical properties of Woflek soil. Identified the nutrient deficient Woflek soil, the use of irrigation towards the growth and yield of potato was ignored by Woflek community and this makes the current study important because no study was conducted in this area.

1.1. Statement of the problem

Potatoes are useful for a good source of food and very suitable for direct marketing due to its popularity and versatility in Ethiopia that lead peasants become more consciously and aware of potato production and the integrated soil fertility management and agronomic practice strategy (Amede *et al.*, 2010). Low soil fertility and soil nutrient imbalances are major obstacles preventing Ethiopia's farmers from realizing the high agricultural productivity because of soil erosion, leaching, over grazing crops by animals, low external input of nutrients, as well as absence of crop residue incorporation for restoration of soil fertility, extensive nutrient depletion and soil quality deterioration found throughout Ethiopia are due in large part to ineffective agricultural practices and inefficient fertilizer applications (Kahsay,2019). Although some of the practices that could address these issues are occasionally utilized independently, a fully integrated package of interventions that is popularized throughout the country is properly needed. In fact, soil health and the related potential increase in crop yield (Agricultural Transformation Agency, 2016).

From the researcher, frequent observation of the Woflek Kebele peasants is in a difficult situation to use fertilizers in cultivating vegetable crops under irrigation condition. In this regard, low soil fertility, soil nutrient depletes, poor marketing access, inadequate agronomic practice and limited awareness of the peasants on the appropriate application rate of fertilizers were amongst the major problems in potato production. No study has been conducted on potato production using both inorganic and organic fertilizers to enhance growth and yield of this crucial crop in this area. This knowledge gaps motivate the current study to determine the impacts of synthetic and organic fertilizers on growth and yield of potato used by peasants in the area.

1.2. Objectives of the study

1.2.1. General objective:

The general objective of the study was to

- ✓ Assess the effect of organic and inorganic fertilizers on growth and yield of irrigated potato at Woflek Kebele, Gishe District, North Shewa Zone, Amhara Regional State, North East Ethiopia

1.2.2. Specific Objectives:

The specific objectives of the study were to

- ✓ Evaluate the awareness of Woflek peasants on usage of fertilizers for potato production
- ✓ Determine the effect of organic and inorganic fertilizers on growth and yield of potato
- ✓ Determine the physio-chemical properties of Woflek soil

1.3. Significance of the study

The main significance of this study is to provide scientific facts on the growth and yield of potato by using integrated (organic and inorganic) fertilizers. The fact can provide a paramount importance in the sustainable cultivation of potato to improve the food security and income generation as it is highly nutritive, high yielding and matures within a short period of time. The current study may help as a reference for other interested researchers who are interested to conduct a research on the same or related topics.

2. Literature review

2. 1. Potato production in globe

Potato (*Solanum tuberosum)* belongs to the genus *Solanum*, the order *Solanales* in the *Solanaceae* family of flowering plants and related closely of tomato, eggplant, pepper, tobacco that is an annual, herbaceous, dicotyledonous plant (Ram *et al*., 2017). Actually, tubers are underground stems and are high in carbohydrates, exceedingly low in sodium and relatively rich in potassium and vitamin C, making it a good dietary complement to meats and pulses (Nand *et al.*, 2011). Potato is the fourth important crop in the world following rice, wheat and maize in terms of the global food crop this means that it is known as a favorite crop and regarded as one of the most vital vegetable crops as humans' food (Kandil *et al*., 2011). It is also a very important source of nutritious food and cash income for globally up to small holder potato producing peasants Muthoni and Nyamango (2009), in addition to this it has a promising prospect in improving the quality of the basic diet in both rural and urban areas of the country (Sikder *et al*., 2017). As a food crop, it has a great potential to supply high quality food within a relatively short period and is one of the cheapest sources of energy (Teklemariam, 2014).

Potato is the world's most important tuber crop worldwide. It is grown in more than 125 countries FAO (2010) of the world with a total production of 308 million tons Kumar *et al.(* 2012) that is consumed almost daily by more than a billion people. Hundreds of millions of people in developing countries depend on potatoes for their survival. Potato cultivation is expanding strongly in the developing world, where the potato's ease of cultivation and nutritive content has made it a valuable food security and cash crop for millions of farmers (CSA, 2018). Developing countries are now the world's biggest producers and importers of potatoes and potato products (FAO, 2010). Annual world production of potato is about 360,365,367 tons of tuber from19, 651,838ha area coverage (FAO, 2018). There are different countries in the World, which potato has produced such as New Zealand 50t/ha, Netherlands 44.7 t/ha, USA 44.6 t/ha (FAOSTAT, 2010). Potato is a staple food crop such as rice, wheat and tomato for the African lives. In Africa, it is grown under different environmental conditions and an important economic role like vegetable crops for local consumption as a food and a cash crop by exportation to other countries (Ahmed *et al*., 2015). Similarly the countries like Algeria, Egypt, and Malawi are potato producing countries in Africa with the productivity of 30.9, 26.4, and 18.4 t/ha, respectively (FAOSTAT, 2017). The annual production of potato in Ethiopia is estimated to be

968,969.6 tons of potato production growing area in the country, accounting for about 40% and this is produced the highlands of Amhara Region, Northwestern Ethiopia and the productivity of potato in Ethiopia is 13.9 t/ha, which is relatively the lowest when we compared to in the world and in Africa, respectively (CSA, 2019).

2.2. Potato production in Ethiopia

In Ethiopia, root crops are also a good source of food, cash and foreign exchange for the growers and the country, respectively (Mesfin, 2009). According to Vita (2015) Ethiopia has possibly the highest potential for potato production of any country in Africa with 70% of the 13.5 million ha of arable land suitable for potato cultivation. However, potato is widely regarded as a secondary non-cereal crop in part because it has never reached the potential that it has in supporting food security (Vita, 2015). In the major potato produced areas of the country, the average yield (less than 10 Mg ha−1) is far below the potential, however, there are improved varieties that yield 19–38 Mg ha−1 on farmers' fields (Hirpa and Meuwissen, 2010). The central area potato production includes the highland areas surrounding the capital city of Ethiopia and potato growing zone are west-shewa and north-shewa (including my study area) in accounting for about 10% of the potato producing small holder peasants and average productivity of potato crops 8t/ha while national average tuber yields are still far below attainable yields of potato then potato is a very important source of nutritious food for North Shewa area where the population experience recurrent malnutrition due to heavy dependence on cereal crops and poor crop productivity (Helen, 2016). Some of the major production problems which have contributed to the limited production of potato in Ethiopia include: biotic factors like: weed, plant pathogenic, virus, bacteria, fungi, pests(plant parasite, insect and higher organisms), lack of good quality planting materials(potato variety), unavailability and high cost of seed tubers and abiotic factors such as: poor soil management practices, improper time of planting, lack of well adapted cultivars, poor agronomic practices, inadequate storage, transportation and marketing facilities, soil nutrient depletion, climatic condition (Chanie *et al.*, 2017). The emphasizing awareness of the potato(cultivars) productive capability and food value of potato has placed the crop, giving in the world's, Africans, and Ethiopians based on its importance like staple food crops, namely cereals crop like, rice, wheat and maize and vegetables crop like potato, related closely of tomato, eggplant, pepper, cabbage, onion, carrot (Israel *et al.,* 2016).

2.2.1. Inputs for potato production

The total amount of plant nutrients available to the crop is a key factor determining yield (FAO, 2010). These nutrients are added to the soil from external sources of organic, synthetic sources FAO (2018), to maintain soil fertility and sustainable production. The two most widely used sources are organic and synthetic fertilizers (Chandrasekaran *et al.*, 2010). These sources are used by farmers, according to their availability and affordability (FAO, 2010).

2.2.1.1. Synthetic fertilizers

Synthetic fertilizers are man-made combinations of chemicals and inorganic substances. They typically combine nitrogen, phosphorus, potassium, calcium, boron and other elements in different ratios and concentrated sources of essential nutrients in a form that is readily available for plant uptake (Mahajan *et al*., 2008). They can supply main nutrients, secondary nutrients, micronutrients or mixtures of nutrients and unlike their organic fertilizers, immediately supply essential nutrients to the soil (FAO, 2019). Advantages of synthetic fertilizers are faster acting than organic making them a good choice for aiding plants in severe distress from nutrient deficiencies, easy to handle, which come as dry, granular pellets or water-soluble products, also provide even, consistent feeding, crops grow faster, increase potato yield/production (Tadesse *et al*., 2013). Disadvantages of synthetic fertilizers are getting washed away by the water easily and cause pollution, harm the microbes present in the soil, reduce soil fertility, expensive, provides only short term benefits, change the nature of soil, making it either too acidic or too alkaline (Zhao *et al*., 2016).

2.2.1.2. Organic fertilizers

Organic nutrient sources are often described as animal manures, composts, cover crops, agricultural wastes, Phyto beneficial soil microbes (Nand *et al.,* 2011). Animal manure is a good source of plant nutrients and contains many of the elements essential for plant growth (David *et al.,* 2015). Chen (2010) explained that organic matter has a high surface area and a high CEC, making it an excellent supplier of nutrients to plants. Compost is decomposed organic materials, such as dry leaves, grass clippings, animal manure (urine, dung) and kitchen waste by the soil microbes. It provides many essential nutrients for plant growth and therefore is often used as fertilizer that is improving soil structure so that soil can easily hold the correct amount of moisture, to improve the soil fertility in gardens, landscaping, horticulture, urban agriculture and organic farming (FAOSTAT, 2017). As with fertilizer, the greatest return obtained from manure by applying it to crops that require the essential nutrients of the soil. The types of microbes are found in soil encompass archaea, bacteria, fungi and protozoa (Suprata *et al.*, 2014). Soil microbes can make nutrients and minerals in the soil available to plants, produce hormones that spur growth, stimulate the plant immune system and trigger or dampen stress responses, more diverse soil micro biome results in fewer plant diseases, higher yield/increased potato production, help in soil fertility that active beneficial bacteria include Bacillus spp, Enterobacter spp, Flavobacterium balustinum , Pseudomonas spp and fungi such as Penicillium spp. (Elshahat *et al*.(2016).

2.2.1.3. Formulations and application methods of organic fertilizers

Organic fertilizers comprise a variety of plant-derived materials that range from fresh or dried plant material to animal manures and litters to agricultural by-products (Kumar et al., 2012). The nutrient content of organic fertilizers varies greatly among source materials, and readily biodegradable materials make better nutrient sources. Therefore, it seems that formulations obtained from byproduct or waste from livestock and some plant products based integrated nutrient management system in crop production has a great potential to supplement and reduce nutrient demand solely supplied through inorganic chemicals. Due to the low cost of these input crops production could be economized. This will also improve the fertilizer use efficiency as well as the soil health. With these facts in view, a field experiment was conducted to explore the possibility of economizing fertilizer use in pigeonpotato by partial replacement of fertilizer through organic formulation as bio-fertilizer (Stark *et al.*, 2004). Organic formulations could be a potent source to move forward soil fertility, crop/potato productivity and quality and additionally control of pest and diseases (Nand *et al.,* 2011). A method of application of organic fertilizer is broadcasting refers to spreading the fertilizer evenly over the soil surface with or without working it into the soil, localized placement refers to applying fertilizer in a hole near the seed row or plants, special placement considerations for furrow irrigated soils, application through the irrigation water (Bationo *et al.,* 2012). Application of these fertilizers was found to be effective, low-cost, improving soil fertility by increasing soil EC as well as soil carbon and nitrogen levels in the soil, increased the yield in potato (Juniarti *et al*., 2012).

