



**RESPONSE OF CHICKPEA TO POTASH AND NPSB  
FERTILIZERS AT SODO DISTRICT, GURAGE ZONE**

**MSc. THESIS**

**HAILEMARIAM TEKLU WILLISO**

**APRIL, 2023**

**WOLKITE, ETHIOPIA**

**RESPONSE OF CHICKPEA TO POTASSIUM AND NPSB FERTILIZERS  
AT SODO DISTRICT GURAGE ZONE**

**HAILEMARIAM TEKLU WILLISO**

**MAJOR ADVISOR: GIRMA WOLDE (Assistance Professor of Soil Science)**

**CO-ADVISOR: GETACHEW MEKONEN (PhD)**

**A THESIS PROPOSAL SUBMITTED TO THE DEPARTMENT OF PLANT  
SCIENCES, COLLEGE OF AGRICULTURE AND NATURAL  
RESOURCE,  
WOLKITE UNIVERSITYA**

**MASTER OF SCIENCE IN AGRONOMY**

**APRIL, 2023**

**WOLKITE UNIVERSITY**



## **DEDICATION**

This thesis is dedicated to my lovely wife and family for their concern, prayer, patience, encouragement, and love in my life's success.

## STATEMENT OF AUTHOR

First, I declared that this thesis is a result of my genuine work and that I have duly acknowledged all sources of materials used for writing. I submitted this thesis to Wolkite University in partial fulfillment for the Degree of Master of Science in (Agronomy) and it is deposited in the library of the University to be made available to borrowers for reference. I solemnly declared that I have not so far submitted this thesis to any other institution anywhere for the award of any academic degree, diploma, or certificate.

Brief quotations from this thesis are allowed without requiring special permission provided that an accurate acknowledgement of the source is made. Requests for permission for extended quotations from or duplicate of this thesis in whole or in part may be granted by the Head of the department of Plant Sciences or the Director of Postgraduate Programs of Wolkite University when in his or her judgment the proposed use of the material is in the interest of scholarship. In all other instances, however, permission must be obtained from the author of the thesis.

Name: Hailemariam Teklu

Signature \_\_\_\_\_

Place: Wolkite University,

Date of Submission: April, 2023

## **BIOGRAPHICAL SKETCH**

The author was born on February 28, 1981 to Mr. Teklu Wulliso and Mrs. Alemnesh Gemesa at Sodo Wereda , Guraghe Zone of SNNPR. He attended his elementary and secondary schools education in Firshy Abo Elementary school and Sodo Buee Senior Secondary school, respectively. Following the successful completion of his secondary education, He joined Welayta Sodo Agricultural Training Center, at November, 2001 and Agarfa Agricultural, Technical, Vocational, Education Training (ATVET) College in February 2003 graduated with Certificate in Development agent and Diploma in Animal Science Respectively. After his graduation, he was employed as Animal Science expert at the District Agricultural Office of Sodo Woreda since August 2006. After serving for three year and Six months, he joined Haromaya University in March 2009 and graduated with BSc degree in Rural Development and Agricultural Extension in 2011. After graduation From 2011 until he joined the Post Graduate Directorate Program of Welkite University for his master degree in Agronomy in October 2019, he served as a Coordinator of Extension Program in Sodo Wereda Agricultural office of Guraghe Zone.

## **ACKNOWLEDGMENTS**

First and for most I would like to thank and praise the almighty God for giving me the opportunity to finalize this thesis. I thanks to my advisor Girma Wolde (Asst.prof) for his constructive comments and suggestions throughout my thesis. Without his professional assistance and guidance this thesis would not be valuable. I would also like to thank Getachew Mekonen (PhD) my co–advisor for his constructive comments and suggestions throughout preparation of this thesis.

## **ABBREVIATION AND ACRONYM**

ANOVA	Analysis of Variance
ATA	Agricultural Transformation Agency
CSA	Central Statistics Agency
Ethio- SIS	Ethiopian Soil Information System
NPSB	Nitrogen, Phosphorous, Sulfur, Boron
SNNPR	South Nation Nationality and Peoples Region
MOP	Muriate of Potash

## TABLE OF CONTENT

<b>DEDICATION.....</b>	<b>iv</b>
<b>STATEMENT OF AUTHOR .....</b>	<b>v</b>
<b>BIOGRAPHICAL SKETCH.....</b>	<b>vi</b>
<b>ACKNOWLEDGMENTS .....</b>	<b>vii</b>
<b>ABBREVIATION AND ACRONYM .....</b>	<b>viii</b>
<b>TABLE OF CONTENT.....</b>	<b>ix</b>
<b>LIST OF TABLES .....</b>	<b>xi</b>
<b>ABSTRACT.....</b>	<b>xii</b>
<b>1. INTRODUCTION.....</b>	<b>1</b>
<b>2. LITRATURE REVIEW .....</b>	<b>4</b>
2.1. Chickpea.....	4
2.2. Production of Chickpea in Ethiopia .....	6
2.3 Importance of chickpea .....	7
2.4. Role of Mineral Nutrients on Yield and Yield Component of Chickpea.....	7
2.4.1 Nitrogen .....	8
2.4.2. Phosphorous.....	9
2.4.3. Sulfur .....	10
2.4.4. Boron .....	11
2.4.5 Potassium.....	12
<b>3. MATERIAL AND METHODS .....</b>	<b>14</b>
3.1. Description of study area.....	14
3.2. Source of experimental material .....	14
3.3. Experimental design and treatment .....	14
3.4. Experimental Procedure and Trial management .....	16
3.5. Soil Sampling and Analysis .....	17
3.6. Data collected method.....	17
3.6.1. Phonological data collected .....	17
3.6.2 Growth parameter .....	17
3.6.3. Nodulation parameter .....	18
3.6.4. Yield and Yield Component .....	18
3.7. Statistical Analysis .....	19
3.8. Partial Budget Analysis.....	19
<b>4. RESULT AND DISCUSSION .....</b>	<b>20</b>
4.1. Physico-chemical Characteristics of Soil before Planting .....	20
4.2. Crop Phenology.....	21
4.2.1. Days to 50% flowering .....	21
4.2.2. Days to 90% maturity .....	22
4.3. Growth Parameters .....	23
4.3.1. Plant height .....	23
4.3.2. Number of primary branches .....	24
4.3.3. Number of Secondary Branches .....	25
4.3.4. Shoot Fresh weight .....	25
4.3.5. Shoot Dry weight.....	27
4.3.6. Root Fresh Weight.....	27

4.3.7. Root dry Weight .....	27
4.3.8. Number of Nodule .....	26
4.3.9. Nodule fresh weight.....	28
4.3.3.1. Nodule dry weight.....	28
4.3.3.2. Nodule Volume.....	28
4.3.3.3. Number of effective nodule .....	28
4.4. Yield and Yield Components of Chickpea.....	31
4.4.1. Number of Pods per Plant.....	31
4.4.2. Number of seed per pod.....	31
4.4.3. Hundred Seed weight.....	32
4.4.4. Biomass .....	33
4.4.5. Grain yield .....	33
4.4.6. Harvest index .....	34
4.5 Soil Nutrient analysis after harvesting .....	36
4.5.1 Total Nitrogen.....	36
4.5.2 Available of Phosphorous(P).....	36
4.5.3 Available Sulfur (S).....	36
4.5.4 Available Boron (B) .....	37
4.5.5 Available Potassium (K).....	37
4.6. Economic Analysis.....	38
<b>5. SUMMARY AND CONCLUSSION .....</b>	<b>63</b>
<b>6. REFERENCE .....</b>	<b>64</b>

## LIST OF TABLES

Tables	Page
1 Improved Kabuli/dubie variety released in Debrezeite Ethiopia .....	14
2 Treatment combinations of the experimental .....	15
1 Physico-chemical analysis result of experimental soil before planting .....	27
4 Two-way interaction effects of NPSB and MOP fertilizer rates on the Phonological data..	36-38
6 Two-way interaction effects of NPSB and MOP fertilizer rates on the Yield and Yield Components.....	43
7 Two-way interaction effects of NPSB and MOP fertilizer rates on soil nutrients after harves.....	46
8 Summary of economic analysis of the response of Chickpea for rates of NPSB fertilizer and Muriate of Potash (MOP).....	49

## ABSTRACT

*Lack of NPSB fertilizer and Muriate of Potash (MOP) is the key yield restrictive factors of chickpea production on verti sols in the Sodo District. Hence, a field experiment was carried out through the main cropping season of 2021/22 in Sodo District, to investigate the effect of blended NPSB fertilizer and Muriate of potash rates on yield and yield components of chickpea at Sodo District. At a four levels of blended NPSB fertilizer (0, 50, 100 and 150 kg ha<sup>-1</sup>) and four level of Muriate of Potash (MOP) (0, 50, 100 and 150). The experiment was conducted in a factorial combination in randomized complete block design with three replications. Data on the effect of blended NPSB fertilizer and Muriate of Potash rates on yield and yield components of chickpea were recorded and subjected to analysis of Variance (ANOVA). ANOVA showed that crop phenology (days to 50% flowering and days to physiological maturity), the growth (plant height, number of primary and secondary branches, shoot fresh and dry weight, root fresh and dry weight), nodulation (number of nodules, nodule fresh and dry weight, nodules volume, number of effective nodules) and yield components (number of pods, number of seeds per pod, hundred seed weight, harvest index and grain yield) were significantly affected by the different factor combinations. The highest mean value of seed yield (1953.33 kg ha<sup>-1</sup>) was gained from combined application rate of 100 kg NPSB ha<sup>-1</sup> and 100 kg MOP ha<sup>-1</sup> which increase over the control (886.67 kg ha<sup>-1</sup>). The partial budget analysis revealed that the maximum (ETB 63132.5ha<sup>-1</sup>) net benefit were achieved from interaction rate of 100 kg NPSB ha<sup>-1</sup> and 100 kg Mop ha<sup>-1</sup> MRR of 5.74% and minimum (ETB 31653.5 ha<sup>-1</sup>) net benefit were obtained from the control, respectively. Hence, with the interaction rate of 100 kg NPSB ha<sup>-1</sup> and 100 kg Muriate of Potash ha<sup>-1</sup> could be tentatively recommended for chickpea production in Sodo District. However, the trial should be repeated over years and sites to give a valid recommendation.*

**Key word:** *Blended NPSB fertilizer, Muriate of Potash, MRR.*

## 1. INTRODUCTION

Chickpea (*Cicer arietinum* L.) which belongs to family *Fabaceae* is one of the most important widely grown pulse crop in the world. Chickpea is the world's third most important food legume next to haricot bean and soybean (Namvar and Sharifi 2011). Globally it was cultivated on area of 13.65 million ha with production of 13.10 million tons (FAOSTAT, 2016). It is a herbaceous annual plant which branches from the base (Joshi *et al.*, 2001). It is almost a small bush with diffused and spreading branches though a few erect cultivars exist. The plant is mostly covered with glandular or non-glandular hairs but some genotypes do not possess hair (Singh and Diwakar, 1995). Globally, chickpea is adapted to black soils in the cool semi-arid areas of the tropics, sub-tropics as well as the temperate areas.

There are two main types of chickpea Desi and Kabuli Desi chickpea the common seed colors contain several shades and mixtures of brown, yellow, green and black. The seeds are mostly small and angular with a rough surface. The flowers are usually pink and the plants show different degrees of anthocyanin pigmentation, although some desi types have white flowers and no anthocyanin pigmentation on the stem. The desi types account for 80-85% of chickpea area. Kabuli chickpea the kabuli type chickpeas are categorized by white or beige-colored seed with ram's head shape, thin seed coat, smooth seed Surface, white flowers, and lack of anthocyanin pigmentation on the stem. As compared to desi types, the kabuli kinds have higher levels of sucrose and lower levels of fiber. The kabuli types generally have large sized seeds and receive higher market price than desi types (Gaur *et al.*, 2010). According to the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) chickpea seeds contain on average- 21.1% protein, 64% total carbohydrates (47% starch, 6% soluble sugar), 5% fat, 6% crude fibre and 3% ash. High mineral content has been reported for phosphorus (340 mg per 100 g), calcium (190 mg per 100 g) and magnesium (140 mg per 100 g), iron (7 mg per 100 g) and zinc (3 mg per 100 g). Recent studies have also shown that they can assist in lowering of cholesterol in the bloodstream (Pittway *et al.*, 2008).

Chickpea can be put into diverse uses: food, feed, nutrition, market, homemade processing, health food and it is a smallholder farmer and gender-friendly crop in that chickpea can be a backyard crop handled by women for home consumption (e.g., green pod, grain, leaves), medium-

sized fields for market and home consumption or at the commercial scale for a wider market and agro-processing (Tabe-Ojonga *et al.*, 2017). Among the pulses crops, chickpea is an important annual crop. It is only cultivated species of genus *Cicer*. Chickpea is the world's third most important food legume next to haricot bean and soybean (Namvar and Sharifi 2011). Globally, it was cultivated on area of 13.65 million ha with production of 13.10 million tons (FAOSTAT, 2016).

Ethiopia is considered as the secondary center of diversity for chickpea. According to Getachew (2019) chickpea is the third most important pulse crop widely grown in Ethiopia. Currently, chickpea is cultivated in several regions of the country such as; Amhara, Oromia, Tigray and also in various zones, some special Woredas and pocket areas in the Southern Nations, Nationalities and Peoples Regional State (SNNPRS) including the study area, Sodo district, Gurage Zone. The diverse biophysical and agro climatic conditions in Ethiopia make it very suitable for growing a number of pulses and legume crops. Chickpea is grown on an area of 242,703.73 hectares of land specify the production year with a production of 499,425.6 tons in Ethiopia (CSA, 2018). Ethiopia is the leading chickpea producer and ranked third in its production next to faba bean and haricot bean (FAOSTAT, 2012). National average productivity is 2.053tone ha<sup>-1</sup> in Ethiopia (CSA, 2018)

The deep root system consumes the untapped moisture resource by the former crop and the chickpea crop breakdowns and disturbs the circuit of regular pest and betters soil fertility by natural nitrogen replacement of the soil for use by cereals planted after. Through biological fixation of approximately 140 kg/ha nitrogen, chickpea contributes to as a minimum one-third of the N fertilizer needs of the next cereal crop (Gowda, *et al.*, 2016). In Ethiopia, much of the produce (75%) is used for home consumption (e.g food,seed,exchange) while the remaining 25% is provided to the market (CSA , 2015). Moisture stress (drought) mostly terminal drought, decline in soil fertility, diseases (dry root rot, wilt) insect pests (pod borer and cut worm) are the major constraints for low productivity of chickpea. Declining in soil fertility is one of the limitations contributing for low chickpea production and productivity (Ethio SIS, 2014).

