**RESPONSE OF CHICKPEA (*Cicer arietinum* L.)VARIETIES TO BLENDED NPSB FERTLIZER RATES IN EZHA DISTRICT, SOUTHERN ETHIOPIA**

**MSc. THESIS**

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**Response of Chickpea (*Cicer arietinum* L.)Varieties to Blended NPSB Fertilizer Rates in Ezha District, Southern Ethiopia**

**A Thesis Submitted to School of Graduate Studies**
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**Marta Negash Alemu**

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**Wolkite University, Wolkite, Ethiopia**

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# BIOGRAPHICAL SKETCH

The author was born on April 24, 1982 in Sodo District of Gurage Zone, Ethiopia. She attended her elementary and secondary education at Sodo Elementary and High Schools respectively. She then joined Sodo ATVET College in October 2002 where she graduated with Diploma in Plant Sciences in August 2004 .Subsequently, she was employed by Abeshge District Agricultural Development Office (Gurage Zone, Ethiopia) where she served for seven years (2005-2014 ) as a Development Agent, largely at the positions of Product Quality Control and Inputs Expert. She then joined St. Merry University and graduated with BSc.in 2014 in Agribusiness Management. Finally, she joined the school of Graduate Studies of Wolkite University in 2020.To pursue her Master of Science Degree in Agronomy.

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ABBREVIATIONS AND ACRONYMYS

| | |
|---|---|
| ANOVA | Analyses of Variance |
| ATA | Agricultural Transformation Agency |
| CSAE, | Central Statistical Agency of Ethiopia |
| WB | World Bank |
| CSA | Central statistical Agency |
| DARC | DebreZeit Agricultural Research Center |
| ESE | Ethiopian Seed Enterprise |
| Ethio-SiS | Ethiopian Soil Information System |
| FAO | Food and Agriculture Organization of the United Nations |
| FAOSTAT | Food and Agricultural Organization Statistical Database |
| ICARDA | International Center for Agricultural Research in the Dry Areas |
| ICRISAT | International Crop Research Institute for  Semiarid Tropics |
| IFDC | International Fertilizer Development Center |
| LSD | List Significant Difference |
| MoARD | Ministry of Agriculture and Rural Development |
| MoA | Ministry of Agriculture |
| NFIA | National Fertilizer Industry Agency |
| SOM | Soil Organic Matter |

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Response of Chickpea (*Cicer arietinum* L.)Varieties to Blended NPSB Fertilizer Rates in Ezha District, Southern Ethiopia

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## ABSTRACT

*Chickpea production is presently restricted to a small area in Southern Ethiopia including Gurage Zone due to a number of limiting factors such as low soil fertility, diseases and pests, and lack of production technologies. To mitigate the low soil fertility, information regarding the actual rate of the newly recommended blended NPSB fertilizer and chickpea varieties are not yet known in the study area-Ezha District, Gurage Zone. Therefore, lack of recommended fertilizer rate and chickpea varieties were the main yield constraints in the area. Hence, an experiment was conducted during the 2021 cropping season to determine optimum blended fertilizer rate and well responded chickpea variety to NPSB rate for the study area. Four levels of NPSB (0, 50, 100, and 150 kg ha$^{-1}$) and four chickpea Varieties (Habru, Dhara, Arerti and Dubie (standard check)) were used as treatments, and set in randomized complete block design with a factorial arrangement of three replications. All the blended fertilizer rates were applied at planting. Surface soil samples was collected before sowing and analyzed. The result shows also recorded clay 34%, sand 26% and silt 40%, which indicates the soil textural class is clay loam.Anaalysis of this composite soil also 0.71% total nitrogen,14.3% organic matter,8.3% organic carbon,6.41ppm available phosphorus, boron 0.08mgkg$^{1}$(ppm), Total sulfur17.83% mg/kg(ppm) and 5.5 P$^{H.}$ On the other hand, the main factors of blended fertilizer rates and chickpea varieties were found statistically significant on the main effect blended NPSB fertilizer and verities (50% days of flowering and days of 90% physiological maturity) and also the main effect variyties plant height and hundred seed weight. The interaction of the main factors had also showed a statistically significant effect on above ground dry biomass, grain yield as well as agronomic efficiency. Generally, the treatment combination of 150 kg ha $^{-1}$ NPSB and Arerti variety recorded the highest above ground dry biomass (7259 kg ha$^{-1}$) and total grain yield (3538 kg ha$^{-1}$). The result of partial budget analysis, showed that 150 kg ha$^{-1}$ NPSB with Arerti variety gave the highest net benefit ( 140,439 ETB) with maximum marginal rate of return (4074%) when compared with the other treatments combinations. Hence, the combined application of 150 kg ha$^{-1}$ of NPSB fertilizers with Arerti variety is recommended for chickpea production in Ezha District as well as areas with similar agro-ecological conditions. However, since the study was conducted only for a single season and in only one location, further research is recommended to be carried out in different locations and seasons.*

**Keywords:** *blended npsb fertilizer, chickpea variety, yield component*

# INTRODUCTION

Chickpea (*Cicer arietinum* L.) is one of the earliest grain legumes to be domesticated in the old world, with two main centers of origin (South-East Turkey and Ethiopia; (Vavilo, 1951)) and four centers of diversity (Mediteranean, Central Asia, Near East and India; (Ramanujiam, 1976; Vavilo, 1951)). After haricot bean and soya bean, chickpea is the world's third most significant food legume (Namvar *et al*., 2011). The Kabuli and Desi chickpeas are two distinct varieties of chickpea that differ in geographical distribution and plant type (Rasool , 2015). Chickpea plants have a well-developed root system. A central strong tap root with multiple lateral branches that spread out in all directions in the upper layer of soils with numerous nodules on roots is typical (Bampidis and Christodoulou, 2011). Although higher premiums for larger chickpeas may compensate for reduced yields, yields are often lower and less predictable than desi cultivars (Bampidis and Christodoulou, 2011).

It was grown on a total of 13.65 million hectares with a production of 13.10 million tons (FAOSTAT, 2016). It's grown in 35 different nations throughout the world. The top ten chickpea-producing countries are India, Turkey, Pakistan, Iran, Mexico, Myanmar, Ethiopia, Australia, Spain, Canada and the United States. Around 3% of the world's chickpea production came from Ethiopia. Ethiopia is the biggest producer of chickpeas in Africa, coming in third after faba bean and haricot bean production (CSA, 2018). In addition, the country is the world's sixth largest producer of chickpeas (FAOSTAT, 2015).

Chickpeas are a popular pulse crop used for food and fodder all over the world. Chickpea consumption is second only to dry beans among all pulse crops, and production has increased by 33.5 % in area and 65.5 % in volume since 2008. (FAOSTAT, 2015). In the underdeveloped world, chickpea is a relatively inexpensive source of protein (20–23% in the grain), energy (carbohydrates, 40%), oil (3–6%), and minerals (Mg, K, P, Fe, Zn, and Mn (Ibrikci *et al.*, 2003) and carotene. Chickpea is an essential contributor to the long-term viability of cereal-legume cropping systems, increasing cereal yields by increasing soil nitrogen and breaking disease cycles of important cereal diseases (Pande *et al*., 2011).

Pulses are grown in Ethiopia all around the country. Chickpeas accounted for 14% of cropped land area in the 2012-13 cropping season (CSAE and WB, 2013).

In Southern Nations, Nationalities and Peoples Regional State (SNNPRS), chick pea is cultivated in various zones, some special woredas and pocket areas of the region. In general, in this region chick pea occupies about 5,896 hectares of land annually with estimated production of 66,363.02 quintals (CSA, 2012/13). Of the total regional area under pulse crops 1.95 % is covered by chick pea and 1.77 % total grain production was obtained from it. The national average yield of chick pea in Ethiopia is 13.36 qt/ha and the regional average yield of 11.26 qt/ha, which is far below the potential yield of 4.5$tha^{-1}$

This could be due to a lack of resources, such as suitable land and improved cultivars, a lack of adequate technology, or a lack of chickpea-specific extension efforts in the region. Because of the economic, nutritional, and agronomic benefits, the southern part of Ethiopia has the potential to enhance chickpea production; however, more research is needed to develop basic crop management for long-term production.

Chemical fertilizer use in Ethiopia has increased dramatically since 1980, yet it still very low (Zeleke *et al.,* 2010). According to (ATA), long-year farming has depleted some micronutrients such as boron from the soil of Ethiopia's key crop-producing areas, in addition to macronutrients. Not only does balanced fertilization provide optimal crop production, higher food quality, and grower benefits, but it is also the most effective strategy to limit the risk of nutrient losses to the environment.

Nutrients like B, S, and K are inexpensive and easy to integrate into new fertilizer formulae; when applied to deficient soils, these nutrients can considerably improve fertilizer efficiency and crop profitability (John *et al*., 2000). According to a soil fertility map constructed over 150 districts, Ethiopian soil is lacking in seven nutrients: (N, P, K, S, Cu, Zn, and B) (Ethio SIS, 2013).

The main focus in Ethiopia has been on the use and administration of nitrogen and phosphorous fertilizers in the form of Di-ammonium phosphate (DAP) (18-46-0) and Urea (46-0-0) or blanket recommendations for primary food crops. Fertilizer recommendations in Ethiopia are based on either generic crop-specific guidelines or, more typically, a single recommendation for all crops (100 kg DAP (18-46-0) and 100 kg Urea), according to the preceding findings (46-0-0).For the past four decades, urea and DAP (Di-ammonium phosphate) have been the only fertilizer supplies available in the country (IFDC, 2015).