In potato production to attain higher tubers, the plants need nutrient fertilization in adequate quantity (Fageria *et al.*, 2011). To use fertilizer in a sustainable manner, management practices must aim at maximizing the amount of nutrients that are taken up by the potato crop and minimizing the amount of nutrients that are lost from the soil (Bationo *et al.*, 2012).The improving agronomic efficiency provides both direct and indirect economic benefits: larger yield increases can be achieved for a given quantity of fertilizer applied; or less fertilizer is required to achieve a particular yield target (Bationo *et al.*, 2012). Best management practices such as the addition of crop residues, green manure, compost, animal manure, use of cover crops, reduced tillage and avoiding the burning of crop residues can significantly improve the level of soil organic manure and contribute to the sustainability of the cropping systems and higher nutrient use efficiency (Gruhn *et al.*, 2000). Integrated plant nutrition systems are the maintenance or adjustment of soil fertility and of plant nutrient supply to sustain a desired level of potato crop production. It is achieved by optimizing the benefits from all possible sources of plant nutrients and by improving the overall management of the farm (CSA, 2018). Bulky organic manures and green manures have an important place in the nutrient management of potato. They add nutrients and also improve the physical environment for better plant and tuber growth. In spite of their low nutrient content, they help with fertilizer economy. The tuber yields obtained with the combined use of organic and synthetic fertilizers are higher than those with the use of synthetic fertilizers or organic fertilizer alone. Thus, the combined use of organic and mineral sources of nutrients is essential for sustaining high levels of potato production (Gomiero, 2016). Potato plant dry matter and nutrient accumulation and partitioning patterns in various parts of the plant are important to fine-tune management practices that optimize the nutrient uptake efficiency and tuber production (Alva *et al.*, 2007).

2.3. Nutrient Management in Potato Production

Development of a cost-effective nutrient management program needs to take into account the nutrient requirements of the crop being grown and the nutrient status of the soil (Zhao *et al.*, 2016).

In contrast to most agronomic crops, potatoes are relatively shallow rooted crops and require intensive management to promote growth and yield (Carl and Peter, 2015). Management factors, including fertility decisions, will influence potato yield, quality, and storage properties (Agegnehu and Amede, 2017). For efficient soil management a farmer must improve the desirable soil characteristics by means of good agricultural practices. In order to ensure sustainable and high agricultural productivity, an appropriate choice of fertilizers with balanced rates, method and time of application and replenishment of organic matter from the important components of good agricultural practices (FAO, 2010). Due to its relatively poorly developed and shallow root system, the potato demands a high level of soil nutrients. Without balanced fertilization management, growth and development of the crop are poor and both yield and quality of tubers are diminished (FAO, 2010). Efficient potato nutrient management systems are designed to ensure that all essential plant nutrients are available in appropriate amounts and at the most beneficial time to provide for optimal vine and tuber growth (Stark *et al.,* 2004). Fertilizer requirement of potato is very high as compared to cereal crops. It responds well to apply fertilizers and gives a good yield per unit area and time (Bationo *et al.,* 2012). Potatoes require optimal levels of essential nutrients throughout the growing season to ensure rapid, steady tuber growth and normal tuber development (Castellanos *et al*., 2015). Growing healthy potatoes for maximum yield and quality requires that all the essential nutrients be supplied at the 4R principles (right source, right rate, the right time and the right place (Farah *et al*., 2014). For potatoes, either deficient or excessive plant nutrition can reduce tuber bulking and quality. Nutrient deficiencies may limit the leaf canopy growth and its duration, resulting in reduced carbohydrate production and tuber growth. Maintaining healthy leaves are a key to producing high yields. However, excessive nutrient applications may cause nutrient imbalances or over-stimulate vegetative growth at the expense of tuber production (Department of Agriculture, Forestry and Fisheries Republic of South Africa, 2013; Compaore *et al.*, 2011).

2.4. Water Management for Potato Production

Potatoes are a water-sensitive crop and require a season-long assured water supply. Proper irrigation water management is essential for minimizing the potential for disease and for optimum potato yield and more quality, then water has a special significance in the potato production at the plant has sparse and shallow root system (Agegnehu and Amede, 2017). The need for water management readily available moisture is pre-planting moisture that important for optimum growth and yield of potato that potato is a short duration crop, which produces large foliage rapidly, readily available moisture is, therefore, essential for maintaining leaves in turgid condition and for tuber enlargement stomata should remain open throughout the day to enable the crop to maintain high photosynthesis rate. They considered pre-emergence, stolon, stage, tuber and bulking stage as critical stages for potato. It profoundly influences photosynthesis, respiration, absorption, translocation, utilization of mineral nutrients, and cell division (Department of Agriculture, Forestry and Fisheries Republic of South Africa, 2013). The potato seed was grown using irrigation and then used the irrigation scheduling practice under furrow-irrigation system throughout the growing period this means that potato crop evaporate transpiration can be estimated using weather data and is the amount of water to be replenished during the growing season in order to assure potential tuber yields at a given site (FAO, 2018). Potato crop evaporate transpiration is important to consider in irrigation planning and its use in irrigation scheduling is a well-developed strategy to improve the effectiveness of irrigation then the irrigation time is determined by the water requirement for a given irrigation interval, water holding capacity of the soil and the uniformity of the irrigation system and irrigation interval depends on the daily water consumption, soil moisture storage capacity and readily soil moisture to maintain the ideal soil moisture content for crop use that is ideally, irrigation scheduling should maintain the crop with in a predetermined narrow range of water stress then the irrigation uses at interval of 7 to 10 days is usually sufficient (Ministry of Agriculture and Natural resources, 2017).

2.5. Weed Management for Potato production

Yield losses in potato due to weeds occur in several ways. Among these, the competition between potato plants and weeds from competing with crops for space, nutrients, water and light are the major contributing factor (Compaore *et al.*, 2011). Weed management is the process of limiting the weed infestation so that the crop could be grown profitably that means successful weed management will improve potato yield through reduced competition for light, nutrients and water, reduce availability of alternate hosts for disease and insect pests and improve harvest efficiency (Masrie *et al.*, 2015). For effective weed management is essential to have the knowledge of weed flora infesting the crops then one of the weed management methods illustrated by as physical methods this means that the physical methods are the methods of weed control include manual energy, animal power or fuel to run the implements that dig out weeds and these methods are also called manual and mechanical methods of weed control as they do not involve chemical so that pulling out of weeds by hand or removal by hand trowel and hand hoe, that is the oldest and still a practical and an efficient method for reducing weed growth in potato and it is very effective against annual and biennial weeds then hand weeding is the most common method of weed control in the peasant sector (Ministry of Agriculture and Natural resources, 2009/2017).

2.6. Soil Fertility Management

One of the most difficult problems facing the horticultural crop production is how to maintain the fertility of the soil that is almost always associated with decline in soil organic matter, with loss of soil structure, lower water infiltration, soil compaction, increasing eroding and leaching, then leading to a decrease in nutrient holding capacities and a poorer environment for faunal(pertaining of animal) activities and integrated plant nutrition systems are the maintenance or adjustment of soil fertility, and plant nutrient supply to sustain a desired level of crop production this means that it is achieved by optimizing the benefits from all possible sources of plant nutrients and by improving the overall management of the farm (Yadav *et al*., 2013). The best remedy for soil fertility management is, therefore, a combination of both inorganic and organic fertilizers, where the inorganic fertilizer provides readily available nutrients and the organic fertilizer mainly increases soil organic matter, improves soil structure and buffering capacity of the soil (Godara *et al*., 2012).

Integrated nutrient management is an approach that seeks both increase agricultural production and safeguard the environment for future generation. The combined application of inorganic and organic fertilizers, usually termed as integrated nutrient management, is widely recognized as a way of needed for proper plant growth, yield, together with effective crop, water, soil and land management, will be critical for sustaining agriculture over the long term, improving the productivity of the soil sustainably (Zhao *et al*., 2016; Mahajan *et al*., 2008). Several researchers have verified the beneficial effect of integrated nutrient management in moderating the deficiency of several macro and micro-nutrients and in view of this fact, identifying the optimum dose of integrated nutrients application is crucial and it is required for maintaining sufficient amount of nutrients for increased yield of the crop (Mahajan *et al*., 2008). Integrated use of various soil fertility amendment inputs aims at alleviating the limiting nutrients problems and improving their availability from soil reserves and several possibilities for restoring or maintaining soil fertility and best management practices such as addition of crop residues, green manure, compost, animal manure, use of cover crops, recycling part of the nutrient through use of manure or decomposes, reduced tillage and avoiding the burning of crop residues can significantly improve the level of soil organic manure and contribute to the sustainability of the cropping systems and higher nutrient use efficiency (Castellanos *et al*.,2015). Fertilizer use efficiency depends to a large extent on soil fertility conditions, then improving agronomic efficiency provides both direct and indirect economic benefits to increase yield that can be achieved for a given quantity of fertilizer applied (Farah *et al*.,2014; Bationo *et al*., 2012; Compaore *et al.*, 2011). The following possible solutions like soil fertility amendments:-

2.6.1. Response of potato plants to the integrated approach (organic and synthetic fertilizers) application

Complementary use of organic and synthetic fertilizer use responds positively to improve growth of the potato plants, yields, output markets and potato crop prices (Caste llanos *et al*., 2015). Potatoes are planted with a long vegetation period; therefore they assimilate nutrients from organic and synthetic fertilizers rather intensively (Chivenge *et al*., 2009). According to Shalini *et al.* (2002), application of organic with synthetic fertilizers significantly increased growth and vigor of the plants over application of synthetic fertilizers alone. Various researches reported that supplementing the synthetic fertilizers with organic fertilizers substantially increased both quantity and quality of potato, improve soil fertility (Christel *et al*., 2014; Teklu *et al*., 2004). Combined application of organic and synthetic fertilizers help to improve the physio-chemical properties as well as biological properties of soils, to improve crop growth by supplying plant nutrients including macro and micronutrients that is cation exchange capacity, exchangeable calcium, available nutrient N, P, K and Zn, Mn, Cu and Fe were increased significantly there by provide the necessary nutrients for growth positive interaction and complementary effect between organic and synthetic fertilizer and a better environment for root growth by improving the soil structure (Tadesse *et al*., 2013). It is a strategy that incorporates both organic and inorganic plant nutrients to attain higher crop yield and the integrated use of organic with synthetic fertilizers is crucial to enhance production so as to supply ever increasing the world's population with sufficient food (Gomiero, 2016). Significantly increased the responses to the integrated application of organic with synthetic fertilizers to the growth and yield of potato crop when compared to the use of organic and synthetic fertilizer alone (Amir Ali Najm *et al*., 2013).