Ethiopia's share in the worldwide chickpea export market is very limited average about 4% by value and volume however, it accounts for 63.5% of the total chickpea export from Africa

(ranks first in Africa and Seventh in the World level). Poor product quality, poor post-harvest practices (harvesting and threshing), absence of marketing information (unable to meet export demand not only in terms of quality but also in terms of quantity, poorly coordinated and extended market chain, high price instability in local markets are considered as Major challenges in Ethiopian chickpea Production. (FAOSTAT, 2013)

As it is true for many tropical and subtropical countries; soil N, P and micronutrient deficiency is common in many African countries. Due to continuous cultivation without external agricultural inputs. Ethiopia faces a wide range of soil fertility problems due to top soil erosion, soil acidity, nutrient and organic matter depletion and soil salinity (Zeleg et al., 2010). Nutrients such as B, S, and K can often be included relatively cheaply in new fertilizer formula; when targeted to deficient soils, these nutrients can dramatically improve fertilizer-use efficiency and crop profitability (John et al., 2000). Ethiopian soil lacks about seven nutrients: (N, P, K, S, Cu, Zn and B) (Ethio SIS, 2013). Moreover, as per soil fertility map of SNNPRS which was developed by ATA (2016), most soils in highland and mid-highland agro-ecologies of Gurage zone in general and Sodo district in particular are deficient with both macro (N, P, K and S) and micro nutrients (B). To reverse yield reduction due to depletion of these nutrients in the study area, the Government of Ethiopia recommend and distributed NPSB fertilizer and Muriate of potash (MOP) to farmers. However, to the best of our knowledge there is no information on optimum rate of blended NPSB fertilizer and Muriate of potash (MOP) that has to be applied for chickpea production in the study area. Hence, there is a need for both site and crop specific fertilizer rate experiment to improve productivity of chickpea in the study areas. Therefore, the study will be conducted with the following objectives to:-

- ❖ To determine effects of blended NPSB and potash fertilizer rates on the yield and yield components of chickpea.
- ❖ To identify the interaction effect of blended NPSB fertilizer and potash fertilizer on chickpea at Sodo District
- ❖ To determine the economically feasible rates of blended NPSB fertilizer for optimum yield of Chickpea in the area.

## **2. LITRATURE REVIE**

### **2.1. Chickpea**

Chickpea is believed to have originated from Turkey and was grown as farbackas 7450 B.C. In Turkey and 4000B.C. in India (ACA, 2004). It is believed that the crop then spread to other parts of Asia, Middle East, and North America and later to other parts of the world (Nuts and Seeds, 2004). Today chickpea is popular throughout China, India, North Africa and Australia, and is also gaining popularity in the United States. In 1994, world production was 7.9 million tons from 10.2 million hectares of which 97% was from developing countries (Nuts and Seeds, 2004). It is a cool-season annual pulse crop that is grown in tropical, subtropical and temperate regions of the world (Muehlbauer and Tulu, 1997).

Chickpea is an herbaceous annual plant which branches from the base. It is almost a small bush with diffused, spreading branches. The plant is mostly covered with glandular or no glandular hairs but some genotypes do not possess hair (Faujdalet *al*, 1995). The habitats of Cicer species can be generalized in to four types: cultivated; weedy; open, dry rubble slopes; and more moist humus- rich forest soils although some species are not exclusively restricted to a single kind of habitat. The chickpea is adapted to the friable soils of agriculture, somewhat cloddy and stony rather than finely tilled. The plant is drought-resistant, but genetic variation exists; the tap root usually extends beyond 1m deep. Proper drainage is required, as with many other species of mountainous areas. The annual *C. bijugum* and *C.Echin ospermum* are often found in disturbed habitats, such as field borders, fallow fields and areas reverting to grass land (Maesen, 1972). Most of the improved chickpea varieties with their appropriate agronomic practices have been demonstrated to farmers, they also constitute elder farmers in the production and marketing of high value improved Kabuli type chickpeas. However, recent study in some districts indicated that on average only about 5% of farmers have adopted any of the improved chickpea varieties (Dad *et al.* 2005). Taken together, this implies the available high yielding varieties with market preferred traits have not fully reached farmer

Chickpea is a cool season legume crop grownup worldwide as a food crop and it is the core edible part of the plant. (FAO, 2008). Not only this it is a cheap and an important source of protein for those people who cannot have enough money to get animal protein or who are mostly

frutitarian. Furthermore, chickpea is too a good source of minerals such as calcium, phosphorus, magnesium, zinc, iron unsaturated fatty acids, fibre and  $\beta$ -carotene with playing additional a significant role of keeping soil fertility by fixing nitrogen at amounts of up to 140 kg/ha/year (Flowers *et al.*, 2010). On the foundation of seed color and geographical delivery, chickpea is grouped into two types: desi (Indian origin) and kabuli (Mediterranean and Middle Eastern origin) (Bampidisa & Christodoulou, 2011). Desi seeds are brown, black or green in color and are cultivated as a legume crop. Kabuli seeds are white to cream colored and are used for cooking purposes for humans (Iliadis, 2001).

The seed weight generally from 0.1 to 0.3 g for desi and 0.2 to 0.6 g for kabuli (Frimpong *et al.*, 2009). The desi type accounts for about 80–85% of total chickpea manufacture, and is grown mostly in Asia and Africa (Jukanti *et al.*, 2012), whereas the kabuli types are mostly full-grown in West Asia, North Africa, North America and Europe. Chickpea (*Cicer arietinum* L.) is supposed to have originated from Turkey and it was grown-up as far back as 7450 B.C. in Turkey and 4000 B.C. in India (ACA, 2004), and it is Domesticated in its innate district (S.E. Turkey), probably as a single event, It present in old Near East archaeological remains (8-9 millenia B.C; and easily identified by its peculiar “ram head” seed shape.) However, it was only well established in the Figurine Age, spread quickly in the Mediterranean area and introduced in India by Aryans in the first millennium BC and in Southern Russia a few centuries BC. Chickpea was the first crop that crossed the Atlantic Ocean as it was transported as food in the Columbus fleet in his first travel of discovery in 1492. Next to its domestication in the Middle East this crop spread all over the Mediterranean region, India and Ethiopia (van der Maesan, 1987). It has now a days remained familiarized to Mexico, Argentina, Peru, Chile, Australia and the USA (Duke, 1981). And other forthcoming chickpea manufacturers include Ethiopia, Iraq, Israel, Jordan, Syria, Canada, Morocco, Malawi and Tanzania.

Chickpea is one of the peak vital cool season legume crops and is full-grown in several countries global as a food basis and in the middle of the food legumes, it is the best nutritious pulse widely used as a source of protein. Which is outstanding nutritious profits and a respect able profitable returns ensured chickpea a smart cash crop in several parts of the world. This crop is the second most important legume after common bean in expressions of cultivation followed by field pea

and third in production among the legume grains comprehensively (Knights *et al.*, 2007). Also it enables to grow in more than 50 countries (89.7% area in Asia, 5% in Africa, 2.6% in Oceania, 2.9% in Americas and 0.4% in Europe) (FAOSTAT.2022). There are two different types of chickpea are recognized, those are Desi and Kabuly types.

Desi chickpea: type is with colored and thick seed coat its common seed colors include many shadows and mixtures of brown, yellow, green and black. These seeds are commonly small and angular with a rough surface. The flowers are generally pink and the plants show various degrees of anthocyanin coloration, while some desi types have white flowers and no anthocyanin coloration on the stem and this type clarification for 80-85% of chickpea area. (Gaur and Gowda, 2010). Kabuli chickpea: These types of chickpeas are categorized by white or beige-colored seed with ram's head character, tinny seed coat, flat seed surface, white flowers, and absence of anthocyanin coloration on the stem. As compared to desi types, the kabuli types have great levels of sucrose and lower levels of fiber. In general it, has large sized seeds and receive higher market price than desi types. (Gaur and Gowda, 2010).

## **2.2. Production of Chickpea in Ethiopia**

Chickpea is Ethiopia's most important pulse crop widely grown in high land and semi-high land regions of the country mainly on clay soil. It is also an excellent source of human and animal food and also plays an important role in the maintenance of soil fertility, particularly in the dry, rain fed areas (Katerji *et al*, 2001). In Ethiopia, archaeological indication from Lalibela caves dated chickpea seed samples as over 2500 years of age (Mitiku Demissie, 2011), and mostly grown up in the central, northern and eastern highland parts of the country at an altitude of 1400-2300 m.a.s.l, somewhere annual rainfall ranges between 700 and 2000 mm.

Ethiopia is the leading producer of chickpea in Africa, accounting for about 46% of the country's production during 1994-2016. It is similarly the seventh largest producer worldwide and pays about 2% to the whole world chickpea a production (Pand *et al*, 2011). Several parts of the country Such, Amhara and Oromya regions are produces 92% of total chickpea (Hulse, 1991). Chickpeais the major cool season food legumes ranked second next to Faba bean, (CSA,

2019). Ethiopia is the largest exporter in Africa, where it is the eighth top chickpea exporter in the world accounting for an average of approximately 3.5% of the global chickpea export market for the last 2 decades, followed by Tanzania with 1.7% (FAOSTAT, 2020).

### **2.3 Importance of chickpea**

Adequate nutrition via food is a necessity of human life. Chickpeas are an ancient crop usually grown for their seed which is nutritionally of a very high quality (Saxena, 1990). The main use of chickpea is for human consumption and the seed provides an excellent source of protein, especially for vegetarians or vegans. The seeds may be eaten as whole; split into halves after removing the seed coat processed into flour or the young shoots may be eaten as a vegetable (Muehlbauer and Tullu, 1997).

Chickpea is economically important in cropping systems because of its ability to assimilate atmospheric nitrogen. Biological nitrogen fixation occurs inside the root nodules of Chickpea species as a result of a symbiosis between the host plant and bacteria (Thavarajah *et al.*, 2005). The fertility benefits are derived from the N-rich chickpea residues remaining after grain harvest and from the higher levels of nitrate that are often found in the root-zone of legume crops at the end of growth. The origin of this nitrate is contentious (Unkovich, 1997). Unkovich and Pate (2000) suggested that the nitrate most likely originates from mineralised rhizodeposits, chickpea roots, and nodules. Soil in which nodulated legumes are growing often contains more nitrate nitrogen (N). Ethiopia exported 48,739 tons of chickpea and received 22.56 M USD (FAOSTAT, 2016)

### **2.4. Role of Mineral Nutrients on Yield and Yield Component of Chickpea**

Application of mineral fertilizers in the tropics had stagnated, and this was explained by poor marketing and in adequate profitability from mineral fertilizer use (Hartemink, 2002). In the past years, mineral fertilizer was advocated for crop production to ameliorate low inherent fertility of soils in the tropics. However, currently it is well recognized that the use of mineral fertilizer has not been helpful in intensive agriculture because it is often associated with reduced crop yield, soil acidity, and nutrient imbalance (Kumar *et al.*, 2013). However, appropriate mineral fertilizer

application, especially nitrogen and phosphorus a required to correct the nutrient imbalance in infertile soils (Peteretal., 2015)

### **2.4.1 Nitrogen**

The most important role of N in the plant is its presence in the structure of protein and nucleic acids which are the most important building and information substances of every cell. In addition, N is also found in chlorophyll that enables the plant to transfer energy from sun light by photosynthesis. Thus, the supply of N to the plant will influence the amount of protein, amino acids, protoplasm and chlorophyll formed. Consequently, it in fluencies cell size, leaf area and photosynthetic activity (Kibe *et al.*, 2006), (Walley *et al.*, 2005), (Salvagiotti *et al.*, 2008). Therefore, adequate supply of N is necessary to achieve high yield potential in crops. In general, N deficiency causes a reduction in growth rate, general chlorosis, often accompanied by early senescence of older leaves, and reduced yield (Caliskan *et al.*, 2008), (Erman *et al.*, 2011).

Dry land fact indicates a number of constraints, which limited farming production. These constraints are climatic in addition to socio-economic and they include use of in appropriate tools, weeds, highly variable response to fertilizers and low organic matter. Not only that in addition to the areas receive insufficient rain which falls mostly as heavy showers, and thus it is lost as runoff and dry lands also have high rates of vaporization, which consequence in reduced productions (Oguya, 2001).

Insufficient biological N fixation in low fertility soil conditions can actually decrease yield in chickpea and additional legume crops (Li *et al.*, 2016). Reservoirs of N in seed and soil can adequately deliver N necessities tray to seedling period of chickpea, while biological N fixation can increase N for the successive plant growth. As a result, indications of N deficit are infrequently presented by chickpea. But, restricted biological N fixation and scarcity of N in soil can encourage N scarcity in chickpea plants, which occurred next expiry of seed N and before the actual nodule development. To recover N scarcity and encourage moral primary growth of chickpea plants starter quantity of N is required, especially in soils with small nutrient holding capability e.g, sandy loam soils (Gan and Warkent, 2010).

Nitrogen application rates also increased grain yield of chick pea. Application of 0, 20, 40 and 60kgN/ha produced 1,099.6; 1,570.5; 1,658.7 and 1,675.8 kg/ha of grain, respectively (Hosseini *et al.*, 2003). There were significant effects of nitrogen fertilizer application ( $P < 0.05$ ) on dry

matter throughout the growth stages. The dry matter production varied with plant population density ranging from 3,429 to 4,689 kg DM/ha in season I and 2,955 to 3,854 kg DM/ha in season II. The highest grain yield was 2,574.4 and 2,353.7 kg grain/ha under 20 and 40 kg N/ha, respectively in seasons I. Grain yields as influenced by planting population densities ranged from 1,273.8 to 3,271.2 kg/ha in season I and 1,027.4 to 1,994.2 kg/ha in season II. Nitrogen fertilizer application at 0, 20, 40 and 60 kg N/ha produced an average of 1,099.6; 1,570.5; 1,658.7 and 1,675.8 kg/ha of grain, respectively Hosseini *et al.* (2003) and Suresh (2004).