Farmers are discouraged from applying fertilizer since this technique fails to account for variances in resource endowment (soil type, labor capability, and climatic risk) or major changes in the input/output price ratio. Furthermore, the nutrients in the blanket recommendation are unbalanced agronomically, and repeated application will deplete soil nutrients, and nutrient reserves are two terms that are used interchangeably. According to those sources, urea and DAP have been the only fertilizers imported into the country since 1971. Urea contains 46% nitrogen, whereas DAP contains 18% nitrogen and 46% phosphorus (NFIA, 2001). As a result of the uneven application of fertilizers, neither yields nor profits can be sustained, as the practice causes accelerated deficits of other soil nutrients.Because the absence of one or more nutrients other than N and P can dramatically reduce production. This could explain why, despite large increases in fertilizer use and investment in the country, crop yields have only improved little over the last few decades. In Ethiopian soils today, shortages in N, P, S, B, and Zn are common, and some soils are also low in K, Cu, Mn, and Fe (Laekemariam, 2016 and Asgelil *et al.,* 2007).

The lack of modern chickpea farming technologies is mainly responsible for Ethiopia's low chickpea yield. This was obvious in 2014-2015, when cultivars were used to manage the whole chickpea crop area (239,747 ha). The remaining production area was sown with indigenous landrace varieties (Millon and Asnake, 2014).

Until the introduction of NPSB fertilizer in 2015/16, the use of fertilizer in the study region, like most other rural areas in Ethiopia, was confined to Urea and DAP. Although the average chickpea yield in Ethiopia is around 1.7 tons per hectare (Bulletin, 2013), agricultural studies on experimental plots in Ethiopia have shown yields ranging from 2.9 to 3.5 tons per hectare (Dadi *et al.,* 2005).

This implies to a production difference of at least 1.2 tons per hectare per year. By bridging this gap, Ethiopia would become one of the world's leading chickpea producers. Despite the national breeding program's production and release of a number of improved chickpea cultivars over the last three decades, the cultivars' potential has not been explored in Ethiopia's southern region. This can be linked to a lack of resources, a lack of adequate equipment, and, to some extent, a lack of attention paid to chickpea by research institutes in the southern region. As a result, the introduction of appropriate and inexpensive technology techniques has the potential to increase chickpea productivity per unit area in the region. The low productivity of chickpeas in particular and legumes in general, can be attributed to a number of causes. Diseases, insect pests, a lack of improved cultivars, and insufficient soil fertility are examples of such causes (Yadessa Anbessa and Geletu Bejiga, 2002).

The response of chickpea varieties to NPSB nutrients in general, as well as the rate at which NPSB nutrients are applied to different varieties, has not been adequately studied or documented in the study area. The effects of newly mixed fertilizers on yield and yield components of chickpea cultivars in the study area were the focus of this study.

**The General Objective**

Determine the optimum rate of application of NPSB fertilizer and identify the response of chickpea varieties for the yield and yield component at the study area condition.

**Specific objectives**

i. To determine the optimum rate of NPSB fertilizer to chickpea varieties
ii. To identify the most responsive chickpea varieties to NPSB fertilizer
iii. To determine the economically feasible rate of NPSB fertilizer.

# 2. LITERATURE REVIEW

## 2.1. Origin and Geographic Distribution of Chickpea

Chickpeas are not well-known in their native condition, however they can be found as weeds in some areas (Westphal, 1974). It is thought to have originated in the regions of Turkey's south-east, as well as Syria and Iran. Chickpea seeds reaching back to roughly 7000 BC have been discovered in Syria and Turkey (Van der Maesen, 1987). The crop spread throughout the Middle East, the Mediterranean region, India, and Ethiopia after being domesticated in the Middle East. Chickpea farming is gaining popularity in areas where it was only recently introduced, such as Australia, New Zealand, the United States, and Canada (Source). It is primarily cultivated in East Africa (Sudan, Eritrea, Ethiopia, Kenya, Tanzania) and Malawi in tropical Africa in cool environments (Geletu Bejiga and, van der Maesen, 2006).

Old landraces and wild relatives of chickpea can be found in three main areas between 8° and 52°N latitude and 8°W to 85°E longitude (Redden and Berger, 2007): I) the western Mediterranean, Ethiopia, Crete, and Greece; (ii) Asia Minor, Iran, and the Caucasus; and (iii) Central Asia, Afghanistan, and the Himalayan region. The Kabuli and the Desi live in different parts of the world, with the Kabuli confined to the Western Mediterranean and the desi mainly missing. The desi version can be found all over the Indian subcontinent, from the Eastern Mediterranean to Central Asia (Moreno and Cubero,1978).

Seed samples from Ethiopia's Lalibela caves were determined to be over 2500 years old, according to archaeological studies (Mitiku 2011). Chickpeas have a secondary diversity in the country (Yadeta and Geletu, 2002). It is usually grown in agro-ecological zones with annual rainfall between 700 and 2000 millimeters and elevations between 1400 and 2300 meters above sea level (Geletu Bejiga and Million Eshete, 1996). Although chickpeas are widely planted in Ethiopia, production is centered in two regions: Amhara and Oromia. These two regions produce about 80% of the country's chickpeas, with over 90% of total chickpea acreage and 92 % of total chickpea production. From 1999 to 2008, Tigray, the Southern Nation Nationalities and Peoples of Ethiopia, and other regions contributed 7.1 percent, 1.3 percent, and 0.7 percent of total farmed chickpea area and output, respectively (Menale Kassie *et al.,* 2009).

## 2.2. Basic Characteristics of Chickpea

The root system of chickpea plants have a strong central tap root and several lateral branches that radiate out in all directions in the upper layer of soils, with numerous nodules on the roots. The rhizobium bacteria found in these nodules fix nitrogen from the air. Roots in deep vertisols can reach depths of more than 120 cm. The overall plant height ranges from 20 to 100 cm, with tall cultivars reaching 130 cm in ideal conditions (Rasool *et al*., 2015). The Kabuli (also known as macro sperm) and Desi are two separate varieties of chickpea that differ in their geographical distribution and plant type (known as micro sperm). Chickpeas of the Desi type feature small angular seeds that weigh around 120 mg, are wrinkled at the beak, and are dark to light brown and fawn in hue. To make dhal, they are usually de-hulled and split. They are popular in the Asian subcontinent. Desi type mature earlier and provide more fruit than Kabuli types. Kabuli seeds are bigger and rounder, weighing around 400 mg. They have a white cream color to them and are virtually always utilized whole. They are popular throughout the Mediterranean. Because they are sold whole, seed size and appearance are vital. Although premiums for larger chickpeas might overcome the yield disadvantage, yields are often lower and more unpredictable than desi cultivars (Bampidis and Christodoulou, 2011).

## 2.3. Chickpea Production Status and Challenges in Ethiopia

In Ethiopia, the total area of production, the quantity of chickpea produced, and the overall productivity of chickpea have all increased over the last 14 years (Tsedeke *et al.*, 2011). Between 2000 and 2013, the harvested area, production, and yield of Ethiopian chickpeas increased at yearly rates of 0.14 %, 7.16, and 7.01 %, respectively (FAOSTAT, 2014). In 2014/15, the average productivity of Ethiopian chickpea was 1.9 tons per hectare (CSA, 2015), which is significantly less than the 3 tons per hectare that can be expected under ideal conditions.

Ethiopia's agro-climatic conditions are ideal for growing both desi and Kabuli chickpeas. The crop is well-integrated into the farming system and is suitable for growing in a variety of environments. Chickpeas can be grown in a variety of soil types as long as they have adequate moisture and drainage. Chickpeas thrive best in well-drained dark soils with a high water retention capacity (Menale *et al.*, 2009).

The Ethiopian Agricultural Research Organization's Chickpea Research Team has focused on breeding and selecting cultivars with higher yields, disease resistance, and drought tolerance. The ICRISAT published 16 improved chickpea cultivars (7 Kabuli types and 9 desi types) between 1974 and 2009. (MoARD, 2009).

However, this did not result in the desired level of productivity because the average yield calculated from 2000 to 2013 was still below 1.6 tones ha$^{-1}$ (FAOSTAT, 2014). Cultivar development can be seen as a component of a technology package through which crop yield can be improved and it has to be supported by appropriate agronomic management including seeding date, land preparation, site selection, optimum fertilizer rate, proper weed control, rhizobium inoculation, and disease and pest control measures.

## 2.4. Nutrient Requirements of Chickpea

### 2.4.1. Nitrogen (N)

Nitrogen application as a basal dose and at the post flowering stage was found to increase production. Application of nitrogen during the post-flowering stage increased nitrate reductase activity and yield (Sekhon *et al.* 1988). Chickpea N intake may range from 60 to 200 kg N ha$^{-1}$ (Saxena and Yadav, 1975). In several cases, foliar application of 2% urea boosted yield (Ali, 1989b).

### 2.4.2. Phosphorus (P)

The reaction to phosphate application is determined by the amount of accessible P in the soil as well as other edaphic parameters (Saxena and Yadav 1975). There was no response to broadcast or deep-placed P application on Vertisols with low P concentration (Saxena and Sheldrake 1980a). With an accessible soil P content of less than 2.5 mg kg$^{-1}$ on terraria soils in Syria, application of 22 kg P ha$^{-1}$ as triple superphosphate has been extremely beneficial (Saxena, 1984). With an application of 32 kg P ha$^{-1}$ under rain fed circumstances on alluvial soils in India with low available soil P, seed yield increased by 78 % (Singh *et al,.* 1981). When phosphorus was applied in conjunction with starter N, Rhizobium (Pal 1986), and irrigation, the effect was more pronounced (Daftardar *et al.* 1988). Under non-irrigated conditions, phosphorus application increased output by 30%, while supplemental irrigation increased yield by 40%. Supplemental irrigation enhanced both the amount of water consumed and the efficiency with which it was used (Prabhakar and Saraf 1989). Maximum seed yield was achieved with a single superphosphate application of 17.48 kg ha$^{-1}$ and two irrigations. Phosphorus application increased dry matter production and resulted in more dry matter being diverted to pods. Furthermore, with one or two irrigations at 0.4 IW: CPE, more dry matter was produced, demonstrating that irrigation during the vegetative period of chickpea increased dry matter production (Prabhakar and Saraf 1991). P was better used when treated as a basal dose rather than as a topdressing or foliar treatment (Singh and Kamath 1989).