2.6.2. Response of potato plants to synthetic fertilizer application

Synthetic fertilizers are very important in the cultivation of horticultural crops and are increasingly used. This increase is due to shortage of animal manures and residues and to the increasing knowledge of their value (Tadesse *et al*., 2013). Synthetic fertilizers will remain a key component of soil fertility management and an essential element of any agricultural development strategy or plan to increase food production. Various reports showed that use synthetic fertilizers in the tropics had stagnated, and this was explained by poor marketing and inadequate profitability from synthetic fertilizer use (Balemi, 2012). According to Muriithi and Irungu (2004), application of synthetic fertilizer in the form of Urea and NPSB significantly increased the vigor and yield of the potato plants. Thus, significant responses to application of synthetic fertilizer to the potato crop when compared to the use of organic fertilizer alone. Soil application of inorganic fertilizer is a basic necessity for growth and yield of crop. As do most other field crops, potato responds well to improved management practices, among which synthetic fertilization plays an important role in producing satisfactory yields (Mahajan *et al*., 2008).

Fertilizer experiments in most potato growing areas indicated inorganic nutrient requirement of potato to be very high. Inorganic fertilizer is generally needed because of its mobility in soils and the large amounts needed by the plant (Mahajan *et al*., 2008). Potato yield, however, can be adversely affected by both insufficient and excess soil N. High soil N delays tuber initiation and promotes excessive vegetative growth at the expense of tubers. Similarly, excess phosphorus may disturb the nutrient balance within the plant and decrease both potato yield and quality (Israel *et al*., 2012). Inorganic fertilizers, on the other hand, supply only nutrients and exert no beneficial effects on the soil's physical condition. Moreover, the continuous and unbalanced use of inorganic nutrients from the inorganic fertilizers under intensive cropping system has been considered to be the main cause for declining crop productivity due to this, nutrients supplied exclusively through chemical sources, though enhance yield initially, and lead to unsustainable productivity over the years (Boke, 2014). Therefore, the inorganic fertilizer use alone continuously may increase soil erosions, to reduce the soil pH (acidic), kill soil microorganisms, it causes environmental pollution, depletion of essential macro and micronutrients and thus reduction of overall soil fertility then decrease crop productivity (Balemi, 2012).

2.6.3. Response of potato plants to organic fertilizer application

The use of organic fertilizer in less developed countries like Ethiopia has received much attention from economic point of view. In view of the current worldwide shortage of synthetic fertilizers and its anticipated adverse effect on food production, the endeavor to discover and develop efficient techniques of utilizing organic materials as fertilizer is urgently needed (Girma *et al*., 2017). Organic fertilizers were regarded as important, but it was realized that organic fertilizers would not be available in sufficient amounts to increase food production drastically (Masrie *et al*., 2015). According to Kumar *et al*. (2012) application of organic fertilizer increased uptake of N, P and K over the application of synthetic fertilizers alone. The authors also revealed that integration of organic with synthetic fertilizer had a marked effect in increasing growth and ultimately yield of knolkhol and also in maintaining soil fertility and availability of nutrients in soil after harvest. Similarly, Kumar *et al*. (2012) reported that application of organic materials like animal manure, compost or green manure in combination with synthetic fertilizer, improved soil physical properties and cation exchange capacity, exchangeable calcium, available nutrient N, P, K and Zn, Mn, Cu and Fe was increased significantly with organic materials in conjunction with inorganic materials. In addition to its nutrient supply, animal manure improves the physio-chemical conditions of soils. The widespread use of animal manure greatly depends, among others, on proper application methods, which increase the value, reduce costs, and enhance effectiveness (Teklu *et al*., 2004). Of all field crops, the potato has the best response to animal manure (Masrie *et al*., 2015). Although the macro and micro elements applied to the potato field contribute to soil fertility, the soil improving effect of organic matter is often considered to be of major importance. Baia *et al*. (2018) also confirmed that organic fertilizers constitute important sources of nutrients and decomposable organic matter for increasing yield and improving soil fertility. The importance of organic manure is also being realized again because of prohibitibitive costs of inorganic fertilizers and poor purchasing power of marginal and small farmers (Amir Ali Najm *et al*., 2013).

2.6.3.1. Response of potato plants to soil microorganisms

The plant growth promoting soil bacteria like *Rhizobium, Azotobacter, Azospirillum, Pseudomonas*, *Bacillus*, *Enterobacter spp.*, and fungi such as Penicillium spp. are found to be potato rhizosphere soil, which is the zone of potato plant roots and the region of soil immediately adjacent to and affected by plant roots that attaches the potato plants, soil, micro-organisms

(Elshahat *et al.,* (2016). Soil microbes are responsible for carrying out many vital functions in the soil. Soil microbes can make nutrients and minerals in the soil available to potato plants, produce hormones that spur growth and yield, stimulate the plant immune system and trigger or dampen stress responses, enhance soil structure, decompose organic materials, maintain soil quality and health, they contribute to the carbon cycle by fixation (photosynthesis) and decomposition (Preeti and Sushil, 2015).

2.7. Yield components of Potato

Yield development in potato is known to be the result of various physiological processes leading to the formation of yield components (Alemayehu *et al.*, 2015). These are stem numbers per plant, tuber numbers per plant and fresh tuber weight per plant and tuber yield. The yield components in potato have been reported to develop sequentially. The sequential system of yield development of the potato involves interactions among individual yield components, in which later developing components are found to be dependent upon earlier developing ones (Ahmed *et al.*, 2015).

2.7.1. Stem Number

The number of stems per plant is reported to be under the influence of variety, seed tuber size, the physiological age of the seed, storage condition, number of viable sprouts at seedling, sprout damage at the time of seedling and growing conditions (Alemayehu & Jemberie, 2018; Teklu *et al.*, 2004). The individual stems of a plant are largely dependent upon their parent tuber for growth until emergence and a considerable time may elapse after emergence before the stems become fully independent. Thus, the competitive interference between stems of a potato plant changes considerably with time and this, together with variation in the number of stems per plant, necessarily results in the effect of plant density being complex (Masrie *et al.*, 2015). Masrie *et al*. (2015) reported that the number of sprouts, which develop per seed tuber, is principally determined by the temperature and duration of storage. Islam *et al*. (2013) reported that the importance of increasing the stem number per plant for increased graded and total tuber yield. Similarly, Ahmed *et al*. (2015) observed close relationships between the number of main stems or aboveground stems and total yields and graded tuber yields. These investigators claimed that high stem number per plant favored high tuber yield through effect on haulm growth and tuber number per plant. Melkamu *et al*. (2020) their studies on yield development of potato as influenced by organic and synthetic fertilizers observed that significantly increased the stem number per plant as a result of the application of organic and synthetic fertilizers.

2.7.2. Tuber Number

Tuber number is a linear function of the main stem number (Kahsay, 2019). According to Girma *et al*. (2017) numbers of tubers set per potato plant largely govern the total tuber yield as well as the size categories of potato tubers. He showed that the number of tubers set of plants was determined by stem density, spatial arrangement, variety, season and crop management. He also noted that increasing the stem density of planting larger seed tubers would result in increased tuber number per plant despite the reduction in the number of tubers per stem. Increasing stem density over a wide range either by planting larger seed tubers or more seed tubers, most varieties resulted in increased number of tubers per plant (Girma *et al*., 2017; Niguse, 2016). According to Niguse (2016) spatial arrangement affected the number of tubers in a similar manner to that of density, since increasing rectangularity reduced number of tubers set per stem, while increasing the tuber number per plant. The main effect was to increase the number of tubers and allow an increased number to grow rapidly then the total number of tubers per plant increased linearly with increasing density (Alemayehu *et al*., 2015). Ram *et al*. (2017) noted that the application of organic and synthetic fertilizers increased the number of tubers set per plant, while affecting the number of tubers different weight grades significantly. Kahsay (2019) found that the use of integrated approaches (organic and inorganic fertilizers) increased significantly the total tuber number per plant.

2.7.3. Fresh tuber weight

Tuber weight is reported to be affected by variety and growth conditions. Environmental factors that favor cell division and cell expansion such as mineral nutrition, organic nutrient source and optimum water supply were reported to enhance tuber size (Sikder *et al*., 2017). The result of a study conducted by Alam *et al*. (2007) showed that variation in tuber yield due to N treatments was related to the tuber weight increment. Ahamad *et al*. (2014) their investigations on the effect of mineral nutrition on size categories of the potato tuber, showed that increase in the yield of tubers with applied organic nutrients was associated with an increase in the number of tubers in the medium and large grades at the expense of small tubers. This was attributed to the increase in the weight of individual tubers. Suh *et al*. (2015) indicated that the increase in the weight of tubers with the supply of fertilizer nutrients could be due to more luxurious growth, more foliage and leaf area and higher supply of photosynthesis that helped in producing bigger tubers resulting in higher yields. Organic and inorganic nutrient applications were also noted to extend the canopy life, thereby prolonging the duration of tuber bulking (Ahmed *et al*., 2015).

