INFLUENCE OF COMBINED APPLICATION OF NPSB BLENDED FERTILIZER AND VERMICOMPOST ON YIELD AND SEED QUALITY OF SOYBEAN VARIETIES (*Glycine max (*L.*) MERRILL*) IN DALE SADI DISTRICT, WESTERN OROMIA, ETHIOPIA

M.Sc. THESIS

BY

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Influence of Combined Application of NPSB Blended Fertilizer and Vermicompost on0 Yield and Seed Quality of Soybean Varieties (*Glycine max* (L.) *Merrill)* in Dale Sadi District, Western Oromia, Ethiopia

By

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A Thesis Submitted to the Department of Horticulture and Plant Science Jimma University College of Agriculture and Veterinary Medicine in Partial Fulfillment of the Requirements for the Degree of Master of Science in Agronomy

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DEDICATION

I dedicate this thesis manuscript to my father Emisha Mengesha, my mother Teme Efa and my wife Alemi Nemera for their continuous support and encouragement throughout my life.

STATEMENT OF THE AUTHOR

First, I declare that this thesis is my own work and that all sources of materials used in this thesis have been duly and accordingly acknowledged. The thesis has been submitted in partial fulfillment of the requirements for M.S.c degree at the College of Agriculture and Veterinary Medicine, Jimma University, and has been deposited in the university library to be made available to users under the rules of the library. I declare that this thesis has not been submitted to any other institution anywhere for reward of any academic degree, diploma, or certificate. A brief quotation from this thesis is allowed without special permission if accurate acknowledgment of the source is made. Requests for permission for extended quotation or reproduction of this manuscript in whole or in part may be granted by the head of the department or the dean of the College when, in his or her judgment, the proposed use of the material is for scholarly interest. In all other instances, however, permission must be obtained from the author.

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LIST OF ABBREVIATIONS AND ACRONYMS

BARC	Bako Agricultural Research Center
BNF	Biological nitrogen fixation
CEC	Cation exchange capacity
CIMMYT	Centro Internatcional de Mejoreminto de Maiz Trigon
CSA	Central Statistical Agency of Ethiopia
FAO	Food and Agricultural Organization of the United Nations
TDM	Total dry matter
INM	Integrated nutrient management
VC	Vermicompost organic fertilizer
NPSB	Blended inorganic fertilizer
WHO	World Health Organization
HSARC	Haro Sabu Agricultural Research Center

BIOGRAPHICAL SKETCH

The author, Lemesa Emisha Mengesha, was born from his father, Mr. Emisha Mengesha and his mother, Mrs. Teme Efa, in 1987G.C at Tibe Hara Kebele, in Gobu Seyo District, in Easter Wollega Zone of the Oromia Regional State, Ethiopia. He attended his elementary education at Goda Hara Elementary School and he joined secondary education in Bako Tibe Senior Secondary School in 2005 G.C and joined Bako ATVET College Western Shoa Zone, Ethiopia in 2007 G.C, and graduated with a Diploma in Plant Science in 2010 G.C. After his graduation, he was employed in Kiramu District Eastern Wollega in Agriculture and Rural Development Office and after two years he transfer to Bako Agriculture and Rural Development Office, and served as development agent from 2010 G.C to 2013G.C. In 2014 G.C he joine Wollega University Shambu Campus and graduated with B.S.c in plant science in weekend program. After graduation he has got the opportunity to work in Oromia Agricultural Research Inistitute (OARI) and employed stationed at Haro Sabu Agricultural Research Center (HSARC) as junior Agronomist on pulse and oil research team case and conducted different agronomic research activities on pulse and oil crops for three years with various commitments and responsibilities in the institute until he joined the School of Graduate Studies at Jimma University for his M.Sc.Degree in Plant Agronomy.

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A B S T R A C T

Soybean (Glycine max (L.) Merrill) is a pulse crop with multiple food and economic advantages for small-scale farmers.However, decline in soil fertility due to nutrient depletion and the cost of fertilizers has been increasing and less availability is a concern to small-scale farmer becoming unaffordable for crop production in most parts of Ethiopia. This study was carried out to evaluate the influence of combined use of different rates of vermicompost with NPSB fertilizers on soil properties, yield, yield components,seed quality and economically feasible on soybean varieties in Dale Sadi district, western Ethiopia. A field experiment was carried out during the main cropping season of 2023 at Haro Sabu Agricultural Research Center (HSARC).The treatments consisted of factorial combination of six NPSB fertilizer combined with vermicompost (0+0, 100+0, 75+2, 50+4, 25+6 and 0 kg+8 tones ha^{-1}) with two soybean varieties (Didessa and Ethio ugozilavia) usin completely randomized block design (RCBD) with three replications. The post harvest soil analysis result showed that the maximum pH value (5.57) was recorded from NPSB 50 kg ha^{-1}+ 4 t Vc fertilizer application on Didessa variety while the minimum soil pH (5.50) was obtained from 1ookg NPSB ha^{-1} treatment with Ethioyugoslavia variety. The (%) change in soil reaction pH maximum result (3.72%) was recorded due the combined application of inorganic NPSB 50 kg ha^{-1}+ 4 t Vc fertilizer over composite soil. The agronomic and yiel data: Days to 50% flowering, number of total nodule per plant, number of effective nodule per plant, days to 90% phsiological maturit , plant height, number of primary branch per plant, number of pod per plant, number of seed per pods, hundred seed weight, aboveground dry biomass yield, seed yield and harvest index analysis of variance results revealed highly significant ($p<0.0001$) effected due to the combined application of NPSB with vermicompost fertilizer application. The maximum above ground dry biomass yield (8.89 t ha^{-1}) was recorded from combined application of 75 kg ha^{-1} NPSB $^{+}$ 2 t ha^{-1} Vc while, the minimum aboveground dry biomas yield (5.34 t ha^{-1}) was obtained from control treatment. Similarly, the maximum seed yield (3.42 t ha^{-1}) was recorded from the combined application of 75 kg ha^{-1} NPSB and 2 t Vc ha^{-1} while, the lowest seed yield (1.39 t ha^{-1}) was obtained from control treatment while only number of primary branch per plant was significantly ($p\leq0.01$) influenced by the main effect of the variety.However, number of pod per plant was high siginificantly ($p<0.0001$) effected by the main effect of variet. The longer to reach days to 50% flowering (74.12 days) was recorded due to (8 t ha^{-1}) alone and the earlier 50% days to flowering was recorded (67.5days) from un-fertilizer treatment. In the case of the main effect of the variety the longest mean days to flowering (74.12) was recorded from variety Ethioyugoslavia while the earlier (68.11days) obtained from variety Didessa. However, the intraction effect of the two factors influenced only by days to 90% physiological maturity. The longest period of days to 90% physiological maturity (126.67dyas)was recorded from the application of 0kg ha-1+8 t Vc ha-1 with Ethioyugoslavia variety while the earlier period of (114 days) was obtained from the control with Dedessa variety. The proximate composition in soybean seed result showed that the maximam protein content and protein yield (41.77% and 1.43t ha^{-1}) was recorded from the application of 75kg NPSB ha-1+2t VC ha^{-1} with Ethioyugoslavia and Didessa variety respectively. However, the lowest protein content and protein yield (38.27% and 0.53 t ha-1) were obtained from control treatment with Ethioyugoslavia variety and Didessa variety respectively. The % change in protein content and protein yield (9.2% and 169.8%) due combined fertilizer application. The maximam oil content and oil yield (21.12%and 0.73 t ha^{-1}) were recorded from 100kgNPSB ha^{-1} and 75kg NPSB+2t Vc ha^{-1}+Didessa variety respectively while the minima oil content and oil yield (17.4%and 0.24 t ha^{-1}) were obtained from control treatment with Ethioyugoslavia variety and both varieties respectively. The % change in oil content and oil yield (21.4% and 204.12%) over control treatment. From the economic point of view, the application of 75kg ha^{-1} NPSB and 2 t Vc ha^{-1} showed the yield advantages of 150.20% over control treatment when we compare the net benefit. Therefore, combined application of 75kg ha^{-1}NPSB + 2 t Vc ha^{-1} with soybean variety could be increases availability of nutrients, especially phosphorus, total nitrogen, as well as soil organic matter and organic carbon in the soil, which are very crucial for betterment of soybean performance, yield and seed quality. However, the influence of NPSB and vermicompost on yield, seed quality and soil properties on different maturity groups of soybean varieties at different locations and years needs further investigation to come up with conclusive recommendations.

Keys Words: Inorganic fertilizer, Organic fertilizer, Ethioyugoslavia, Didessa, Crude protein

1. INTRODUCTION

Soybean (*Glycine max* (L). *Merrill)* is a legume species that is widely grown all over the world and considered as golden bean or miracle bean because it acts as an alternative source of human nutrition, animal feed and bioenergy for the twenty-first century (Dei, 2011, Islam *et al.* 2019, Dukariya *et al.*, 2020, Dilawari *et al*., 2022). It has been also used worldwide in soil fertility programm as it can add substantial amount of nitrogen in the soil through biological nitrogen fixation when it forms symbiosis association with bradyrhizobium rhizobium bacteria(Postgate, 1982, Singh *et al.,* 2010). Several studies have reported that legume crops such as cowpea, mungbean, soybean, common bean and groundnuts can natural fix and accumulate nitrogen ranging from 75 to 350 kg ha^{-1} per year (Salvagiotti *et al.*, 2008, Nyoki *et al.*, 2019). This crop is short day self-pollinated C_3 plant grown worldwide under a wide range of temperature over wider agro-ecologies in the tropical, subtropical and temperate of the countries has a wide range of adaptation for climatic conditions (Getahun *et al.*, 2016, Achamyelh *et al*., 2020).

Soybean is the highest oil and protein contents of seed crops which is a crucial component of food security around the world as a source of protein in human and animal diet, as well as providing cooking oil and biofuels (Whaley *et al.,* 2019) and it is a promising pulse crop proposed for alleviation of acute shortage of protein since it contains on average about 40% protein, 20% oil, 35% carbohydrate and about 5% ash, which determine the economic worth of the seed in the glob (Messina *et al*., 2010, Banaszkiewicz, 2011).Globulin is largely responsible for the nutritional value of soybean meal, accounting for about 70% of the total protein storage in soybean seed and the quality of soybean protein is comparable to animal proteins from meat, milk and eggs (Mariotti, 2017, Kudełka *et al*., 2021). The nutritional value of this crop is very important for human health benefits (Asif and Acharya, 2013, Rizzo and Baroni, 2018).

This indicates that this crop has excellent nutritional values for the low-income population of the developing world who cannot afford animal proteins. Therefore, due to its high nutritional value and multi form of uses, it is recognized as 'Golden Bean' and has become the miracle crop of the 21st century(Tewari *et al.,* 2016). Globally its production and productivity has expanded and it is the most of fifth grown crop in the world (Kothari *et al.,* 2022).The main producers in the world are Brazil (33%), USA (32%) and Argentina (19%) contributing collectively to (84%) of the world`s production among other countries;

such as China producing (6%) of the world production and India producing (4%) were reported (Terzic *et al.*, 2018, FAOSTAT, 2022).Currently global average productivity of 3.21t $ha^{-1.}$ and its potential productivity that could go up to 4 t ha^{-1} (FAOSTAT, 2022).

In Ethiopia Soybean production is crucial to addressing the issue of malnutrition particularly for smallholder farmers who cannot afford animal source proteins. Its production and seed quality provides a promising opportunity for smallholder farmers. Since 1950s Soybean introduction and its area coverage and production have been increasing year by year (Tesfaye *et al.*,2018). The area covered by soybean production is 54,543 ha with total production of 125,623 t ha^{-1} (CSA, 2020). However, the productivity of this crop is CSA (2.30 t h^{-1}) (Agegn *et al*., 2022) which is still below the world average productivity. The low yield of soybean production and productivity both in national and Western Oromia region is limited due to the lack of improved varieties, poor soil fertilityand crop management practices and etc.As a result of these the production of this crop is below the potential yield. For instance soybean Ethioyugoslavia variety at research field 1.7-3.5 t ha^{-1} and at farmers levels 1.6-3.0 t ha^{-1} and Didessa at research field 2.-3.3 and at farmesr levels 1.4 -2.8 t ha^{-1} were reported by (BARC, 2008, MoARD, 2008). Similarly, the national average yield of soybean varied from 1.8 t ha^{-1} in 2012 to 2.0 t ha^{-1} in 2013 while the potential yield obtained from on-station and on-farm research fields was 3.5 and 2.6 t ha^{-1}, respectively (MARD,2013).