### 2.4.3. Sulfur (S)

In a sandy loam soil, 10 kg elemental sulfur increased nitrogen and phosphorus uptake as well as yield (Gupta and Singh 1983). Sulfur application in the range of 40-80 kg $ha^{-1}$ enhanced yield and seed protein content, according to Singh and Ram (1990). Ground pyrites (FeS2) were used to increase symbiotic nitrogen fixation in saline alkaline soils, resulting in increased yields (Rai and Prasad 1983). Tiwari and Pathak (1988) also found that applying 200-400 kg $ha^{-1}$ pyrites increased chickpea yield in alkaline soils.

### 2.4.4. Boron (B)

In general, boron deficit in chickpeas can be mitigated with a soil application of 1-2.5 kg B ha-1 or a foliar application of 0.25 kilogram B $ha^{-1}$ in the form of borax (Ahlawat, 1990).

## 2.5. Varieties Differences on Growth and Yield Components of Chickpea

During the 2004 Meher Season, a study was carried out on station and on farm in three districts of the Wolayta and Hadiya Zones in Ethiopia's south region to assess farmer preferences and evaluate chick pea varieties for yield performance and adaptability under researcher and farmer managed conditions (Yasin, 2014).

On both the station and the farm, trials were set up in a randomized complete block design with four replications. On 4.8m2 plots with 0.1m*0.3m spacing, Arerti, Shasho, Habru, Chefe, and Dz-10-4 were planted. On-farm trials were conducted with twenty farmers representing three districts and four villages, with each farmer acting as a replicate. The kinds Arerti and Habru were chosen by researchers and farmers because of their large seed size, long pod length, number of pods per plant, early maturity, and high yield (Yasin, 2014).

Those types outperformed the standard inspection in three districts, four villages, and on stations. The top producing varieties, Arerti and Habru, produced 1358.85 kgha-1 and 1326.84 kgha-1 of grain, respectively, 39.2 % and 35.9% more than the standard check in on-farm testing (Dz-10-4). Similarly, over two stations, those two top yielding varieties produced 45.6 percent and 37.7 percent more grain than Dz-10-4, yielding 1630.75 kgha-1 and 1542.2 kgha-1, respectively. As a result, on-station and on-farm tests showed that

Ararti and Habru outperformed other varieties, which were also ranked as the most preferred variety by farmers and researchers (Yasin, 2014).

Farmers' opinions on which chickpea types they prefer Farmers have their own criteria for selecting new varieties, which are generally based on the crop's value in the farming system and usage (Abebe *et al*,. 2005). In, the ranking of chickpea types is offered based on farmer perceptions. Farmers ranked variety *Habru* as the most favoured chick pea variety, followed by *Arerti*. Chick pea variety *Habru* was ranked first by framers because it produced large seed size, taste, quicker maturity, long pod length, pod quantity, and high yield. *Arerti* came in second place out of the five varieties. Farmers preferred the variety Chefe third because it generated appealing large seed size. Farmers dislike the variety Dz-10-4 because of its small seed size and low production (Yasin, 2014).

This research looked at the yield performance and adaptation of chick pea varieties in the agro-ecological environments of Ethiopia's South Region's Bobicho, Jewi, Offa, and Gacheno districts. The results show that Habru and Arerti performed significantly better (P0.05) than the other species, especially Dz-10-4, which had the lowest values for all of the characteristics examined.

Habru and Arerti achieved the highest yields in on-farm and on-station trials. Arerti and Habru are the best chick pea varieties for increasing chick pea production, according to yield, research, and farmer perceptions, and should be promoted for cultivation to farmers in the study districts' Wolayata and Hadiya Zones, as well as similar agro-ecological environments in Southern Ethiopia (Yasin, 2014).

### 2.6. Effect of NPSB Fertilizer on Chickpea

Soil inventory data from Ethiopian Soil Information System (Ethio-SiS) has revealed that, in addition to N and P most of Ethiopian soil including those in the study area is deficient in nutrients like S and B (ATA, 2015). To avert the situation, the Ministry of Agriculture of Ethiopia (MoA) recently introduced a newly blended fertilizer (NPSB) which contains N (18.9%), P (37.7%), S (6.95%) and B (0.1%) which substituted DAP as the main source of phosphorous (Ministry of Agriculture and Natural Resource, 2013). However, its optimum rates of application for the production of most of the crops.

A study published on the response of two chickpea varieties to blended fertilizer rates and row spacing in the Tselemti district of northern Ethiopia found that a combination of four blended (NPSB) fertilizer rates (0, 50, 100, 150 kg ha-1) produced the best results. The subplot was given to Kabuli and Desi chickpea varieties such as Ararti and Mariye, which were 100 kg/ha and 150 kg/ha, respectively, and were indicative of Kabuli and Desi chickpea kinds such as Ararti and Mariye, which were 100 kg/ha and 150 kg/ha, respectively. Similarly, for the analyzed parameters, the major influence of blended fertilizer rates and cultivars revealed no significant difference. However, there were considerable changes between the varieties in terms of phonology, yield components, and yield. In most of the traits studied, blended fertilizer rates used in Tselemti District did not reveal any variations (Tesfhun *et al.,* 2018)

According to a review by Ewnetu Teshale and Afework Legesse (2020) the productivity of chickpea is below potential due to low soil fertility and little use of soil amendment practices, especially mineral fertilizers. *Ararti Dhera* According to China, (2018), application of 193 kg NPSZnB $ha^{-1}$ shortened the days to flowering (49.33) and physiological maturity (99.3) of Chickpea. Similarly, total number of nodules (32.81 $plant^{-1}$), above ground biomass (6494 kg $ha^{-1}$), seed production (3187 kg $ha^{-1}$) were obtained from 193 kg NPSZnB $ha^{-1}$. The application of 193 kilograms NPSZnB $ha^{-1}$, which was statistically equivalent to the typical fertilizer practice of applying 100 kg DAP $ha^{-1}$, resulted in generally significantly improved and optimal growth, yield, and yield components (China, 2018).

Kiros Wolday & Atsede Teklu (2020) found a substantial interaction effect of NPSB and Rhizobium inoculation on chickpea yield and yield components in Laelay Maichew, Central Zone of Tigray, and Northern Ethiopia. According to their findings, 125 kg $ha^{-1}$ NPSB with rhizobium inoculation yielded the most pods per plant (76.8), whereas 150 kg $ha^{-1}$ (3609 kg $ha^{-1}$) and 125 kg $ha^{-1}$ NPSB (3514 kg $ha^{-1}$) with rhizobium inoculation yielded the best grain yields. The best marginal rate of return was seen in chickpea treated with rhizobium and 125 kg $ha^{-1}$ NPSB treatment (4106.68 %). According to the findings, the optimal treatment combination for enhancing chickpea production and profitability in soils with low levels of accessible plant nutrients (NPSB) is 125 kg $ha^{-1}$ NPSB paired with rhizobium inoculation seeds (Kiros Wolday 2020).

Another experiment on the reaction of chickpea (*Cicer arietinum* L.) to nitrogen and phosphorus fertilizers rates in Halaba and Taba, Southern Ethiopia, to find the optimum N and P fertilizer rates for chickpea production indicated that *Habru* both N and P had a substantial impact on chickpea nodulation capacity, yield, and yield components in both locations.In Halaba, N sprayed at 11.5 and 23 kg $ha^{-1}$ enhanced chickpea grain yield by 32 and 36 % over the control, respectively (Lema e*t al.*,2013).The equivalent increases in

Taba were 61 and 40 %, respectively, over the control. P administered at 20 and 10 kg $ha^{-1}$ in Halaba and Taba, respectively. In conclusion, chickpea responds significantly to N and P fertilizers in both locations suggesting low levels of soil N and P. Biological and economic optimum yields of chickpea were obtained from N: P applied at 11.5: 20 and 11.5: 10 kg $ha^{-1}$ in Halaba and Taba, respectively (Lema e*t al.*, 2013).

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# 3. MATERIALS AND METHODS

## 3.1. Description of the Study Area

The experiment was conducted in 2021 at Darecha Kebele, Ezha district, Gurage Zone, Southern Ethiopia; the experimental site is located 170 km Southwest of Addis Ababa at an altitude between 1500-2500 m.a.s.l between approximate geographic coordinate of 8º32' 37" N latitude and 37º 8' 58"E longitudes. The annual rainfall is about 1500-2300 mm with the mean maximum temperature $21^0$C and $27^0$C respectively (Ezha Woreda Agricultural Office and Begnenda Research Farm, year).