Nitrogen fertilizer application at 0, 20, 40 and 60 kg N/ha produced an average of 1,099.6; 1,570.5; 1,658.7 and 1,675.8 kg/ha of grain, respectively. Plots without nitrogen fertilizer (0 kg N/ha) had significantly ( $p < 0.05$ ) lower yield while the other treatments showed no difference in terms of grain yield. And also use of much higher rates of N fertilizer i.e., 0, 50, 75 and 100 kg ha<sup>-1</sup>. Due to higher levels of N fertilizer was achieved almost double branching in treatment with 100 kg N ha<sup>-1</sup> as compared to control. N is structural component of protein, nucleic acids and chlorophyll, therefore its supply to the plant will promote amino acid, protein, protoplasm and chlorophyll formation and ultimately promote cell division and size, photosynthetic activity, leaf area and growth rate (Caliskan *et al.*, 2008), (Namvar *et al.*, 2011).

#### **2.4.2. Phosphorous**

Phosphorus (P) is a vital nutrient equally as a quantity of particular important plant arrangement combinations and as a catalysis in the change of several significant biochemical responses in plants. Phosphorus is Well-known particularly for its character in taking and changing the energy into valuable plant complexes; therefore P is necessary for the overall healthiness and strength of plants. Certain particular growth factors that have exists related with P are: encouraged root growth, improved stalk and stem strength, enhanced flower development and seed production, more identical and previous crop maturity, enlarged nitrogen N-fixing capacity of chickpea, enhancements in crop quality, and increased resistance to plant diseases (Griffith, 2010). Phosphorus conversions and movement in the soil-plant arrangement are organized by a mixture of biological, chemical and physical procedures and quantities, forms and related dynamics of soil P are influenced by a sum of issues counting soil type and ecological situations, as well as land-use and managing follows. In natural environments plant growth is frequently restricted by P accessibility, whereas P is mostly recycled and reserved competently (Frossard *et al.*, 2000).

Still, in managed ecological unit constant inputs of P in the arrangement of fertilizers and introduced fodder deeply disturb the quantity, accessibility and dynamics of soil P (Pierzynski *et al.*, 2000).

The phosphorus application at the rate of 55 kg ha<sup>-1</sup> ranked first with 72.98 % germination, taking 75.50 days to flowering, 44.50 pods plant<sup>-1</sup>, 49.33 seeds plant<sup>-1</sup>, 1.38 cm pod length, maximum number of secondary branches plant<sup>-1</sup> (14.38) was recorded from application of 46kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>, while the minimum number of secondary branches plant<sup>-1</sup> (11.63) was recorded from control Yadav *et al.* (2014). The maximum number of nodules plant<sup>-1</sup> (52.38) was recorded from application 46 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>, while the minimum number of nodules plant<sup>-1</sup> (44.15) was recorded from control. The effects of 23kg 415.80 g seed index and 1691.21 kg ha<sup>-1</sup> seed yield. Phosphorus level of 45 kg, 35 kg, 25 kg and 15 kg ha<sup>-1</sup> categorically ranked 2nd, 3rd, 4th and 5th in almost all the studied traits. However, least performance was resulted by the crop receiving no phosphorus (control). These results are further supported by the findings of Frossard *et al.*, (2000). The P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> and 69kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> were statistically at par. The mean number of nodules plant<sup>-1</sup> increased with increased phosphorus fertilizer rates. Increasing in number of nodules plant<sup>-1</sup> might be due to the fact that application of phosphorus results profuse growth of roots which ultimately resulted formation of more number of nodules of large size. This result was agreed with the findings of Yadav *et al.* (2014). Significantly higher grain yield (2945 kg ha<sup>-1</sup>) was obtained from with the application of 46 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>, while lower seed yield (1265 kg ha<sup>-1</sup>) was recorded for rate of P<sub>2</sub>O<sub>5</sub> applied increased from zero (control) kg P<sub>2</sub>O<sub>5</sub>ha<sup>-1</sup>. Rashid A *et al.*, (2013).

### **2.4.3. Sulfur**

Sulfur(S) fertilizer is recognized to increase crop yield and uptake of macronutrients mainly nitrogen (Islam *et al.*, 2012a).Sulfur is now a days standard as main plant nutrient next to with nitrogen (N), phosphorus (P) and potassium (K) and a basic element of greater chickpea production, is essential in the establishment of proteins, vitamins and enzymes. Also, it is involved in biological nitrogen fixation. In other way deficit of sulfur in soil is limited due to extensive use of sulfur free fertilizer combined with wide spread farming of high sulfur demanding crop, additionally, sulfur necessity of crop plants is relatively high, with high yielding varieties and increased cropping amount large quantities of nutrients are removed from

the soil gradually. If scarcity of S becoming more serious with each passing year which is harshly limiting crop yield, produce quality, nutrient use competence and economic returns on millions farms. Similar as any vital nutrient, sulfur also has certain exact purpose to achieve in the plant. Therefore, sulfur insufficiencies can only be improved by the application of sulfur fertilizer (Tendon and Messick, 2007).

Highest seed yield (1421 kg /ha) noted with 40 kg S/ha (S4) level which was 80.32, 40.97 and 26.64% significantly superior seed yield over 10 kg S/ha (S1), 20 kg S/ha (S2) and 30 kg S /ha (S3) level. 30 kg significantly higher seed yield over 10 kg S /ha (S1) and 20 kg S/ha (S2). Treatment 40 kg S/ha (S4) show higher seed yield over 30 kg S/ha (S3) but did not touch the levels of significance in all the three varieties. Thus, the variety (V1) (DCP 92-03) with 40 kg S/ha (V1S4) resulted in significantly higher seed yield (2408 Kg/ha) Vatsal and Kushwaha, (2017). It was observed from the results that there was increasing trends in chickpea yields from L0 to L2 fertility strips due to increasing S level. Highest yield of 23.51 q ha<sup>-1</sup> was observed in L2 strip with a good response to the application of highest dose of fertilizer and 7.33 q ha<sup>-1</sup> was observed in the L0 strip without fertilizer (control). (Vedhika *et al.*,2015).

#### **2.4.4. Boron**

Boron (B) is a micronutrient plays a major role in enhancing yield of chickpea crop, which is very significant in cell division and in pod and seed creation. Boron ranks third places among micronutrients in its concentration in seed and stem in addition to its total amount next zinc. (Agric., 2007). Boron significantly affected the seed yield of chickpea. (Progress Agric. 2000). The application of boron lead to in a great production of dry matter, due to an increase of the dry weight of pods as well as seeds (Valenciano *et al*, 2010).

The highest number of pods per plant (22.73 pods plant<sup>1</sup>) and the highest seed yield (7.61 g plant<sup>1</sup>) were obtained with 241 g B ha<sup>-1</sup> and the lowest number of pods per plant (15.30 pods plant<sup>1</sup>) and the lowest seed yield (4.99 g plant<sup>1</sup>) were obtained at the control ,Shil *et al.*, (2007). Soil applied 0.45 mg B kg<sup>1</sup> produced 13.5% taller plant height than control. Similarly, no. of pods of Bittle-98 was measured 38.7% maximum than Noor-2013. Boron application of 0.45 mg kg<sup>1</sup> gave 15% more no. of pods. Among different treatments, Bittle-98 with 0.45 mg kg<sup>1</sup> had 47.9% higher no. of pods than Noor-2013 with B0. Likewise, 0.45 mg B kg<sup>1</sup> had 34.8% significantly

maximum no. of grains per pod than control. Cultivar Noor-2013 produced 24.6% more no. of grains per pod than Bittle-98 in different concentrations of B. Cultivar Noor-2013 produced 41.5% more no. of grains per plant than Bittle-98 under different concentrations of B. Regarding 100-grain weight; 0.45 mg kg<sup>-1</sup> had 11.6% more grain weight than control Atique *et al.*, (2021). Boron doses exerted significant influence on seed yield of chickpea. From the results of the experiment we can see that the highest seed yield (1.70 t ha<sup>-1</sup>) was obtained with the application of highest level of boron (3 kg B ha<sup>-1</sup>) and the lowest seed yield (1.39 t ha<sup>-1</sup>) was obtained at the control (Shil *et al.*, 2007).

#### **2.4.5 Potassium**

Potassium (K) is one of the three major essential nutrients required by crop plants and it is absorbed by the plants in large amounts than any other mineral element except nitrogen (Brady, 1990). Potassium is the outer most significance for water status of plant meristematic tissues, supports the plant to struggle pest and diseases and adjusts enzymatic actions and translocation of photosynthetic (Mengel and Kirkby, 1987). Since the extensive choice of biochemical and physiological activities in plant, potassium is essential for gaining the maximum yield of chickpea. (Krauss, 1997). A field experiment was carried out to study the effect of potassium fertilization on chickpea, yield production during rabi 2008-09 to 2010-11. The growth and yield attributes were significantly improved by different potash levels. The application of 20 kg K<sub>2</sub>O/ha increase the seed and straw yield significantly over RDF alone and absolute control.

The significantly minimum plant height, branches/plant-1, pods/plant-1, nodules/plant-1 and 100-seed weight were recorded in plots where the crop was grown without fertilizer application. Plant height, branches/plant-1 and 100 seed weight increased significantly with gradual increase in potash levels up to 40 kg K<sub>2</sub>O/ha-1. Significant increase in plant height could be attributed to the fact that potassium enhances plant vigor and strengthens the stalk, further it has synergistic effect with nitrogen and phosphorous resulted in better plant growth and more number of branches/plant (Das, 1999). The increased pods/plant and 100-seed weight due to K application eventually contributed to higher seed yield. The increased branches/plant-1, pods/plant-1, grain weight/plant-1 and 100-seed weight due to potassium application eventually contributed to higher seed yield. Similar results have been reported by Singh *et al.* (1994) and Samiullah and Khan (2003).

It is clear that significantly maximize the grain and straw yield was with the application of 90 kg potassium ha<sup>-1</sup> (K4) 18.80 and 19.13 q ha<sup>-1</sup>, which was significant and superior to other potassium level treatments like, K3 (15.46 & 15.74 q ha<sup>-1</sup>) and K2 (14.00 & 14.46 q ha<sup>-1</sup>). The magnitude of increase in yield average was to be 37.02 per cent over the control. However, the significantly minimum grain and straw yield (11.84 & 12.58 q ha<sup>-1</sup>) was recorded in the control K1 (0 kg potassium ha<sup>-1</sup>). Reduction of potassium doses reduced these yield may be supported by growth and yield parameter like plant population, plant height, number of branches, dry matter plant<sup>-1</sup>, seed plant<sup>-1</sup>, seed weight plant<sup>-1</sup> and 100 seed weight, which are maximized at 90 kg potassium ha<sup>-1</sup>. It is also clear from that data that an application of potassium with increasing doses also increased grain yield. The yield increased in K4 by margin of K3 (3.34 q ha<sup>-1</sup>), K2 (4.80 q ha<sup>-1</sup>) and K1 (6.96 q ha<sup>-1</sup>), respectively. Thus, this dose performed better in the respect of growth, yield attributes and yield of chickpea. The growth and yield attributes were significantly improved by application of different potash levels (Goud *et al.*, 2014). Similar finding have been reported by Deshmukh *et al.* (1993) and Sharma (2001).

The various yield attributing characters viz. number of pods per plant, number of seed per plant, seed weight per plant and weight of 100 seeds were recorded significantly maximum in application of 90 kg potassium ha<sup>-1</sup> at all stage of growth observations might be due to enhanced availability of plant nutrients, photosynthetic activity, followed by efficient transfer of metabolites and subsequent accumulation of these metabolites in the seed with the resulting in the all yield attributing character. Almost similar results were reported by Rajiv *et al.* (2005), Tomar *et al.* (2001) and Sharma (2001). It was significantly maximize the grain and straw yield was with the application of 90 kg potassium ha<sup>-1</sup> (K4) 18.80 and 19.13 q ha<sup>-1</sup>, which was significant and superior to other potassium level treatments like, K3 (15.46 & 15.74 q ha<sup>-1</sup>) and K2 (14.00 & 14.46 q ha<sup>-1</sup>). The magnitude of increase in yield average was to be 37.02 per cent over the control. However, the significantly minimum grain and straw yield (11.84 & 12.58 q ha<sup>-1</sup>) was recorded in the control K1 (0kg potassium ha<sup>-1</sup>).The growth and yield attributes were significantly improved by application of different potash levels (Goud *et al.*, 2014).

### 3. MATERIAL AND METHODS

#### 3.1. Description of study area

The experiment was conducted from September to November 2021 at Firshy Kebele, Sodo District, Gurage zone of Southern Nations, Nationalities and Peoples Regional state. Sodo District was located 126 km at Eastern part of Wolkite and 103 km Southern of Addis Ababa. It's location at the coordinate of 8° 19' N and 38° 39' E with an altitude of 1800 m.a.s.l. The experimental site found at an altitude of 1800 m.a.s.l and with 1020 mm of annual rain fall and 25 °C and 10 °C with a maximum and minimum temperature of respectively. The soil was classified as Vertisol (SWFEO, 2019).

#### 3.2. Source of experimental material

The experiment was used the improved Kabuli chickpea /dubie/Arartie variety which was released by Debrezeite Agricultural Reaserch Center (DZARC) Ethiopia in 1978 E.C (Table.1).