Soybean being a high protein and energy crop and its productivity is often limited by the low availability of essential nutrients. Soil fertility reduction is the root cause for smallholder farmer the production and productivity of soybean is limited by nutriets deficiencies (Mafongoya *et al.,* 2006). This clearly shows that this crop nutrient exhaustive among the legumes crops and therefore, the crop does not give high yield unless sufficient quantity of nutrients is supplied during the growth period (Singh *et al.,* 2007). For instance, Dibabe (2000) who reported that most agricultural soils of Western Oromia region have consistently shown multinutrients; nitrogen (N),phosphorus (P), sulfur(S), andboron (B)deficiencies. Similarlly,soil fertility mapping by (Ethiopia SIS, 2014) revealed low levels of Nitrogen, Phosphorus, Sulfur and Boron (NPSB) in most areas of Kellem Wollega Zone. Likewise, Amsal and Tanner (2001) reported that soil fertility reduction is one of the major challenges for crop production and productivity in Ethiopia.

Martey *et al*. (2019) also who reported soil fertility depletion is the major cause of food insecurity and poverty in developing countries and necessitates the use of fertilizer.

Inorganic fertilizers, because of their high nutrient contets, provide nutrients that are in short supply, thereby increasing the initial survival and/or growth rate of introduced plants and convenient transportation and application are very attractive and commonly used to enhance crop yields. Beside of this the roles of both macro and micronutrients are crucial in crop nutrition and thus important for achieving higher yields (Arif *et al.*, 2006). In line with this, the government of Ethiopian has given high attention as fertilizer is needed for the crops and great efforts have been underway to adopt, promote and the use of it(FDRE, 2015). Similarly, appropriate application of inorganic fertilizers has resulted in an increment of crop yield of about 30% to 50% (Vlek., 1990, Stewart *et al,* 2005). Likewise, the total consumption and the demand for inorganic fertilizer have shown an increasing trend. However, currently the main challenging issue is the cost of inorganic fertilizers price and less availability has been reached becoming unaffordable for small-scale farmer in most parts of Ethiopia(Maatman *et al.,* 2007). Due to this, farmers were facing severe problem and soaring price of fertilizers has posed a great challenge for farmers in Ethiopia.

This situation is stagnant with recent yield estimated at less than 30% of actual potential land only about 7% of favorable land allocated to soybeans (SSA) presents a great opportunity for closing this global demand-supply gap report(Deribe., 2021). Indespite of its importance the long-term use of inorganic fertilizers without organic supplements deteriorating the physical, chemical biological properties of soil and cause the environmental pollution (Liu *et al.,* 2010). However, manyscholars reported that vermicompost is increasingly beingconsidered in agricultureas apromising alternativeto inorganicfertilizers (Lazcanoetal.2011,MupambWa *et al.,* 2018).It is nutrient-rich and environmentally friendly with many potential uses in agriculture as soil conditioners (Zaller et al., 2007, Usmani et al., 2019).The results of several studies have shown that the addition of compost/vermicompost/ improves soil physical properties by decreasing bulk density and increasing the soil water holding capacity (Weber *et al.,* 2007).

The increased amount of humus in soil through application of vermincompost by earthworms would certainly help favorable change in physical, chemical and biological properties of soil and in enhancing the water-holding capacity (Singh *et al.,* 2011). It is

easily available, eco-friendly and enhances soil health that will have a positive impact on human health and soybean production and productivity (Baligah *et al*., 2021, Iqbal *et al.,* 2024).Similarly, Aritonang,(2020) who reported that vermicompost fertilizer application increase the yield and yield components soybean when he compared to without applying vermicompost fertilizer. Likewise, application of vermicompost 50% + NPK 50% ha^{-1} supplies higher macro and micronutrients to the soil and plants in the available from which results in better growth, yield and quality of beans (Mahmoud *et al.,* 2020). Many scholars have reported that remarkable results from the integrated application of organic and mineral fertilizers, including yield difference on common bean (Fouda, 2017, Fekadu *et al*., 2018, Elka and Laekemariam, 2020).

This fertilizer is commonly regarded as a viable solution to the problem of soil nutrient depletion and food production sustainability (Chaudhary *et al.*,2004). However, there is limitation on vermicompost accessible nutrients relatively inorganic fertilizer low nutrient content, high application rates and high labor requirements. Vermicompost fertilizer alone may not be able to adequately meet crop nutrient demand unless it is combined with inorganic fertilizers (Masrie *et al.,* 2019). The Combined application of fertilizer reduced doses of inorganic fertilizers by half and hold potential to improve soils health, soybean productivity and supporting associated biodiversity in agro-ecosystem (Khaliq *et al.,* 2019, Adane *et al.,* 2020, Banik, *et al*., 2023).The other bottleneck is the demands of soybean seed quality study is rapidly increasing demand of global meat and fuel consumption (Voora *et al*., 2020).Malnutrition is the major global health problem particularly for developing countries including Ethiopia (Amare *et al.,* 2016).

Ethiopia is one of the highest countries regarding child malnutrition rate in the world besides food insecurity.Ethiopia edible oil industry mapping shows most of the oil processing factories (64%) are found in Oromia Region, 18% in Amhara Region, and 16% in Addis Ababa particularly in the capital city,for inistance Faffa Food Share Company, East African Flour Factory, Health care food manufacturing private limited companies etc. are using local and imported soybeans in the preparation of enriched food products for children and adults (WHO, 2003), Soybeans are also used to make corn-soy blend (CSB) for emergency food assistance programs run by international organizations and the Ethiopian government. This indicates that as further research is needed, for soybean seed

quality. In line to this Jangilwad *et al.(*2019) who repoted that nutrient management has effect on on yield and quality of Soybean.

However, the effects of vermicompost either alone or in combination with inorganic fertilizers, on the soybean yield and seed quality are not yet identified in study area. In despite of these constraints in western Oromia the response of soybean varieties to the combined application of inorganic NPSB with vermicompost is also not yet identified. According to Tesfaye *et al.*, (2018) studies result reported that the major reasons for low productivity of soybean in Ethiopia were low varietal stability. Likewise, Liu *et al.(*2022) reported shows that the growth, yield and yield components of soybean varieties were influenced with the adaption potential of the varieties to an edaphic-climatic condition as well as their response to varying nutrient managements. Research finding on soybean response to inorganic NPS fertilizers rate had done by (HSARC, 2021).

However, further research is needed, on selection of right varieties to combined application of vermicompost with inorganicNPSB fertilizer on soybean yield and seed quality. In this view, searching an optimam combination of in organic NPSB fertilizer with vermicompost and varities is critical issue to increasing soybean production and seed quality in study area.Therefore, this study was initiated with the following objectives.

General Objective

- To evaluate the influence of combined use of different rates of vermicompost with NPSB fertilizers on soil properties, yield, yield components,seed quality and economically feasibility on soybean varieties.

Specific objectives

- To determine combined application rates of NPSB fertilizer with vermicompost on soybean yield, yield components and seed quality in study area
- To assess the response of soybean varieties to combined application of NPSB fertilizers with vermicompost for the study area.
- To identify the influence of combined application of inorganic NPSB fertilizers with vermicompost on soil physico chemical properties
- To determine the economically feasible of combined application rates of NPSB fertilizer with vermicompost on soybean varieties

2. LITERATURE REVIEW

Soybean (*Glycine max (*L.) *Merrill*) is the family Leguminosae, subfamily *Papilionoideae* and the genus *Glycine* (L).Historical and geographical evidence suggests that soybean is originated and domesticated during the Shang dynasty in the eastern half of northern China (primary center of origin) during (1700–100 B.C., Hymowitz (1970). It was the oldest cultivated food legumes and it has been known to man for over 5,000 years. This crop is proposed as a candidate based on place of its domestication (Hymowitz, 1970). Molecular diversity studies conducted on soybean populations collected from north and south regions suggested that the crop was domesticated in South China (Wang *et al*., 2016, Jeong *et al*., 2019).Soybean was disseminated from China to Asia, Europe and the USA (Shurtleff *et al*., 2009, Wysmierski *et al.,* 2013). Know day's this crop is grown well on worldwide under a wide range of temperature over wider agro-ecologies in the tropical, subtropical and temperate climates and grown in many parts of country (Achamyelh *et al.,* 2020).

2.1. Botanical Description of Soybean (*Glycine max* (L). *Merrill*)

Botanically soybean is the family Leguminosae, subfamily *Papilionoidae* and the genus *Glycine* L. *G. soja* is the progenitor of the cultivated soybean Chromosomes number 2n=4x=40 (both the cultivated and the wild soybean). It is annual plant generally exhibiting erect, sparsely branched, bush type growth habit with pinnately trifoliate leaves. Flowers develop as short axillary with terminal racemes in cluster of 8-16 flowers are white, pink or purple. The seed coats range in color from light yellow, olive green and brown to reddish black (Hymowitz, 2004).The cultivated and wild soybeans are crossable and F1s are fertile. Soybean is strictly self-pollinated with less 1% outcrossing.

2.2. Importance of Soybean

Soybean is a legume species that is considered as golden bean or miracle bean because it acts as an alternative source of human nutrition , animal feed and bioenergy for the twenty-first century (Dei, 2011, Islam *et al.* 2019, Dukariya *et al*.,2020, Dilawari *et al*., 2022). It is the leading source of oil and high quality protein meal in the world (Warrington *et al.,* 2015).This crop is a promising pulse crop proposed for alleviation of acute shortage of protein since it contains on average about 40% protein, 20% oil, 35% carbohydrate and about 5% ash, which show economic worth of seed in the

globally(Messina *et al*., 2010, Banaszkiewicz, 2011). The nutritional value of this crop is high for human health benefits for instance Linoleic and linoleic acids help the absorption of vital nutrients required for human health and soy products have also been shown to be useful in prevention and treatment of bone resumption, inhibiting ovarian, breast and colon cancer and other chronic heart and kidney diseases (Asif and Acharya, 2013, Rizzo and Baroni, 2018, Kim *et al*.,2021).

Globulin is largely responsible for the nutritional value of soybean meal, accounting for about 70% of the total protein storage in soybean seed and the quality of soybean protein is comparable to animal proteins from meat, milk and eggs (Millward *et al.*, 2012, Kudełka *et al*., 2021). It is quite high in fat (7.7% to 47%) compared with other beans and are considered comparable to that of animal protein (Messina, 1999, Mariotti, 2017, Kudełka *et al*., 2021). This indicates that soybean has excellent nutritional values for the low-income population of the developing world who cannot afford animal proteins. The other merit of this crop is since it is a legume it is also used in climate mitigation and adaptation through N2 fixation, as crop diversification and reducing the amount of inorganic nitrogen fertilizer use (Rahman *et al*., 2022).

Several studies have reported that legume crops such as cowpea, mungbean, soybean, common bean and groundnuts can fix and accumulate nitrogen ranging from 75 to 350 kg ha^{-1} per year (Salvagiotti *et al.*, 2008 , Nyoki *et al*., 2019). Due to this these legumes are known as natural fertilizers factory having high nitrogen fixing capacity in the soil in association with *Bradyrhizobium* rhizobia bacteria. It also contributes to increased soil organic N and carbon through its fallen senescent leaves and below ground parts (Ronner *et al*., 2016). As a result, it has an additional advantage of reducing N fertilizer requirement for subsequent crops in a rotation. Therefore, soybean is an important crop with multiple benefits, which can be grown in rotation with cereals like maize, finger millet and sorghum.

2.3. Global Soybean Production

Soybean is extensively grown all over the world it is production and productivity is increasing year by year. Globally its production has expanded and it is one of the five most most grown crop in the world (Kothari *et al.*, 2022). The main producers in the world are Brazil at 33%, USA at 32% and Argentina at 19% contributing collectively to 84% of the world`s producers and other countries such as China producing 6% of the world

production and India about 4% were reported (Nchogu *et al.,* 2022). According to FAOSTAT (2022) reported Brazil occupies the largest cropping area in the world (over 126 million hectares) and the second-largest cropping area in the USA 33.3 million hectares the global average productivity of this crop is 3.21 t ha^{-1} and its potential productivity could go up to 4 t $ha^{-1.}$

2.3.1. Soybean production in Africa

First introduced to Africa by Chinese traders in the 19th century, soybeans were cultivated from seeds as an economic crop in South Africa in 1903 and then used for industrial purposes, ownership of raw materials, pests, crop rotation control, etc.Since second half of 20th century the production and productivity of soybean has a lot of potentials in Africa countries (Hartman *et al*., 2011). Over the last 40 years, acreage and production of soybeans in Africa has increased exponentially from about 20,000 hectares and 13,000 tons in the early 1970s to 1.5 million hectares and 2.3 million tons in 2016 (Varsha, 2019). The main producers are South Africa, Nigeria, Zambia and Uganda (Khojely *et al.*, 2018). Nigeria and South Africa are the leading producers of soybean in Africa (Cornelius, 2019).