Table 1:- Monthly maximum and minimum temperature and monthly rainfall weather condition of the experimental site at growing season (2021) of the crop.

| | Weather elements | | |
|---|---|---|---|
| Month | Average temperature (°C) | | Total rainfall (mm) |
| | Max. | Min. | |
| July | 18.5` | 12.3 | 139 |
| August | 21.9 | 12.3 | 296 |
| September | 22.2 | 12.1 | 279 |
| October | 24.4 | 10.7 | 49.5 |
| November | 25.2 | 8.26 | 30.9 |
| Average | 22.45 | 11.145 | 158.82 |

Source: SNNPS National Metrology Agency, Hawassa (2021)

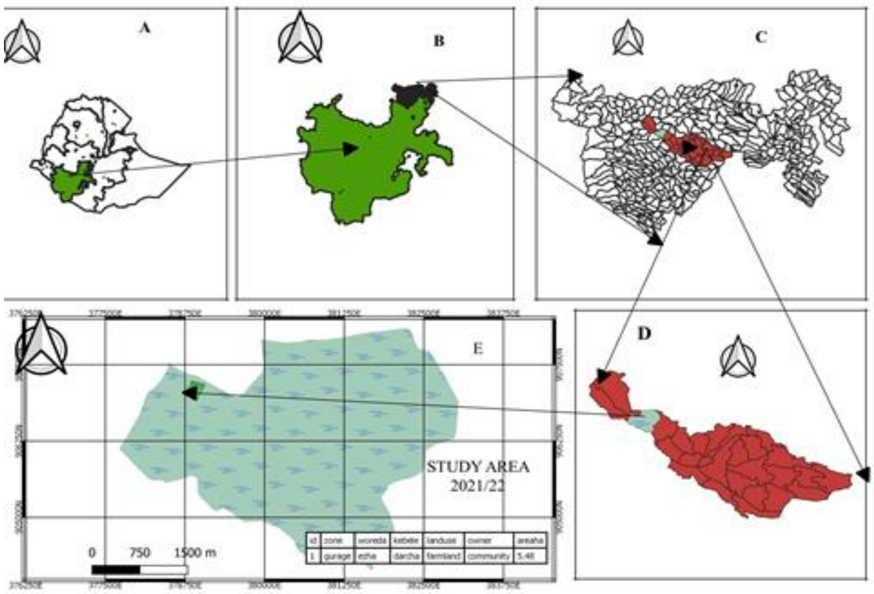


Figure 1:- Map of the experimental site

## 3.2. Experimental Materials

### 3.2.1. Chickpea Varieties

Three improved chickpea varieties (*Dhara*, *Habru* , *Arerti* and *Dubie* (standard check)) developed and released by DebreZeit Agricultural Research Center (DZARC) *Dubie* were used for the study. The varieties were selected based on their wide scale adaptation. The three chickpea varieties seeds were obtained from the DebreZeit Agricultural Research Center, while *Dubie* was from the farmers in the study area. *Habru Dhera Arerti*

Table 2:- Description of Chickpea Varieties used for the study

| Characteristics | Varieties | | | |
|---|---|---|---|---|
| | *Dhara* | *Habru* | *Arerti* | *Dubie* |
| Altitude (masl) | 1600-2400 | 1800-2600 | 1900-2600 | 1800-2300 |
| Annual rainfall(mm) | 700-1200mm | 700-1200 | 700-1200 | 700-1100mm |
| Planting date | Late-Aug-early September | Mid-august-early September | Mid-august-early September | Mid-august early September |
| Days to 50% flowering | Late>80day | Early (40-60) | Medium (61-80) | Medium (61-80) |
| Days to 95% maturity | 110-155 | 91-150 | 105-155 | 110-115 |
| Growth habit | Semi Erect | SemiSpreading | Semi Erect | Semi Erect |
| Seed colour | White | White | White | Gray |
| Yield in research site ($tha^{-1}$) | 2.3-3.6 | 1.4-5.0 | 2.6-4.6 | 1.7-2.8 |
| Year of release | 2016 | 2004 | 1999 | 1978- |

Source: MoARD (2016)

### 3.2.2. Fertilizer

Blended NPSB fertilizer that contains 18.7%N, 37.4%$P_2O_5$, 6.9%S and 0.25%B were used as source of fertilizer. The rates of NPSB fertilizer and their nutrient contents of treatments used during the experiment are indicated on Table 3.

Table 3:- Rates of blended NPSB fertilizer used and nutrient contents.

| | NPSB Rate (kg $ha^{-1}$) | Nutrient content (kg) | | | |
|---|---|---|---|---|---|
| | | N | $P_2O_5$ | S | B |
| 1 | 0 kg NPSB | 0 | 0 | 0 | 0 |
| 2 | 50 kg NPSB | 9.35 | 18.7 | 3.45 | 0.125 |
| 3 | 100 kg NPSB | 18.7 | 37.4 | 6.9 | 0.25 |
| 4 | 150 kg NPSB | 28.05 | 56.1 | 10.35 | 3.375 |

### 3.3. Soil Sampling and Analysis

Pre-planting soil samples from the experimental site were collected from 5 spots in a zigzag pattern from the depth of 0-30 cm and composited and one kg from the composite sample was taken to the laboratory. The samples were air dried, ground using pestle and mortar and allowed to pass through a 2-mm-sieve in Wolkita soil laboratory and Hort cop Ethiopia Soil and Plant Tissue Analysis laboratory. Working samples were obtained from each submitted samples and analyzed for organic carbon, total N, soil pH, available phosphorus, and soil textural analysis using standard laboratory procedures. Organic carbon content was determined by the volumetric method (Walkley and Black, 1934). TN content of the soil was analyzed by Kjeldahl digestion, distillation and titration procedure (Brumner and Mulyaner, 1982). Available phosphorus was determined by the Olsen's method using a spectrophotometer (Olsen *et al.*, 1954). Soil pH was measured in water at soil-to-water ratio of 1:2.5 (Van Reeuwijk, 1992). Soil textural analysis was performed by Bouyoucous hydrometer method (Day, 1965).boron and sulfur determined by Mehlich-3

### 3.4. Treatments and Experimental Design

The experiment was conducted in a factorial combination of four levels of blended NPSB fertilizer (0, 50, 100, and 150 kg $ha^{-1}$) and four varieties of Chickpea (*Dhera, Habru, Arerti*, and *Dubie*) using randomized complete block design (RCBD) with three replications. The gross plot size was 2.4 m × 1.8 m= 4.32 $m^2$ which accommodated 6 rows totally and net plot size was 1.4 × 1.6 m= 2.24 $m^2$ which contained 4 rows and one row was left for destructive sampling and two border rows were left for border effect. The spacing between blocks and plots were 1 m and 0.5 m, respectively.

Table 4:- Treatment combinations the use of blended fertilizer (NPSB) rate and Chickpea varieties

| No | Treatment combinations | Description |
|---|---|---|
| 1 | $F_1V_1$ | 0 kg NPSB $ha^{-1}$ and *Dhera* |
| 2 | $F_1V_2$ | 0 kg NPSB $ha^{-1}$ and *Habru* |
| 3 | $F_1V_3$ | 0 kg NPSB $ha^{-1}$ and *Arerti* |
| 4 | $F1V_4$ | 0 kg NPSB $ha^{-1}$ and *Dubie* |
| 5 | $F_2V_1$ | 50 kg NPSB $ha^{-1}$ and *Dhera* |
| 6 | $F_2V_2$ | 50 kg NPSB $ha^{-1}$ and *Habru* |
| 7 | $F_2V_3$ | 50 kg NPSB $ha^{-1}$ and *Arerti* |
| 8 | $F2V_4$ | 50 kg NPSB $ha^{-1}$ and *Dubie* |
| 9 | $F_3V_1$ | 100 kg NPSB $ha^{-1}$ and *Dhera* |
| 10 | $F_3V_2$ | 100 kg NPSB $ha^{-1}$ and *Habru* |
| 11 | $F_3V_3$ | 100 kg NPSB $ha^{-1}$ and *Arerti* |
| 12 | $F3V_4$ | 100 kg NPSB $ha^{-1}$ and *Dubie* |
| 13 | $F_4V_1$ | 150 kg NPSB $ha^{-1}$ and *Dhera* |
| 14 | $F_4V_2$ | 150 kg NPSB $ha^{-1}$ and *Habru* |
| 15 | $F_4V_3$ | 150 kg NPSB $ha^{-1}$ and *Arerti* |
| 16 | $F4V_4$ | 150 kg NPSB $ha^{-1}$ and *Dubie* |

Where, $F_1$: fertilizer rate 0; $F_{2:}$ fertilizer rate 50; $F_3$: fertilizer rate 100; $F_4$: fertilizer rate 150; $V_{1:}$*Dhera* variety; $V_2$: *Habru* variety; $V_3$: *Arerti* variety, $V_4$: (*Dubie)*

### 3.5. Experimental Procedure and Management

The land was ploughed by oxen. The field was cleared from all unwanted materials and plant residues, leveled and the field layout was prepared. The field was divided into three blocks and sixteen plots in each block. The spacing between rows and plants was 40 cm and 10 cm, respectively. The Chickpea seed was sown on August 20, 2021 after land preparation at the depth of 5 cm. Two seeds per hill were sown and thinned to one plant per hill after establishment throughout the plots. NPSB was applied between two hills at the time of sowing. All necessary agronomic managements were carried-out properly starting from field preparation to harvesting uniformly.

### 3.6. Phenological and Growth Parameters

#### 3.6.1. Phenological parameters

**Days to 50% flowering:** It was recorded as the number of days from planting to the date when 50% of the plants in each plot produced flower.

**Days to 90 % physiological maturity:** It was recorded as the number of days from planting to the date when 90% of the plant in each plot showed yellowing of pod.

#### 3.6.2. Growth parameters

**Plant height (cm):** It was measured as the height of five randomly taken plants from the ground level to the apex of each plant at the time of physiological maturity from the net plot area.

**Total number of nodules:** It was determined by counting their numbers in randomly taken five plants at pod setting time. Roots were carefully exposed with the bulk of root mass and nodules. The nodules were separated from the soil by washing and the numbers of effective nodules and numbers of non-effective were determined by counting based on their color, i.e. pink, red or brown colors as effective, and rest as non-effective.

### 3.7.. Yield Components and Yield

**Number of pods per plant:** It was determined by counting the total number of pods of 5 randomly taken plants from each net plot area at physiological maturity and averaged.

**Number of seeds per pod:** It was recorded as the total number of seeds per pod from pods of randomly selected five plants at maturity from net plot area and averaged.

**Hundred-seed weight (g):** It was determined by taking weight of 100 randomly sampled seeds from the total harvest of each net plot area and adjusted to 12% moisture level.

**Total aboveground dry biomass (kg ha$^{-1}$):** At physiological maturity, from each net plot area the aboveground biomass of randomly taken five plants was collected and weighed after oven-drying at 70$^{o}$C for 48 hours to a constant weight. For obtaining the total aboveground dry biomass, the dried biomass per plant thus obtained was multiplied by the total number of plants per net plot and was converted into kg ha$^{-1}$. This was used to calculate the harvest index also.