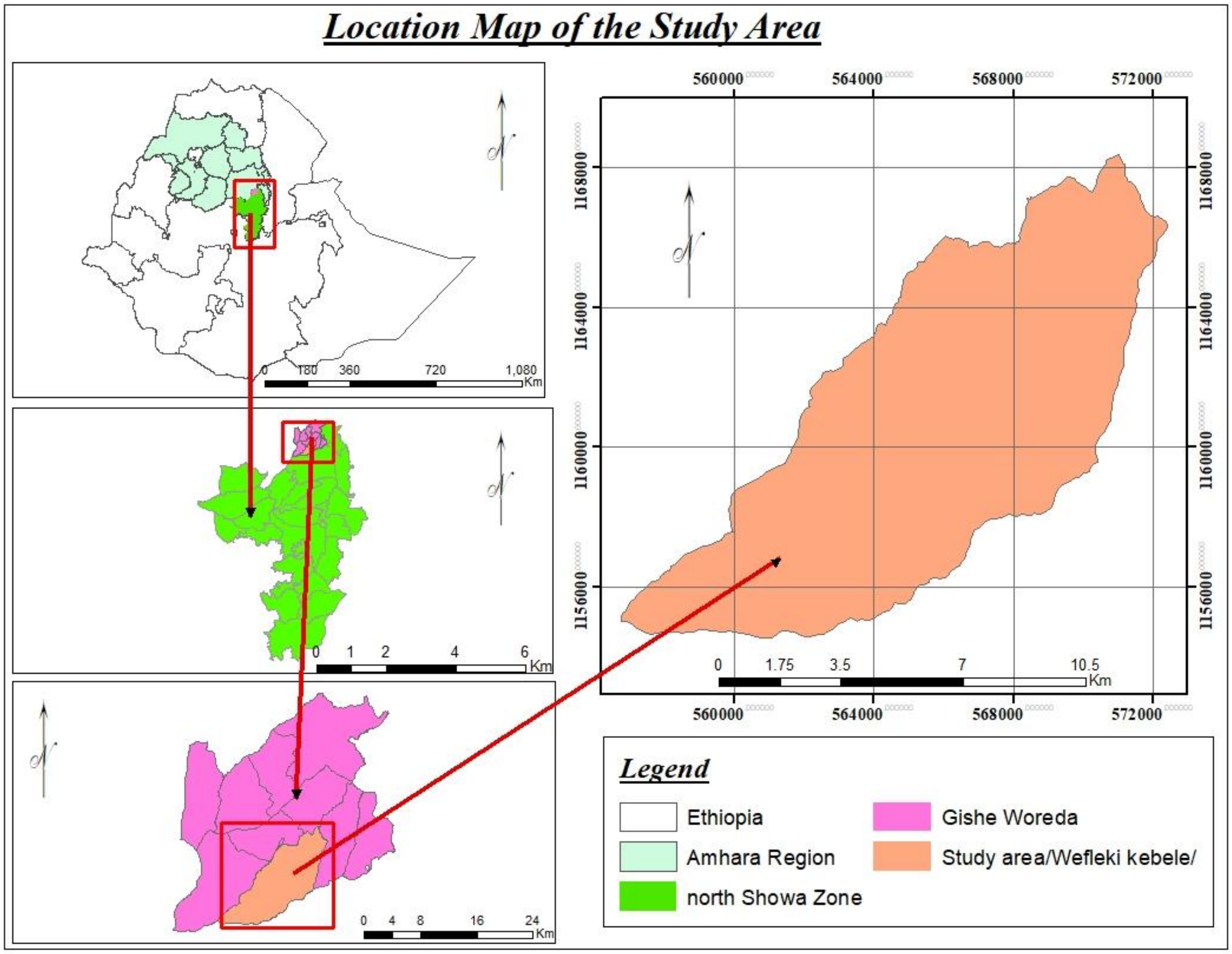
2.7.4. Tuber yield

Several factors limiting potato crop yields have been reported by many workers. According to Workat (2019) and Girma *et al*. (2017), factors limiting crop yield (both in quantity as well as quality) can be categorized into four major headings: the soil upon which the crop grows, the genetic make-up of the crop, the climatic conditions during the growth of the crop, and the management practices, mainly soil fertility. Maintaining adequate levels of soil fertility has been recognized as one of the management practices that affect growth, development and yield of plants (Ahamad *et al*., 2014). Fertilizer recommendations for potassium in potato production are high. The amount of nutrient needed by the potato crop is observed to be directly proportional to tuber yield (Ahmed *et al*., 2015). Many investigators reported that on uses fertilizer responsive soils there was a significant tuber yield response to organic and inorganic fertilization (Workat, 2019; Girma *et al*., 2017; Suh *et al*., 2015). The potato tuber yield is also known to be influenced by fertilizers through its effect on the number of tubers produced, the size of the tubers and the time at which maximum yield is obtained (Islam *et al*., 2013). They also noted that excess use of fertilizers is usually associated with reduced tuber weight by hastening the maturation period and reducing tuber size. According to Najm *et al*. (2012), there seemed to exist a positive interaction between organic and synthetic fertilizers on potato tuber yield. They observed significant positive interaction between organic and inorganic fertilizers indicating these fertilizers increase yields when applied together than singly. Increased yields come from achieving the optimum tuber numbers, maintaining a green leaf canopy, and increasing tuber size and weight. The production of potato tubers of a requisite size may be of much economic value both for seed to be used for planting and human consumption as the market demand for different shapes and size of tubers varies (Islam *et al*., 2013).

3. Materials and Methods

3.1. Description of the study area

The study was conducted in Woflek area that is, located at 390 km North of Addis Ababa, the capital city of Ethiopia. Woflek is geographically located at 10.4^0-10.6^0N latitude and 39.5^0-39.7^0E longitude with an altitude of 2524 meters above sea level (Fig.1). The area receives mean annual rainfall of 1100mm and the agro ecology covers highland (80.85 %) and midland (19.15 %) (Fig.1).The average annual maximum and minimum temperature is 20^oCand10^oC, respectively. The cropping system in the study area is dominated by diversifying field crops production with limited horticultural crop production under irrigation. Major field crops grown in the study area are wheat, barley and teff under rain condition and vegetable crops, such as onion, carrot, cabbage and more limited amount of potato under irrigation (Gishe District office of agriculture, 2018). From the total area of the study site (9,425.72 ha), the bare land covered 3,833. 43ha (40.67%), cultivation, 2,318. 30ha (24.60%), grassland, 2,727. 51ha (28.94%), shrub land, 546. 33ha (5.80%). The topography of the study area is hilly and undulating. As a result of this, the land is severely eroded by the flood and the fertility of the soil becomes low.



Source: - Arc GIS 10.1 versions

Fig. 1. Map of the study area

3.2. Study design and period

A randomized block experimental study design was used. The study was carried on irrigated condition from October, 2019 to January, 2020. Plot preparation was done in October, 2019 and the potato plants were harvested in January, 2020. Potato seed/tuber stayed in the field during sowing up to the end of the harvesting of 100 days.

3.3. Sampling technique and sampling population

The data of the study were gathered primary sources. The primary data considered in this study were Woflelk householder peasants on the growth and yield of potato plant carried out under irrigated condition from October, 2019 to January, 2020 who took source of data to get relevant information to the study at hand. At Woflek householder peasants are distributed across six villages (Gishe District Administration office, 2018). Out of the six villages, three villages were taken namely (Yedure, Melekamba and Tiyemidir) by using a simple random sampling technique, particularly through a lottery method that gives equal opportunity for the selection of the villages to conduct the study. During observation in the Woflek location, the researcher identified the householders of informants for this study by discussing the study area administration team such as chairperson, agricultural extension workers and particular team leaders by attending the general meeting of the Woflek location dwellers and selecting active participants from the householder of peasants in each study site was the source of my study subjects. Then, using purposive sampling techniques from the three villages namely (Yedure has 160 householders, Melekamba has165 householders and Tiyemidir has175 householders) 111 informants were taken as participants of the target study. The present study gives an equal number of informants from three villages based on the experience of the farming of potato, knowledgeable elders and responsible stakeholders.

3.4. Data collection of potato cultivars in Woflek informants

Data about the use of organic and inorganic fertilizers, growth, yield and economical value of potato were collected from the potato cultivars using structured questionnaire (Appendix 1). The questionnaires were employed in order to gather the necessary data. They were aimed at eliciting the required data or information for the sake of the growth and yield of potato at Woflek area. The questionnaires were prepared before hand in English and then translated to Amharic because they do not understand the English Language. The items in the questionnaires were all closed ended, which consists of 10 questions containing the components like personal data of the respondents, information on growth and yield of potato designed for the peasant participants. The questionnaire items were focusing on basic concepts of the growth and yield of potato plant. As a result the informants were given a brief orientation by the researcher and feel free to respond what they are asked in order to get relevant information to this study.

3.5. Soil sample collection and physio-chemical analysis

About 1 kg of composite soil samples were collected from a Woflek location of potato fields from 0-30 cm depth using a soil auger and added into the sterilized polyethylene bag and immediately transported to Debire Birhan Agricultural Research Center soil and water laboratory. The collected soil samples were air dried and sieved via 2 mm mesh sieve. The physio-chemical properties of soil samples, including: Soil pH, electrical conductivity, soil texture, organic carbon, organic matter, cation exchange capacity, total nitrogen, available potassium and available phosphorous were analyzed to the procedure of (Estefan *et al.*, 2013; Sahlemedhin and Taye, 2000; Dewis and according Freitas, 1970).

3.5.1. Total Nitrogen

Soil total N was determined by the Kjeldahl method. Air dried samples was passed through a 0.5 mm sieve and 1g of soil sample used. These were put into boiling tubes and a 0.5g selenium mixture catalyst added, followed by 7 ml of concentrated sulfuric acid to start the digestion process. The set-up was left in the digestion chamber for 2 hours. After 2 hours, the digests were retrieved from digestion chamber and allowed to cool for 30 minutes, after which they were transferred into distillation flask and 40 ml of 10N NaOH were added then followed by the distillation process. NH3 released was collected in 20 ml of 1% Boric acid and titration done against 0.01 M H_2SO_4 (Dewis and according Freitas, 1970).

3.5.2. Phosphorus

Available soil P was determined by Olsen method. Five grams of air dried soil was passed through a 2 mm sieve and weighed into a 100 ml extracting tube and 50 ml double acid reagent added. The tubes were corked tightly, placed horizontally in a rack on a mechanical shaker and shaken for 30 minutes. The soil was filtered through Whatman filter paper No. 42 and filtrate collected in specimen bottles. A suitable aliquot of the soil extract was measured and put into a 50 ml volumetric flask. Twenty-five ml of distilled water was added to each tube followed by 8 ml of reagent and immediately distilled water was added to the mark and mixed thoroughly. The solution was allowed to stand 25 minutes before the readings and measured absorbance spectrophotometer at 882 nm and finally the calculation was used (Sahlemedhin and Taye, 2000).

3.5.3. Potassium

Available soil K was determined by Morgan's extracted solution method. Ten grams of air dried soil was passed through a 2 mm sieve; the samples were put into plastic containers and leached with 100 ml of 1M NH4OAc at pH 7.0. The leachate was diluted ten times; 5 ml of the leachate was pipetted into a 50 ml volumetric flask. One hundred ml 1N KCl was added in each container and the contents diluted with 1M NH4OAc. Potassium (K) was measured using flame photometry (Sahlemedhin and Taye, 2000).

3.5.4. Soil pH

The pH of the soil was determined using 1:2.5 (weight/volume) soil samples to water ratio using a glass electrode attached to a digital pH meter. Ten grams of air dried soil were passed through a 2 mm sieve, weighed and put into plastic bottles. Fifty ml of distilled water was added and the bottles tightly corked. The mixture was shaken for 30 minutes with the mechanical shaker and allowed to stand for 30 minutes. The pH of the soil suspension was then measured using a pH meter (Estefan *et al*., 2013).

3.5.5. Electrical conductivity

The electrical conductivity was determined by saturating paste extract method. Ten grams of soil sample were taken into a 250ml beaker and 50 ml of distilled water was added and shaken on the automatic stirred the mixture periodically for 30 minutes. The cell constant was verified by using solutions of known conductivity; in general in KCl 0.02N and0.01N solutions. Measured and noted the temperature of the 0.02 N KCl solutions in the beaker with a thermometer. It should be necessary to check the standard solutions and adjusted the conductivity meter during a sample batch, then measured and read conductivity (Sahlemedhin and Taye, 2000).

3.5.6. Soil texture

The soil texture was determined by using the hydrometer method of Bouyoucos (Sahlemedhin and Taye, 2000). The contents of sand, silt and clay were computed and the soil textural class was identified from the textural triangle. One hundred grams of air dried soil was passed through a 2 mm sieve and weighed into a 1 liter plastic bottle with a stopper and 100 ml of dispersing reagent was added then it was shaken for 3 hours on an Oscillatory shaker. Transferred the soil and the solution into the cup of a mixer or mechanical stirrer by washing the bottle very well and brought the volume to 500 ml in the cup then stirred for 5minutes. Transferred the dispersed soil suspension to a hydrometer jar, washed out the stirrer cup and adjusted the volume in the jar to 1 liter with distilled water. The temperature and the hydrometer reading were taken at 40 seconds after the cylinder was set down. This reading measured the percent of soil particles (clay, silt and sand) (particles < 50 microns) in suspension (Sahlemedhin and Taye, 2000).

3.5.7. Organic carbon and organic matter

Soil organic carbon was determined by walkley and blacks method the procedure as outlined by (Sahlemedhin and Taye, 2000). Soil organic matter was determined by wet digestion methods and recorded based on the oxidation of organic carbon with acid, potassium di-chromate ($k_2c_2o_7^{2-}$

) as described by (Dewis and Freitas, 1970). At 0.1 grams of air dried soil was passed through a 2 mm sieve and transferred to a 500ml Erlenmeyer flask and 0. 1g of organic soils then added 10 ml of 1 N potassium di-chromate ($K_2Cr_2O_7$) solution with a pipette to both samples and blank. Carefully added 20ml of conc. H_2SO_4 with measuring cylinder in the fume cupboard and swirled the flask and allowed to stand on an asbestos or cork pad for 30 minutes and obtained the % of carbon and finally calculated the organic matter of the soil based on the oxidation of organic carbon (Sahlemedhin and Taye, 2000).