The production of soybean holds great promise in improving agricultural systems in sub-Saharan Africa and it counters the effects of depletion of plant nutrients in the soil resulting from continuous mono-cropping of cereals (Liana and Peter, 2019). However, soybeanyields in Africa have stagnated at about 1.1 t ha1 for decades, well below the global average of about 1% Nchogu *et al.*,2022. This is one of the most difficult problems in the SSA soy industry (Khojely *et al.*,2018). This is due to soybean production in Kenya meets less than 0.09% that gives Africa meets 1% of the world soybean production in terms of the yields quality (Murithi *et al.*, 2016).

2.3.2. Soybean production in Ethiopia

According to Tesfaye *et al.* (2018) reported with its diverse environment and climatic conditions, Ethiopia is endowed with a very large area of land, where soybean can be suitably produced. The land suitability analysis showed that soybean is the second among legumes in terms of land area that is moderately and highly suitable for its production in the country, with an estimated 42,067,700 (37.2%) hectares of land (Nigusie, 2018). It can be grown in altitudes ranging from 1250 to 2200 m above sea level (m.a.s.l.). It can also be grown in an area receiving 450 to 1500 mm annual rainfall(Besufikad, 2020, Dinsa *et*

al.,2020). It performs well between 1300 m.a.s.l and 1700 m.a.s.l. Soybean requires average temperature ranging from 23- 25^{o}C and medium relative humidity for optimum yield production (Mesfin and Abush, 2019). Similarly, Hatfield *et al*. (2015) reported that soybean grows in the tropical, subtropical and best at temperatures between 20 °C and 30°C.The growing season ranges from 90 to over 150 days and three different soybean varieties have been distinguished based on maturity, early maturing group, medium maturing group and late maturing group (Gurmu, 2009).

Early maturing group with 90-120 days (Awassa-95, Williams, Crawford and Jallale, Katta, Korme, Boshe), Medium maturing group with 121-150 days (Clarck-63K, Cocker-240, Davis, Cheri and AFGAT) and Late maturing group with >150 days (Belessa-95, slavia) (Gurmu, 2007). Soybean varieties such as Dhidhessa, Ethioyugoslavia Gazelle, Pawe-01, and Pawe-02 were newly released varieties by (2008, 2015) and they are medium and late maturity group varieties. The production is crucial to addressing the issue of malnutrition particularly smallholder farmers who cannot afford animal source proteins. Its production and seed quality provides a promising opportunity for smallholder farmers. The main soybean-producing in Ethiopia are in the western part of the country Oromiya, Benishangul Gumuz, Amhara and to a lesser extent Southern Nation Nationality and Peoples are the main regions of soybean production (Achamyelh *et al*., 2020).

Oromia and Benishangul-Gumuz regions account for the highest production of soybean in the country, about 51% and 40%, respectively. These areas have vast fertile land and a favorable agro-climate suited to growing soybean .Currently, the area covered by soybean production is 54,543 ha with total production of 125,623tons (CSA, 2020). However, according to CSA (Agegn *et al*., 2022) soybean productivity is (2.30 t ha^{-1}) is still below the world average productivity of 3.21 t ha$^{-1.}$. Due to this fact, still Ethiopia imported 522,000 metric tons of cooking oil, Valued at nearly $530 million in the (2017) of this oil, more than 87% by volume was palm oil and Ethiopia imports 15 million kilograms of soybean products and spends 11 million USD for importing various soybean products every year (CSA, 2018) which may be related several constraints and management of the crops.

2.4. Soybean Production Constraint in Ethiopia

The major factors that limits the productivity of soybean in Western Ethiopia particularly in western Oromia might be soil fertility reduction, nutrient imbalances inorganic fertilizer to the soils and escalating inorganic fertilizers prices, due to soil acidity low N-fixing Brady rhizobium japonicum strains, low varietal stability, narrow genetic base of cultivar, poor agronomic practices and poor soil management practices is one of the major challenges to crop production and productivities.

2.5. Soil Fertility Problem and Opportunities Enhance the Production

The productivity of soybean is limited due to the lack of improved varieties and poor soil and crop management practices. Due to this the production obtained by smallholder farmers is far below the potential production. For instance Ethioyugoslavia at research field 1.7-3.5 t ha^{-1} and at farmers levels 1.6-3.0 t ha^{-1} and Didessa at research field 2.-3.3 and at farmesr levels 1.4 -2.8 t ha^{-1} were recording (BARC, 2008, MoARD, 2008).Similarly, the national average yield of soybean varied from 1.8 t ha^{-1} in 2012 to 2.0 t ha^{-1} in 2013 while the potential yield obtained from on-station and on-farm research fields was 3.5 and 2.6 t ha^{-1}, respectively (MARD,2013). According to Amsal and Tanner (2001) report soil fertility reduction is one of the major challenges to crop production and productivity in Ethiopia.

Similar findings also reported by Mafongoya *et al*. (2006) soil fertility depletion in smallholder farmers is the basic root cause for declining production and productivity of soybean. This crop is high protein and energy crop and its productivity is often limited by the low availability of essential nutrients. This clearly showed that this crop nutrient exhaustive among the legumes crops and therefore, the crop does not high yield unless the sufficient quantity of nutrients is supplied during the growth period (Singh *et al*., 2006, EthioSIS, 2018). Dibabe (2000)who reported that most agricultural soils of Western Oromia region and Ethiopia have consistently shown multi-nutrient are nitrogen(N), phosphorus(P), sulfur(S) and boron(B) deficiencies. However, fertilizers used for many years by farmers in Ethiopia have been limited to urea (46N-0-0) and diammonium phosphate (DAP) (18N- 46P2O5-0), which supply only N and P, which may not meet the nutrient requirements of the crop, creating nutrient imbalances in soils (Nandwa *et al.,* 1998, Tan *et al*., 2005).

Soil infertility is the major cause of food insecurity and poverty in developing countries and it necessitates the use of inorganic fertilizer (Martey *et al*., 2019). Likewise soil fertility mapping survey by (Ethiopia SIS, 2014,Ethiopia SIS, 2016, EthioSIS, 2018) revealed low levels of (N, P, S and B) in most areas of Kellem wollega Zone. Balanced use of fertilizers is the key to achieve sustainable high yields(Manna *et al.*, 2005).The appropriate application of commercial fertilizers has resulted in an increment of crop yield of 30% to 50% (Vlek *et al.*, 1990, Stewart *et al.*, 2005). This is major indicator for food insecurity and poverty in developing countries(Amsal and Tanner, 2001, Martey *et al*., 2019). Similarly, The total consumption and the demand for inorganic fertilizer have shown an increasing trend.

However, currently the main issue is escalating inorganic fertilizers prices, apart from supply constraints; global fertilizer prices have seen a sharp increase. The soaring price of fertilizers has posed a great challenge for farmers in Ethiopia. Due to this small holder farmers of resource-poor farmers due to the price of inorganic fertilizers inreament and less availibities the are becoming unaffordable and huge lands' of the framer not under cultivation (Nyoki and Ndakidemi, 2016). This situation is stagnant with recent yields estimated at less than 30% of actual potential land only about 7% of favorable land allocated to soybeans Sub sahara Africa (SSA) presents a great opportunity for closing this global demand-supply gap report by (Deribe, H., 2021). On the other hand, long-term use of chemical fertilizers without organic supplements damages the soil properties, causes for soil acidity and environmental pollution and can affect microbial communities and reduce microbial activity in the soil (Sturz and Christie, 2003, Hailu Abdi *et al*., 2015).

Similarly, the long-term use of inorganic fertilizers without organic supplements deteriorating the physical, chemical and biological properties of soil and cause environmental pollution (Liu *et al.*, 2010). One of the fertilizers used in sustainable agriculture is vermicompos(Vc) is a kind of natural eco-manure produced through the deterioration of organic matter by the interactions between microorganisms and earthworms (Yang *et al.*, 2015). This fertilizer is produced as a result of the process of digestion and conversion of organic waste such as livestock manure and plant leftovers and passing through the digestive. This organic vermicompost is easily available, eco-friendly and enhances soil health which will have a positive impact on human health and soybean production and productivity (Iqbal *et al.*, 2021). According to Arancon *et al*. (2004) report vermicompost improves the soil condition, increases sulfur oxidation and as

a carbon source, aggravates the activity of phosphorus solubilizing and oxidizing sulfur microorganisms.

Vermicompost/Organic matter/ can improve soil structure and increase the ability of the soil to absorb nutrients (Santos *et al.,* 2023) and the other is functions of organic matter in the soil is to provide a loose, crumbly and easily processed soil structure; so that it becomes a good medium for plant growth and production(Suhardjo, 2010). This because vermicompost fertilizer consist of macro and micronutrients such as nitrogen, phosphorus, potassium, and microelements such sulphur, manganese, zinc, and molybdenum important for plant growth and enzymes activation substances (Meena *et al*., 2023, Chaudhary *et al*., 2021). According to Pandit *et al*. (2020) reported vermicompost having a C: N ratio below 15 is desirable for agronomic use. Vermicompost fertilizers are directly affected by plant growth and their positive effects on soil physicochemical and biological properties (Nazli *et al.,* 2020, Mitra *et al.,* 2019).

The results of the research on the application of vermicompost fertilizer to the growth of soybean plants have a better number of branches, number of pods and weight of seeds per sample compared to without applying vermicompost fertilizer (Krishnaveni *et al.,* 2023).This is due to vermicompost is improved leaf chlorophyll content, grain oil and grain yield in soybean and chlorophyll and carotenoids in milk thistle (Shahrusvand *et al.,* 2020).Likewise,application of vermicompost in beans was reported to improve net photosynthetic rate (Pirdashti *et al*., 2010, Khurmizi *et al*., 2015). Shahrusvand *et al.* (2020) who reported increase in grain yield of soybean due to vermicompost application compared to control. However, limitation of organic vermicompost accessible nutrients, relatively in organic fertilizer is low nutrient content, high application rates, and high labor requirements, organic fertilizer alone may not be able to adequately meet crop nutrient demand unless it is combined with inorganic fertilizers(Masrie *et al.,* 2019).

2.6. Influence of combined NPSB fertilizer and vermicompost on soybean variety

Soil fertility and productivity require the use of both organic and inorganic fertilizers. The combined use of organic and inorganic sources of plant nutrients not only pushes the production and profitability of field crops but also helps in maintaining the permanent fertility status of the soil" (Ramesh P, 2008, Habtamu *et al*., 2015).The adoption of combination nutrient management practices involving organic and inorganic fertilizers is the best approach to make the production system more sustainable and profitable (Sarkar

et al., 2020). Different findings reported that the use of integration application of fertilizers management has not only sustaining the productivity and soil health but also in meeting part of crops nutrients requirement and quality (Najar *et al*., 2011, Ram *et al.*, 2014, Dhakal *et al.*, 2016, Chaudhary *et al*., 2019).Likewise, many scholars have reported remarkable results from the integrated application of organic and inorganic fertilizers, including common bean (Fouda, 2017, Fekadu *et al*., 2018, Elka and Laekemariam, 2020).

For example, Fouda *et al*. (2017) recorded the highest grain yield values of 1681.12 (g) per plot (m^2) for common bean following an integrated application of NPK 100% + compost. Tadesse *et al.* (2016) also observed a 173.8% increase in grain yield over the control due to the integration of NPK and FYM. Similarly, Elka and Laekemariam (2020) reported a 312% grain yield gain advantage over the control in response to integrated application of 150 kg NPS·ha^{-1} and 2.5 t organic material from Croton (Croton macrostachyus) and Erythrina (*Erythrinabrucei*).The combined application of fertilizer was influenced significantly on seed quality of soybean due to nitrogen fertilizer is a basic constituent of protein in the soybean seed the soybean oil, content were also significantly influenced by integrated nutrient management were reported (Pirdashti *et al*., 2010, Bonde *et al.*, 2017).

2.7. Influence of Nutrient Management on Soybean Varieties

According to Tesfaye *et al*., (2018) reported the major reasons for low productivity of this crop poor agronomic practices, low fertilization, multi-nutrient deficiencies limited access to improved soybean seed production and productivity. Seed is a key input for improving crop production and productivity; increasing the quality of seeds can increase the yield potential of the crop and the most economical and efficient inputs to agricultural development (Wimalasekera, 2015).Different scholars reports show the growth, yield and yield components of soybean varies were influenced with the adaption potential of the varieties to an edaphic-clim atic condition as well as their response to varying nutrient managements (Lay New *et al*., 2022). Likewise, the improved soybean varieties have their own agro ecological requirements to attain highest yield that may vary with the genotypes, management activities and geographical locations(Wondimu *et al*.,2016).Therefore, selecting the best varieties for combined application of inorganic and inorganic fertilizers is necessary for better soybean grain yield and seed quality production.