**Grain yield (kg ha$^{-1}$):** It was determined after threshing the seeds harvested from each net plot area. The seed yield was adjusted to 12% moisture level and converted to kg ha$^{-1}$.

**Harvest index (%):** It was expressed as the ratio of seed yield (kg ha$^{-1}$) to the total aboveground dry biomass of sampled plants multiplied by 100.

**Agronomic efficiency of the treatment**

Agronomic efficiency is defined as extra crop yield produced per unit of fertilizer nutrient applied (Vanlauwe *et al*., 2001; Vanlauwe and Gallery, 2006). Agronomic efficiency was determined using the following formula:

AE = (Y-Y0)/F

Where: Y= yield of harvested portion of crop with nutrient applied

Y0= yield without nutrient applied

F= amount of nutrient applied

### 3.8. Data Analysis

The data collected from experiment was subjected to statistical analysis using SAS software (SAS institute 2003).The least significance difference (LSD 0.05) test was used to separate significance difference between treatments.

### 3.9. Partial Budget Analysis

Partial budget analysis of the blended (NPSB) fertilizer treatments were performed on the basis of prevailing market prices (CIMMYT, 1988). The partial budget analysis was performed to assess treatment combinations that would give acceptable returns at low risk to farmers. All costs and benefits were calculated on hectare basis in Ethiopian birr (ETB). Variable costs (fertilizer Application and transport costs) were considered for partial budget analysis. Mean grain yield of result were used for partial budget analysis. The average grain yield was adjusted to 10% downwards to reflect the difference between the experimental yield and the yield farmers expect from the same treatment.

Definitions of some terms and the methods of calculation are described as follows:

**Average yield**: the yield is the quantity of output produced per unit area. Yield is expressed in kg $ha^{-1}$.scaling down is necessary to prevent overestimation of the returns that farmers are likely to obtain from a treatment.

**Output prices**: we used farm gate prices to compute returns. The farm gate price of the output is the value (price) farmers receive or can receive for their harvested crops. In other words, it is the price farmers received at the end of the production process.

**Gross return**: the gross return is the product of the farm gate price of the output and the adjusted yield.

**Total variable input costs**: the total variable input cost is the sum of all variable input costs and varies from one treatment to another. These are farm gate costs of the variable inputs for each of the treatments. Inputs used for the analysis include: seed, labor, NPSB, pesticide, harvest bags, and workforce

**Net return**: net return is the difference between the gross return and the total variable input cost.

**Marginal rate of return**: is the % change of net returns as a result of the introduction of the technology. It is the ratio of increased benefits to increased costs which is put in a % age form.

# 4. RESULTS AND DISCUSSION

## 4.1. Soil Physicochemical Properties of the Experimental Site

Particle size analysis results of the study area indicates that the soil of the study area has the percentage of sand (26%), silt (40%) and clay (34%) which was categorize in the textural class of clay loam (USDA,1987). The soil pH was 5.5 (pH $H_2O$) which was moderately acidic (Hazelton and Murphy, 2016) Soil pH is an important soil attribute because it can impact that availability of nutrients for plant uptake.

The experimental soil had 8.3 % organic carbon and 14.3 % organic matter, which was classified as medium (Hazelton and Murphy, 2016). The value of total nitrogen of the soil of the experimental field was 0.71 %. According to Goronski, *et al*. (2010), soil with a nitrogen content of 0.15-0.25 % is medium, whereas soil with nitrogen content greater than 0.25 % is high. The available phosphorus in the soil was characterized as low (6.41ppm) as described by Hazelton and Murphy's (2016). Available sulfur is characterized as 2 very low, 5-20 medium, and >20 mg/kg high, according to Horneck, *et al* (2011). In terms of available sulfur, the experimental site had 17.8ppm, which was under the category of medium range. The available boron of the study area was found 0.08mg/kg.According to Benton (2003) report the critical level boron value for most Ethiopian soil ranged from 1.1-2 $mg/kg^1$, however below this range indicated as boron deficiency.

Table 5:-Physicochemical properties of the experimental site soil before planting (0-30cm)

| Soil characters | Value | Rating | References |
|---|---|---|---|
| Physical Analysis | | | |
| Sand (%) | 26 | - | - |
| Silt (%) | 40 | - | - |
| Clay (%) | 34 | - | - |
| Textural class | | Clay loam | (USDIA,1987) |
| Chemical Analysis | | | |
| Soil pH. $H_2O$ | 5.5 | Moderately Acidic | Hazelton and Murphy(2016) |
| Organic Carbon (%) | 8.3 | High | Hazelton and Murphy(2016) |
| Total Nitrogen (%) | 0.71 | High | Goronski *et al.*, (2010) |
| Available Phosphorus (ppm) | 6.41 | Low | Hazelton and Murphy(2016) |

| | | | |
|---|---|---|---|
| OM(%) | 14.3 | Medium | Hazelton and Murphy(2016) |
| TS (ppm) | 17.83 | Medium | Hornec *et al.*,(2011) |
| TB (ppm) | 0.08 | Low | Benton (2003) |

**Where:** OC=Organic carbon, OM= Organic Matter, $pHH_2O$ =potential of hydrogen TN=Total nitrogen, TS=total sulfur, TB= total boron.

## 4.2. Phenological Parameters

### 4.2.1. Days to 50% Flowering

The analysis of variance revealed that the main effects of blended NPSB fertilizer and variety had significant ($p<0.05$) effect on days to 50% flowering of chickpea; however their interaction effect had non-significant effect (Appendix Table 1).

The highest number of days (61.58 days) to reach 50% flowering was recorded on variety *Dhera*. However, the earliest days to flowering (53.25 days) were recorded by *Habru* variety (Table 5). Variety *Habru* was flowered earlier by about 8.33, 6.33 and 3.25 days from varieties *Dhera*, *Dubie* and *Arerti*, respectively (Table 5). The observed variation in terms of days to 50% flowering of chickpea varieties included in the study might be attributed genetic variation of the varieties in completing their vegetative growth. The current finding was in line with Tripathi *et al*. (2013) and Tamiru *et al. (*2021) who reported difference among varieties of chickpea in days to 50% flowering.

In the case of the main effect of blended NPSB fertilizer, the longest days to flowering (60.41 days) was recorded from the maximum application rate (150 kg $ha^{-1}$). In contrast, the earliest days to 50% flowering (55.58 days) was recorded from the control treatment which did not received any NPSB fertilizer, which is statistically at par with a treatment that received 50 kg $ha^{-1}$ and 100 kg $ha^{-1}$ NPSB fertilizer. In general, increasing the rates of blended NPSB fertilizer days to flowering became delayed. This might be attributed to the positive effect of nitrogen that stimulated growth and prolonged vegetative phase, and delaying the reproductive phase of plants. In conformity with this study, Arena and Zenebe (2019) reported delayed days to flowering with increasing rate of NPKSB fertilizer in common bean.

### 4.2.2. Day to 90% physiological maturity

The analysis of variance showed that the main effects of NPSB fertilizer and varieties had highly significant ($P<0.01$) effects on days to 90% physiological maturity. However, their interaction effect did not show significant difference on days to 90% physiological maturity of chickpea (Appendix Table 1).

The earliest days to maturity (92.2 days) was recorded from variety *Habru*, whereas the longest days to maturity (119.2) was obtained from variety *Dhera* (Table 5). This might be the genetic difference of the crops variety. This finding in line with. Tamiru *et al*., (2021)

Regarding to NPSB effect, treatment with 150 kg $ha^{-1}$ NPSB had the longest days to 90% physiological maturity (111.4 days), while the treatment with 50 kg $ha^{-1}$ NPSB fertilizer had the shortest days to 90 % physiological maturity (106.8 days), but statistically non-significant from the untreated plot and that of a plot received 100 kg NPSB $ha^{-1}$. This could be due to the presence of N, P, S and B plant nutrients which played an important role in protein synthesis, formulation of some growth hormone that prolong crop on field duration and promote seed maturation and production. The result of this finding was in line with Arega and Zenebe (2019) showed that delayed days to maturity with increasing rates of NPKSB fertilizer indicating favor of each NPKSB nutrient sources for vegetative growth and reproductive phase. However, the study contradicts with the finding of Ewnetu and Afework (2020) an application of 193 kg NPSZnB $ha^{-1}$ shortened days to physiological maturity.

Table 6:- Days to 50% flowering and physiological maturity as influenced by the main effect of NPSB fertilizer and chickpea varieties

| Treatments | Phenological Parameters | |
|---|---|---|
| Varieties | Days to 50% flowering | Days to 90% Physiological maturity |
| *Habru* | $53.25^{d}$ | $92.2^{d}$ |
| *Dhera* | $61.58^{a}$ | $119.2^{a}$ |
| *Arerti* | $55.25^{c}$ | $109.8^{c}$ |
| *Dubie* | $58.33^{b}$ | $114^{b}$ |
| NPSB fertilizer (kg $ha^{-1}$) | | |
| 0 | $55.58^{b}$ | $107^{b}$ |
| 50 | $55.75^{b}$ | $106^{b}$ |
| 100 | $56.66^{b}$ | $109.2^{ba}$ |
| 150 | $60.41^{a}$ | $111.4^{a}$ |
| LSD (0.05) | 1.855 | 2.78 |
| **CV (%)** | 3.89 | 3.07 |

**Where:** CV= Coefficient of Variation; LSD= Least Significant Difference; Means with the same letter in columns are not significantly different at 5% level of significance.