3.5.8. Cation exchange capacity

Soil cation exchange capacity (CEC) was determined by ammonium acetate method. 5 g of soil was taken into a 250 ml beaker and added 100 ml of ammonium acetate 1 M pH 7.0 solution. Stirred instantly with a stirring rod and allowed to stand overnight while taken the precaution to cover the beakers with watch glasses, then the next day transferred the soaked samples onto filter funnels placed on 250 ml volumetric flasks and washed the remaining soil with about 50 ml of 1 M ammonium acetate, pH 7.0 into the funnel while making sure that each filtration was completed and removed the volumetric flasks and brought up to volume with distilled water. In the ammonium acetate method, the saturated ammonium displaced by neutral salt was measured by distillation to determine the Cation exchange capacity (CEC) then CEC was determined by ammonium acetate method and finally the calculation was used (Sahlemedhin and Taye, 2000).

3.6. Field experiment

3.6.1. Experimental design

A field experiment was arranged in a randomized complete block experimental design with eight treatments replicated three times. Experimental units are called blocks and treatments are randomly selected to the experimental units. Each block and plots within a block were spaced 0.75m and 0.5 m apart, respectively. The gross plot size was 4.15 m wide × 13.5 m length (56.03 m^2) following the procedures of Amana Mama *et al*. (2016). The border all sides were left 0. 2m to avoid the border effect of the treatment. Therefore, the net each plot size was 0.75 m wide × 1.2m length (0.9m^2). The experiments were carried out irrigated condition. The treatments consisted of three types of fertilizers such as Urea, NPSB and Compost. Urea (210 kg/ha), NPSB (180 kg/ha) and compost (8000kg/ha) applied in Debre Birhan area (North Shewa Ethiopia) then using based on this experiment Urea = 18.9g/m^2, NPSB = 16.2g/m^2 and compost = 720g/m^2 and the experiment contained different fertilizer rates, in which used randomly in various plots of the field experiment following the procedure of (Ministry of Agriculture and Natural resources, 2009/2017; Israel *et al*., 2018) then details were given below in Table 1.

Table 1: Formulation of treatments

T.NO	Treatments rate (g/m^2)	
1	Control	0
2	NPSB	16.2
3	Urea	18.9
4	Compost	720
5	NPSB +Urea	16.2 + 18.9
6	Compost + Urea	720 + 18.9
7	Compost + NPSB	720 +16.2
8	Compost + Urea +NPSB	720 +18.9 +16.2

Where: -control = absence of any fertilizer pool; NPSB fertilizer = 18. 9%N, 37.7% P_2O_5, 6.95% S, 0.1% B; Urea fertilizer = 46% N, 20% C, 6.713% H, 26.641% O; Compost = contained (N, P, K, CA, Mg, C, H, S, some micro elements and heavy metals (Al, Cu, Fe)

3.6.2. Plot preparation and seed sowing

Plot preparation was done in October, 2019 using with oxen ploughing and human labor two times before sowing. The land was leveled and ridges were made by hand, which was given from the Woflek householder peasants as the land rent. The width and length of each plot were measured 0.75 m and 1.2 m, respectively. The total numbers of the plots were twenty four and each plot had a size of 0.9 m^2area. The distance between the blocks and plots were 0.75 m and 0.5 m, respectively. A standard potato seed variety (Jalene) was used as planting material for this study. The potato seed variety (Jalene) was obtained from Holleta Agricultural Research center. The inorganic fertilizer was obtained from the Debrebirhan Menz Center and the composing materials are dry leaves, grass clippings, animal manure (urine, dung) and kitchen waste collected from the Woflek area. Composing materials were allowed to decompose in a pit or underground. The size of the pit where materials were to be stored 3 m in length, 1.2m in breadth and 1m in depth were prepared for this process and the composing materials are placed in layers. To enhance the decomposition process of the layer should be inverted two times with one month intervals. Then it was covered with a thin layer of soil 4 cm thick within about four months, finally making the compost in the Woflek area for using as an organic fertilizer and the compost was taken to prepare the samples from Gishe District Agricultural-expert. Well-sprouted medium sized potato seed variety (Jalene cultivar) was sown on the prepared experimental plots in October, 2019 at a spacing of 75 cm and 30 cm between rows and plants. After preparing and lining the plots, each plot was watered. Eight potato seed/ tuber (Jalene), were planted in each plot and a total of 192 potato seed/tuber was used.

At the time of planting all fertilizers (inorganic fertilizers such as Urea and NPSB and organic fertilizer such as compost) were applied to the prepared experimental plots. The whole rate of NPSB fertilizer was applied with dry compost during in potato seed application. The Urea fertilizer was used after dividing three times before sowing. Firstly, the rate of Urea fertilizer was applied with dry compost during seed application. Next the rate of Urea fertilizer was applied during seedling application and finally, the rate of Urea fertilizer was applied during hoeing and weeding of the practical work on the experimental plots. The experimental plots were carried out under irrigated condition from October, 2019 to January, 2020. Average relative humidity during the growing period of potato (October–January) was 65.70%. The average temperature during the same months was 11.44 and 15.54 °C (Gishe district Agricultural office, 2019). The potato seed was grown using irrigation and then used the irrigation scheduling practice under the furrow - irrigation system. The source of water is a pond, then receiving water for irrigation and enters the canal. Watering of the plants was done by using a plastic watering can that was locally used seven days in twelve weeks watering frequencies throughout the growing period.

3.7. Harvesting and data collection

The potato plants were harvested in January, 2020. Potato seed/tuber stayed in the field during sowing up to the end of the harvesting of 100 days. Days to flowering was recorded when 50 percent of the potato plant population in each plot reached the flowering stage. It is required for all 45-55 days to flowers. Days to physiological maturity was recorded when 75 percent of potato plant leaves turning yellowish in each plot. It requires 90-120 days to mature. Data were collected from the center of the experimental plots. Data were collected for potato growth parameters (shoot length, stem diameter, branch number, shoot fresh weight and leaf number per plant) and yield parameters (tuber number, marketable tuber number, marketable tuber yield and fresh weight of tubers per plant) reached at physiological mature. The potato growth and yield parameters were harvested 95 days after sowing. For the potato growth and yield parameters, data were collected from two randomly selected potato plants from each treatment in the three blocks/plots for recording observation and enough relevant data was taken.

3.7.1. Plant vigor and yield measurements

At the end of the experiments, the potato growth and yield parameters were measured: the fresh weight of the tuber (g), shoot fresh weight (g), marketable tuber number (g) then converted in hectare and marketable tuber yield (g) then changed to t/ha were measured by using the digital electronic balance. The shoot length (cm) was measured by using the plastic ruler and the stem diameter (cm) was measured by using a plastic tape and then directed, by counting the number of tubers, branches and leaves per plant from the experimental plots. Tubers were taken and measured free from the mechanical damage that means using healthy tuber. A field experiment was conducted on the growth and yield of potato in the Woflek area to evaluate the performance of potato varieties for tuber yield. The results of analysis of variance (ANOVA) showed the potato tuber yield was significant ($P<0.01$) influenced by the use of organic and synthetic fertilizers as well as the combined use of over control or differences among varieties overall traits studied. The mean squares for location were also significant in indicating the influence of environments on the traits of the studied varieties.

3.8. Data analysis

The potato plant vigor and tuber were subjected to analysis of variance (ANOVA) using the procedure of SAS software version 9.3 (SAS, 2011). The Fisher's protected least significant difference (LSD) test at $P<0.05$ level was employed to separate treatment means where significant treatment differences occurred. Homogeneity of variances was calculated using the F-test as described by Gomez (1984) and since the F-test has shown heterogeneity of the variances of the treatments for most of the parameters, a separate analysis was used for the different treatments and the data collected through respondent questionnaires were analyzed quantitatively by using Microsoft Office Excel 2016 application software.

4. Results

4.1. Socio-demographic characteristics of Woflek informants

As shown clearly in table 2 most of the informants (74.77%) responded that greater than 40 in age and 25.23% of the informants were less than 40 in age. A total of 111 (84.68%) of the respondents were male and 15.32% of them were female. From the total informants of 111 (86.49%) of the respondents were primarily educated and 13.51% of them were secondary educated.

Table 2: Socio-demographic characteristics of Woflek informants

Parameters		A number of informants=111	Percentage (%)
Age	<40	28	25.23
	≥40	83	74.77
Sex	Male	94	84.68
	Female	17	15.32
Educational level	Illiterate	0	0
	Primary Education	96	86.49
	Secondary Education	15	13.51

4.2. Awareness of potato cultivar in the Woflek informants

As shown clearly in Table 3 most of the informants (90.09%) responded that there was not a potato plant disease and 9.91% of the informants responded that there was potato plant disease under irrigation conditions in the study area. A total of 111 (92.79%) of the informants said that the growth and yield of potato plant were low and 7.21% of the respondents said that the growth and yield of potato plant was not in the study area. Over 90% of the respondents said that they were not interested in the cultivation of the potato plant and 9.01% of the informants said that they were interested in the cultivation of the potato plant. A total of 111 (89.19%) of the respondents responded that they did not use organic fertilizers on growth and yield of potato plant and 10.81% of the informants responded that they used organic fertilizers on growth and yield of potato plant. Over 90%) of the respondents responded that they did not use inorganic fertilizers on the growth and yield of potato plant and 9.01% of the informants responded that they used inorganic fertilizers on growth and yield of potato plant. A total of 111 (94.59%) of the respondents said that they did not use integrated with organic and inorganic fertilizers on growth and yield of potato plant and 5.41% of the respondents said that they used integrated with organic and inorganic fertilizers on growth and yield of potato. Over 93% of the respondents responded that the soil fertility was low and 6.31% of the informants responded that the soil fertility was not lower in the study area. A total of 111 (96.4%) of the respondents responded that they used available of enough river/water on growth and yield of potato. Most of the informants (92.79%) responded that they did not use timely planting, hoeing and avoid weeding on growth and yield of potato plant and most of the respondents (91.89%) said that they didn't have enough marketing potato in the study area.