2.7.1. Influence of nitrogen nutrient on soybean variety

Nitrogen (N) is one of the primary nutrients that crops require for optimal growth and grain production. Soybean seeds have on average about (~40%) protein and have relatively high nitrogen requirement to produce the high-protein grain. Soybean seed protein concentration varies among genotypes and environments (McClure *et al.,* 2017, Assefa *et al.,* 2018). The management crops and environmental factors like fertilizer application can also affect soybean seed (Borja Reis *et al*., 2020). The relationships between management, nitrogen metabolism and yield seed composition are complex. According to La Menza *et al.* (2017) report soybean requires a relatively large amount of nitrogen. Due to this this crop need additional supplied with nitrogen fixation and soil mineralization (Ohyama *et al.*, 2013). Soybean and other nitrogen fixing legumes, nitrogen requirements in the field are met by either soil mineral nitrogen acquisition or symbiotic N2 fixation.

According to Epie *et al.* (2023) report the relative contributions of soil (N) and biological nitrogen fixation to seed (N) can vary among genotypes that differ in seed protein concentration and other agronomic parameters. Due to this Nitrogen fertilization is not a common practice in soybean due to soybean's biological nitrogen fixation in symbiosis with rhizobacteria, soybean yield responses to nitrogen application have been tested extensively and are highly variable (La Menza *et al.,* 2017).According to Zahid *et al.* (2020) reported a positive grain yield response of soybean to nitrogen-fertilizer application at 30 to 60kg ha^{-1}.Nitrogen is the key component of healthy growing plants; all plants other than legumes should be fertilized by nitrogenous fertilizer.

2.7.2. Influence of phosphorus nutrient on soybean variety

According to Jilani *et al.* (2021) reported phosphorus is the second plant growth-limiting nutrient despite being abundant in soils in both inorganic and organic forms. However, many soils throughout the world are phosphorus deficient because the free phosphorus concentration (the form available to plants) even in fertile soils is generally not sufficient (Gyaneshwar *et al.*, 2002). Large amount of phosphorus applied as fertilizer enters into the immobile pools through precipitation reaction with highly reactive Aluminium (Al^{+}) and Iron (Fe^{3+}) in acidic and Calcium (Ca^{2+}) in calcareous or normal soils(Majumdar,2017). However, according to De Freitas Duarte *et al.* (2023) finding microorganisms enhance

the phosphorus availability to plants by mineralizing organic phosphorus in soil and by solubilizing precipitated phosphates.

Similarly, Shahid *et al.* (2009) reported that in soybean production, phosphorus and inoculation with the appropriate *Rhizobium* strains have quite prominent effects on nodulation, tolerate stresses, growth and yield parameters. In addition phosphorus must be supplied to nitrogen fixing plants to maintain nodule tissue and for the energy consuming biochemical processes involved in the nitrogenase system which makes nodules an important P sink in N fixing plants (Weisany *et al.*, 2013).

Similar finding reported by Kumar *et al.* (2008) and Shahid *et al.* (2009) in soybeans, the demand for phosphorus is greatest during pod and seed development where more than 60% of phosphorus ends up in the pods and seeds. Fageria *et al. (*2016) finding showed phosphorus application has an important role in the growth, development and yield productivity of common beans as it is involved in various metabolic processes such as photosynthesis, respiration and signal transduction, among others. Likewise, Rotaru (2014) reported that both biomass production and nutrient contents in soybean increased with higher Phosphorus application level. Morshed *et al.* (2008) also reported the content of soybean nutrient can be determined to the quality of the grain as well as the biomass phosphorus has a key role in the energy metabolism of all plant cells, particularly in nitrogen fixation as an energy-requiring process.

2.7.3. Influence of sulfur nutrient on soybean variety

According to Leustek and Saito (1999) reported sulphur (S) is an essential element for growth and metabolic functioning in plants. Likewise Abbas *et al*. (2021) reported sulphur is an important macronutrient has for its most important source sulphate ($SO4^{-2}$) and plant roots are responsible for its uptake as divalent Sulphate anions and then, the nutrients' transportation to xylem and phloem. It is along with nitrogen, constitutes the essential building blocks of protein, particularly methionine, cystine, and cysteine amino acids (Narayan *et al.*, 2023). As a secondary nutrient, sulfur (S) plays a critical role in the growth and development of high-yielding soybeans. This nutrient has a role in the formation of amino acids and increases the amount of protein and oil in soybeans (Shahrusvand *et al.*, 2020).

This nutrient is important inputs can range from 15 to 60 kg S ha^{-1} depending on the environment soil type, previous crops (Grant *et al*., 2012). However, Samborska *et al.* (2019) reported sulphur is an immobile element and its deficiency symptoms include leaf yellowing, anthocyanin accumulation and stunted growth, with symptoms first appearing in younger leaves. Thus, according to Poisson *et al. (*2019) reported it is limitation can severely affect seed yield (40% to 50%) of loss and quality in oilseed rape. As a nutrient, sulfur has a role in the formation of amino acids and increases the amount of protein and oil in soybeans (Asisan Minz *et al.,* 2017). These seed proteins with high level of S-containing amino acids could be potentially used in human food products with the increasing global demands for vegetable proteins for human nutrition (Von Der Haar *et al*., 2014). Sulfur plays a pivotal role in the process of pod filling because vegetable soybean seeds are rich in protein.

The increased yield under sulphur application might be ascribed to increased pods per plant and grains per pod along with heavier grains (Fageria, 2009). According to Getachew *et al.* (2017) reported seed yield of soybean increased by 28.8% and 25.2% when 30kg and 40 kg/ha Sulfur applied as compared to control. Likewise, Krishna *et al*. (2020) reported nodulation, plant height, days to maturity, dry weight, and pods per plant have been significantly improved by the application of sulfur resulting in maximum seed yield per plant or hectare. Sharma (2014) also reported in soybean sulphur increases leaf chlorophyll content and grain yield. The concentration was found to be highest in oil seed (1.1-1.7%), intermediate in pulses (0.24-0.32%) and the lowest (0.12-0.20%) in cereals (Belachew *et al.,* (2022).

2.7.4. Influence of boron nutrient on soybean variety

Several studies have indicated boron nutrient is used as structural element of cell walls and membranes and functions in sugar transport and metabolism, lignification, meristem tissue cell division, flower and seed formation and protein synthesis (Kaur *et al.,* 2015, Wimmer *et la*., 2019). It is essential for all plant growth and is known to promote flowering, pollen germination, grain fill and yield; where it is applied near flowering. Soybeans, like all legumes, have a high boron requirement. This nutrient has important roles in sugar translocation, carbohydrate metabolism, flowering activity of hormones (Ozturk *et al.,* (2010). The studies result shows that there are many differences in response to application of boron in soybean varieties. Many findings showed increment in

productivity and the physiological quality of seeds (Dameto et *al*., 2023) while, others did not obtain beneficial effects in its use.

2.8. Influence of NPSB Fertilizer with Vermicompost on Nutrient Availabilities

According to Amede *et al*. (2022) findings in acid soils, where P fixation is a problem application of organic FYM releases a range of organic acids that can form stable complexes with Al and Fe thereby blocking the P retention sites, and as a result, the availability and use efficiency of P in the soil is improved.Organic matter have small particle size which have large negatively charged surface area which shows more position to hold cation i'e have high CEC; this situation influence the soils' stability to hold onto essential nutrients and provides buffers against soil acidification which increase soil pH value while increase availability of phosphorus to plants.

Munthali (2007) who reported that application of vermicompost resulted with increasing of soil buffering capacity, nutrient availability and water holding capacity and supply micronutrients, which may not be provided by commercial fertilizers. The combined appropriate applications of inorganic nutrients with organic nutrients improve soil chemical properties and increase the availabilities of nutrients (Tana *et al.,* 2017, Jibrila and G, 2022). Similarly, Joshi *et al.* (2000) report the use of organic fertilizers in combination with fertilizers meets the need of micronutrients of soybean.

For instance, According to Jibril and Bekele (2022) reported that the higher total nitrogen (26%), available phosphorus (3.57%), and sulfur (4.36%) were obtained from a combined application of 7.5 t of coffee husk compost and 112.5 kg of NPSB·ha$^{-1.}$ According to Zengeni *et al.* (2006) who report manure application, increases indigenous rhizobium populations, which serve as a source of C and offer a suitable environment for bacterial proliferation. Likewise, Ramesh *et al*. (2008) reported the combined use of organic and inorganic sources of plant nutrients not only pushes the production and profitability of field crops but also helps in maintaining the permanent fertility status of the 'soil' and it is highly desirable to make massive efforts to adopt organic sources as a source of plant nutrients as well as soil productivity in developing countries.

Long-term integrated nutrient management practices increase soil quality and is a potential tool for knowing the crop yields and yield trends (Garnaik *et al.,* 2022).Generally, from this review the main importance of using organic fertilizer like vermicompost with the

combination of inorganic fertilizer like NPSB blended fertilizer was boldly identified as it is increasing the production and productivity of the crops through boosting the soil nutrients available to plants and enhances soil structure and microbial activity in the soil ecosystem.

2.9. Previous Studies gaps in Ethiopia

Generally, in our country many researchers had contributed and have been contributing to increase the production and productivity of the farmers as well to the country. However, still there are some limitations, which need further finding. Many scholars were conducted there searching which may not meet the nutrients requirements of the crop, creating nutrient imbalances in soils (Nandwa *et al*., 1998, EthioSIS, 2013, EthioSIS, 2018).The other studies were focused on chemicals fertilizers alone to increase soybean production and productivity which are costly, unsustainable, contribute to environmental pollution and soil structure degradation without considering environmental health (Kumar *et al.*, 2019).

The others findings were concerned only about a matter of quantity production not minding for the quality; for quick feeding and monetary gains which may not meet the nutrient requirements of the crop, creating nutrient imbalances in human and soils. The intention of this literature review was to use the NPSB a new mixed blended fertilizer based on the national soil fertility survey results recommended for Kellem Wollega zone of western Oromia is not yet did for the current study area (EthioSIS, 2014). Moreover, the demand for green agriculture and high-quality food supply has suggested a shift or, at least, a reduction in the application of agrochemical inputs. Generally, extensive cultivation of land will affect natural ecosystems and may result in a heavy cost such as huge and irreversible losses of biodiversity (Mondal *et al*., (2022).Therefore, adoption of combined application practices involving organic and inorganic fertilizers is the best approach.

2.10. Current Study Scenario in Ethiopia

Currently, many researchers looking for a technology that is financially effective, environmentally sustainable, has no negative effects on the environment, ecosystem and is good to society.The combined application of inorganic with vermcompost fertilizer management reduced doses of inorganic fertilizer with vermicompost which hold

potential to improve soil health and soybean productivity and can effectively fulfill crop nutritional needs along with supporting associated biological, chemical and physical processes to produce soybean yield as per varietal potential and support the rural-based farm economy (Banik *et al.*, 2021, Iqbal *et al*., 2021). The adoption of combined application practices involving organic and inorganic fertilizers is the best approach to make the production more sustainable and profitable (Sarkar *et al*., 2020). Vermicomposting is comparatively in organic chemical fertilizers cheaper, easily available, eco-friendly, and enhances soil health that will have a positive impact on human health, flora, and fauna. Several researchers have demonstrated the beneficial effect of combined nutrient management in mitigating the deficiency of several macro- and micro-nutrients (Getachew, 2009, Woldesenb *et al*., 2014).

Generally, from this literature review the utilization of inorganic fertilizers; because of their high nutrient concentration, easy availability to the plant roots and convenient transportation and application are very attractive. However, escalating prices year by year small holder farmers of resource-poor farmers becoming unaffordable and huge lands' of the framer not under cultivation. Similarly, the long- term use of inorganic fertilizers without organic supplements deteriorating the physical, chemical biological properties of soil and cause the environmental pollution. The over-reliance on inorganic fertilizers can disrupt the natural balance of nutrients in the soil, leading to nutrient imbalances and reduced soil quality. This can result in the loss of soil organic matter, decreased soil fertility, and increased susceptibility to erosion.

While vermicompost fertilizer is regarded as a viable solution to the problem of soil nutrient depletion and food production sustainability and it is easily available, eco-friendly and enhances soil health which will have; a positive impact on human health and soybean production and productivity. Due to this, the utilization vermicompost is increasingly being considered in agriculture as a promising alternative to chemical fertilizers. Likewise, the utilization of organic vermicompost nutrient sources as fertilizer in less developed nations like Ethiopia has a lot of attention. However, the limitation of organic vermicompost is accessible nutrients; relatively inorganic fertilizer low nutrient content, high application rates and high labor requirements, organic fertilizer alone may not be able to adequately meet crop nutrient demand unless it is combined with inorganic fertilizers.

The objective of this review is to identify and develop efficient using organic vermicompost nutrient sources as fertilizer with combined inorganic fertilizer is urgently needed for seed yield and seed quality in the current global shortage of chemical fertilizers and their expected negative environmental degradation.