## 4.3. Growth Parameters of Chickpea

### 4.3.1. Plant height (cm)

The main effect of varieties had significant ($P<0.05$) effect on plant height, however blended NPSB fertilizer and the interaction effect of varieties and NPSB fertilizer had no significant effect on plant height of chickpea (Appendix Table 2). The highest plant height (67.6cm) was recorded from variety *Dhera*. In contrast, the shortest plant height (54cm) was recorded from *Dubie* variety, which was statistically similar to variety *Arerti* (Table 7). This might be the genetic variability of the variety in vegetative growth of chickpea which is in line with the findings of Geletu and Yadetaa (1977-1982.);Tameru., *et al* (2021) the variation in height might be due to genetic characteristics of the varieties.

Table 7:- Plant height as influenced by the main effect of chickpea varieties

| Variety | Plant height (cm) |
|---|---|
| *Habru* | 58.9$^{b}$ |
| *Dhera* | 67.6$^{a}$ |
| *Arerti* | 54.4$^{c}$ |
| *Dubie* | 54.0$^{c}$ |
| LSD(0.05) | 4.15 |
| CV(%) | 8.5 |

Where: CV= Coefficient of Variation; LSD= Least Significant Difference; Means with the same letter in columns are not significantly different at 5% level of significance.

### 4.3.2. Number of nodule per plant

The analysis of variance revealed that main effects of blended NPSB fertilizer had significant ($p<0.05$) effect on number of effective nodules of chick pea. However, the main effect of variety and the interaction effect had non-significant effect (Appendix table 2).

The highest number of nodules per plant (50.17) was recorded from the application rate of 150 kg NPSB ha$^{-1}$, while the lowest number of nodules per plant (40.42) was recorded from unfertilized plots (0 kg NPSB ha$^{-1}$) which was statistically non-significant difference from the application rates of 50 kg NPSB ha$^{-1}$ (Table 7). In general, number of nodule per plant increased with increasing the rates of NPSB fertilizer from zero to 150 kg ha$^{-1}$ (Table 7). This finding in line with Ewentu and Afewerk(2020) chickpea responses led in the largest total number of nodule(32.8 $plants^{-1}$), In general the application of 193kg NPSZnB $ha^{-1}$.

### 4.3.3. Number of effective nodules

The analysis of variance indicates that the main effects of blended NPSB fertilizer application had significant ($p<0.05$) effect on number of effective nodules of chickpea (Appendix table 2)

Number of effective nodules per plant increased with the increasing rates of blended NPSB application. Increasing of blended NPSB fertilizer from 0 to 150 kg $ha^{-1}$ enhanced the number of effective nodules per plant. The highest number of effective nodules per plant (39.58) was recorded when NPSB was applied at the rate of 150 kg $ha^{-1}$, while the lowest number of effective nodules per plant (31.00) was recorded at the rates of 0 and 50 kg NPSB $ha^{-1}$(Table 8). Many authors have argued that legume nodules with dark pink or red colors due to the presence of leg hemoglobin are a sign of rhizobia strain effectiveness, which is linked to nitrogen fixation.

According to Arega and Mekonnon, (2019), maximum number of nodules was recorded from the highest rate of blended NPSBK fertilizer $ha^{-1}$, while the minimum number was noted from control treatment. Their results clearly indicated that integrated use of blended NPKSB fertilizer rate significantly increased total nodulation and effective nodule number in common bean.

### 4.3.4. Nodule Dry Weight per plant (g)

The main effects of blended NPSB fertilizer significantly ($p<0.05$) influenced nodule dry weight per plant however the main factor varieties and the interaction of main factors did not show a significant difference on nodule dry weight per plant (Appendix Table 2). The highest nodule dry weight (1.29g/plant) was recorded from the treatment that received 150kg $ha^{-1}$NPSB, while the lowest nodule dry weight (0.76g/plant) was obtained on the control treatment (0 kg NPSB $ha^{-1}$) (Table 8). Pochiman (1991) reported that phosphorus plays a key role in various physiological processes concerning root production, nodulation, seed formation and also improves the seed quality.

Table 8:-The main effect of NPSB fertilizer rate on total number of nodule, effective nodules, and nodule dry weight in chickpea plant

| Treatments | Nodule parameters | | |
|---|---|---|---|
| NPSB fertilizer kg ha-1a | Nodule Number | Number of Effective Nodule | Nodule dry weight g/plant) |
| 0 | 40.42$^{c}$ | 31.00$^{c}$ | 0.76$^{b}$ |
| 50 | 42.25$^{c}$ | 31.00$^{c}$ | 0.97$^{b}$ |
| 100 | 46.25$^{b}$ | 35.25$^{b}$ | 1.24$^{a}$ |
| 150 | 50.17$^{a}$ | 39.58$^{a}$ | 1.29$^{a}$ |
| LSD (0.05) | 2.75 | 1.25 | 0.23 |
| CV(%) | 7.38 | 4.4 | 26 |

**Where:** CV= Coefficient of Variation, LSD: Least Significant Difference. Means with the same letter in columns are not significantly different at 5% level of significance

### 4.4. Yield Components and Yield of Chick pea

#### 4.4.1. Number of pod per plant (Pods plant $^{-1}$)

Analysis of variance showed that the main effects of blended NPSB fertilizer application rate had highly significant ($p<0.01$) effects on the number of pods per plant of chickpea, however not affected by the main factor variety and their interaction (Appendix Table 3).

The highest number of total pods per plant (97.5) was recorded at the application rate of 150 kg NPSB ha$^{-1}$, whereas the lowest number of total pods (38.5) was obtained from the unfertilized plot (Table 9).

Number of pods plant$^{-1}$ is a key factor for determining the yield performance in leguminous plants. The productive capacity of chickpea is ultimately dependent on the number of fertile pods plant$^{-1}$

In principle under optimum fertilizer application the number of pods per plant is usually high, whereas the least number of pods per plant recorded in the control treatment. This increase in the number of pod plants$^{-1}$ with increased the application NPSB could be attributed to pronounced plant's growth, which resulted in an increase in the number of pods per plants (Seid *et al.,* 2015).

#### 4.4.2. Number of seed per pod (seeds pod$^{-1}$)

The analysis of variance showed that number of seed per pods was significantly ($P<0.05$) affected by the main effects of NPSB fertilizer rate. However, varieties and their interaction were not significantly affected number of seed per pod of chickpea (Appendix Table 3).

The highest number of seeds per pod (1.21) was observed from the main effect of NPSB rate at 100 kg $ha^{-1}$, while the lowest number of seeds per pod (1.09) was recorded at NPSB rate of 0 kg $ha^{-1}$ (Table 9). This result is similar to that of Shabeer, (2015), who discovered that the greatest phosphorus content resulted in the highest number of seeds $plant^{-1}$ in the chickpea crop.

On the other finding is similar with the finding of Erdemci *etal.(* 2016) who reported significant effect of phosphors fertilizer application on number of pod per plant and number of seed per pod..

Table 9:-The main effect of NPSB fertilizer rate on number of pod per plant and number of seed per pod in chickpea plant

| Treatments | Yield component parameters | |
|---|---|---|
| NPSB fertilizer (kg $ha^{-1}$) | Number of pod per plant | Number of seed per pod |
| 0 | 38.55$^{d}$ | 1.097$^{b}$ |
| 50 | 50.67$^{c}$ | 1.09$^{b}$ |
| 100 | 65.6$^{b}$ | 1.21$^{a}$ |
| 150 | 97.5$^{a}$ | 1.18$^{a}$ |
| LSD (0.05) | 8.81 | 0.07 |
| CV (%) | 16.7 | 7.6 |

**Where:** CV= Coefficient of Variation, LSD: Least Significant Difference. Means with the same letter in columns are not significantly different at 5% level of significance

### 4.4.3. Hundred Seeds weight (g)

Hundred-seed weight is also an important yield component which reflects the magnitude of seed development which ultimately impacts heavily on the final yield of a crop. The main effects of variety had highly significant ($p<0.01$) effect on hundred-seed weight of chickpea, however not affected by the main factor NPSB fertilizer rates and the interaction of main factors (Appendix Table 4).

*Dhera* variety gave the highest hundred-seed weight (29.4 g) which was statistically at par with *Habru* variety, while local *Dubie* gave the lowest hundred-seed weight (21.9 g) (Table 10). The difference among varieties in hundred seed weight could be due to genetic difference in response to environmental condition.

In line with this result many authors (Tamiru *et al*., 2021; Tesfahun *et al*.2018; Tripathi *et al*., 2012) reported significant differences among genotypes of chickpea on hundred seed weight.

Table 10:-Hundred seed weight as influenced by the main effect of chickpea

| Variety | Hundreseed weight(g) |
|---|---|
| *Habru* | 28.75[a] |
| *Dhera* | 29.42[a] |
| *Arerti* | 23.75[b] |
| *Dubie* | 21.9[c] |
| LSD (0.05) | 1.79 |
| CV(%) | 8.28 |

**Where:** CV= Coefficient of Variation; LSD= Least Significant Difference; Means with the same letter in columns are not significantly different at 5% level of significance

#### 4.4.4. Above ground dry biomass (kg ha$^{-1}$)

The main effects of blended NPSB fertilizer rate and varieties had highly significant ($p<0.01$) effect on aboveground dry biomass yield of chickpea, while their interaction effect of NPSB rate with varieties was significant ($p<0.05$) (Appendix table 5).

The highest aboveground dry biomass yield (7259 kg ha$^{-1}$) was recorded due to the application of highest rate of NPSB fertilizer (150 kg NPSB ha$^{-1}$) for variety *Arerti*, whereas the lowest (3514 kgha$^{-1}$) dry above ground biomass yield was obtained from *Dhera* Variety under control treatment (Table 11). These results show increasing the rate of fertilizer with in variety increase the above ground biomass this implies the nutrient use efficacy of different varieties.