**Table 2.**Improved Kabuli/ Arartie variety released in Debrezeite Ethiopia (Chickpea Production in SNNPR , 2015)

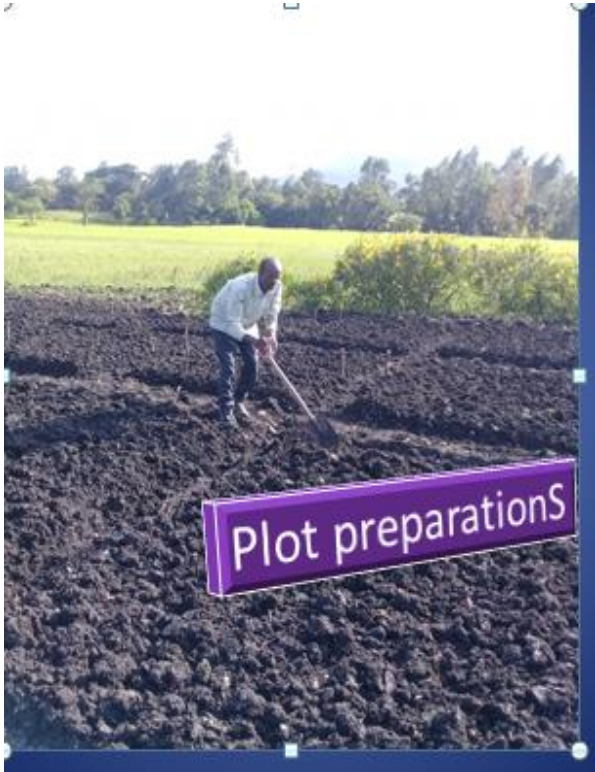
Variety	Center released the variety	Year of release	Days to Maturity.	100seed wt(g)	Seed rate (kg/ha)	Altitude (m.a.s.l.)	Rainfall (mm)	Pro duc tivity(t/ ha)	
								Pro duc	Far me
Arartie	Debrezeite	1999	110-115	25.0	100-90	1900–2600	700-1200	2.6-4.6	2.0-3.2

Muriate of Potash (MOP) (0–0–60) and NPSB (18.9N+, 37.7P2O5+6.95S+0.1B) fertilizer were obtained from Sodo Wereda Farmers Co-oprative Assosiation. Farmers in the study area were applied both fertilizers at a rate of 100 kg ha<sup>-1</sup> for chickpea.

#### 3.3. Experimental design and treatment

The experiment was a factorial experiment. Four levels of NPSB fertilizer rate (0, 50, 100 and 150 kg ha<sup>-1</sup>) and four levels of Muriate of potash (0, 50, 100 and 150 kg ha<sup>-1</sup>) was laid out in randomized complete block design (RCBD) with three replications. Each replication had sixteen plots corresponded to the sixteen treatments (Table 2). Each plots had a gross plot size of 6 m<sup>2</sup> (2m \*3m) which was accommodated ten rows per plot and twenty plants per each rows. The spacing between each plots was 0.5 m and the spacing between each blocks was 1 m. The

spacing between the plant and row was 10 cm and 30 cm, respectively. Treatment combination was assigned randomly to each plot with in the block using lottery method. All the recommended agronomic practice was performed uniformly in all plots.



**Table 3** Treatment combinations of the experiment

Treatment number	NPSB kg ha <sup>-1</sup>	Muriate of potash (MOP) kg ha <sup>-1</sup>
T1	0	0
T2	0	50
T3	0	100
T4	0	150
T5	50	0
T6	50	50
T7	50	100
T8	50	150
T9	100	0
T10	100	50
T11	100	100
T12	100	150
T13	150	0
T14	150	50
T15	150	100
T16	150	150

### 3.4. Experimental Procedure and Trial management

Land preparation was done according to the local farmers practice. Therefore, the land was ploughed four times using oxen before planting and the last plough was done as farmers practice before sowing to make it ready for sowing and insuring seedbeds are well leveled. Then individual treatment was allocated randomly to the trial plot with-in each block. Planting was done at September 20, 2022 which was a common practiced in the study area. Seed were sown at recommended rate 80kg h<sub>1</sub> and spacing to the respective plots. Application of the blended NPSB fertilizer and Muriate of Potash (MOP) was done at the time of sowing in a furrow, 5 cm away from the row and covered with soil after application. The crop was harvested when it was matured properly. The time of harvesting is crucial in maintaining the quality of seeds. The crop should be harvested when leaves start to senesce and start shedding. The pods on the plant will turn yellow and seeds in the pods feel hard and rattle within the pod. Other agronomic practices like weeding, hoeing, fencing, guarding and related to the crop have been kept uniformly and carried out as per the recommendation.



### 3.5. Soil Sampling and Analysis

About 30 sub-samples using random sampling technique were collected before planting by using auger from the upper 0-30 cm soil depth in a “W” sampling pattern and a composite was made. Sampling was also made from each plot immediately after harvest. Soil texture, organic carbon, total nitrogen and CEC before planting and pH, available K, available P, available S and available B after harvest were analyzed following standard procedures at Soil laboratory of Areka Research Center, Ethiopia. Soil samples were dried in air at a dust free environment. Samples for all parameters except organic carbon and total N were allowed to pass through 2 mm sieve. For organic carbon and total N determination samples were ground to pass a 0.5 mm size sieve.

Particle size distribution was analyzed using hydrometer method (Bouyoucos, 1951) pH using digital pH meter in 1:2.5 soil to water ratio (Van Reeuwijk, 1992). Available phosphorus was determined by Olsen method (Olsen *et al.*, 1954), total N by Kjeldahl method (Bremner and Mulvaney, 1982), organic carbon using wet oxidation method (Walkley and Black, 1934), CEC by ammonium acetate saturation method (Chapman, 1965). Available S turbidimetric method, available B spectrophotometric methods. (Gupta, 1979). Available K 1N ammonium acetate (Simon R.H, 1945).

### 3.6. Data collected method

#### 3.6.1. Phonological data collected

**Days to emergence:** was recorded when 50 percent of the plants in each plot were emerged.

**Days to flowering:** was recorded when 50 percent of the plant population in each plot was produced flowers. (Janagrad *et al.*, 2009).

**Days to maturity:** was recorded when 90 percent of the plants of different treatments were ready for harvested as shown by the senescence of stem. The days were counted from emerged to maturity of the crop. (Masumba, 1984).

#### 3.6.2 Growth parameter

**Plant height (cm):** average height of ten randomly selected plants was measured from the soil surface to the top most growth point of aboveground at full maturity.

**Primary branches (number):** primary branches of ten plant was counted and the average was reported as primary branch per plant.

**Dry weight:** ten plants were taken from two destructive the plants were kept at 65°c in oven until getting constant weight at full developed stage of flowering. The mean value from ten plants was taken as shoot dry weight per plant.

### **3.6.3. Nodulation parameter**

For determining of nodulation parameters from ten plants per each plot at 50% flowering stage of the crop. Uprooting was done by spade and shovel and soil was removed from the root system by hand. The adhering soil was removed by washing the roots gently with water over a metal sieve. Nodules remaining in the soil were picked up by hand. The plants from each plot were used to record the following observations.

**Number of nodules per plant:** Number of nodules from ten uprooted plants per plot was counted and average was taken as number of nodules per plant

**Nodule dry weight per plant:** The collected nodules was labeled and placed in perforated paper bags. The nodule dry weight per plant was measured after drying the collected nodules in an oven with a temperature of 65 °C for 48 hrs. The average of ten Plant were taken as a nodule dry weight per plant.

**Number of effective nodules per plant:** After dissecting nodule with pink to brown color were considered as effective and those with green and white color nodules were sorted as non-effective nodules.

**Nodules Volume:** the collected nodules were immersed in previously measured volume of water In measuring cylinder. The volume of water displaced by nodules was considered as nodule volume (ml).

### **3.6.4. Yield and Yield Component**

**Number of seeds per pod:** from ten randomly selected plant pods was separated and threshed and then number of seeds was counted from five pods per plant. Average number of seeds per pod were reported as number of seed per plant

**Number of pods per plants:** Number of pods for the ten plants was counted and then the mean number of pods per plant was obtained at physiological maturity

**Hundred seed weight:** was recorded by weighing 100 randomly taken dry seeds harvested from the net plot using a sensitive balance and the weight was adjusted to 10% seed moisture content.

**Above ground biomass (kg ha<sup>-1</sup>):** biological yield was measured by weighing the sun-dry total above ground plant biomass (straw + grain) of the net plot area and converted to a hectare base.

**Grain yield (kg ha<sup>-1</sup>):** Chickpea from the net plot area was harvested and threshed to determined crop yield and then the seed was adjusted to moisture level of 10 %. Finally, the yield per plot was converted to kilogram per hectare.

**Harvest index (HI) %:** was considered as proportion of dry grain yield to the above ground biomass yield.

$$\text{H.I.} = \frac{\text{dry seed yield}}{\text{Total dry weight}} \times 100$$

### 3.7. Statistical Analysis

A data was examined through Analysis of Variance (ANOVA) used general linear model (GLM) technique in statistical analysis software (SAS Version 9.4, SAS. Inc). Whenever significant differences detected in the F- test, means was associated using the LSD at 5% level of significance. Correlation analysis was was made between relevant parameter

### 3.8. Partial Budget Analysis

The economic effect of NPSB blended fertilizer application on chickpea was evaluated using a partial budget analysis. Inorganic NPSB blended fertilizer was considered as the variable costs. An economic assessment was done using partial budget procedure described by CIMMYT (1988). The variable costs of NPSB fertilizer ETB 3500 per 100 kg ha<sup>-1</sup> and Muriate of Potash (MOP) fertilizer ETB 3000 per 100 kg ha<sup>-1</sup> at time of planting were taken from Sodo Districts Farmer's Cooperative association. The price of the current chickpea grain at harvest (ETB 4000 per 100 kg) was taken from Office of Trade and Industry Marketing Case Team of Sodo District and local pay rate of ETB 90 person<sup>-1</sup> day<sup>-1</sup>. The average yield was adjusted downward by 10% to reflect the farmer's field yield as described by CIMMYT (1988), while the marginal rate of return for each blended NPSB blended fertilizer rate and Muriate of Potash was calculated as a change of net benefit divided by change of variable cost and multiplied by 100 (CIMMYT,1988).

## 4. RESULT AND DISCUSSION

### 4.1. Physico-chemical Characteristics of Soil before Planting

Composite soil sampling analysis before planting result showed that the soil is clay in texture with pH of 7.65, Organic carbon of 1.26. Total N content of 0.082% available P content of 13.62 ppm , available S content of 12.52 ppm available K(246.53 ppm and CEC of 21.53 cmol (+)/kg soil<sup>-1</sup>. According to the rating of Tekalign (1991), the experimental soil was rated as moderately alkaline and the organic carbon was low. According to Havlin *et al.* (1999), total nitrogen content (TN) of the experimental soil was rated as low. Available P was rated as medium as per Olsen et al. (1954). CEC was rated as medium. As per the nutrient rating of Karlton (2013) the study soil had low available S. Similarly, the extractable B (0.51 mg/kg) before is also bellow the critical level (0.8 mgkg<sup>-1</sup> soil). As per the rating of Karlton (2013).

**Table 4.** Physico-chemical analysis result of experimental soil before planting

Soil characters	Unit	Value	Rating	References
Sand	%	32		–
Silt	%	24	_	–
Clay	%	44	_	–
Textural class	–	Clay		–
PH	–	7.65		Tekalign <i>et al.</i> (1991)
Organic carbon	%	1.26		Landon, (1991).
CEC	cmol (+) kg <sup>1</sup>	21.53		Olsen et al., (1954)
Total nitrogen	%	0.10		Havlin <i>et al.</i> , (1999)
Available P	mg kg <sup>-1</sup>	13.62		Olsen et al., (1954)
Available S	mg kg <sup>-1</sup>	12.52		Karlton ,(2013)
Extractable B	mg kg <sup>-1</sup>	0.51		Karlton ,(2013)
Available K	ppm	246.53		Kundsen ,et al.,(1982)

Where Cmol = Cent mole, pH = hydrogen power, OC (%) = percent of organic carbon, TN = Percent of total nitrogen, Av.p (ppm) = available P in parts per million, Av. S = A availabl sulphur , av.B available Boron,K= Potassium, of Potash, CEC = Cation exchange capacity.

## 4.2. Crop Phenology

### 4.2.1. Days to 50% flowering

ANOVA showed that days to 50% flowering was highly significant ( $P < 0.0001$ ) influenced by two way interactions between MOP and rates of NPSB fertilizer (Appendix Table 1). Thus, a treatment with  $0\text{kg NPSB ha}^{-1}$  was earlier (88.33 days) to 50% flowering and the longest days to 50% flowering (91.00) was observed on the interaction rate of  $100\text{kg NPSB/ ha}^{-1}$  and  $100\text{kg MOP/ha}^{-1}$  fertilizer application (Table 4 and Figure 1a,1b & 1c). The data obtained in this study revealed that with an increase in the rate of the blended fertilizer date of flowering was longer. Moreover, significant variations among different levels of NPSB application might be due to enhancing property of (NPSB) in many aspects of plant physiology like process of photosynthesis, flowering, seed formation and maturation. This means that time of beginning of flowering is always earlier by NPSB fertilizer deficiency. Among macro nutrients Muriat of Potash (MOP) plays a vital role in photosynthesis, enzyme activation, protein synthesis and resistance against the pest attack and diseases (Arif *et al.*, 2008). The present finding confirms the findings of Acharya *et al.* (2007) who observed that phosphatic fertilizer promotes flowering, seed formation and crop maturity.



Figure 1. Vegetative stage of the trial



Figure 1a. Flowering stage of the trial



Figure 1b. Flowering stage of the trial



Figure 1c. Flowering stage of the trial

#### 4.2.2. Days to 90% maturity

ANOVA showed the two way interaction rate of Blended NPSB Fertilizer and Muriate of Potash (MOP) was highly significant ( $p < 0.0001$ ) on 90% of maturity days (Appendix Table 1).

A treatment with both of  $0\text{kg NPSB ha}^{-1}$  and  $0\text{kg MOP ha}^{-1}$  was earlier (111.33) days to 90% maturity days and the longest days to 90% maturity day (120.33) was observed on the interaction rate of  $100\text{kg NPSB/ha}^{-1}$  and  $100\text{kg MOP/ha}^{-1}$  fertilizer application (Table 4 and Figure 4).