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study was conducted at Haro Sabu Agricultural Research Center (HSARC) which is located in Western Oromia, in Kellem Wollega Zone, at about 552 km away from the capital city of Addis Ababa on the way to Dambi Dollo town under rain fed conditions during (July to December) in 2023/24 in the main cropping season. Dambi Dollo is the capital town of Kellem Wollega Zone located to the western parts of Oromia, which is 640km far from Addis Ababa on the way to Nekemte town. The experimental site is located at 08^0 52''40904'N latitude and 035^0 13'' 56.039'E longitude and an altitude of 1558m above sea level (Figure.1).

The selection of field location was based on adaptability of soybean varieties and production potential of the zone. The climatic data of HSARC/Dale Sadi District/ daily temperature is characterized by mimam-13^0C, mid-21^0C and max-29^0C air temperature.

Similarly, the area has a warm humid climate with annual mean minimum and maximum temperatures of 14.86^0C and 29.643^0C, respectively and it receives annual rainfall of (1996.72mm) mainly from May to October with maximum precipitation in the month of July with rain fall mean (166.39 mm) (Figure.3).The predominant soil type of the area is Nitisols which is characteristically reddish brown and soil textural class which is sandy loam with a pH that falls in the range of strongly acidic according to Hazelton and Murphy (2016) soil pH value rating.

The study area is located at mid to high land agro- ecological zone and encompassed by abundant natural vegetation. The agro climatic condition of the area is known for its mixed crop- livestock farming system in which cultivation from cereals maize (*Zea mays* L.), Sorghum (*Sorghum bicolor* L. *Moench*), tef (*Eragrostis tef Zucc)*, from pulse and oil crops, soybean (*Glycine max* (L.), common bean (*Phaseolus vulgaris* L.), from spices and coffee, (*Coffea arabica* L), hot pepper (*Capsicum annuum* L.), from horticulture banana (*Mussa spp*), and the others crops are the major crops.

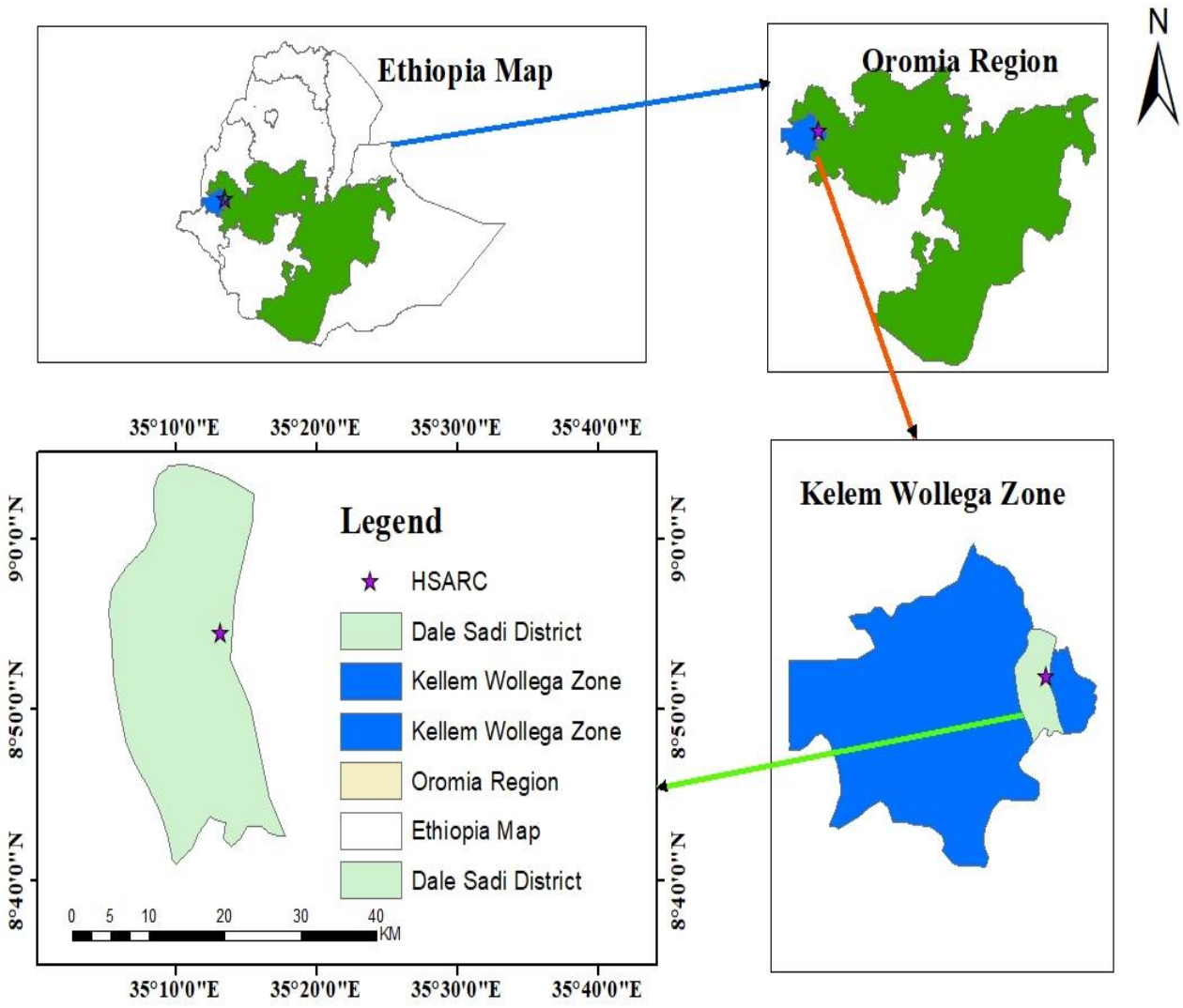
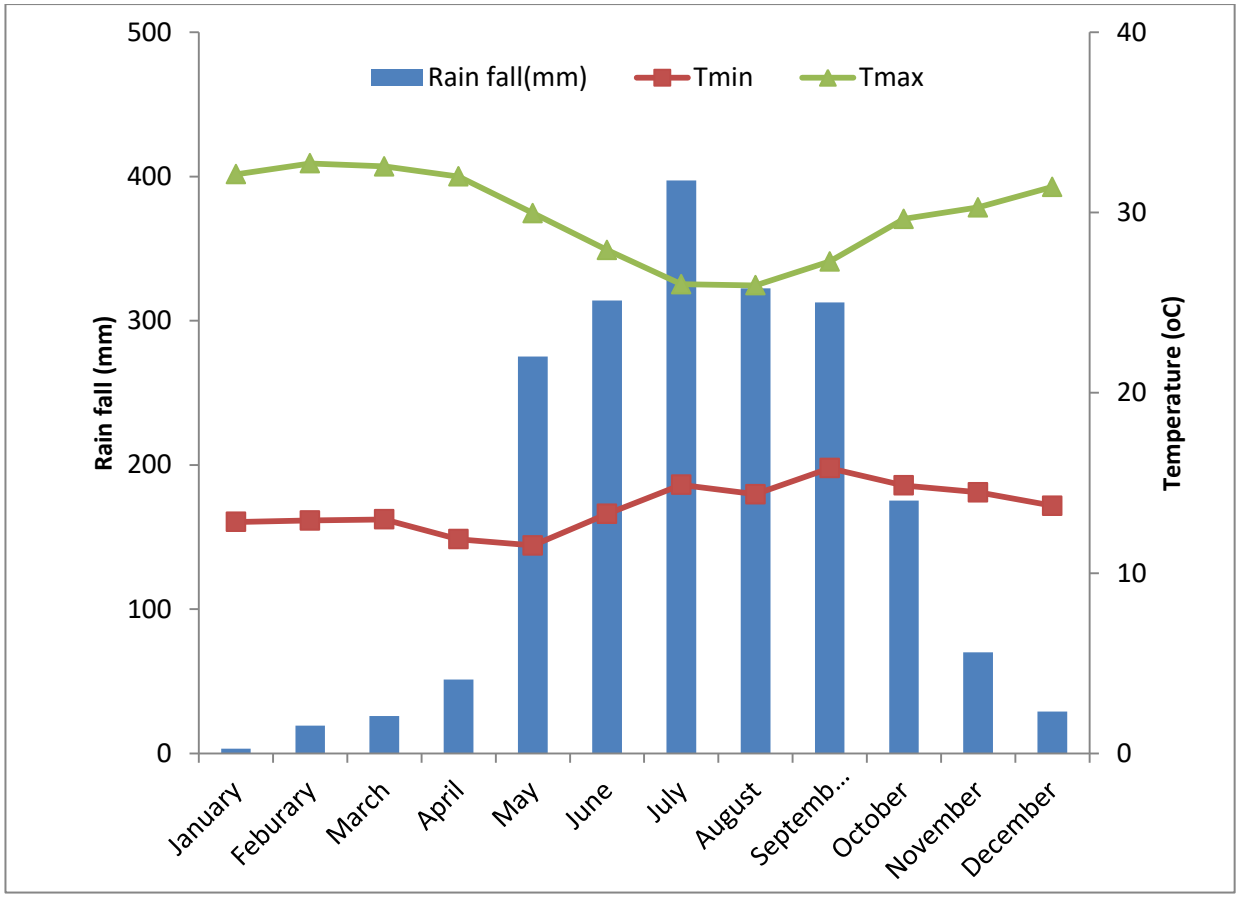


Figure 1. Map of the study area Haro Sabu Agricultural Research Center HSARC



Y-axis =Rainfall, **X** axis = Months of the year. **Source:** Ethiopian Meteorology

Figure 2. Annual Rainfall and Annual mean Temperature (Tmin and Tmax) of HSARC

3.2. Description of Experimental materials

NPSB blended fertilizer servey mapped for Kellem Wollega Zone by (EthioSIS, 2014) was used to conduct the experiment with 100kg NPS ha^{-1} recommendation rate for western Shoa and Eastern Wollega by Bako Agricultural Research Center (BARC) and 75kg NPS ha^{-1} + 2 t Vc ha^{-1} recommended by (Debela *et al.*, 2021), Similarly, Haro Sabu Agricultural Research Center (HSARC) recommended 100kg NPS ha^{-1} for Kellem Zone and western Wollega Zones, and two soybean varieties: Ethioyugoslavia and Didessa released by BARC in (2008) were used for this study.

Table 1. Description of the two soybean varieties

Description	**Variety**	
	Ethioyugoslavia	Didessa
Altitude (m. a.s. l)	1200-1900	1200-1900
Rainfall amount (mm)	1000-1200	1000-1200
Days to maturity	145-154	137-145
Growth habit	Indeterminate	Indeterminate
Maturity group	Late	Medium
Yield (t ha-1)		
Research field	1.7-3.5	2-3.3
Farmers field	1.6 -3.0	1.4-2.8
Year of release	2008	2008
Releasing Institution	BARC/OARI	BARC/OARI

Source: BARC, (2008), MoARD, (2008)

3.3. Treatments and Experimental Design

The treatments consists of six NPSB fertilizer combined with vermicompost (0+0, 100+0, 75+2, 50+4, 25+6 and 0 kg+8 tones ha^{-1}) with two soybean varieties (Didessa and Ethio ugoszilavia)were listed in (Table 2). The combined treatments were arranged with the combined factors in completely randomized block design (RCBD) and replicated three times with the combination of inoragic NPSB blended fertilizers, verm compost and variety. Both fertilizers levels were applied with combined at planting time except the two control treatments. The total plot size was 10.2m × 47m = 479.4 m^2.The spacing between blocks and plots was 1.5 m and 1 m were used, respectively. The gross plot size area of 7.2 m^2 (2.4m × 3m) and net plot size of 6 m^2 (2m ×3m) were used with the inter and intra row spacing of 40cm x 10cm. (Table.2)

Table 2. Treatment combination of the experiment and nutrient composition of fertilizers

Treatment combination		Nutrient composition							
Soybean variety	NPSB+Vermicompost ($kg\ ha^{-1}$, $t\ ha^{-1}$)	NPSB(kg)				Vermicompost(g/kg)			
		N	**P_2O_5**	**S**	**B**	**N**	**P_2O_5**	**S**	**B**
Didessa	0 + 0	0	0	0	0	0	0	0	0
	100 + 0	18.9	37.7	6.95	0.1	0	0	0	0
	75 + 2	14.17	28.27	5.21	0.08	1.01	14.7	9.59	0.652
	50 + 4	9.45	18.85	3.47	0.05	1.01	14.7	9.59	0.652
	25 + 6	4.72	9.42	1.74	0.03	1.01	14.7	9.59	0.652
	0 + 8	0	0	0	0	1.01	14.7	9.59	0.652
Ethioyugoslavia	0 + 0	0	0	0	0	0	0	0	0
	100 + 0	18.9	37.7	6.95	0.1	0	0	0	0
	75 + 2	14.17	28.27	5.21	0.08	1.01	14.7	9.59	0.652
	50 + 4	9.45	18.85	3.47	0.05	1.01	14.7	9.59	0.652
	25 + 6	4.72	9.42	1.74	0.03	1.01	14.7	9.59	0.652
	0 + 8	0	0	0	0	1.01	14.7	9.59	0.652

3.4. Experimental Procedure and Crop Management

3.4.1. Soil physico - chemical properties of experimental site before sowing

Pre-planting soil samples were taken at a depth of 0-20 cm from area designed randomly selected across the experimental field. A representative soil samples were taken using a cylindrical auger from the whole experimental field and combined to form a composite sample. The collected soil composite sample was air-dried, ground and sieved to pass through a 2 mm sieve. A 1 kg of composite sample was prepared and put into polyethylene bug. The prepared composited soil sample was sent to soil analytical testing laboratory at Nekemte Soil Research center(NSRC) and Jimma Soil and Plant Tisue Analaysis Laboratory (JSPTAL) to determine the physicochemical properties of the soils. The composite samples was analyzed for soil texture analysis (sand, silt and clay) classes determined by Boycous Hydrometer Method (Aderson and Ingram 1993and) and for physicochemical properties of soil were determined as follows.