The productivity of a crop is largely determined by the above ground dry biomass. Production of large amount of biomass is among the attributes of seed yield. Above ground dry biomass showed significant effect due to the interaction effects of variety *Arerti* with 150kg-h NPSB fertilizer

When blended fertilizer rates and kinds were used, Tesfahun et al.,(2018) found no significant variation in biomass yield .This is in contrast to my findings, which showed that the interaction between fertilizer rates and chickpea varieties had a significant impact on above ground dry biomass yield. On the other hand according to Ewentu and Afewerk(2020) chickpea responses led in the largest total number of nodule(32.8 plants$^{-1}$),above ground biomass(6494 kg ha$^{-1}$)despite an application of 193kgNPSZBha$^{-1}$,and seed yield In general the application of 193kg NPSZnB $ha^{-1}$ resulted in greatly increased and optimal growth, yield, and yield components.

### 4.4.5. Grain Yield (kg $ha^{-1}$)

The analysis of variance indicated that the main factors blended NPSB fertilizer rate and varieties; and their interaction highly significant ($p<0.01$) affected grain yield of chickpea (Appendix Table 4). The highest grain yield (3538 kg $ha^{-1}$) was recorded on variety *Arerti* at 150 kg NPSB $ha^{-1}$, while the lowest grain yield (1217 kg $ha^{-1}$) was recorded on variety *Dhera* in control treatment (Table 11). Differences in gain yield among the chickpea varieties might be related to the genotypic variations in nutrient-use-efficiency. Hence, the cultivars which produced higher grain yield might have been either to the better ability to absorb the applied nutrient from the soil solution or translocate and use the absorbed nutrients for grain formation than the low yielding cultivar. Dry matter production and its transformation into economic yield is the ultimate outcome of various physiological, biochemical, phonological and morphological events occurring in the plant system. Seed yield of a variety is the result of interplay of its genetic makeup and environmental factors in which plant grow This finding goes with the finding of Yasin, (2014) who observed the highest grain yields obtained from 150 kg $ha^{-1}$ (3609 kg $ha^{-1}$) and 125 kg $ha^{-1}$ NPSB (3514 kg $ha^{-1}$) along with rhizobium inoculation. Moreover, the yield *Arerti* and *Habru* were the best chickpea varieties which can improve the chickpea production (Yasin, 2014). Similarly Kaysha *et al*.(2020) reported the improved performance of varieties at 100 and 150 kg NPS $ha^{-1}$, which might be attributed to higher growth and dry matter production due to applied NPS and genotypic variation in mungbean. Different researchers reported significant interaction effect of variety and blended NPS fertilizer on grain yield of pulses (Arega and Zenebe, 2019; Dame and Tasisa, 2019; Baza, 2019; Deresa *et al.*, 2018)

### 4.4.6. Agronomic Efficiency (kg/$h^{-1}$)

The main effects of blended NPSB fertilizer and Variety as well as their interaction highly significantly ($p<0.01$) affected Agronomic efficiency of Chickpea (Appendix table 5).
The highest Agronomic Efficiency (11.5 $kgha^{-1}$) was recorded by the interaction of 150 kg $ha^{-1}$ NPSB fertilizer rate and variety of *Arerti*. On the other hand, the lowest (1.8 kg/ $ha^{-1}$) Agronomic Efficiency was recorded from plants grown with 50 $kgha^{-1}$ fertilizer at *Dhera* variety (Table 11).

Differences in seed yield among the chickpea varieties might be related to the genotypic variations in nutrient-use-efficiency. Hence, the cultivars which produced higher grain yield might have been either to the better ability to absorb the applied nutrient from the soil solution or translocate and use the absorbed nutrient for grain formation than the low yielding cultivar.

Table 11:- The interaction effect of Varieties and NPSB fertilizer on above ground Dry biomass, Grain yield and Agronomic efficiency

| Treatments Varieties with NPSB (kgha$^{-1}$) | Above ground Biomass(kgha$^{-1}$) | Grain yield (kgha$^{-1}$) | Agronomic efficiency(kgha$^{-1}$) |
|---|---|---|---|
| V1*0 | 3993.7fg | 1414$^{hg}$ | - |
| V1*50 | 4137.7$^{feg}$ | 1518$^{hg}$ | 2.1$^{f}$ |
| V1*100 | 5132$^{cbd}$ | 2029.3$^{cd}$ | 6.15$^{c}$ |
| V1*150 | 4800.7$^{ced}$ | 1771.3$^{ef}$ | 2.38$^{f}$ |
| V2*0 | 3514$^{g}$ | 1278$^{h}$ | - |
| V2*50 | 3574.7$^{g}$ | 1368$^{h}$ | 1.8$^{f}$ |
| V2*100 | 3912$^{fg}$ | 1772$^{ef}$ | 4.9d$^{c}$ |
| V2*150 | 5562$^{cb}$ | 2562$^{b}$ | 8.56$^{b}$ |
| V3*0 | 4399fed | 1810$^{def}$ | - |
| V3*50 | 4551$^{fed}$ | 1941$^{de}$ | 2.6$^{fe}$ |
| V3*100 | 5653.7$^{b}$ | 2256$^{c}$ | 4.46$^{de}$ |
| V3*150 | 7259$^{a}$ | 3538$^{a}$ | 11.5$^{a}$ |
| V4*0 | 4049feg | 1370$^{h}$ | - |
| V4*50 | 4164$^{feg}$ | 1466.7$^{hg}$ | 1.94$^{fe}$ |
| V4*100 | 4849$^{ced}$ | 1911$^{de}$ | 5.4$^{dc}$ |
| V4*150 | 4568$^{fed}$ | 1627$^{gf}$ | 1.71$^{fe}$ |
| LSD(0.05) | 804.74 | 249.4 | 1.8 |
| CV (%) | 10.4 | 8.1 | 31 |

**Where:** LSD= List significant difference, CV=Coefficient of variation V1=*Habru* ,V2=*Dhera*,V3= *Arerti* and V4= *Dubie* varieties of chickpea. Means with the different letter are significantly different

### 4.4.7. Harvest Index (%)

The main effects of blended NPSB fertilizer rates and varieties highly significantly ($p<0.01$) affected harvest index of chickpea, however their interaction was not significant ($p<0.05$)(Appendix Table 5).

The highest harvest index was obtained from variety *Arerti* (43.41%) which was statistically similar with *Dhera* variety; while the lowest harvest index (37.07%) was recorded from variety *Dubie*, which was at parity with *Habru* variety. The variation observed among varieties in harvest index could be due to genetic variation. This fining was similar to the findings of Tesfhun *et al.* (2018).

Moreover, NPSB rate of 150 kg $ha^{-1}$ gave the highest harvest index (42.9%) which was statistically at par with 100kg NPSB $ha^{-1}$, while the lowest harvest index (37.02%) was recorded from the control treatment, which was at parity with 50kg NPSB $ha^{-1}$ (Table 12). *Arerti Habru*. This might be due to the higher NPSB fertilizers rate which had high influence on vegetative growth than nutrient translocation from plant biomass to seed. Similar to this study, Arega and Zenebe (2019) also reported non-significant interaction of NPKSB with variety in harvest index of common bean.

Harvest index is useful in measuring storage nutrient partitioning in crop plants, which provides an indication of how efficiently the plant utilized acquired nutrients for grain production. So, the highest harvest index also implies higher partitioning of dry matter into grain.

Table12:- Harvest index as influenced by the main effect of variety and NPSB fertilizer rates

| NPSB | HI (%) |
|---|---|
| 0 | (37.02)c |
| 50 | 38.34bc |
| 100 | 41.2ba |
| 150 | 42.9a |
| Variety | HI (%) |
| *Habru* | $37.5^{b}$ |
| *Dhera* | $41.5^{a}$ |
| *Arerti* | $43.41^{a}$ |
| *Dubie* | $37.07^{b}$ |
| LSD (0.05) | 2.88 |
| CV (%) | 8.7 |

**Where:**CV= Coefficient of variation, LSD: Least significant difference. ; HI= Harvest index; Means with the different letter are significantly different

### 4.5. Partial Budget Analysis

The economic analysis was carried out the benefits of each treatment where the costs of NPSB fertilizer (Birr 19 $kgh^{-1}$).

The farm get price of the marketable yield of check pea during the time of harvesting was Birr 45 $kg^{-1}$, which was used in the present study. Accordingly, the highest net benefit (Birr 140,439) was obtained from the treatment combination of 150.kg $ha^{-1}$ NPSB fertilizer and *Arerti* variety. The lowest net benefit (Birr 51,795) was recorded from plants without NPSB fertilizer and *Dhera* variety indicated in (table 13)

Table 13:- Partial Budget Analysis of NPSB application on chickpea grain yield

| Treatment | Combination | Av.GrainYied (kg $ha^{-1}$) | Adjusted yield (kgha$^{-1}$ha) | Gross field benefit (ETB $ha^{-1}$) | Total variable costNPSB (ETBha$^{1}$) | Net benefit (ETB $ha^{-1}$) |
|---|---|---|---|---|---|---|
| NPSB | Varieties | | | | | |
| 0kgha$^{-1}$ | V1 | 1414 | 1272.7 | 57240 | - | 57240 |
| | V2 | 1278.7 | 1151 | 51795 | - | 51795 |
| | V3 | 1810.3 | 2208.3 | 73470 | - | 73470 |
| | V4 | 1370 | 1232 | 55458 | - | 55458 |
| 50kgha-1 | V1 | 1514 | 1366.2 | 61479 | 950 | 60529 |
| | V2 | 1368.7 | 1231.6 | 55422 | 950 | 54472 |
| | V3 | 1941 | 1746.9 | 78585 | 950 | 77635 |
| | V4 | 1466.7 | 1368.4 | 61594 | 950 | 60644 |
| 100kgha-1 | V1 | 2026.67 | 1826.7 | 82208 | 1900 | 80308 |
| | V2 | 1772 | 1594.6 | 71756 | 1900 | 69858 |
| | V3 | 2256 | 2030.4 | 91368 | 1900 | 89468 |
| | V4 | 1911.7 | 1781 | 80160 | 1900 | 78260 |
| 150kgha-1 | V1 | 1771.33 | 1594.2 | 71739 | 2850 | 68889 |
| | V2 | 2363 | 2208.3 | 99377 | 2850 | 96527 |
| | V3 | 3538 | 3184.2 | 143289 | 2850 | 140439 |
| | V4 | 1626.5 | 1464 | 65880 | 2850 | 63030 |

**Where:**V1=*Habru*varieties,V2=*Dhera*varayties,V3=*Arerti*varieties,V4=*Dubie* ,(0,50,100,150) different rate of NPSB fertilizer

Current Price of chickpea= 45 birr/kg. 50kg ,100kg and 150kg =NPSB fertilizer.