Figure 3. Grain filling period



Figure 4. Maturity and/or harvesting time

### 4.3. Growth Parameters

#### 4.3.1. Plant height

The analysis of variance showed highly significant ( $P < 0.0001$ ) effects at the two way interactions of NPSB and Muriate of Potash (MOP) (Appendix Table 1). Thus, the tallest plant height (67.00cm) was recorded at interaction rate of 150kg NPSB/ ha<sup>-1</sup> and 150kg MOP/ha<sup>-1</sup> fertilizer application. While the shortest plant height (25.33cm) was recorded 0 kg NPSB ha<sup>-1</sup> and 0 kg MOP ha<sup>-1</sup> (Table 4 and Figure 5). Significant increase in plant height could be attributed to the fact that potassium enhances plant vigor and strengthens the stem additional it has synergistic effect with nitrogen and phosphorous resulted in better plant growth and more number of branches/plant (Das, 1999). Tomar *et al.* (2004) found the positive interaction effect of NPSB and MOP. Furthermore, the presence of Potash in the blended fertilizer might have also significantly increased plant height due to it plays important role in the cell division and nitrogen absorption from the soil, enhancing plant growth eventually plant height increased.



Figure 5. Stage of measuring plant height while completion of vegetative growth

#### 4.3.2. Number of primary branches

The analysis of variance (ANOVA) showed that number of primary branches of chickpea was significantly ( $P < 0.0396$ ) influenced by the two way interactions of NPSB fertilizer rate and Muriate of Potash fertilizer rate (Appendix Table 1). A treatment received  $150 \text{ kg NPSB ha}^{-1}$  and  $150 \text{ kg ha}^{-1}$  was produced the highest (8.00) number of primary branches per plant. Whereas, a treatment with  $0 \text{ kg NPSB ha}^{-1}$  and  $0 \text{ kg MOP ha}_1$  produced the lowest (2.67) number of primary branches per plant (Table 1). This might be due to the fact that lack of the available growth resources and more competition of the limited nutrition resources for branching as on the other hand, optimal supply of NPSB & MOP in the early stage of plant growth enhanced the crop lateral growth. On the other hand, the possible reason for lower number of primary branches per plant at  $0 \text{ kg NPSB ha}^{-1}$  might be due to the fact that the legumes require NPSB & MOP for optimal symbiotic performance.

#### 4.3.3. Number of Secondary Branches

The analysis of variance (ANOVA) showed the Number of Secondary Branches chickpea was highly significantly ( $P < 0.0001$ ) influenced by the two way interaction of NPSB blended fertilizer and MOP. The highest secondary branches chickpea was recorded (16.00) branches on a treatment received 150 kg NPSB  $\text{ha}^{-1}$  and 150 kg  $\text{ha}^{-1}$  fertilizer rates, Whereas the lowest secondary branches was recorded (5.67) at the control.



Figure 6. Stage of counting primary and secondary branch

#### 4.3.4. Shoot Fresh weight

The analysis of variance (ANOVA) showed that a two way interaction of Blended NPSB Fertilizer rate and Muriate of Potash (MOP) was highly significant ( $P < 0.0001$ ) on the Shoot Fresh weight (Appendix Table 1). The highest shoot fresh weight (135.33 g/plant) was recorded on the interaction of Blended NPSB Fertilizer rate and Muriate of Potash (MOP) 150 kg  $\text{ha}^{-1}$  and 150 kg  $\text{ha}^{-1}$  respectively. While, the lowest shoot fresh weight (90.67kg/plant) was recorded at the control (Table 4).

**Table 4: Two-way interaction effects of NPSB and MOP fertilizer rates on the Phonological data**

Treatments		FD	MD	PLH	PB	SB	SFW	SDW
NPSBrate (kg ha <sup>-1</sup> )	MOPrate (kg ha <sup>-1</sup> )							
0	0	85.00 <sup>f</sup>	111.33 <sup>h</sup>	25.33 <sup>m</sup>	2.67 <sup>e</sup>	5.67 <sup>i</sup>	90.67 <sup>j</sup>	17.00 <sup>k</sup>
	50	88.67 <sup>bcd</sup>	116.67 <sup>def</sup>	32.00 <sup>k</sup>	2.33 <sup>e</sup>	5.00 <sup>j</sup>	92.00 <sup>j</sup>	19.33 <sup>j</sup>
	100	88.00 <sup>cde</sup>	116.67 <sup>def</sup>	35.00 <sup>j</sup>	5.67 <sup>cd</sup>	8.0 <sup>fgh</sup>	98.67 <sup>h</sup>	21.67 <sup>i</sup>
	150	90.00 <sup>abc</sup>	118.33 <sup>bcd</sup>	35.00 <sup>j</sup>	5.00 <sup>cd</sup>	7.00 <sup>hij</sup>	94.33 <sup>i</sup>	20.33 <sup>ij</sup>
50	0	88.00 <sup>cde</sup>	112.33 <sup>gh</sup>	30.00 <sup>l</sup>	3.33 <sup>e</sup>	7.33 <sup>hi</sup>	95.67 <sup>i</sup>	24.00 <sup>h</sup>
	50	89.00 <sup>abcd</sup>	114.67 <sup>fg</sup>	35.33 <sup>j</sup>	5.00 <sup>cd</sup>	7.67 <sup>ghi</sup>	107.00 <sup>f</sup>	26.00 <sup>gh</sup>
	100	86.00 <sup>ef</sup>	118.0 <sup>bcd</sup>	41.00 <sup>h</sup>	6.00 <sup>bc</sup>	9.67 <sup>defg</sup>	116.33 <sup>e</sup>	27.33 <sup>fg</sup>
	150	90.00 <sup>abc</sup>	119.33 <sup>abc</sup>	45.00 <sup>g</sup>	5.33 <sup>cd</sup>	10.0 <sup>def</sup>	116.33 <sup>e</sup>	27.33 <sup>fg</sup>
100	0	88.67 <sup>bcd</sup>	118.00 <sup>bcd</sup>	36.33 <sup>ij</sup>	4.67 <sup>d</sup>	8.00 <sup>fgh</sup>	102.67 <sup>g</sup>	29.00 <sup>ef</sup>
	50	88.00 <sup>cde</sup>	118.3 <sup>bcd</sup>	53.67 <sup>e</sup>	6.00 <sup>bc</sup>	11.00 <sup>de</sup>	123.00 <sup>d</sup>	31.33 <sup>cd</sup>
	100	91.00 <sup>a</sup>	120.33 <sup>abc</sup>	67.00 <sup>a</sup>	8.33 <sup>a</sup>	15.33 <sup>ab</sup>	135.00 <sup>a</sup>	31.67 <sup>bcd</sup>
	150	85.33 <sup>f</sup>	120.67 <sup>ab</sup>	58.00 <sup>c</sup>	6.0 <sup>bc</sup>	11.67 <sup>cd</sup>	129.00 <sup>b</sup>	30.33 <sup>de</sup>
150	0	88.0 <sup>d</sup>	115.67 <sup>ef</sup>	38.00 <sup>i</sup>	4.67 <sup>d</sup>	9.00 <sup>efgh</sup>	98.67 <sup>h</sup>	29.00 <sup>de</sup>
	50	88.0 <sup>d</sup>	118.00 <sup>bcd</sup>	50.67 <sup>f</sup>	6.00 <sup>bc</sup>	15.33 <sup>ab</sup>	124.33 <sup>cd</sup>	33.33 <sup>abc</sup>
	100	87.7 <sup>de</sup>	118.33 <sup>bcd</sup>	61.67 <sup>b</sup>	7.00 <sup>b</sup>	16.00 <sup>a</sup>	125.67 <sup>c</sup>	33.67 <sup>ab</sup>
	150	90.7 <sup>ab</sup>	121.3 <sup>a</sup>	55.67 <sup>d</sup>	6.00 <sup>bc</sup>	13.67 <sup>bc</sup>	130.3 <sup>b</sup>	34.00 <sup>a</sup>
P value		0.03219	0.2464	0.0655	0.07563	0.08447	0.2114	0.1521
LSD (5%)		2.1	2.1	1.7	1.2	1.8	2.1	2.0
CV (%)		1.2	1.1	2.3	13.9	11.0	1.14	4.3

**Whereas:** FD=Flowering date, MD=Maturity Date, PLH=Plant Height in centimeter, PB=Primary Branch, SB=Secondary Branch, SFW=Shoot Fresh Weight and SDW=Shoot Dry Weight

#### **4.3.5. Shoot Dry weight**

The analysis of variance (ANOVA) showed that a two way interaction of Blended NPSB Fertilizer rate and Muriate of Potash (MOP) was highly significant ( $P < 0.0001$ ) on the Shoot dry weight (Appendix Table 1). The heist Shoot dry weight (33.67g/plant) was recorded on the interaction of Blended NPSB Fertilizer rate and Muriate of Potash (MOP) 150 kg ha<sup>-1</sup> and 150 kg ha<sup>-1</sup> respectively. Whereas, the lowest shoot dry weight (17.00 g/plant) was recorded at the control (Table 4).

#### **4.3.6. Root Fresh Weight**

The analysis of variance (ANOVA) showed that a two way interaction of Blended NPSB Fertilizer rate and Muriate of Potash (MOP) was highly significant ( $P < 0.0001$ ) on the Root Fresh Weight (Appendix Table 1). The heist Root Fresh Weight (17.00 g/plant) was recorded on the interaction of Blended NPSB Fertilizer rate and Muriate of Potash (MOP) 100 kg ha<sup>-1</sup> and 100 kg ha<sup>-1</sup> respectively. Whereas, the lowest shoot dry weight (3.67 g/plant) was recorded at the control (Table 1).

#### **4.3.7. Root dry Weight**

The analysis of variance (ANOVA) showed that at the two-way interaction of blended NPSB fertilizer and Muriate of Potash (MOP) was highly significant ( $P < 0.0001$ ) on root dry weight of chickpea per plant (Appendix Table 1). The heist Root dry Weight was recorded (5.33 g/plant) on the interaction of Blended NPSB Fertilizer rate and Muriate of Potash (MOP) 150 kg ha<sup>-1</sup> and 150 kg ha<sup>-1</sup> respectively. Whereas, the lowest shoot dry weight (1.67 g/plant) was recorded at the control (Table 4).

#### **4.3.8. Number of Nodule**

The analysis of variance (ANOVA) showed that the two way interaction of NPSB fertilizer rate and Muriate of Potash (MOP) was highly significant ( $P < 0.0001$ ) on the number of nodules (Appendix Table 1). Thus, the highest number of total nodules per plant (13.00) was obtained from the application of blended NPSB rate of 150 kg ha<sup>-1</sup> and 150 kg ha<sup>-1</sup> Muriate of Potash (MOP) (Table 5 and Figure 7). Whereas the lowest

#### 4.3.9. Nodule fresh weight

The analysis of variance showed that the two way interaction effect blended NPSB fertilizer rate and Muriate of Potash (MOP) was significant ( $P < 0.04$ ) on the Nodule fresh weight (Appendix Tabel 1). Thus, the highest weight of total nodules per plant (8.00) was obtained from the application of blended NPSB rate of  $100 \text{ kg ha}^{-1}$  and  $100 \text{ kg ha}^{-1}$  Muriate of Potash (MOP). Whereas the lowest number of nodule (2.00) was obtained at the Control (Table 5 and Figure 7).

##### 4.3.3.1. Nodule dry weight

The dry weight of total nodules per plant in chickpea was significantly ( $P < 0.05$ ) influenced by the two way interaction of NPSB blended fertilizer rate and Muriate of Potash (MOP) (Appendix Table 1). Thus, the highest (4.67mg) dry weight of total nodules per plant was obtained from a received  $150 \text{ kg NPSB ha}^{-1}$  and  $150 \text{ kg ha}^{-1}$  Muriate of Potash (MOP). while the lowest (1.67 mg) total nodules dry weight values were obtained at the Control (Table 5 and Figure 7).

##### 4.3.3.2. Nodule Volume

The analysis of variance (ANOVA) showed that the two way interaction of NPSB fertilizer rate and Muriate of Potash (MOP) was highly significant ( $P < 0.0001$ ) on the Volume of Nodule (Appendix Table). A treatment received  $100 \text{ kg NPSB ha}^{-1}$  and  $100 \text{ kg MOP ha}^{-1}$  was produced the highest (3.67ml) Volume of Nodule per plant. Whereas, a treatment with  $0 \text{ kg NPSB ha}^{-1}$  and  $0 \text{ kg MOP ha}^{-1}$  produced the lowest (1.67ml) Volume of Nodule per plant (Table 5).

##### 4.3.3.3. Number of effective nodule

The analysis of variance showed that the two way interaction effect of NPSB fertilizer application had highly significant ( $P < 0.0001$ ) effect on the number of effective nodules per plant in chickpea (Appendix Table 1). The highest number of effective nodules per plant (7.67) was recorded at the rate of  $100 \text{ kg NPSB ha}^{-1}$  and the rate of  $100 \text{ kg MOP ha}^{-1}$ . while the lowest number of effective nodules per plant (1.67) was recorded at the Control (Table 5). As a result, their interaction increased the rate of nitrogen fixation that improved the effectiveness of nodules. The current finding is in line with many authors have been reported that legume nodules having dark pink or red colors due to presence of leg hemoglobin are an indication for effectiveness of the Nodules, which is well correlated with nitrogen fixation (Butler and Evers, 2004).