Methods for soil pH determination

Soil pH was measured potentiometrically in 1:2.5 soil-water suspensions with standard glass electrode pH meter (Van Reeuwijk, 1992) :The pH 10g of air dried <2mm sieved soil was weighed and added into 100 ml beaker then 25 ml of distilled water was added by measuring cylinder for 1: 2.5 soil/water suspension. The samples were transferred to an automatic stirrer for 30 minutes and the pH was measured on the upper part of the suspension.

Methods for nitrigen determination

Nitrogen(N) was determined with Kjeldahl procedure (Cotteinie, 1980),1g of soil was weighed accurately (<0.5 mm sieved) and transferred into the digestion tube. 2g of catalyst mixture and a few carborundum boiling stones, were mixed and rinsed with water. 7 ml of conc. H_2SO_4 was added and mixed by swirling. The digestion tube stand with the samples was placed beside the block digester and the exhaust manifold on top of it was fitted. The samples were digested for 3 hours and pale yellow on a block digester wa250 ml formed. The acid was digested quantitatively transferred to the macro-Kjeldahl and rinsed using distilled water. The measured 20ml of boric acid solution was received in an Erlenmeyer flask corresponding to the number of samples.2 drops of indicator solution were added and placed under the condenser.

The boric acid solution in the Condenser was immersed to prevent ammonia loss. 75 ml of 40 percent NaOH was added carefully into distillation flasks containing the digested and mixed gently. 250ml Kjeldahl distillation flaks contained the digested to the corresponding holder were prepared.80 ml of distillation were collected distillation was completed, the flask containing the receiver was removed and the next sample was continued. The flask contained in the receiver was titrated by 0.1 N H_2SO_4 until the color changed from green to pink endpoint. The reading of the burette was recorded. The acid was standardized to get the exact normality of the titrant.

Calculation: The volume of 0.1 N H_2SO_4 used after correcting for the blank.

N x V = meq of N/g of soil

N x V x 14 = mg of N per g of soil

N x V x 0.014 = g of N per g of soil

% N = $\frac{a-b}{s}$x N x 0.014 x 100 x mcf

Where a = ml of H_2SO_4 required for titration of a sample

b = ml of H_2SO_4 required for titration of blank

s = air-dry sample weight in grams

N = Normality of H_2SO_4 (0.1 N)

0.014 = meq weight of nitrogen in g

mcf = moisture correction factor

Methods for phosphorous determination

Phosphorus was determined by the Olson II methods using a spectrophotometer (Olsen *et al*, 1954), 50g of soil < 2mm sieved were added into 250ml of polythene bottle.100ml of extracted Sodium bicarbonate solutions were added. It was shaken by a mechanical shaker. It was filtered by 42 Whatman filter paper. 3 ml of standard series were pipetted to the short test tube to the blank and the sample extracted.3ml of a mixed reagent made from 50 ml of 4 M H_2SO_4, 15 ml of NH4 - molybdate solution,30 ml of ascorbic acid solution,200 ml of water. And 5 ml potassium antimony tartrate solution was pipetted. It was allowed for 1 hour until the blue color developed and the absorbance was taken on an 882mm spectrophotometer.

Calculation: P(ppm or mg/Kg soil) = (a-b) x $\frac{100}{s}$ x mcf = (a-b) x$\frac{100}{s}$ x mcf

Where: a = mg/l P in sample extract

b = mg/l P in blank

s = sample weight in grams (5 g)

mcf = Moisture correction factor

100 = ml of extracting solution. Conversion factor P_2O_5 = 2.29 x P

Methods for organic carbon determination

Organic Carbon (OC) was estimated by wet digestion method (Walkey and Black, 1934), Organic carbon 1 gram of air-dried soil (< 2 mm) was weighed and transferred to a 500ml Erlenmeyer flask. 10 ml of 1 N $K_2Cr_2O_7$ solution were pipetted to both samples and blank. 20ml H_2SO_4 was added and padded for 30 minutes. Then 200 ml of distilled water was added. 10ml of conc. orthophosphoric acid added. 0.5 ml of barium diphenylamine

sulphonate indicator was added both samples and blanks were titrated with0.5 N ferrous sulfate solution until the color changed to purple or blue, then ferrous sulfate solution was added drop by drop until the color flashed to green then continued a light green endpoint.

Calculation:% C = N x $\frac{v_1 - v_2}{s}$x 0.39 x mcf

Where: N = normality of ferrous sulfate solution (from blank titration).Type equation here.

$\frac{Nkr_{207 \times vkr_2 0^7}}{vFeSO_4}$V

V1 = ml ferrous sulfate solution used for blank.

V2 = ml ferrous sulfate solution used for the sample.

S = weight of air-dry sample in gram

0.39 = 3 x 10-3 x 100 % x 1.3

3 = equivalent weight of carbon

mcf = moisture correction factor.

Methods for soil organic matter determination

Soil organic matter (SOM) was determine by soil organic matter contains 58% C. Conversion of % carbon to % organic matter is, therefore, done with the empirical factor of 1.724, which is obtained by dividing 100 by 58 (100/58) % Organic matter = 1.724 x % carbon

Methods for sulphur determination

Determination of sulphur in soil (turbidimetric method), determination of available the soil sulphur became an ordinary analysis in soil fertility evaluation programs. The available sulphur is extracted from the soil by extracting solution of $Ca(H_2PO4)2$. Sulphur is determined after subsequent oxidation of S to SO4 and then precipitated in form of BaSO4. Precipitated barium sulphate is then determined by turbidimetric method.

Procedure

1.Weigh 10 g of air-dried soil in a 150 ml Erlenmeyer flask.

2.Add 50 ml of extracting solution.

3.Shake for 30 min. and filter through whatman No. 5 or equivalent filter paper.

4. Pipette 10 ml of aliquot in a test tube.

5. Add 1 ml of gum acacia.

6. Add 1 ml of 6 N HCl

7. Add 0.5 of BaCl2 solution. Let the mixture stand for 2 min. and shake the tube in a test tube shaker.

8.Prepare a standard curve by placing 10 ml of each 0, 0.5, 1.0, 2.0, 4.0 and 8.0 ppm S standard solution into seven test tubes. Add 1 ml of Gum acacia, 1 ml of 6 N HCl and 0.5 ml of $BaCl_2$ solution. Let the mixture stand for 2 min. and shake the tubes in a test tube shaker. If the turbidity is low is low, add 1 ml of 10 ppm S seed solution in both standard and the soil sample extract.

9. Read the standard solutions and the sample extract after 5 min in spectrophotometer on a wavelength of 420 nm.

10. Draw a standard curve by plotting the absorbance readings against the S standard concentrations and find out the S content of the extract from the curve.

11. Run a blank determination simultaneously.

Calculation:

S, ppm in soil = S, ppm (found from the curve)*DF. A convenient method for determining total sulphur in soils has been developed. It consists of the fusion of 0.500 g soil with 1.4 g of sodium peroxide, followed by the determination of sulphate by turbidimetric measurement after interfering ions have been removed.

Methods for determination of boron

Boron (B) can be quantified using spectrometric and colorimetric methods. Inductively coupled plasma mass spectrometry (ICP-MS) is the most sensitive method currently available having a detection limit of 0.01 mg/L (Kmiecik et al., 2016) but requires a sample volume of 5 ml.To determine the concentration of boron in a soil sample, the boron must first be extracted. The hot water soluble (HWS) test, total acid digestion, and saturated paste extraction. The boron present within the extract solutions is then commonly quantified via inductively coupled plasma optical emission spectroscopy (ICP-OES), ICP-mass spectroscopy (ICP-MS), or by spectrophotometry.The total acid digestion method is performed by the addition of one or more acids and an oxidizer to a pre-dried and milled soil sample. The solution is heated, and the resultant extract is analyzed.

Most soils tested for boron by the total acid digestion analysis contain 5-30 ppm of total boron, of which only 1-3% is water soluble and bioavailable for plants to absorb.The saturated paste extraction method involves a slow addition of water to a soil sample to generate a saturated paste. The saturated paste is vacuum filtered and the resultant extract is analyzed. This approach is considered to afford boron concentrations more representative of the boron available for plant uptake and can be used to evaluate toxicity. For soils tested by a saturated paste extraction method, boron concentrations less than 0.7 ppm are considered safe to sensitive plants, concentrations of 1.5 – 4 ppm are considered toxic to most plants, and above 4 ppm, is toxic to all plants.

Cation exchange capacity determination

Cation Exchangeable Capacity (CEC) was determined by leaching the soil with neutral 1N ammonium acetate (FAO, 2008), 5g of soil was weighed and added to a 250 ml beaker, and 100 ml of ammonium acetate 1 M pH 7.0 solution was added and allowed overnight after stirring. The next day it was transferred to 250 ml of volumetric flasks and the remaining soil was washed by 50 ml of ammonium acetate pH 7.0. To bring up the volume of volumetric flasks to 200ml it was washed to times by 25ml of M ammonium acetate with distilled water. 250ml plastic bottles Placed under filter funnels and washed the soil on the filter with 25 ml ethanol. this process is repeated 2 to 3 times. some drops of the filtrated were taken into Nessler tubes and 3 drops of Nessler's reagent were added. a yellow precipitate is deposited at the bottom of the tube.

The precipitation was tested with Nessler reagent, repeating the procedure until no precipitate formed the soil was saturated with Na by washing with successive 20 ml of sodium chloride (NaCl 10%); the filtrate was collected into 250ml plastic bottles. A total of 20 ml successive washed gives a total of 100 ml. Including a blank.The filtrate was used for CEC determination by distillation. All soil parimeters were analysed using the appropriate laboratory procedures at Nekemte Soil Research center(NSRC) and Jimma Soil and Plant Tisue Analaysis Laboratory (JSPTAL).

3.4.2. Vermicompost materials and process

Vermicompost prepared with methods (Dede *et al.*,2006) by Haro Sabu Agricultural Research Center (HSARC) from maize stalk, soybean Residues, common bean residue, green table Plant, cow dug (50%), H_2O=20-30%, regularl ,Types of the Worm: *Essainta fetida* were selected due their adaptability and effectiveness. These worm only use

(0.03/100(g) for body mass from the feed. From what they feed 95% convert to vermicompost product.

Procedures

1st –Layer bedding materils of 1 inch thick with soft leaves,

2nd -Layer 9 inch thick organic residues layers fanelly chopped materials.

3rd- Layer cow dung + water equals mixture of 2 inch layers,continue the layer up to the ground level then the require moisture in the range of 20%-30%. The duration of vermicompost prepared was taken 60-90 days.The representative vermicompost samples was taken using a manual from the whole vermicompost randomly and combined to form a vermicompost composite sample. The prepared vermicompost composite sample 1 kg of composite sample was prepared and put into polyethylene bug. Then the sample was sent to soil analytical testing laboratory to determine the physicochemical properties of the vermicompost to Nekemte Soil Research center(NSRC) and Jimma Soil and Plant Tisue Analaysis Laboratory (JSPTAL).The sample was analyzed for selected physicochemical properties vermicompost mainly with following parameters.

3.4.3. Experimental procedure and agronomic practice

The land was ploughed, disked and harrowed by tractor. Then it was oxen ploughed, pulverized and leveled in order to have a smooth seedbed for planting. The plots were leveled manually. The different levels of blended NPSB and vermicompost prepared. Both fertilizers levels were applied with combined at planting time except the two control treatments. All the varieties/seeds were sown on early July (2023) by hand at a specified spacing (40 cm × 10 cm) by placing two seeds per hill and later thinned to one plant per hill after emergence. Furthermore, all necessary cultural and agronomic practices were carried out uniformly for all plots as per the recommendation for the crop at all stages of growth and development. Then the crop was harvested manually when 90% of the leaves and pods turned yellow and dried under the Sun before threshing. Threshing was done separately for each plot manually.