Table 3: awareness of potato cultivar informants in the study area

No	Parameters	A total of 111 potato cultivar Woflek informants´ responses			
		Yes	%	No	%
1	Presence of potato disease in the study area	11	9.91	100	90.09
2	Low potato growth and yield	103	92.79	8	7.21
3	Having the interest of cultivate potato	10	9.01	101	90.99
4	Using organic fertilizer	12	10.81	99	89.19
5	Using inorganic fertilizer	10	9.01	101	90.99
6	Using integrated approach fertilizer	6	5.41	105	94.59
7	Low soil fertility	104	93.69	7	6.31
8	Availability of enough river/water	107	96.4	4	3.6
9	Using timely hoeing and avoid weeding	8	7.21	103	92.79
10	Having enough marketing potato	9	8.11	102	91.89

4.3. Effect of organic and inorganic fertilizers on Potato growth

4.3.1. Shoot length per plant

Shoot length per plant was significantly ($P<0.01$) increased due to individual use of organic and inorganic fertilizers as well as the combined use compared to the control (Table 5). The results of data from Table 4 showed that the maximum value of potato shoot length per plant indicated as follows: the shoot length per plant (54.8 cm/plant) was recorded an application of organic fertilizer (compost) at a rate of 720 g/m2, the shoot length per plant (61.8 cm/plant) was recorded from the use of inorganic fertilizers at a rate of 18.9 g/m^2 of Urea and 16.2 g/m^2 of NPSB and the shoot length per plant (64.9 cm/plant) was recorded from the combined use of inorganic and organic fertilizers at a rate of 18.9 g/m^2 of Urea, 16.2 g/m^2 of NPSB and 720 g/m^2 of compost while the minimum value of shoot length per plant (44.8 cm/plant) was recorded in the absence of any fertilizer pool. The longest shoot length per plant (64.9 cm/plant) was recorded from the mixed application of inorganic and organic fertilizers at a rate of 18.9 g/m^2 of Urea, 16. 2 g/m^2 of NPSB and 720 g/m^2 of compost and increased by 31% over the control treatment.

4.3.2. Stem diameter per plant

Stem diameter per plant was significantly ($P<0.01$) increased due to individual application of organic and inorganic fertilizers as well as the integrated use over the control (Table 5). The results of data from Table 4 revealed that the maximum value of potato stem diameter per plant indicated as follows: the stem diameter per plant (5.0 cm/plant) was recorded due to application of organic fertilizer at a rate of 720 g/m^2 of compost, the stem diameter per plant (5.4 cm/plant) was recorded when inorganic fertilizers applied at a rate of 18.9 g/m^2 of Urea and 16.2 g/m^2 of NPSB and the stem diameter per plant (5.7 cm/plant) was recorded from the mixed use of inorganic and organic fertilizers at a rate of 18.9 g/m^2 of Urea, 16.2 g/m^2 of NPSB and 720 g/m^2 of compost while the minimum value of stem diameter per plant (4.5 cm/plant) was recorded in untreated with fertilizers. The highest stem diameter per plant (5.7 cm/plant) was recorded from the combined application of inorganic and organic fertilizers at a rate of 18.9 g/m^2 of Urea, 16.2 g/m^2 of NPSB and 720 g/m^2 of compost and increased by 21% over the absence of any fertilizer pool.

4.3.3. Number of branches per plant

The results data from Table 5 revealed that the number of branches per plant were significantly ($P<0.01$) increased due to individual application of organic and inorganic fertilizers as well as integrated use of untreated with fertilizers. The maximum value of potato number of branches per plant showed as follows: the number of branches per plan (6.8/plant) were recorded with the usage of organic fertilizer at a rate of 720 g/m^2 of compost, the number of branches per plant(10.3/plant) was recorded with the use of inorganic fertilizers at a rate of 18.9 g/m^2 of Urea and 16.2 g/m^2 of NPSB and the number of branches per plant (13.0/plant) were recorded from the integrated use of inorganic and organic fertilizers at a rate of 18.9g/m^2 of Urea, 16.2g/m^2 of NPSB and 720g/m^2 of compost while the minimum value of branch number(3.9) was recorded in untreated with fertilizers (Table 4). The highest number of branches per plant (13.0/plant) was recorded from the mixed application of inorganic and organic fertilizers at a rate of 18.9 g/m^2 of Urea, 16.2 g/m^2 of NPSB and 720 g/m^2 of compost and increased by 70% over the absence of any fertilizer pool.

4.3.4. Number of leaves per plant

The results data from Table 5 revealed that the number of leaves per plant were significantly ($P<0.01$) increased due to individual application of organic and inorganic fertilizers as well as combined usage of untreated with fertilizers. The maximum value of potato number of leaves per plant showed as follows: the number of leaves per plant (27.3/plant) were recorded with use of organic fertilizer at a rate of 720 g/m^2 of compost, the number of leaves per plant (34.1/plant) were recorded with use of inorganic fertilizers at a rate of 18.9 g/m^2 of Urea and 16.2 $g/m^2$of NPSB and the number of leaves per plant (40.5/plant) were recorded from the integrated use of inorganic and organic fertilizers at a rate of 18.9 g/m^2 of Urea, 16.2 g/m^2 of NPSB and 720 g/m^2 of compost while the minimum value of leaf numbers (16.4/plant) were recorded in untreated with fertilizers (Table 4). The highest number of leaves per plant (40.5/plant) was recorded from the mixed application of inorganic and organic fertilizers at a rate of 18.9g/m^2 of Urea, 16.2g/m^2 of NPSB and 720g/m^2 of compost and increased by 60% over the control treatment.

4.3.5. Shoot fresh weight per plant

The results data from Table 5 showed that shoot fresh weight per plant was significantly ($P<0.01$) increased due to individual use of organic and inorganic fertilizers as well as the combined use of the control treatment. The maximum value of shoot fresh weight per plant indicated as follows: the shoot fresh weight per plant (163.3 g/plant) was recorded with the usage of organic fertilizer at a rate of 720 g/m^2 of compost, the shoot fresh weight per plant (195.7 g/plant) was recorded with the use of inorganic fertilizers at a rate of 18.9 g/m^2 of Urea and 16.2 g/m^2 of NPSB and the shoot fresh weight per plant (201.3 g/plant) was recorded from the mixed use of inorganic and organic fertilizers at a rate of 18.9 g/m^2 of Urea, 16.2 g/m^2 of NPSB and 720 g/m^2 of compost while the minimum value of shoot fresh weight (124.0 g/plant) was recorded in absence of any fertilizer pool (Table 4). The highest shoot fresh weight per plant (201.3 g/plant) was recorded from the mixed application of inorganic and organic fertilizers at a rate of 18.9 g/m^2 of Urea, 16.2 g/m^2 of NPSB and 720 g/m^2 of compost and increased by 38% over the control treatment.

Table 4: Effect of organic and inorganic fertilizers above ground of potato growth: shoot length, stem diameters, number of branches, shoot fresh weight and number of leaves per plant

Treatment (T)	SL	SDP	NPB	SFW	NLP
T_1=Control	44.8g	4.5e	3.9e	124. 0e	16.4h
T_2=16.2 NPSB	49.2f	4.9d	6.4d	152. 5d	21.1g
T_3=18.9 Urea	59.2d	5.2bc	7.4cd	162. 3c	29.3e
T_4=720 Compost	54.8e	5.0cd	6.8cd	163. 3c	27.3f
T_5=16.2NPSB+18.9 Urea	61.8$_{bc}$	5.4ab	10.3b	195. 7b	34.1c
T_6=720 Compost+18.9 Urea	62.9b	5.6a	11.4ab	198. 2b	37.3b
T_7=720 Compost+16.2NPSB	60.9c	5.2bc	8.3c	195. 8b	32.3d
T_8=720Compost+16.2NPSB+18.9 Urea	64.9a	5.7a	13.0a	201. 3a	40.5a
CV (%)	1.08	6.25	12.9	2.43	4.3
LSD (P<0.05)	1.09	0.24	1.9	3.02	1.8

SL=Shoot Length, SDP= Stem Diameter per Plant, NBP= Number of Branches per Plant, NLP=Number of Leaf per Plant, SFW = Shoot Fresh Weight, CV= Coefficient of Variance, LSD= Least Significant Difference

Table 5: Mean squares analysis of variance for the effect of Organic and Inorganic fertilizer on Potato growth parameters and yield components

Source of variation	DF	NBP	SDP	NLP	SL	SFW	FTW
Rep	2	0.784	0.0388	5.98	1.77	1.89	2.09
Treatment	7	26.43**	0.4523**	178.7**	152**	2353**	140078**
Error	14	1.195	0.0188	0.93	0.39	2.98	0.58

DF=Degree of Freedom, SL=Shoot Length, SDP= Stem Diameter per Plant NLP=Number of Leaf per Plant, NBP=Number of Branch per Plant, SFW= Shoot Fresh Weigh, **= Level of significance, Rep = Replication

4.4. Effect of organic and inorganic fertilizers on Potato yield

4.4.1. Number of tubers per plant

The results data from Table 7 revealed that the number of tubers per plant were significantly ($P<0.01$) increased due to individual application of organic and inorganic fertilizers as well as integrated compared to untreated with fertilizers (control). The maximum value of potato number of tubers per plant showed as follows: the number of tubers per plant (11.0/plant) were recorded with the usage of organic fertilizer at a rate of 720 g/m^2 of compost, the number of tubers per plant (12.5/plant) were recorded with the use of inorganic fertilizers at a rate of 18.9 g/m^2 of Urea and 16.2 g/m^2 of NPSB and the number of tubers per plant (13.7/plant) were recorded from the integrated use of inorganic and organic fertilizers at a rate of 18.9 g/m^2 of Urea, 16.2 g/m^2 of NPSB and 720 g/m^2 of compost while the minimum value of the number of tubers per plant (9.8) were recorded from untreated with fertilizers (Table 6). The highest number of tubers per plant (13.7/plant) was recorded from the mixed application of inorganic and organic fertilizers at a rate of 18. 9 g/m^2 of Urea, 16.2 g/m^2 of NPSB and 720 g/m^2 of compost and increased by 29% over the absence of any fertilizer pool.

4.4.2. Fresh weight of tubers per plant

Fresh weight of tubers per plant was significantly ($P<0.01$) increased due to individual use of organic and inorganic fertilizers as well as the combined use compared to the control (Table 5). The results data from Table 6 showed that the maximum value of fresh weight of tubers per plant indicated as follows: the fresh weight of tubers per plant (581.0 g/plant) were recorded with the application of organic fertilizer at a rate of 720 g/m^2 of compost, the fresh weight of tubers per plant (891.2 g/plant) were recorded with the usage of inorganic fertilizers at a rate of 18.9 g/m^2

of Urea and 16.2 g/m^2 of NPSB and the fresh weight of tubers per plant (904.5 g/plant) were recorded from the combined use of inorganic and organic fertilizers at a rate of 18.9 g/m^2 of Urea, 16.2 g/m^2 of NPSB and720 g/m^2 of compost while the minimum value of fresh weight of tubers per plant (305.0 g/plant) were recorded in absence of any fertilizer pool. The highest fresh weight of tubers per plant (904.5 g/plant) was recorded from the integrated use of inorganic and organic fertilizers and increased by 66% over the control treatment.

4.4.3. Marketable tuber number per plant

Table 7 reveals a marketable tuber number per plant that was significantly ($P<0.01$) increased due to individual application of organic and inorganic fertilizers as well as integrated use compared to untreated ones. The maximum value of marketable tuber number per plant showed as follows: the marketable tuber number per plant (2,37,037 t/ha) was recorded with the use of organic fertilizer at a rate of 720 g/m^2 of compost, the marketable tuber number per plant (2,96,296 t/ha) was recorded with the usage of inorganic fertilizers at a rate of 18.9 g/m^2 of Urea and 16.2 g/m^2 of NPSB and the marketable tuber number per plant (3,40,741 t/ha) was recorded from the combined use of inorganic and organic fertilizers at a rate of 18.9 g/m^2 of Urea, 16.2 g/m^2 of NPSB and 720 g/m^2 of compost while the minimum value of marketable tuber number per plant (1,488,148 t/ha) was recorded from untreated ones (Table 6). The highest marketable tuber number (3, 40,741 t/ha) was recorded from the mixed application of inorganic and organic fertilizers and increased by 57% over the absence of any fertilizer pool.