Figure 7. Stages of nodules data capturing

**Table 5: Two-way interaction effects of NPSB and MOP fertilizer rates on the Root and Nodules related data**

Treatments		RFW	RDW	NN	NFW	NDW	NV	EN
NPSBrate (kg ha <sup>-1</sup> )	MOPrate (kg ha <sup>-1</sup> )							
0	0	3.67 <sup>f</sup>	1.67 <sup>f</sup>	7.33 <sup>h</sup>	2.00 <sup>e</sup>	1.67 <sup>f</sup>	1.67 <sup>e</sup>	1.67 <sup>f</sup>
	50	9.00 <sup>d</sup>	2.33 <sup>ef</sup>	13.00 <sup>bc</sup>	3.00 <sup>cde</sup>	2.33 <sup>ef</sup>	2.67 <sup>cde</sup>	2.33 <sup>ef</sup>
	100	10.0 <sup>cd</sup>	2.33 <sup>ef</sup>	11.67 <sup>cdef</sup>	4.00 <sup>bcd</sup>	3.00 <sup>cd</sup>	2.67 <sup>cde</sup>	2.67 <sup>e</sup>
	150	10.00 <sup>cd</sup>	3.33 <sup>cde</sup>	12.00 <sup>cde</sup>	5.00 <sup>b</sup>	3.00 <sup>cd</sup>	2.67 <sup>cd</sup>	2.67 <sup>e</sup>
50	0	6.00 <sup>e</sup>	1.67 <sup>f</sup>	8.00 <sup>h</sup>	2.67 <sup>de</sup>	1.67 <sup>f</sup>	1.67 <sup>e</sup>	2.67 <sup>e</sup>
	50	10.00 <sup>cd</sup>	3.00 <sup>de</sup>	10.67 <sup>efg</sup>	4.00 <sup>bcd</sup>	3.33 <sup>cd</sup>	2.33 <sup>de</sup>	2.67 <sup>e</sup>
	100	12.00 <sup>b</sup>	3.33 <sup>cde</sup>	13.00 <sup>bc</sup>	4.67 <sup>b</sup>	3.33 <sup>cd</sup>	3.33 <sup>bcd</sup>	5.00 <sup>b</sup>
	150	11.00 <sup>bc</sup>	3.33 <sup>cde</sup>	12.00 <sup>cde</sup>	4.00 <sup>bcd</sup>	3.33 <sup>cd</sup>	3.67 <sup>bc</sup>	3.67 <sup>d</sup>
100	0	8.00 <sup>cd</sup>	2.67 <sup>ef</sup>	10.00 <sup>fg</sup>	4.00 <sup>bcd</sup>	2.33 <sup>ef</sup>	2.33 <sup>de</sup>	2.33 <sup>ef</sup>
	50	10.00 <sup>cd</sup>	4.00 <sup>cd</sup>	12.67 <sup>bcd</sup>	4.67 <sup>b</sup>	3.67 <sup>cd</sup>	2.33 <sup>de</sup>	2.67 <sup>e</sup>
	100	15.00 <sup>a</sup>	6.33 <sup>a</sup>	15.00 <sup>a</sup>	8.00 <sup>a</sup>	6.33 <sup>a</sup>	6.33 <sup>a</sup>	7.67 <sup>a</sup>
	150	12.00 <sup>b</sup>	3.33 <sup>cde</sup>	13.00 <sup>bc</sup>	5.00 <sup>b</sup>	3.33 <sup>cd</sup>	4.00 <sup>b</sup>	5.33 <sup>b</sup>
150	0	8.33 <sup>d</sup>	2.67 <sup>ef</sup>	9.00 <sup>gh</sup>	3.00 <sup>cde</sup>	2.33 <sup>ef</sup>	2.33 <sup>de</sup>	2.67 <sup>e</sup>
	50	11.00 <sup>bc</sup>	5.33 <sup>ab</sup>	11.00 <sup>def</sup>	4.33 <sup>bc</sup>	4.67 <sup>b</sup>	3.33 <sup>bcd</sup>	4.00 <sup>cd</sup>
	100	11.67 <sup>bc</sup>	4.33 <sup>bc</sup>	11.00 <sup>def</sup>	5.33 <sup>b</sup>	4.00 <sup>bc</sup>	2.67 <sup>cde</sup>	4.00 <sup>cd</sup>
	150	12.00 <sup>b</sup>	4.33 <sup>bc</sup>	14.00 <sup>ab</sup>	4.3 <sup>bc</sup>	3.67 <sup>cd</sup>	2.67 <sup>cde</sup>	4.67 <sup>bc</sup>
P value		0.006812	0.02809	0.1241	0.1483	0.686	0.1175	0.01932
LSD(5%)		1.6	1.04	1.7	1.4	1.0	0.9	0.8
CV (%)		9.4	18.5	9.2	19.3	21.0	19.3	13.8

Whereas: RFW=Root Fresh Weight, RDW=Root Dry Weight, NN=Nodule Number, NFW=Nodule Fresh Weight, NDW=Nodule Dry Weight, NV=Nodule Volume and EN=Effective Nodules

## **4.4. Yield and Yield Components of Chickpea**

### **4.4.1. Number of Pods per Plant (NPpP)**

The analysis of variance (ANOVA) showed that highly significant ( $P < 0.001$ ) at the two way interaction of blended NPSB fertilizer rate and the rate of Muriate of potash on the number pod per plant (Appendix Table 1). Thus the highest (131.33) total number of pods per plant was recorded at the interaction rate of 100 kg NPSB ha<sup>-1</sup> and 100 kg MOP ha<sup>-1</sup> on the number of pods per plant. While, the lowest (63.33) total number of pods per plant was recorded at the Control of treatments (Table 6 and Figure 8).

Plant growth behavior of legume crops including chickpea can be determined by number of pods per plant. So, this indicate that increase in number of pods per plant with the increased NPSB and Muriate of Potash rates might possibly be due to adequate availability of N, P, S, B and MOP which might have facilitated the production of primary branches and plant height which might in turn have contributed for the production of higher number of total pods per plant In agreement with the result of Moniruzzaman *et al.*

### **4.4.2. Number of seed per pod (NSPP)**

The analysis of variance (ANOVA) showed that highly significant ( $P < 0.001$ ) at the two way interaction of blended NPSB fertilizer rate and the rate of Muriate of potash on the number of seeds per pod (Appendix Table 1). Thus the highest (1.36) total number of seeds per pod was recorded at the interaction rate of 100 kg NPSB ha<sup>-1</sup> and 100 kg MOP ha<sup>-1</sup> on the number of seeds per pod. While, the lowest (1.07) total number of seeds per pod was recorded at the Control of treatments (Table 6).



Figure 8. The performance of the trial and the number of pods looks like

#### 4.4.3. Hundred Seed weight (HSW)

The analysis of variance revealed that the two way interaction effect of NPSB application rates and Muriate of Potash (MOP) was significant ( $P < 0.01$ ) affected on the hundred Seed weight (Appendix Table 1). Maximum hundred seed weight (22.19g) was recorded from in the interaction of 150 kg NPSB ha<sup>-1</sup> fertilization and 150 kg Muriate of Potash ha<sup>-1</sup> rate; while, minimum (21.8g) was recorded at the control (Table 6 and Figure 9). The increase in 100 seed weight with fertilizer application is in agreement with the finding of Shamim and Naimat (1987). The increased pods/plant and 100-seed weight due to K application eventually contributed to higher seed yield. The result further shows that potassium increased the number of nodules per plant Singh *et al.* (1994) and Samiullah and Khan (2003).



Figure 9. Stages of hundred seed weight measured

#### 4.4.4. Biomass(BM)

The analysis of variance (ANOVA) showed significant ( $P < 0.001$ ) at the two way interaction of blended NPSB fertilizer rate and the rate of Muriate of potash on the Biomass (Appendix Table 1). The highest Bio Mass ( $28600 \text{ kg ha}^{-1}$ ) was recorded on the interaction NPSB rate of  $100 \text{ kg ha}^{-1}$  and  $100 \text{ kg ha}^{-1}$  Muriate of Potash (MOP) application rates and the lowest Biomass ( $888.67 \text{ kg}$ ) was recorded at the control (Table 6 and Figure 10).

#### 4.4.5. Grain yield (GY)

The analysis of variance (ANOVA) showed highly significant ( $P < 0.001$ ) at the two way interaction of blended NPSB fertilizer rate and the rate of Muriate of potash on the Grain Yield (Appendix Table 1). The highest Grain yield ( $1953.33 \text{ kg ha}^{-1}$ ) was recorded on the interaction NPSB rate of  $100 \text{ kg ha}^{-1}$  and  $100 \text{ kg ha}^{-1}$  Muriate of Potash (MOP) application rates and followed by second with interaction NPSB levels of  $150 \text{ kg ha}^{-1}$  and MOP level of  $150 \text{ kg ha}^{-1}$  with grain yield of ( $1760.00 \text{ kg}$ ). The lowest Grain yield ( $888.67 \text{ kg}$ ) was recorded at the control (Table 6). The growth and yield attributes were significantly improved by application of different potash levels (Goud *et al.*, 2014). Similar finding have been reported by Deshmukh *et al.* (1993) and Sharma (2001).



Figure 10. Stage biomass measured

#### **4.4.6. Harvest index (HI)**

Analysis of variance indicated that, harvest index was highly significant ( $P < 0.001$ ) affected by the two way interaction of NPSB application rates and Muriate of Potash on the harvest index (Appendix Table 1). Thus maximum (0.07) harvest index was recorded with interaction of  $100\text{kg NPSB ha}^{-1}$  and  $100\text{kg ha}^{-1}$  Muriate of Potash application rate and minimum(0.06) was recorded at the control (Table 6). Indicating that harvest index is a measure of physiological productivity potential of a crop or variety. It is the ability of a crop to convert the dry matter into economic yield.

**Table 6: Two-way interaction effects of NPSB and MOP fertilizer rates on the Yield and Yield Components.**

Treatments		NPPP	NSPP	HSW	BM	GY	HI
NPSB rate (kg ha <sup>-1</sup> )	MOP rate (kg ha <sup>-1</sup> )						
0	0	61.67 <sup>i</sup>	1.07 <sup>j</sup>	21.84 <sup>e</sup>	15300.00 <sup>j</sup>	886.67 <sup>m</sup>	0.0577 <sup>k</sup>
	50	63.33 <sup>i</sup>	1.18 <sup>i</sup>	21.99 <sup>cde</sup>	17333.33 <sup>hi</sup>	1216.67 <sup>k</sup>	0.0643 <sup>j</sup>
	100	71.67 <sup>g</sup>	1.26 <sup>ef</sup>	22.02 <sup>cde</sup>	18233.33 <sup>g</sup>	1296.67 <sup>j</sup>	0.0657 <sup>ij</sup>
	150	71.33 <sup>g</sup>	1.25 <sup>efg</sup>	22.04 <sup>cde</sup>	18166.67 <sup>g</sup>	1300.00 <sup>ij</sup>	0.0660 <sup>ij</sup>
50	0	67.67 <sup>h</sup>	1.17 <sup>i</sup>	21.95 <sup>de</sup>	16833.33 <sup>i</sup>	1086.67 <sup>l</sup>	0.072 <sup>bcd</sup>
	50	72.00 <sup>g</sup>	1.22 <sup>gh</sup>	22.16 <sup>cde</sup>	19200.00 <sup>f</sup>	1343.33 <sup>hi</sup>	0.0717 <sup>cde</sup>
	100	81.67 <sup>f</sup>	1.28 <sup>de</sup>	21.99 <sup>cde</sup>	20466.67 <sup>e</sup>	1503.33 <sup>f</sup>	0.0713 <sup>cde</sup>
	150	85.67 <sup>e</sup>	1.26 <sup>ef</sup>	22.18 <sup>cde</sup>	20733.33 <sup>e</sup>	1550.00 <sup>e</sup>	0.0707 <sup>def</sup>
100	0	73.67 <sup>g</sup>	1.23 <sup>fgh</sup>	21.91 <sup>de</sup>	17766.67 <sup>gh</sup>	1183.33 <sup>k</sup>	0.0693 <sup>efg</sup>
	50	108.67 <sup>b</sup>	1.32 <sup>bc</sup>	22.17 <sup>cde</sup>	19066.67 <sup>f</sup>	1380.00 <sup>h</sup>	0.0687 <sup>fgh</sup>
	100	131.00 <sup>a</sup>	1.36 <sup>a</sup>	24.19 <sup>a</sup>	28600.00 <sup>a</sup>	1953.33 <sup>a</sup>	0.0687 <sup>fgh</sup>
	150	102.33 <sup>c</sup>	1.33 <sup>b</sup>	22.44 <sup>cd</sup>	23700.00 <sup>b</sup>	1696.67 <sup>c</sup>	0.0667 <sup>hij</sup>
150	0	73.33 <sup>g</sup>	1.22 <sup>gh</sup>	21.93 <sup>de</sup>	21533.33 <sup>d</sup>	1430.00 <sup>g</sup>	0.0730 <sup>abd</sup>
	50	98.00 <sup>d</sup>	1.31 <sup>bc</sup>	22.19 <sup>cde</sup>	23300.00 <sup>bc</sup>	1616.67 <sup>d</sup>	0.0743 <sup>ab</sup>
	100	108.33 <sup>b</sup>	1.29 <sup>cd</sup>	23.20 <sup>b</sup>	23700.00 <sup>b</sup>	1663.33 <sup>d</sup>	0.0747 <sup>a</sup>
	150	107.33 <sup>b</sup>	1.26 <sup>ef</sup>	22.50 <sup>c</sup>	23033.33 <sup>c</sup>	1760.00 <sup>b</sup>	0.0737 <sup>abc</sup>
P value		0.3738	0.6386	0.01056		0.0001534	
LSD (5%)		2.6	0.03	0.51	0.6	0.42	0.003
CV (%)		1.8	1.2	1.4	1.6	1.7	2.3

NB: NPSB = Nitrogen, Phosphorus, Sulfur, Boron, MOP = Muriate of Potash, LSD = Least Significant Difference, CV = Coefficient of Variance.

## **4.5 Soil Nutrient analysis after harvesting**

### **4.5.1 Total Nitrogen**

ANOVA showed that the rate of the main factor of Post harvested Total Nitrogen was highly significant ( $P < 0.0001$ ) affected by the blended NPSB fertilizer rate and effect on total nitrogen content of the soil. Moreover, the interaction effect of NPSB and MOP rates was significantly ( $p < 0.05$ ) affecting total nitrogen of the soil after harvest (Appendix table7). The high total nitrogen were recorded from 100 NPSB kg ha<sup>-1</sup> with the interaction of 150 MOP kg ha<sup>-1</sup>; and also 150 NPSB with the interaction of 50 kg ha<sup>-1</sup> and 100kg ha<sup>-1</sup> MOP (0.11)(Table 7).