3.4.4. Post harvesting soils sampling and analysis

I soon as the experiment was harvested the post-harvest soil sample was taken again at a depth of 0-20 cm from each experimental plot. A representative soil samples were taken using a cylindrical auger from the whole experimental plot/from three replication/ and

combined with its twelve(12)treatments composite sample. The collected twelve treatment from three replication composite soil sample were air-dried, ground and sieved to pass through a 2 mm sieve. A 1 kg of composite sample for each treatment were prepared and put into polyethylene bug. The prepared 12 composited soil samples were sent to soil analytical testing laboratory to determine the physic-chemical properties of the soils. All soil parimeters were analysed using the appropriate laboratory procedures at Nekemte Soil Research center(NSRC) and Jimma Soil and Plant Tisue Analaysis Laboratory (JSPTAL) (Table.5).

3.5. Data collection

3.5.1. Soybean agronomic attributes

3.5.1.1. Days to 50% flowering

Days to 50 % flower initiation was recorded as the number of days from sowing to the time when at least one open flower appeared on 50% of the plants in a plot at any node on the main stem.

3.5.1.2. Days to 90% phsilogical maturity

Days to 90% physiological maturity was recorded as the number of days from date of sowing to the date when days to 90% of the plants showed yellowing of leaves and pods and seed hardening in the pods

3.5.1.3. Number of total nodules per plant

This was determined by counting nodules from five plants randomly taken plants from destructive row at days to 50% flowering. Roots were carefully exposed with the bulk of root mass and nodules. The all nodules were separated from the soil and washed thoroughly and the total numbers of nodules were determined by counting.

3.5.1.4. Number of effective nodules per plant

The number of effective nodules out of the total number of nodules per plant at 50% flowering was determined by dissecting each nodule and observing the cross section of the nodules, where nodules made with pocketknife showed a strong pink to dark red color were considered as effective while those showing green, brown, or white color were considered as ineffective nodules. The strong pink color of the nodule while

slicing/dissecting is caused by the presence of leghaemoglobin, which is indicator of active nitrogen fixation capacity of the nodules.

3.5.1.5. Plant height

Plant height was recorded for five randomly selected plants from harvestable rows in each plot at physiological maturity and it was measured from the base ground surface to the tip of main stem of the plant.

3.5.1.6. Number of primary branches per plant

It was determined by counting the average number of primary branches on the main stem of five randomly selected plants in each net plos at physiological maturity.

3.5.2. Yield and yield components

3.5.2.1. Number of pods per plant

The total number of pods on five randomly selected plants from each net plot area was counted at the time of harvest and the average value was expressed as the number of pods per plant.

3.5.2.2. Number of seeds per pod

Randomly selected five plants were taken from harvestable rows and the total number of seeds were threshed and counted to determine the average number of seeds per pod.

3.5.2.3. Seed yield

Seed yield was measured after allowing the harvested plants to dry in an open air until they attained constant weight. Finally the seed yield from net plot area of each treatment was converted to hectare basis and the average yield was expressed in t $ha^{-1.}$

3.5.2.4. Hundred seeds weight

Hundred seeds were counted from the harvested bulk of seeds per net plot and their weight by giram(g)) was determined at 10% moisture content by using a sensitive balance. Hundred seed weight is also an important yield component which reflects the magnitude of seed development that ultimately affects the final yield of a crop.

3.5.2.5. Aboveground dry biomass yield

The total above ground dry biomass of five randomly selected and tagged plants per net plot area was determined by harvesting close to the soil surface at physiological maturity and by sun-drying to a constant weight. Finally the biomass yield plants selected was converted to hectare and expressed in t ha^{-1}

3.5.2.6. Harvest index

The harvest index was calculated as the ratio of grain yield to total above ground dry biomass yield i.e. it is a ratio between economic character (seed yield) and total plant dry weight (seed yield + straw weight). It is very useful in measuring nutrient partitioning in crop plants, which provides an indication of how efficiently the plant utilized acquired nutrients for grain production.

$$\text{Harvest Index} = \frac{\text{Economic yield}}{\text{Total Dry biomass yield}} x100$$

3.6. Soybean Proximate Composition Determination Parameters

3.6.1. Crude protein determination

Crude protein was determined according to method, 920.87 using a VELP SCIENTIFICA Kjeldahl method analyzer (UDK 159, USA). Briefly, 1.0000 g of sample was put in digestion flask and CaSO4 (0.250 g) and K_2SO4 (7.00 g) were also mixed with the sample in digestion flask. Next, fifteen milliliters (15 mL) of concentrated sulfuric acid (98%) was added. Thereafter, the sample was digested by heating at 420°C for 2 hour. Then, the sample was cooled for 30 minutes after the completion of the digestion process. After that, titration and distillation performed by machine automatically. During the titration and distillation, the machine was used with 50 mL distilled water, 50 mL of 4% boric acid solution and 50 mL 40% sodium hydroxide solution and 0.20 N hydrochloric acid (HCl). Finally, the crude protein content of soybean was calculated using the formula below.

$$\mathrm{N}(\%) = \frac{(\mathrm{Vs} - \mathrm{Vb}) * \mathrm{N} * 14}{\text{sample weight}} * 100$$

$$\text{Crude protein} = \mathrm{N}(\%) * 6.25 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2.$$

Where: N(%) = percentage of nitrogen content in the sample, Vs = volume of acid consumed by the sample Vb = the volume of acid consumed by the blank N = normality of hydrochloric acid 14 = molecular weight of nitrogen, and 6.25 = conversion factor.

Then Crude protein yield was calculated as indicated formula below.

Crude protein) = Crude protein content in seed (%) × Seed Yield
Yield (kg ha^{-1} 100 (kg ha^{-1})

3.6.2. Crude oil determination

Crude fat content was determined according to AOAC (2000) using the official method 920.39. First, the extraction cylinder was cleaned and placed in a drying oven (Blast Air Oven, DHG-9240A, and China) at 105 °C for one hour. After dried, it was cooled in a desiccator for 15 minutes. Briefly, 1 g of the sample was placed in the thimble, covered with cotton, and placed in a Soxhlet extractor. Then, the mass of the pre-cleaned and dried extraction cylinder was measured (w1), and 70 mL of diethyl ether was added to each extraction cylinder for extraction. The extraction process was carried out for four hours and then oven dried at 92 °C for one hour. After one hour, the extraction cylinder was removed from the drying oven and cooled in a desiccator for 30 minutes. Then, the mass of each extraction cylinder with fat was measured (w2). Finally, the percent crude fat content of the sample was calculated according to the following equation.

$$\text{Crude fat (\%)} = \frac{\text{W2} - \text{W1}}{\text{sample weight}} * 100 \ldots\ldots\ldots\

mass of the burned sample with crucible was measured (W3). Finally, the crude ash content of the soybean was calculated using the following equation.

$$\text{Crude ash}(\%) = \frac{W2 - W3}{W2 - W1} * 100 \ldots\ldots\ldots\

3.5. 2.Statistical analysis

Factorial analysis of variance for all collected data was performed following the procedure of Gomez and Gomez (1984), using the statistical analysis system computer SAS software version 9.3 (SAS InstituteInc, 2008). The normality of the data was tested by using the scatter plot technique. The treatments that showed significant differences was subjected to least significant difference (LSD) test for mean separation at 0.05 probability level.

3.6. Economic Analysis

Economic analysis was performed by using partial budget analysis following the procedures described by International Maize and Wheat Improvement Center (CIMMYT, 1988). For the analysis, the average market prices of inputs from the months June to July (inorganic fertilizer (44.59 ETB kg^{-1}) and fertilizer application cost (150 ETB ha^{-1}) two persons were usedfor fertilizer application for each of them (75 ETB ha^{-1}) perday, and Vermicompost application cost (350ETB ha^{-1}) it means five persons applied vermicompost daily ha^{-1}) the daily payment was (75ETB) for each of them were used and other costs were constant for all treatment. In addition, the average prices of grain (45ETB kg^{-1}) and was collected during (December, 2023). The mean grain yield data were adjusted by deducting 10% of the actual yield (CIMMYT, 1988). All costs and benefits were calculated on hectare basis in Ethiopian Birr (ETB).The total variable cost (TVC) was determined as the sum of all variable costs (the cost of inorganic fertilizer,cost of vermicompost, and labor costs for the application of the fertilizer). total marketable tuber yield (t ha^{-1}) for each treatment by the current open market price of soybean (ETB ha^{-1}); Net benefit (NB) was calculated by subtracting Gross Benefit (GB) from Total variable cost (TVC). Marginal Rate of Return (MRR %)was calculated by dividing the change in net benefit (ΔNB) divided by change in total variable cost (ΔTVC) then multiplied by 100.

$$\mathbf{MRR(\%) = \frac{NBt2 - NBt1}{TVCt2 - TVCt1} x100}$$

Where T2 and T1 are consecutive treatments, arranged in ascending order based on their TVC after excluding treatments with low NB and high TVC. After treatments were arranged in ascending order by TVC value, treatments with high NB and greater TVC than the preceding treatments were selected for further analysis treatments with a lower NB value and a greater TVC than the preceding were excluded. Finally, marginal rate of return

was calculated as change in net benefit divide by change in total variable cost times as the following equation.

From this equation if the value of MRR <100 it is non-dominance it is not important for farmer use and if the Value of MRR>100 it is dominance it is important for the farmer. Dominance analysis: Was carried out by first listing all the treatments in their order of increasing costs that vary (TVC) and their net benefits (NB) are then put aside. Any treatment that has higher TVC but net benefits that are less than or equal to the preceding treatment (with lower TVC but higher net benefits) is dominated treatment marked as ("D"). Finally, a treatment having marginal rate of return (MRR) greater than 100% and with the highest net benefit was considered to be economically the best.

4. RESULTS AND DISCUSSION

4.1. Physicochemical Properties of the Experimental Site

The soil of study site physico-chemical characteristics were reported in (Table 3).The laboratory results indicated that the soil textural class of the experimental site was Sandy Loam, with relative proportions of 16% clay, 20% silt and 64% sand Aderson and Ingram (1993). Soil reaction result analysis showed that the pH value of the soil of the experimental site before planting (5.37). According to Hazelton and Murphy (2016) interpretation report soils wit pH value 5.5-5.1 strongly acidic. Based on these soil pH classifications, the soil of the experimental site was strongly acidic in reaction. This soil reaction could affect the yields of sensitive crops and need management practices to monitor changes in the soil pH for crop production and productivity of soybean.

Nitrogen and organic carbon level- The result showed that the total nitrogen and organic carbon content of the soil before applying inorganic NPSB and vermicompost fertilizer were found to be 0.18% and 2.08%, respectively.The percentile nitrogen (N %) is rated by Nelson *et al.* (1980) who, rating soil which have (0.15 to 0.25) medium range for total nitrogen. Similarly, recent soil classification interpretation rating by Hazelton and Murphy (2016) is nitrogen is (0.15-0.25) medium range. Likewise, Nelson *et al.* (1980), Hazelton and Murphy (2016) nitrogen content in soil of the experimental site was indicated medium. Soil organic carbon is an essential soil property in soil fertility decline studies (Pandy and Awashi, 2014). According to the organic carbon rating by Birhanu (1980) soil organic carbon content of the experimental site was (2.08%) which was in range midium organic carbon.

Available phosphorus level- The result showed that the level of phosphorus for the experimental site before the application of the treatments was (6.07mg kg^{-1}) (Table 3). According to Sahlemedhinnd (2002), described rating of phosphorus was which was in very low (0-7). Hence, the available P content in soil of the experimental site was very low range; which might be due to fixation. According to Solomon *et al*. (2002) reported that the availability of P in most soils of Ethiopia has been declining due to the impacts of fixation because of low or high pH. According to Tana (2017) and Jibrila and G (2022) reported the combined appropriate application of inorganic nutrients with organic nutrients improves soil chemical properties and increases the availabilities of nutrients (Tana, 2017, Jibrila and G, 2022).

Available sulfur and Boron level: The result showed that the level of sulfur and born for the experimental site before the application of the treatments (0.177mgkg^{-1}) and 0.29 (gmkg^{-1}) were recorded respectively in (Table 4). According to Horneck (2011) rated soil avialabity of sulphur soil value (<2 low) and boron availability rated (<0.5) soil value is low rage. The availability of sulfur and boron before the treatment conducted result show in the low range. So the addition of fertilizer S and boron containing nutrients is relevant.