4.4.4. Marketable Tuber Yield

Marketable tuber yield was significantly ($P<0.01$) increased due to individual application of organic and inorganic fertilizers as well as mixed use without any fertilizer pool (Table 7). The maximum value of marketable tuber yield showed as follows: the marketable tuber yield (21.7 t/ha) was recorded with the use of organic fertilizer (compost), the marketable tuber yield (22.8 t/ha) was recorded with the use of inorganic, the marketable tuber yield (36.9 t/ha) was recorded from the integrated use of inorganic and organic fertilizers while the minimum value of marketable tuber yield (9.1 t/ha) was recorded from the absence of any fertilizer pool (Table 6). The highest marketable tuber yield (36.9 t/ha) was recorded from the combined application of inorganic and organic fertilizers and increased by 75% over the absence of any fertilizer pool.

Table 6: Effect of Organic and Inorganic fertilizers on potato yield: tuber number per plant, fresh weight of tuber per plant, marketable tuber number and marketable tuber yield of Potato

Treatment (T)	NTP	FTW	MT N	MTY
T_1	9.8e	305.0h	148148d	9.1d
T_2	11.7c	599.5d	266667bc	21.3bc
T_3	10.8d	546g	222222c	20.1c
T_4	11.0cd	581.0e	237037c	21.7bc
T_5	12.5b	891.2c	296296ab	22.8b
T_6	11.3cd	579.0f	251852bc	21.8bc
T_7	13.3a	901.3b	325926a	36.7a
T_8	13.7a	904.5a	340741a	36.9a
CV (%)	6.81	0.11	11.1	6.1
LSD ($p<0.05$)	0.81	1.34	50953.0	2.6

NTP= Number of Tuber per Plant, CV= Coefficient of Variance, LSD= Least Significant Difference, FTW= Fresh Tuber Weight, MTN=Marketable Tuber Number, MTY= Marketable Tuber Yield

Table 7: Mean squares analysis of variance for the effect of Organic and Inorganic fertilizer Potato yield components

Sources of variation	DF	NTP	MTN	MTY
Rep	2	2.51	3950649383	13
Treatment	7	5.14**	11463855203**	249.6**
Error	14	0.21	846566137	2.1

DF=Degree of Freedom, NTP= Number of Tubers per Plant, MTN=Marketable Tuber Number, MTY= Marketable Tuber Yield

4.5. Physio-chemical analysis of soil samples

The results of the laboratory analysis before planting of the soil physio- chemical properties of the experimental site were presented as shown below in table 8. Soil analysis results before planting showed that the experimental soil of under irrigation condition in the study area has contained organic carbon (1.14%), available phosphorus (3.6 ppm), exchangeable potassium (1.16 cmol (+) /kg soil), total nitrogen (0.112%), organic matter (1.97%), electrical conductivity (0.053 Ms/cm) and medium in cation exchange capacity with clay in texture and a pH of 7.54 (DBARC, 2019). These properties indicated that the experimental soil has some soil nutrient limitations with regard to its use for potato crop production and the results of the laboratory analysis of experimental soil. Such findings further signify that the soil required external application of inputs (fertilizers) for the potato growth and yield.

Table 8: Pre- planting soil test result of the study area

Sample site	pH	EC (Ms/cm	%OC	%TN	%OM	P(ppm)	K	CEC	Textures
Yedur	7.54	0.053	1.14	0.112	1.97	3.6	1.16	48.63	Clay
Melekamba	7.46	0.110	1.12	0.120	1.89	3.3	1.18	46.52	Clay
Tiyemidir	7.49	0.035	1.21	0.114	1.91	3.8	1.14	49.23	Clay

Where: EC=Electrical Conductivity (Ms/cm), OC=Organic Carbon, TN=Total Nitrogen, OM= Organic Matter, P=Phosphorus, K=Potassium (cmol (+) /kg soil), CEC= Cation Exchange Capacity (meq/100g soil)

5. Discussion

The study revealed that increased growth and yield of potato plants, measured from the combined application of inorganic and organic fertilizers compared to utilization of the inorganic and organic fertilizers alone. Therefore, the use of integrated fertilizers reduced the formation of soil-acidity, help to improve the physio-chemical properties as well as biological properties of soils, improved cation exchange capacity, easily find useful nutrients in the soil and maintaining the soil fertility (Amir Ali Najm *et al*., 2013). Continuous use of organic fertilizer(compost) alone is more advantageous than inorganic fertilizers alone because of the improving of soil fertility by influencing its physical, chemical and biological properties of soil, increase the soil moisture holding capacity, provide balanced micro and macronutrients as well as enhanced availability of plant nutrients, which help to enhance the metabolic activity of microorganisms to restoring soil fertility then obtaining optimum growth and yield of potato plant (Baia *et al*., 2018).

The longest shoot length (64.9 cm/plant) was recorded from the combined application of inorganic and organic (compost) fertilizers and increased by 31% over the control might be due to the fact that the improvement of growth and production by fertilization with synthetic and organic manures; thus are a good source of plant nutrients and adequate fertilization of surface soils encourages greater vegetative growth and also a more vigorous and extensive root system.The result of this study was in agreement with Melkamu *et al*. (2020) conducted an experiment to know the integrated application of NPS fertilizer and farmyard manure for economical production using Belete variety in silt clay at pH 6.08 of irrigated potato (*Solanum tuberosum*) in highlands of Ethiopia shows that the highest shoot length of potato was recorded from the combined fertilizers at a rate of 245.1 kg ha−1 NPS and13.5 t ha−1 of farmyard manure increase the shoot length of the potato by 61.8 cm/plant over control treatment and also the results are in agreement with the findings of other researchers who observed increase shoot length when potato plant were applied with combined organic and inorganic fertilizers (Ahmed *et al*., 2015; Suh *et al*., 2015; Ahamad *et al*., 2014; Islam *et al*., 2013).

The maximum value of stem diameter (5.7 cm/plant) was recorded from the integrated application of inorganic and organic fertilizers and increased by 21% over the control may be due to the available nutrients that nitrogen fertilizer plays an important role in maintaining thickness stem growth and development, especially on the shoots of plants including potato, phosphorus stimulated root development, increased stalk and stem strength, improved flower formation and seed production. Sulfur and boron supplied to beneficial to potato growth, enzymatic reaction and protein synthesis. The finding of this study was in agreement with Amana Mama *et al*. (2016) who conducted experiment on effects of different rates of organic (farmyard manure) and inorganic (nitrogen)fertilizer on growth and yield components of jalene variety in siltclay soil at pH 4.51 in southwest Ethiopia, where maximum value of potato stem diameter was recorded from the combination of fertilizer at rate of 0.02 kg/ha farmyard manure and 0.07 kg/ha of nitrogen fertilizer with stem diameter of potato of 5.1 cm/plant over the control. The results obtained in the present study were also in agreement with those reported by other investigators (Alemayehu & Jemberie, 2018, Masrie *et al*., 2015; Islam *et al*., 2013).

In the present study the maximum number of leaves (40.5/plant) was recorded from the integrated use of inorganic and organic fertilizers at a rate of 18.9g/m^2 of Urea, 16. 2g/m^2 of NPSB and 720g/m^2 of compost and increased by 60% over the control. The current result was in agreement with Amana Mama *et al*. (2016) who reported the effects of different rates of organic(farmyard manure) and inorganic (nitrogen)fertilizer on growth and yield components of jalene variety in siltclay soil at pH 4.51 of potato (solanum tuberosum) in southwest Ethiopia where maximum value of potato leaf number was recorded from the combination of fertilizer at rate of 0.02 kg/ha farmyard manure and 0.035 kg/ha of nitrogen fertilizer applied increase the leaf number of the potato of 91.67 cm/plant over the control and also in agreement with the findings of the previous studies (Islam *et al*., 2013; Hassanpanah and Azimi, 2012).

In the present study the highest shoot fresh weight of the potato (201.3 g/plant) was recorded from the combined application of inorganic and organic fertilizers and increased by 38% over the control may be due to the available soil nutrient uptake in the shoot and tuber were improved by its supply from added in the form of fertilizers. The finding of this study was in agreement with Alam *et al*. (2007) who reported the effect of vermin compost and chemical fertilizers on growth, yield and yield components of Potato in at pH 5.4 Barind Soils of Bangladesh, where maximum value of shoot fresh weight of the potato was recorded from the combination of fertilizer at rate of 10 t/ha of vermicompost and 100% NPKS of nitrogen fertilizer applied increase the fresh weight shoot of potato by 192. 33 g/plant over the control and also in agreement with the findings of the previous studies (Ahmed *et al*., 2015; Suh *et al*., 2015; Ahamad *et al*., 2014). The highest number of branches (13.0/plant) was recorded from the combined use of inorganic and organic fertilizers and increased by 70% over the control due to the branch number increase in response to the mixed application of inorganic and organic fertilizers could be attributed to an increase in stolon number through its effect on Gibberellins biosynthesis in the potato plant. The current result was in agreement with (Amana Mama *et al*., 2016; Ahamad *et al*., 2014).

In the current study the highest fresh weight of tubers (904.5 g/plant) was recorded from the integrated use of inorganic and organic fertilizers at a rate of 18.9 g/m^2 of Urea, 16. 2 g/m^2 of NPSB and 720 g/m^2 of compost and increased by 66% over the control may be in response to the increased supply of fertilizer nutrients due to more luxuriant growth, more foliage and leaf area and higher supply of photosynthates which may have induced formation of bigger tubers thereby resulting in higher yields (Sikder *et al*., 2017). In other words, the increased size and duration of the haulm stemming from improved supply of nutrients favored tuber weight increased. This study obtained the result was in agreement with Melkamu *et al*. (2020) who conducted an experiment to know the integrated application of NPS fertilizer and farmyard manure for economical production using Belete variety in siltclay soil at pH 6.08 of irrigated potato (*Solanum tuberosum*) in highlands of Ethiopia shows that the highest fresh weight of tuber was recorded from the combination of fertilizers at a rate of 245.1 kg /ha NPS and13.5 t ha−1 of farmyard manure increase the fresh weight of tuber by 916 g/plant over the control. The results obtained in the present study were also in agreement with those reported by other investigators (Girma *et al*., 2017; Abebe *et al*., 2013; Abebe *et al*., 2012).

The maximum number of tubers (13.7/plant) were recorded from the integrated use of inorganic and organic fertilizers and increased by 29% over the control may be due to the combined use of organic and inorganic fertilizers can trigger the vegetative growth, attributed to the increased number of main stems, root development, increased the size of the potato tubers and attributed to an increase in stolon number through its effect on Gibberellins biosynthesis in the potato plant while the highest marketable tuber number (34,0741 t/ha) was recorded from the combined use of inorganic and organic fertilizers and increased by 57% over the control. This study obtained the result was in agreement with Alemayehu *et al*. (2015) who conducted an experiment to know the response of potato (*solanum tuberosum*) yield and yield components to nitrogen fertilizer and planting density using bubu variety of potato seed, in clay soil, pH 7.86, rainy season of Eastern Ethiopia shows that the highest marketable tuber number was recorded from the application of nitrogen fertilizer with the rate of 110 kgN/ha significantly increased the marketable tuber number by 42, 3549 t/ha over the control and also in agreement with the findings of the previous studies (Girma *et al*., 2017; Niguse,2016; Alemayehu *et al*., 2015).