The, supply of N to the plant will influence the amount of protein, amino acids, protoplasm and chlorophyll formed. Consequently, it influences cell size, leaf area and photosynthetic activity (Kibe *et al.*, 2006), (Walley *et al.*, 2005), (Salvagiotti *et al.*, 2008). Therefore, adequate supply of N is necessary to achieve high yield potential in

### **4.5.2 Available of Phosphorous (P)**

ANOVA indicated that the rate of two way interactions between MOP and rates of NPSB fertilizer had highly significant ( $p < 0.001$ ) effect on Post harvested Phosphorous . P is necessary for the overall healthiness and strength of plants. Certain particular growth factors that have exists related with P are: encouraged root growth, improved stalk and stem strength, enhanced flower development and seed production, more identical and previous crop maturity, enlarged nitrogen N-fixing capacity of chickpea, enhancements in crop quality, and increased resistance to plant diseases (Griffith, B (2010).

### **4.5.3 Available Sulfur (S)**

ANOVA indicated that the rate of two way interactions between MOP and rates of NPSB fertilizer had highly significant ( $p < 0.003$ ) effect on Post harvested Sulfur. Whereas the rate of the main factor on blended NPSB rate of fertilizer was Non-Significant. Sulfur(S) fertilizer is recognized to increase crop yield and uptake of macronutrients mainly nitrogen (Islam *et al.*, 2012a),

#### **4.5.4 Available Boron (B)**

ANOVA showed that the rate of two way interactions between MOP and rates of NPSB fertilizer had highly significant ( $p < 0.001$ ) effect on Post harvested available Boron. And also the two way interactions between MOP and rates of NPSB fertilizer had highly significant ( $p < 0.001$ ) effect on Post harvested Sulfur. Whereas the rate of the main factor on blended NPSB rate of fertilizer was Non-Significant. Boron (B) is a micronutrient plays a major role in enhancing yield of chickpea crop, which is very significant in cell division and in pod and seed creation (Agric, 2007)

#### **4.5.5 Available Potassium (K)**

ANOVA showed that the rate of two way interactions between MOP and rates of NPSB fertilizer had highly significant ( $p < 0.001$ ) effect on Post harvested available Potassium.

Potassium (K) is one of the three major essential nutrients required by crop plants and it is absorbed by the plants in large amounts than any other mineral element except nitrogen (Brady, 1990). Potassium is the outer most significance for water status of plant meristematic tissues, supports the plant to struggle pest and diseases and adjusts enzymatic actions and translocation of photosynthetic (Mengel and Kirkby, 1987). The increased pods/plant and 100-seed weight due to K application eventually contributed to higher seed yield. Similar results have been reported by Singh *et al.* (1994) and Samiullah and Khan (2003).

**Table 7: Two-way interaction effects of NPSB and MOP fertilizer rates on soil nutrients after harvest**

Treatments		TN	Avail. P	Avail. K	Avail. S	Extractable B
NPSB rate (kg ha <sup>-1</sup> )	MOP rate (kg ha <sup>-1</sup> )					
0	0	0.07 <sup>c</sup>	15.53 <sup>bc</sup>	245.59 <sup>g</sup>	17.73 <sup>c</sup>	0.59 <sup>h</sup>
	50	0.08 <sup>d</sup>	15.74 <sup>bc</sup>	246.87 <sup>g</sup>	17.69 <sup>c</sup>	0.70 <sup>fgh</sup>
	100	0.09 <sup>d</sup>	15.41 <sup>bc</sup>	262.96 <sup>ef</sup>	18.147 <sup>c</sup>	0.73 <sup>efgh</sup>
	150	0.10 <sup>bc</sup>	15.87 <sup>abc</sup>	269.04 <sup>e</sup>	17.62 <sup>c</sup>	0.79 <sup>efgh</sup>
50	0	0.08 <sup>d</sup>	15.23 <sup>bc</sup>	252.34 <sup>fg</sup>	18.76 <sup>c</sup>	0.63 <sup>gh</sup>
	50	0.09 <sup>d</sup>	16.75 <sup>ab</sup>	284.30 <sup>d</sup>	19.37 <sup>c</sup>	0.94 <sup>ef</sup>
	100	0.09 <sup>d</sup>	17.86 <sup>ab</sup>	286.98 <sup>d</sup>	23.27 <sup>ab</sup>	1.21 <sup>bc</sup>
	150	0.11 <sup>a</sup>	18.42 <sup>ab</sup>	309.35 <sup>c</sup>	24.29 <sup>b</sup>	1.37 <sup>b</sup>
100	0	0.09 <sup>cd</sup>	16.34 <sup>ab</sup>	254.99 <sup>fg</sup>	17.73 <sup>ab</sup>	0.88 <sup>defg</sup>
	50	0.10 <sup>bcd</sup>	16.51 <sup>ab</sup>	286.35 <sup>d</sup>	18.69 <sup>c</sup>	1.09 <sup>bcd</sup>
	100	0.10 <sup>bcd</sup>	19.45 <sup>b</sup>	363.96 <sup>b</sup>	21.21 <sup>c</sup>	1.14 <sup>bcd</sup>
	150	0.11 <sup>a</sup>	19.05 <sup>b</sup>	371.37 <sup>b</sup>	24.83 <sup>a</sup>	1.66 <sup>a</sup>
150	0	0.09 <sup>cd</sup>	17.73 <sup>ab</sup>	272.54 <sup>e</sup>	23.83 <sup>ab</sup>	0.96 <sup>efgh</sup>
	50	0.11 <sup>a</sup>	19.99 <sup>b</sup>	293.72 <sup>d</sup>	23.33 <sup>c</sup>	0.99 <sup>cde</sup>
	100	0.11 <sup>a</sup>	18.27 <sup>ab</sup>	368.17 <sup>b</sup>	24.44 <sup>b</sup>	1.34 <sup>b</sup>
P Value		0.2551	0.5130	0.2496	0.0128	0.0014
LSD (5%)		0.0136	3.3083	11.332	3.7172	0.29
CV (%)		7.03645	6.19903	1.99909	7.093418	16.52355

Interaction means within a column followed by the same letter (s) are not significantly different from each other at 5% level of significance based on Fishers LSD test; \*\*\* = significant at  $P \leq 0.001$ ; LSD= least significance difference, CV= Coefficient of variation

#### 4.6. Economic Analysis

The partial budget analysis was used to identify treatments with the peak return for the farmer's investment. The results of the partial budget analysis for NPSB blended fertilizer rate as compared to Muriate of Potash (MOP) and their combination response of yield and yield components of chickpea. For partial budget analysis, the variable cost of fertilizer and labor were taken at the time of planting and during other operations.

The average yield was adjusted down ward by 10 % to reflect the field yield as described by CIMMYT (1988). The return was calculated as total gross return minus total variable cost. Blended NPSB fertilizer price (35 Birr kg<sup>-1</sup>), price of Muriate of Potash (MOP) (30Birr kg<sup>-1</sup>) during planting time, labor cost at (100 Birr per person per day), price of land rent (8000 Birr ha<sup>-1</sup>), price for fence (3000 Birr for total area of treatment), were used for variable cost. All input for economic analysis was based on mean value over location. The highest gross farm gate benefit 70320 ETB ha<sup>-1</sup> was gain from yield obtained at interaction effect of 100kg NPSB ha<sup>-1</sup> + 100kgMOP ha<sup>-1</sup> (Table 8).

Therefore, the marginal rate of return was done based on a treatment to be considered as valuable to farmers, that is 50% and 100% marginal rate of return (MRR) is the minimum acceptable rate of return (CIMMYT, 1988). Hence, it is important to compare treatments to eliminate undesirable treatments in view of economic viability rather than only looking at the highest grain yield, because it may not be attractive if they required very much higher cost. Thus, the highest net benefit was 63132.5ETB ha<sup>-1</sup> achieved at plot treated with a rate of 100kg NPSB ha<sup>-1</sup> and 100kg MOP ha<sup>-1</sup> interaction (Table 8). Consequently, interaction effect of 100 kg NPSB ha<sup>-1</sup> and 100kg MOPkg<sup>-1</sup> was more economically attractive than all other treatment. Application of 100 kg NPSB ha<sup>-1</sup> + 100kg MOP ha<sup>-1</sup> resulted in the highest mean grain yield increase as compared to all other treatments (Table 8).

It could be considered as the most profitable treatment. It has the highest return to the money invested in its production; it exploited profit and output and reduced costs. All combination effect from rate of NPSB fertilizer and Muriate of Potash, were economically viable and had progressive marginal rate of returns. The economic analysis has led to 100 kg NPSB ha<sup>-1</sup> + 100kg MOP ha<sup>-1</sup> was suitable for potential acceptance by farmers if additional study required to be accepted on the same experiment to confirm for additional use. Generally, significant maximum grain yields were obtained from 100kg blended NPSB ha<sup>-1</sup> fertilizer interacted with 100kg MOP ha<sup>-1</sup> had maximum marginal rate of return.

**Table 8 Summary of economic analysis of the response of Chickpea for rates of Blended NPSB fertilizer and Muriate of Potash (MOP).**

Treatments		Grain yield					
NPSB g ha <sup>-1</sup>	Muriat Potash (MOP)kg/ha <sup>-1</sup>	UGY/kg /ha	AGY/kg /ha	GFB (ETBha <sup>1</sup> )	TVC (ETB ha1)	NB (ETBha <sup>-1</sup> )	MRR(%)
0	0	886.67	798	31941	687.5	31653.5	0
0	50	1300.00	1170	46800	2187.5	44612.5	868
0	100	1296.67	1167	46680	3687.5	42992.5	D
0	150	1216.67	1095	43800	5187.5	36812.5	D
50	0	1086.67	978.07	39121.2	2437.5	36683.7	D
50	50	1343.33	1209	48360	3937.5	44422.5	19.38
50	100	1503.33	1353	54120	5437.5	48682.5	35.21
50	150	1550.00	1395	55800	6937.5	48862.5	833.33
100	0	1380.00	1242.33	4693.2	4187.5	505.7	D
100	50	1183.33	1068.03	42721.2	5687.5	37033.7	4.10
100	100	1953.33	1758	70320	7187.5	63132.5	5.74
100	150	1696.67	1527.07	61082.8	8687.5	55145.3	D
150	0	1616.67	1455.07	58202.8	5937.5	52265.3	D
150	50	1430.00	1288	51520	7437.5	44082.5	D
150	100	1663.33	1497.03	59881.2	8937.5	50943.7	21.86
150	150	1760.00	1584	63360	10437.5	52922.5	75.80

Where, UGY = Unadjusted grain yield; AGY = adjusted grain yield; GFB = gross field benefit; TVC= total variable costs; NB = net benefit; MRR = marginal rate of return; ETB ha<sup>-1</sup> = Ethiopian Birr per hectare; D=dominated treatments.

## 5. SUMMARY AND CONCLUSION

Use of proper blended NPSB application rate and Muriate of Potash (MOP) are the major agronomic practices that can increase the productivity of chickpea. Therefore, a field experiment was conducted at Sodo District in 2021/22 with the objectives of to investigate the effect of blended NPSB fertilizer and potash rates on yield and yield components of chickpea at Sodo District. And four rates of (0, 50, 100 and 150 kg of NPSB ha<sup>-1</sup>) and also four label of Muriate of potash /MOP/ (0, 50, 100 and 150 kg ha<sup>-1</sup>) were conducted in a factorial RCBD with three replication. Combined use of rate of blended NPSB fertilizer with Muriate of Potash was a significant corresponding strategy in improving chickpea production as well as reducing production price. The analysis of variance had shown that the interaction effect of blended NPSB fertilizer with Muriate of Potash on growth components such as plant height, number of primary and secondary branches per plant, shoot fresh and dry weight, roots dry and fresh weight, all nodules parameter and yield parameters were highly significant. This could be reason for highly significant increase on yield and yield component as the rate increases.

The interaction of 100 kg NPSB ha<sup>-1</sup> and Rate of 100 kg MOP ha<sup>-1</sup> indicated that dominance over all treatments by giving 131 pods plant<sup>-1</sup>, 24.2 hundred seed weight and 1953kg ha<sup>-1</sup> seed yield. The development and use of high yielding cultivars may suggestion as one of the suitable components of eco-friendly practice. The interaction effect of Blended NPSB rate of 100 kg ha<sup>-1</sup> and rate of 100 kg ha<sup>-1</sup>Muriate of Potash (MOP) shown the highest net benefit (63132.5 ETE) and the lowest (ETB 31653.5 ha<sup>-1</sup>) net return was recorded at the control. Based on the results of this study, it can be concluded that chickpea productivity highly varied due to application rates of NPSB fertilizer and Muriate of Potash.

Although the experiment was conducted at one site and for one season and rate of Blended NPSB fertilizer and Muriate of Potash were used, it is reasonable to point out that at application rate of 100 kg NPSB ha<sup>-1</sup> with 100 kg MOP ha<sup>-1</sup> produced the highest yield of chickpea production.