Table 14:- Marginal rate of analysis of NPSB application on chickpea grain yield

| Treatment Variety*NPSB | Adjusted Kg ha-1a$^{-}$ | Yield Gross field benefit | Total variable cost Birr $ha^{-1}$ | Net benefit Birr $ha^{-1}$ | MRR% |
|---|---|---|---|---|---|
| v1*100 | 1826.7 | 82201.5 | 950 | 80308 | 1818.74 |
| v1*150 | 1594.2 | 71739 | 1900 | 68889 | 308.7 |
| v2*100 | 1594.8 | 71766 | 950 | 69858 | 718.7 |
| v2*150 | 2208.2 | 99368 | 1900 | 96527 | 1763 |
| v3*100 | 2030.4 | 91368 | 950 | 89468 | 2782 |
| v3*150 | 3184.2 | 143289 | 1900 | 140439 | 4074 |
| v4*100 | 1781.6 | 80172 | 950 | 78260 | 1603 |

**Where:** MRR= Marginal rate of return = Marginal net benefit x 100/Marginal cost; Current Price of chickpea= 45 birr/kg. 100kg and 150kg =NPSB fertilizer.

# 5. SUMMERY AND CONCLUSION

Ethiopia is the largest producer, consumer and exporter chickpea in Africa, and is among the top ten most important chickpea producers in the world. Ethiopian chickpea production is changing from traditional varieties to improved varieties from desi to Kabuli types. The farmer are increasingly using market preferred varieties and adopting improved crops production practices recommended by researchers.

In Southern Nations, Nationalities and Peoples Regional State (SNNPRS), chick pea is cultivated in various zones, some special woredas and pocket areas of the region. In general, in this region chick pea occupies about 5,896 hectares of land annually with estimated production of 66,363.02 quintals. Of the total regional area under pulse crops 1.95 % is covered by chick pea and 1.77 % total grain production was obtained from it. The national average yield of chick pea in Ethiopia is 13.36 qt/ha and the regional average yield of 11.26 qt/ha, which is far below the potential yield of 4.5$tha^{-1}$

In the underdeveloped world, chickpea is a relatively inexpensive source of protein (20–23% in the grain), energy (carbohydrates, 40%), oil (3–6%), and minerals (Mg, K, P, Fe, Zn, and Mn (nd –carotene). Chickpea is an essential contributor to the long-term viability of cereal-legume cropping systems, increasing cereal yields by increasing soil nitrogen and breaking disease cycles of important cereal diseases.

Chickpea production is presently restricted to a small area in Southern Ethiopia including Gurage Zone due to a number of limiting factors such as low soil fertility, diseases and pests, and lack of production technologies, that remains low in its productivity. To mitigate the low soil fertility challenges, information regarding the actual rate of the newly recommended blended NPSB fertilizer and chickpea varieties are not yet known in the study area-Ezha District, Gurage Zone. Therefore, lack of recommended fertilizer rate and chickpea varieties were the main yield constraints in the study area. Hence, an experiment was conducted during the 2021 cropping season on farmers’ field to determine optimum blended fertilizer rate and well responded chickpea variety`s to NPSB rate for the study area production. Four levels of NPSB (0, 50, 100, and 150 kg $ha^{-1}$) and four chickpea Varieties (*Habru*, *Dhera*, *Arerti* and *Dubie* (standard check) were used as treatments and set in randomized complete block design with a factorial arrangement of three replications.

The surface soil samples which was collected before sowing indicated that the soil has 0.71% total nitrogen, 14.3% organic matter, 8.3% organic carbon, 6.41 ppm available phosphorus, 0.08ppm boron,17.8 ppm available sulfur  and 5.5 $P^H$, with the soil textural class of  clay loam ( clay 34%, sand 26% and silt 40%).,

In the present study, almost all the assessed phenological, growth, yield and yield components influenced by that of variety and blended NPSB fertilizer. Likewise, the interaction effect of variety and blended fertilizer influenced a number of traits like above ground biomass, grain yield and agronomic efficiency. Moreover, the present study confirmed that increasing the rates of blended NPSB fertilizer from 0 to 150 kg $ha^{-1}$ increased day to flowering, physiological maturity, effective nodule, dry weight of nodule, number of pods per plant, number of seed per pod, and harvest index. However, almost all traits increased with increased NPSB fertilizer level up to 100 to 150 kg $ha^{-1}$but less than 100 kg $ha^{-1}$ (at 0 and 50 kg $ha^{-1}$) these parameter showed  insignificant changes.

Generally, improved varieties used in the present study performed well in all the tested parameters of chickpea than the local cultivar, where *Arerti* variety recorded the highest grain yield with application of 150 kg $ha^{-1}$ NPSB (3538kg $ha^{-1}$),which is increased grain yield by 95% increment over the control check (zero fertilizer) with  the  local check. Application of 150 kg $ha^{-1}$ with *Arerti* obtained the highest net benefit (140,439 ETB $ha^{-1}$) with maximum marginal rate of return (4074%) which is economically feasible for chickpea production area.

Based on the results of the present study, the application of 150 kg $ha^{-1}$ of NPSB fertilizer, in combination with *Arerti* is recommended for agronomical and economically chickpea production in the study area. However the study was conducted only for a single season and in only one location, further research is recommended to be carried out in more other locations as well as at different seasons.

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# 7. APPENDICES

Appendix table 1:- Mean square value of phonological parameter of chickpea as influenced by blended NPSB fertilizer and variety.

| Source of Variation | Degree of Freedom | Days to Flowering | Dayto Physiological Maturity |
|---|---|---|---|
| Rep | 2 | 33.08 | 225.6 |
| Variety | 3 | 159.5** | 1642.** |
| NPSB | 3 | 61.24** | 48.52** |
| NPSB*VARIETY | 9 | 2.41$^{NS}$ | 5.04$^{NS}$ |
| Error | 30 | 4.95 | 11.14 |
| CV(%) | | 3.89 | 3.07 |

Where: CV(%)=Coefficient0fVariation,**=highlySignificant,*=Significant,NS=noneSignificant

Appendix table 2:-Mean squares from analysis of variance (ANOVA) growth parameter plant height, Number of pod per plant

| Source of Variation | Degree of Freedom | Number of nodule | Effective Nodule(no) | Nodule dry Weight(g) | Plant Height |
|---|---|---|---|---|---|
| Rep | 2 | 442.021 | 9.520 | 0.02 | 191.3 |
| Variety | 3 | 10.076$^{NS}$ | 6.354$^{NS}$ | 0.07$^{NS}$ | 480.5** |
| NPSB | 3 | 226.46** | 244.02** | 0.75** | 20.19$^{NS}$ |
| NPSB*VARIETY | 9 | 5.87$^{NS}$ | 3.02$^{NS}$ | 0.199$^{NS}$ | 30.98$^{NS}$ |
| Error | 30 | 10.93 | 2.854 | 0..077 | 24.74 |
| CV(%) | | 7.4 | 4.4 | 26.1 | 8.48 |

Where:CV(%)=Coefficient0fVariation,significant,**=highlySignificant,*=Significant, NS=noneSignificant

Appendix table 3:- Mean squares from analysis of variance (ANOVA) number of pod per plant, number of seed per pod

| Source of Variation | Degree of Freedom | Number of Pod per plant | number of seed per pod |
|---|---|---|---|
| Rep | 2 | 58.13 | 0.04 |
| Variety | 3 | 55.94Ns | 0.009$^{NS}$ |
| NPSB | 3 | 7796.3** | 0.05** |
| NPSB*VARIETY | 9 | 102.06$^{NS}$ | 0.005$^{NS}$ |
| Error | 30 | 111.56 | 0.008 |
| CV(%) | | 16.74 | 7.26 |

Where:CV(%)=CoefficientofVariation,**highlysignificant,*=Significant,NS=noneSignificant

Appendix table 4:-Mean squares from analysis of variance (ANOVA) hindered seed weight, above ground biomass, grain yield.

| Source of Variation | Degree of Freedom | Hundred Seed weight | Above Ground Biomass | Grain Yield |
|---|---|---|---|---|
| Rep | 2 | 6.33 | 601076 | 393308 |
| Variety | 3 | 163.9** | 4014337** | 1567994** |
| NPSB | 3 | $1.69^{NS}$ | 6354485** | 2070010** |
| NPSB*VARIETY | 9 | $4.21^{NS}$ | 972251** | 409017** |
| Error | 30 | 4.62 | 232904 | 22371 |
| CV(%) | | 8.28 | 10.3 | 8.07 |

Where:CV(%)=CoefficientofVariation,**=highlySignificant,*=Significant,NS=none Significant

Appendix table 5:-Mean squares from analysis of variance (ANOVA) yield parameter harvest index agronomic efficiency

| Source of Variation | Degree Freedom | Harvest Index | Agronomic Efficiency |
|---|---|---|---|
| Rep | 2 | 93.07 | 0.92 |
| Variety | 3 | 115.4** | 11.19** |
| NPSB | 3 | 85.6** | 97.42** |
| NPSB*VARIETY | 9 | $21.19^{NS}$ | 17.59** |
| Error | 30 | 11.95 | 1.163 |
| CV(%) | | 8.67 | 31 |

Where:CV(%)=Coefficient of Variation,**=highly Significant,*=Significant, NS=non-Significant,