In the present study the highest marketable tuber yield (36.9 t/ha) was recorded from the combined application of inorganic and organic fertilizers at a rate of 18.9g/m^2 of Urea, 16. 2g/m^2 of NPSB and 720g/m^2 of compost and increased by 75% over the control may be due to the positive interaction and complementary effect between organic and inorganic fertilizers in affecting and increasing the marketable tuber yield, ensures maintenance of photosynthetically active leaves for longer duration and formation of new leaves. The result of this study was in agreement with Workat (2019) who conducted an experiment to know the effects of inorganic fertilizers on potato production using nitisol soil, acidic, belete variety, irrigation season in high land of Ethiopia the highest marketable yield was recorded with the mixed use of nitrogen at a rate of 165 kg ha^{-1} and phosphorous at a rate of135 kg ha^{-1} increased the marketable tuber yield by 36.13 t ha^{-1} over the control and also in agreement with the findings of this study, various researchers reported the marketable tuber yield increment when potato plants were applied with combined application of different organic and inorganic fertilizers (Girma *et al*., 2017; Suh *et al*., 2015; Ahmed *et al*., 2015; Ahamad *et al*., 2014; Islam *et al*., 2013; Najm *et al*., 2012).

In all of the measured parameters of potato growth and yield, inorganic fertilizer used in a small amount is better than organic fertilizer in a large amount. This is due to inorganic fertilizer is good for rapid growth of potato as the nutrients are already water soluble or it delivers a rapid dose of nutrients and immediately available to the potato plant growth and yield depending on them to provide essential nourishment in the form of nitrogen, phosphorus, potassium and other nutrients. In addition to this, inorganic fertilizers could be dissolved within a short period of time by the action of bacteria and this leads to the improvement of the potato plant growth and yield (Tadesse *et al*., 2013)..

In the present study the results of the pre-planting soil test analysis showed that the soils at the sites were presented under irrigation conditions in the Woflek area has contained organic carbon (1.14%), available phosphorus (3.6 ppm), exchangeable potassium (1.16 Coml. (+) /kg soil), total nitrogen (0.112%), organic matter (1,97%), Electrical conductivity (0.053 Ms/cm) and cation exchange capacity (48.63 meq/100g soil) with clay in texture and a pH of 7.54 (Table 7). This could be attributed to the poor management of crop residue, thus resulting in nutrient reduction and the decline in soil fertility. The potato crop response to added the integrated with organic and inorganic fertilizers under irrigation conditions in the study area that was expected to show responses on potato crops and soils. The current pre-planting soil test result was in agreement with Israel *et al*. (2018) who conducted an experiment to know the effect of combined use of cattle manure and inorganic fertilizer on yield components yield and economics of Potato (Solanum tuberosum) in Belg Season at Abelo Area Masha District, South-Western Ethiopia showed that the results of the initial soil test analysis reported that the soils at the sites were low amounts of total nitrogen (0.1%), organic carbon (1.2%), extractable phosphorous (5.5 mg/kg),available potassium (0.42 Cmol(+)/kg soil), Electrical conductivity (16.9 Ms/cm and loam in texture in Abelo area with pH of 5.01 in Belg season. In agreement with the result of this study, various other studies have also shown the importance of organic nutrient sources, particularly when integrated with organic and synthetic fertilizer in improving the fertility status of the soil (Melkamu *et al*., 2020; Israel *et al*., 2016; Alemayehu *et al*., 2015).

6. Conclusion

The integrated application of inorganic and organic fertilizers has increased growth and yield parameters of potato plants under field conditions. The combined application of organic and inorganic fertilizers gave a better result than the application of a single fertilizer, which indicated that integrated nutrient management (integrated use of organic and inorganic fertilizers) is the best method for soil fertility management.

7. Recommendation

Based on the findings, the following recommendations are forwarded to improve the growth and yield of potato at Woflek location,

- ✓ The stakeholders (Gishe District Agricultural experts, Woflek Kebele Agricultural experts) should educate and create awareness for the peasants to use integrated fertilizers to improve the soil fertility, the growth and yield of potato.
- ✓ Further studies are also recommended to be conducted in other types of plant products in the study area for better agricultural production using organic and inorganic fertilizers in combination.

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Appendix

College of Natural sciences

Department of Biology

Checklist of the questionnaires for Woflek farmers collecting on growth and yield of potato plant data.

Dear respondents,

The following questions are intended to gather information on growth and yield of potato plant. I assure that the information gathered is intended for research purpose only and no need of writing your name.

I. Information on respondents

1. Region____________Zone_____________District______________ Location __________ Village____________.

2. Age: __________________

Direction- Mark "x" in the space provided below

3. Sex: Male__________________ Female _____________

4. Education level: Illiterate ____________Primary education/1-8 grade/ ___________Secondary education/9-12 grade/ __________

5. Religion: Christian _______ Muslim _____

6. Marital Status of respondents: Unmarried _____ Married ______Divorced______Widowed__________

7. Work ________________.

II. Questionnaires for Woflek farmers based on the growth and yield of potato plant data.

Instruction –Choose the letter & circle it

1. Is there a common potato plant disease in your area?

A. Yes B. No

2. Are the growth and yield of potato plant under irrigated condition in your area low?

A. Yes B. No

3. Are you interested in cultivation of potato plant under irrigation condition in your area?

A. Yes B. No

4. Do you use organic fertilizer on growth and yield of potato plant under irrigation conditions in your land?

A. Yes B. No

5. Do you use inorganic fertilizers on growth and yield of potato plant under irrigation conditions in your land?

A. Yes B. No

6. Do you use integrated with organic and inorganic fertilizers on growth and yield of potato plant under irrigation conditions in your land?

A. Yes B. No

7. Is the soil fertility in your land low?

A. Yes B. No

8. Is there enough river/water in your area to use irrigation?

A. Yes B. No

9. Do you use timely planting, hoeing and avoid weeding on growth and yield of potato plant under irrigation conditions in your land?

A. Yes B. No

10. Is there enough marketing in your area potato production?

A. Yes B. No

አባሪ

ጅማ ዩኒቨርሲቲ

የተፈጥሮ ሳይንስ ኮሌጅ

የባዮሎጂ ትም/ት ክፍል

በድንች ዕፀዋት እድገትናምርትላይ በተመለከተ ከወፍለቅ አርሶአደሮች መረጃ መሰብሰቢያ የሚሆን የፅሁፍ - መጠይቅቅፅ

ውድ የተከበራችሁ የወፍለቅ አርሶአደሮች

የሚከተሉት የፅሁፍ መጠይቆች በድንች እፀዋት እድገትናምርት ላይ መረጃ ለማሰባሰብ የተዘጋጁ የፅሁፍ መጠይቆች ናቸው፡፡

የዚህ የፅሁፍ መጠይቅ ዓላማ ለጥናትናምርምር ብቻ መሆኑን አረጋግጥላችኋላሁ ነገርግን ስም መፃፍ ፊፅሞ አያስፈልግም፡፡

ትዕዛዝ አንድ ፡-ለተጠያቂዎቹ የሚቀርብ አጠቃላይ መረጃ

1. **ክልል**------------- **ዞን** --------- **ወረዳ** --------- **ቀበሌ** -------- **ጎጥ/መንደር/** -----------

2. **ዕድሜ** ----------

አቅጣጫ:- **በተሰጠው ክፍት ቦታ ላይ የ** "x" **ምልክት ያድርጉ**

3. **ፆታ** - **ወንድ** ------**ሴት** -----

4. **የትም/ትሁኔታ** - **ያልተማረ** ----------- **የመጀመሪያ ደረጃ ትም/ት** (**ከ**1**ኛ**-8**ኛክፍል**) ----- **ሁለተኛ ደረጃ ትም/ት** (**ከ**9**ኛ**-12**ኛክፍል**) -----------

5. **ሀይማኖት** - **ክርስቲያን** ------**ሙስሊም** -----

6. **የጋብቻ ሁኔታ** - **ያላገባ/ች** ------- **ያገባ/ች**------- **የፈታ/ች** ------- **የሞተበት/ባት**----

7. **ስራ** ----------------------

ትዕዛዝ ሁለት፡-

በድንች ዕፀዋት እድገትናምርት ላይ በተመለከተ ከወፍለቅ አርሶአደሮች የሚሰበሰብ የፅሁፍ- መጠይቅ መረጃ

ትክክለኛ መልስ ይሆናል ብላችሁ ያሰባችሁትን ፊደል በማክበብ መልሱ፡፡

1. በአካባቢዎ የተለመደ የድንች ዕፀዋት በሽታ አለን? ሀ አለ ለ. የለም

2. በአካባቢዎ በሚገኘው የመስኖ አጠቃቀም ሁኔታ ስር ያለው የድንች ዕፅዋት እድገትናምርት ዝቅተኛ ነውን?

ሀ. አዎ ለ. አይደለም

3. በአካባቢዎ በሚገኘው የመስኖ አጠቃቀም ሁኔታ ስር የድንች ዕፀዋትን ለማልማት ፍላጎት አለዎትን?

ሀ. አለኝ ለ. የለኝም

4. እርስዎ በመሬትዎ ባለው መስኖ ሁኔታ ስር በሚበቅለው ድንች ዕፅዋት እድገትናምርት ላይ የተፈጥሮ ማዳበሪያ ለምሳሌ፡- ኮምፖስት ይጠቀማሉን?

ሀ. እጠቀማለሁ ለ. አልጠቀምም

5. እርስዎ በመሬትዎ ባለው መስኖ ሁኔታ ስር በሚበቅለው ድንች ዕፅዋት እድገትናምርት ላይ የሰው ስራሽ ማዳበሪያ ለምሳሌ፡- ዩሪያ፣ኤን ፒኤስቢ ይጠቀማሉን?

ሀ. እጠቀማለሁ ለ. አልጠቀምም

6. እርስዎ በመሬትዎ ባለው መስኖ ሁኔታ ስር በሚበቅለው ድንች ዕፅዋት እድገትናምርት ላይ የተፈጥሮና የሰው ሰራሽ ማዳበሪያዎችን በጋራ በማዋሀድ ይጠቀማሉን?

ሀ. እጠቀማለሁ ለ. አልጠቀምም

7. በአካባቢዎ ያለው የአፈሩ ለምነት ዝቅተኛ ነውን?

ሀ. አዎ ለ. አይደለም

8. በአካባቢዎ በቂ የሆነ ለመስኖ መጠቀሚያ የሚሆን ወንዝ/ዉሃ አለን?

ሀ. አለ ለ. የለም

9. እርስዎ በመሬትዎ ባለው መስኖ ሁኔታ ስር በሚበቅለው የድንች ዕፅዋት እድገትናምርት ላይ ድንችን በወቅቱ የመትከል፣የመኮትኮትና አረም የማረም/ የማስወገድ ሁኔታ ይጠቀማሉን?

ሀ. እጠቀማለሁ ለ. አልጠቀምም

10. በአካባቢዎ በሚገኘው በድንች ምርታማነት ላይ በቂ የሆነ ግብይት አለን?

ሀ. አለ ለ. የለም