## 6. REFERENCE

- ACA. (2004), Agriculture crops: Alternatives chickpea. Alternative crop species Eds. R. S. Jessop, R. L. Wright pp. 27-38.
- Ahlawat IPS, Gangaih B & Zahid MA (2007). Nutrient management in chickpea. In Chickpea Breeding and Management. Ed: S.S. Yadav. CAB International pp 214.
- Ahlawat IPS, Gangaiah B, Ashraf ZM. Nutrient management in chickpea. In: Chickpea breeding and management (Yadav SS., Redden R., Chen W., Sharma B, eds). CAB International, Wallingford, Oxon, United Kingdom. 2007;213-232.
- Bampidisa VA, Christodoulou V (2011), Chickpeas (*Cicerarietinum* L.) in animal nutrition: A review. *Animal Feed SciTechnol* 168: 1–20.
- Brady, N. C. (1990). The nature and property of soils.
- Caliskan S, Ozkaya I, Caliskan ME & Arslan M (2008). The effect of nitrogen and iron fertilization on growth, yield and fertilizer use efficiency of soybean in Mediterranean type soil. *Field Crops Res* 108: 126-132.
- CIMMYT. Economics Program, International Maize and Wheat Improvement Center (1988). From agronomic data to farmer recommendations: an economics training manual No 27. Pp20.
- CSA (Central Statistical Authority). Crop Production Forecast Sample Survey; Statistical Bulletin; CSA: Addis Ababa, Ethiopia, 2015.
- DadiL, Regassa S, Fikre A and Mitiku D. 2005. Adoption of chickpea varieties in the central high and of Ethiopia. Research Report 62. EARO (Ethiopian Agricultural Research Organization), AddisAbaba ,Ethiopia
- Das, PC. (1999). Plant Nutrients. In: Manures and Fertilizers 2nd Edition. Kalyani Publishers, New Delhi, India, pp: 5-10.
- . Deolankar, K. P. (2005). Effect of fertigation on growth and yield of chickpea (*Cicer arietinum* L.). *Journal of Maharashtra Agricultural University*, 30(2) : 170-172.4
- Deshmukh, Atre, V. N., A. H. Rangacharya and R. P. M S. S.Ravatkar (1993). Effect of phosphorus and potassium application on growth, yield, quality and nutrient uptake by groundnut (*Arachis hypogia*). *Journal of Potassium Research*, 9(1) :72-75

- Duke JA (1981) Handbook of Legumes of World Economic Importance. Plenum Press, New York.
- Ethiopian Agricultural Transformation Agency (ATA) and Ministry of Agriculture (2014). Soil fertility status and fertilizer recommendation atlas for Tigray regional state, Addis Ababa, Ethiopia.
- FAOSTAT 2020. Available online: <https://www.fao.org/faostat/en/#data> (accessed on 23 August 2020).
- FAOSTAT.2022. <https://www.fao.org/faostat/en/#data/QCL/visualize>.accessed .Feb 23, 2022
- Frimpong A, Sinha A, Tañan B (2009), Genotype and growing environment influence chickpea (*Cicer arietinum* L.) seed composition. *J Sci Food Agric* 89: 2052–2063.
- Frossard, E., L. M. Condon, A. Oberson, S. Sinaj, and J. C. Fardeau. (2000), Processes governing phosphorus availability in temperate soils. *J. of Environ Quality*. 29: 15-23.
- Flowers TJ, Gaur PM, Laxmipathigowda CL, (2010), Salt sensitivity in chickpea. *Plant cell Environ* 33:490-509.
- Gaur PM, Tripathi S, Gowda CLL, RangaRao GV, Sharma HC, Pande S and Sharma M. (2010), Chickpea Seed Production Manual. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics
- Gan YT, Warkentin TD, Bing DJ, Stevenson FC & McDonald CL (2010), Chickpea water use efficiency in relation to cropping system, cultivar, soil nitrogen and Rhizobial inoculation in semiarid environments. *Agric Water Manag* 97(9): 1375-1381.
- Griffith, B (2010), Efficient Fertilizer Use — Phosphorus.
- Gowda, C.L.L.; Gaur, P.M.; Samineni, S. Chickpea Research and Development: Current Status and Future Perspectives in the Semi-arid Tropics. In Proceedings of the Harnessing Chickpea Value Chain for Nutrition Security and Commercialization of Smallholder Agriculture in Africa, Debre Zeit, Ethiopia, 30 January–2 February 2016; Korbu, L., Damite, T., Fikre, A., Eds.; EIAR: Addis Abäba, Ethiopia, 2016. Available online: <http://oar.icrisat.org/id/eprint/9977> (accessed on 15 March 2020).
- Goud, V. V., N. M. Konde, P. V. Mohod and V. K. Kharche (2014). Response of chickpea to potassium fertilization on yield, quality, soil fertility and economic in vertisols. *Legume Research*, **37(3)** : 311-315



- Namvar A, Sharifi RS & Khanda T (2011). Growth analysis and yield of chickpea (*Cicer arietinum* L.) in relation to organic and inorganic nitrogen fertilization. *Ekologija* 57(3): 97-108 Nuts and Seeds- Chickpea Newsletter, (2004), 1/12/2004.
- Oguya V, 2001. The use of information and communication technologies to deliver dry land farming information in Eastern Africa. *Greening the Brown, Progress and Prospects* 13: 143-150.
- Olika, E.; Abera, S.; Fikre, A. Effect of Processing Methods on Proximate Composition and Functional Properties of Improved Chickpea (*Cicer arietinum* L.) Varieties Grown in Ethiopia. *Food Sci. Qual. Manag.* **2018**, 72, 36–42.  
<https://iiste.org/Journals/index.php/FSQM/article/view/40992/42150> (accessed on 15 Mar 2020).
- Pande S, Sharma M, Gaur PM, Tripathi S, Kaur L, Basandrai A, et al. 2011; Development of screening techniques and identification of new sources of resistance to *Ascochyta* blight disease of chickpea. *Australasian Plant Pathology*. 40(2):149-156.
- Pande, S., Desai, S. and Sharma, M. (2010), Impacts of Climate Change on Rainfed Crop Diseases: Current Status and Future Research Needs. National Symposium on Climate Change and Rainfed Agriculture, Hyderabad pp. 55-59.
- Pierzynski, G.M., J.T. Sims, and G.F. Vance. (2000), Soil phosphorus and environmental quality. In: *Soils and Environmental Quality*, 2nd edn. CRC Press, Boca Raton, Florida. 155-207.
- Pittaway, J. K., I. K. Roberston and J. B. Madeleine (2008). Chickpea may influence fatty acid and fiber intake in an ad Libitum Diet, leading to small improvements in serum lipid profile and glycemic control. *J.the Academy of Nutrition & Dietetics*, **108(6)**:1006-1013.
- Pundir, R.P.S., and M.H. Mengesha. 1995. Cross compatibility between chickpea and its wild relative, *Cicer echinospermum* Davis. *Euphytica* 83:241–245. doi:10.1007/BF01678136
- Rashid A, Ishaque M, Hameed K, Shabbir M, Ahmad M (2013) Growth and yield response of three chickpea cultivars to varying NPK levels. *Asian J Agric Biol* 1: 95-99.
- Saimullah and Khan, N. (2003). Physiological investigation on interactive effect of P and K on growth and yield of chickpea. *Indian Journal of Plant Physiology* 8(2): 165-170.
- Saxena N.P. (1990). Status of chickpea in the Mediterranean basin. In: Present Status and Future Prospects of Chickpea Crop Production and Improvement in the Mediterranean Countries. *Options Méditerr. (CIHEAM) Ser.*, 9: 17-24

- Singh, B. K. H.(1997). Studies on medico-botany of Meitei community in Manipur state, India (III), Adv. Plant Sci., Supplement (III), 9: 2
- Singh, ON, Singh, RS, and Singh, JP. (1994). Supplementing fertilizer potassium to chickpea. Journal of Potash Research 10:83-85.
- Sharma, K. C. (2001). Fertilizer management in chickpea (*Cicer arietinum* L.) under rain fed conditions of Jammu region of Kashmir. *Advances in Plant Sciences*, **14(2)** :519-523.
- Shil NC, Noor S, Hossain MA. Effects of boron and molybdenum on the yield of chickpea. *Agric. Rural Dev.* (2007), ;5(1-2): 17.
- Srivastava SP, Yadav CR, Rego TJ, Johansen C, Saxena NP. Diagnosis and alleviation of boron deficiency causing flower and pod abortion in chickpea (*Cicerarietinum* L.) in Nepal. In: Boron in soils and plants. Developments in Plant and Soil Sciences 76 (Bell R.W., Rerkasem B., eds). Luwer Academic Publishers, Dordrecht, The Netherlands. 1997;9599.
- SWAO,(2020) Annual report of Sodo wereda's chickpea production in Sodo wereda Agricultural office.
- Swarup, A. (2002), Lessons from long term fertilizer experiments in improving fertilizer use efficiency and crop yields. *Fertilizer news*, 47 (12): 59-73.
- Sunil, C.M., Shekara, B.G., Ashoka, P., Murthy, K.K.,& Madhukumar, V. (2011), Effect of integrated weed management practices on nutrient uptake in aerobic rice. *Research on Crops*, 12(3), 629–632. [Google Scholar]
- Tondan HLS, Messick DL. Practical of sulphur guide. Sulphur uptake of chickpea (*cicerarietinum*. L.) under late sown condition Indian soil. *Agron.* 2007; 49(1):5759
- Tabe-Ojonga, M.P., Jr.; Kai, M. Impacts of Improved Chickpea Adoption on Smallholder Production and Commercialization in Ethiopia. In Proceedings of the Tropentag 2017, Bonn, Germany, 20–22 September 2017.
- Thavarajah D, BallA, R,and Schenau J.J,(2005). Nitrogen fixation, Amino Acid,and Ureid Associations in Chickpea *Crop Science* 45: 2497-2502, Wageningen, Netherland.
- Tomar, Kanzaria R. S. and M. V. V. K. Jain (2001). Response of chickpea (*Cicer arietinum* L.) to potassium in a calcareous soil. *Journal of Potassium Research*, **17(1/4)** :98-100.
- Tondan HLS, Messick DL. 2007Practical of sulphur guide. Sulphur uptake of chickpea (*cicerarietinum*. L.) under late sown condition Indian soil. *Agron.*; 49(1):5759

- Yadav, B.K. and Kumar, S., 2014. Performance of chickpea (*cicer arietinum*) under different levels of phosphorous and sulphur application. *Plant Archives*, 14(2), pp.1115-1117.
- Yadeta A and Geletu B (2002) Evaluation of Ethiopian chickpea land races for tolerance to drought. *Genetic Resources and Crop Evolution* 49:557-564.
- Unkovich MJ, Pate J.S and Sanford P.(1997) Nitrogen fixation by annual legumes in Australian, Mediterranean, agriculture, *Australian Journal Research* 48,267-293.
- Valenciano JB, Marcelo V, Boto JA. Response of chickpea (*Cicer arietinum*) yield to micronutrient application under pot conditions in Spain. *Spanish Journal of Agricultural Research*. 2010;8(3):797-80
- Van der Maesen LJG (1987) Origin, history and taxonomy of chickpea. In: Saxena MC, Singh KB(eds), *The Chickpea*. CAB International, Wallingford, UK, pp11-34
- Zeleeke *et al*, 2010 *Fertilizer and Soil Fertility Potential in Ethiopia*.

## **APPENDIX TABLE**

**Appendix Table 1. ANOVA Phenology, growth, root, nodule, yield and related traits of analysis of variance (ANOVA)**

	DE			DF		DM		PLH		PB		SB		SFW		SDW	
	DF	MS	Pr>f	MS	Pr>F	MS	Pr>f	MS	Pr>f	MS	Pr>f	MS	Pr>f	MS	Pr>f	MS	Pr>f
NPSB	3	3.0556	0.002	4.465	0.0155	12.69	4E-04	1278.965	<.0001	13.33333	<.0001	116.4653	<.0001	2014.743	<.0001	124.7431	<.0001
MOP	3	11.889	<.0001	1.688	0.2255	71.08	<.0001	868.2431	<.0001	18.16667	<.0001	46.85417	<.0001	1214.576	<.0001	151.8542	<.0001
Rep	2	1.6458	0.043	8.521	0.0019	9.771	0.006	6.270833	0.0054	1.6875	0.0563	6.520833	0.01	5.395833	0.0492	8.770833	0.0048
NPSB*MOP	9	0.2778	0.792	14.34	<.0001	10.89	<.0001	64.35417	<.0001	1.240741	0.0396	7.076389	0.0001	105.9097	<.0001	51.72454	<.0001
CV		12.82773		1.185742		1.066852		2.291562		13.89229		10.97587		1.14361		4.313096	
R-Square		0.782861		0.833105		0.886713		0.995735		0.872333		0.939813		0.995464		0.969627	
Mean		5.333333		88.39583		117.4792		43.72917		5.25		10.02083		111.2292		1.170826	

	SFW		SDW		RFW		RDW		NNPP		NFW		NDW		Nvol		EN	
	MS	Pr>f	MS	Pr>f	MS	Pr>f	MS	Pr>f	MS	Pr>f	MS	Pr>f	MS	Pr>f	MS	Pr>f	MS	Pr>f
NPSB	2014.743	<.0001	124.7431	<.0001	13.35417	<.0001	6.854167	<.0001	10.13194	0.0002	8.6875	<.0001	2.333333	0.002	4	<.0001	9.861111	<.0001
MOP	1214.576	<.0001	151.8542	<.0001	57.85417	<.0001	8.243056	<.0001	29.07639	<.0001	16.85417	<.0001	3.722222	0.0001	5.611111	<.0001	14.91667	<.0001
Rep	5.395833	0.0492	8.770833	0.0048	5.395833	0.0067	1	0.0444	5.145833	0.0159	2.645833	0.01	1.395833	0.0356	1.270833	0.0282	0.770833	0.053
NPSB*MOP	105.9097	<.0001	51.72454	<.0001	10.09491	<.0001	2.150463	<.0001	8.798611	<.0001	2.428241	0.0004	0.833333	0.0481	2.981481	<.0001	3.435185	<.0001
CV	1.14361		4.313096		9.425184		16.86224		9.216971		17.06067		20.95671		19.25129		13.76018	
R-Square	0.995464		0.969627		0.920555		0.884924		0.864811		0.875857		0.717437		0.860222		0.937454	
Mean	111.2292		1.170826		10.10417		3.1875		11.27083		4.104167		2.916667		2.916667		3.541667	

	NPPP			NSPP		NSPPOD		HSW		BM		GY	
	DF	MS	Pr>f	MS	Pr>f	MS	Pr>f	MS	Pr>f	MS	Pr>f	MS	Pr>f
NPSB	3	3532.354	<.0001	567.0764	<.0001	0.032147	<.0001	1.310606	<.0001	91.61	<.0001	51.07472	<.0001
MOP	3	1812.743	<.0001	1671.188	<.0001	0.036247	<.0001	1.951239	<.0001	66.05722	<.0001	54.90694	<.0001
Rep	2	7.89583	0.0489	23.27083	0.0003	0.000752	0.0532	0.34334	0.0371	0.881458	0.0017	0.289375	0.0174
NPSB*MOP	9	316.0579	<.0001	102.669	<.0001	0.002534	<.0001	0.738548	<.0001	5.285741	<.0001	2.160093	<.0001
CV		1.785097		1.548817		1.217728		1.369291		1.625704		1.746473	
R-Square		0.996263		0.991725		0.970554		0.859625		0.993702		0.994503	
Mean		86.10417		94.39583		1.251042		22.29333		20.43333		14.2875	