Cation Exchange Capacity (CEC)-The result of the experimental site before planting showed that the cation exchange capacity of the experimental site was 24.60 cmol (+) kg^{-1} (Table 4). According to the classification of Hazelton and Murphy (2016) the soil CEC < (12-25) moderate range. Therefore, the CEC of the experimental field was rated as medium. The CEC of soil is a measurement of the magnitude of the accessible negative charge per unit weight of the soil, or the number of cations a particular soil sample can hold in an exchangeable form. It provides a buffering effect to changes in pH, available nutrients, calcium levels and soil structural changes. Meaning that, it is a major controlling agent for stability of soil structure, nutrient availability for plant growth, soil pH and the soil's reaction to fertilizers and other ameliorants.Exch. Acidity (Al^{3+} +H^{+}) =1.03 = which is strongly acidic(Hazelton and Murphy ,2007).

General, the results of the soil pre-analysis clearly indicate that the soil fertility problems that include deficiency of major plant nutrients such as phosphorus the mojor plant nutrient due to soil acidity that limit successful production of crops in the study area. 'This is calls for development of appropriate combination of nutrient management practices that enhance crop production on a sustainable production and productivity in basis.

4.2. Chemical Properties of Soil after Harvesting

Chemical properties of the soil of the study site after harvesting were shown in (Table 3).

Soil reaction (pH): The result of laboratory show that the pH value of the soil of the experimental site after harvesting significantly affected by combined application of NPSB with vermicompost application numerically. The maximam pH value (5.57) was recorded from treatment obtained 50kgNPSB ha^{-1} + 4 t Vc ha^{-1} fertilizer application with Didessa varity listed in (Table.3). However, the lowest pH value (5.50) was obtained from 100kg NPSBha^{-1} fertilizer treatment with Ethioyugoslavia variety. According to Hornec (2011) reported soil test interpretation rating soil pH value 5.2-6.0 is moderately acidic (Table3).

This change might be due to the lime application was applieyed for adjusting (buffering) for the experimental factors,and due to the combined application of inorganic and vermicompost. Vermicompost was found to be effective in improving soil physical, chemical and biological properties (Amanolahi- Baharvand *et al*., 2014).This finding in agreement with Amede *et al*. (2022) who reported in acid soils, where P fixation is a problem application of organic farm yard manure (FYM) releases a range of organic acids that can form stable complexes with Al and Fe thereby blocking the P retention sites, and as a result, the availability and use efficiency of P in the soil is improved. Similarly, Munthali (2007) report application of vermicompost resulted with increasing of soil buffering capacity, nutrient availability and water holding capacity and supply micronutrients, which may not be provided by commercial fertilizers. It has been demonstrated that using organic matter and mineral fertilizers as a soil amendment and fertility management technique is effective (Singh *et al*., 2011).

Nitrogen and soil organic matter - The laboratory analysis result shows after combined application of inorganic NPSB + vermicompost fertilizer application the result listed in (Table3). The nitrogen and organic matter of the experimental site significantly influenced. The maximum total nitrogen and organic matter (0.26% and 5.21.%) were recorded respectively from the treatment 0kgNPSB fertilizer +8t Vc ha^{-1} vermicompost while the lowest nitrogen and soil organic matter (0.18%and 3.54%)were recoreded from control un fertilizer treatment. According to Horneck (2011) rated soil avialabity of total nitrogen a soil value (0.15- 0.25) medium range and according to Horneck (2011) rated soil organic matter (3.00-5.15) was rated in high rage.

Therefore, soil organic matter (5.51%) high range was listed in (Table 3).This might be due to the vermicompost application increase soil organic matter and total nitrogen. According to Waters and Oades (1991), Beare *et al*. (1994) soil organic matter is an important 'building block' for soil structure and for the formation of stable aggregates. The benefits of soil organic matter (OM) are linked closely to the fact that it acts as a storehouse for nutrients, is a source of soil fertility and contributes to soil aeration, thereby reducing soil compaction.

The other benefits are related to the improvement of infiltration rates and the increase in storage capacity for water. Furthermore, OM serves as a buffer against rapid changes in soil reaction (pH) and it acts as an energy source for soil microorganisms. Similarly,

organic carbon was increased over composite soil by (16.8%). The ratio of organic carbon over total nitrogen(C: N) (11.58%) show increment. Allison (1973) suggests the interpretation of the C/N ratio of organic materials (C: N% 10–12**)** is normal for an arable soil. The result of experimental plot showed normal range. The carbon/nitrogen ratio measures the relative nitrogen content of organic materials. It is relevant to the breakdown of organic materials in the soil and is especially applicable in discussing the effects of crop residues on soil nitrogen levels and the rate of breakdown of crop residues.

Available phosphorus level-The result of the laboratory indicated that soil of the experimental site after harvesting significantly affected by combined application of NPSB and vermicompost application numerically listed in (Table3). The maximum avialabity of phosphorus after harvesting was (8.4%) was recorded due to the application of 8t vermicompost ha^{-1} alone and while the minimum phosphorus (6%) was obtained from unfertilized treatment. According to Horneck (2011) rated avialabity of phosphures (5-10) low range which shows deficit in (Table 3).

This result clearly shows the application combined application of in organic NPSB and vermicompost could be influenced on (p) fixation. Similarly, according to Chen *et al.* (2006) finding microorganisms enhance the phosphorus availability to plants by mineralizing organic phosphorus in soil and by solubilizing precipitated phosphates. Therefore the alternative use combined application of inorganic and vermicompost the best nutrient management for soybean production and productivity. Furthermore, legumes particularly soybean which uses nitrogen through dinitrogen fixation require more P than those using mineral nitrogen (Olufajo, 1990).

The Available sulfur and boron level- The laboratory result indicated soil after harvesting was listed in (Table3).The result shows after combined application of inorganic NPSB+ vermicompost fertilizer (0.177 and 0.29) were recorded respectively. According to Horneck (2011) rated soil avialabity of sulphur as soil value (<2 low), (2-10) medium,>10 sufficient. The boron average availabilities of in the soil value (<0.5 low), 0.5-2 medium, >2 high. The sulphur avialabity was increased after harvesting with combined application of inorganic NPSB fertilizer and vermicompost the maximum(143.8%) increment after harvesting was recorded by application of inorganic 100kg ha^{-1} NPSB with Didessa variety while the lowest (6.3%) was obtained by the application of 50kg ha^{-1}NPSB + 4 t Vc ha^{-1} with Ethioyugoslavia over un-fertilizer

treatment. However, the combined application of inoragic NPSB and vermicompost on boron availability show reduction below the composite result (Table3)

Cation Exchange Capacity (CEC): The result showed that the cation exchange capacity of the experimental site after harvesting mean (26.2 cmol (+) kg^{-1} was recorded. According to the classification of Hazelton and Murphy (2016), the soil (CEC 12-25) moderate range. The result of CEC of the experimental field was rated as moderate. After lime and combination of fertilizer (5.6 cmol (+) kg^{-1}) was recorded over composite soil.The CEC of soil is a measurement of the magnitude of the accessible negative charge per unit weight of the soil. It indicates the number of cations a particular soil sample can hold in an exchangeable form. It provides a buffering effect to changes in pH, available nutrients, calcium levels and soil structural changes. Meaning that, it is a major controlling agent for stability of soil structure, nutrient availability for plant growth, soil pH, and the soil's reaction to fertilizers and other ameliorants

Table 3. Pre –sowing, and post harvest soil properties result as affected by combined NPSB fertilizer with vermicompost on soybean varieties

Soybean Variety	Combined N PSB with Vermicompost (kg ha^{-1}, t ha^{-1})	Nutrient contents(g/kg)																	
		Pre soil result /Before planting soil result						Soil result after the experiment harvested						% change after harvesting					
		pH	SOM	N	P	S	B	pH	OM	N	P	S	B	pH	OM	N	P	S	B
Didessa	0 + 0	5.37	3.59	0.18	6.07	0.16	0.362	5.52	3.75	0.19	6.20	0.15	0.062	2.79	4.45	5.5	2.1	0	0
	100 + 0	5.37	3.59	0.18	6.07	0.16	0.362	5.51	3.60	0.18	6.00	0.39	0.302	2.6	0.28	0	0	143.8	0
	75 + 2	5.37	3.59	0.18	6.07	0.16	0.362	5.54	3.93	0.20	6.60	0.22	0.372	3.17	9.45	11.1	8.7	37.5	2.8
	50 + 4	5.37	3.59	0.18	6.07	0.16	0.362	5.57	4.27	0.21	7.00	0.08	0.252	3.72	18.9	16.7	15.3	0	0
	25 + 6	5.37	3.59	0.18	6.07	0.16	0.362	5.55	4.66	0.23	7.40	0.19	0.432	3.35	29.8	27.7	21.9	18.8	19.4
	0+8	5.37	3.59	0.18	6.07	0.16	0.362	5.55	5.05	0.25	8.20	0.31	0.642	3.35	40.6	38.9	35	93.8	77.3
Ethioyugoslavia	0 + 0	5.37	3.59	0.18	6.07	0.16	0.362	5.51	3.54	0.18	6.00	0.12	ND	2.6	0	0	0	0	0
	100 + 0	5.37	3.59	0.18	6.07	0.16	0.362	5.50	3.57	0.18	6.20	0.03	0.502	2.42	0	0	2.1	0	38.7
	75 + 2	5.37	3.59	0.18	6.07	0.16	0.362	5.53	3.94	0.20	6.80	0.21	0.202	2.98	9.74	11.1	12	31.3	0
	50 + 4	5.37	3.59	0.18	6.07	0.16	0.362	5.56	4.19	0.21	7.60	0.17	0.172	3.54	16.7	16.7	25.2	6.3	0
	25 + 6	5.37	3.59	0.18	6.07	0.16	0.362	5.54	4.61	0.23	8.20	0.14	0.082	3.16	28.4	27.7	35	0	0
	0+8	5.37	3.59	0.18	6.07	0.16	0.362	5.52	5.21	0.26	8.40	0.16	0.212	3.35	45.1	44.4	38.4	0	0

4.2. Phenological Data

4.2.1. Days to 50% flowering

The analysis of variance result showed that days to 50% flowering was highly significantly ($p<0.0001$) influenced by the main effect of combined application of inorganic NPSB with vermicompost fertilizers as well as the main effect of the variety. However, the interaction between variety and combined application of inorganic NPSB with vermicompost did not show significant effect (0.83) on days to 50% flowering (Appendix Table.2).

The treatment received vermicompost (8 t ha^{-1}) without mineral fertilizer took longer to reach 50% flowering (74.12 days) which is high significantly delayed flowering as compared to nil fertilizer application while the earlier 50% days to flowering was recorded (67.5days) from un- fertilizer treatment. Days to flowering shows decreasing fashion with increasing from un-fertilizer application to 8t $ha^{-1.}$ Listed in (Table 5)

Scientifically could be linked to luxuriant vegetative growth of the crop due to the application of organic vermicompost fertilizer vermicompost have excessive supply of nitrogen that promotes luxuriant and succulent vegetative growth, dominating the reproductive phase. The possible reason why the earlier /shortest/ days to flowering was might be due to the treatment is not fertilized the lesser availability of nutrients, especially nitrogen to the crop at the growth stages of crop when the nutrient degenerate and the nitrogen supply falls short of crop requirements during that development phase was changed to early flowering. This result was in line with the findings of Habtamu *et al*. (2018), who reported that applying N delayed the flowering of soybeans.

Similarly, Reta (2015), who reported that increasing the nitrogen rate from (0- 69 kg N ha^{-1}) significantly prolonged days to 50% flowering of linseed (*Linum usitatissimum* L.). In the case of the main effect of the variety the longest mean days to flowering (74.12) was recorded from variety Ethioyugoslavia while the earlier (68.11days) obtained from variety Didessa were given in (Table 5). The difference observed between the varieties might be attributed to the fact that days to flowering are genetically controlled and individual variety trait is difference.

4.2.2. Days to 90% physiological maturity

The analysis of variance revealed that days to 90% physiological maturity was highly significantly ($p<0.0001$) influenced by the main effect of combined application of inorganic NPSB fertilizer with vermicompost, main effect of soybean varieties and their interactions (Appendix Table 2).

The longest days to maturity (126.67) was recorded from combined 8 t vc ha^{-1} alone of with Ethioyugoslavia variety while the shortest day to maturity (114.00) was recorded from control with Didessa variety (Table 4). With regards of nutrient amagement to days 90% flowerin result showed as nutrient levels increases from zero to maximum the duration of days to maturity shows superior over unfertilizer treatments and the longest days to90% maturity was recorded due to + 8 t vc ha^{-1}. Fertilizer application alone.This miht be due to as vermicompost rate increase encouraged vegetative growth of the soybean and this may prolong the days to maturity.

This might be linked to luxuriant vegetative growth of the crop due to the application of vermicompost. In other words, vermicompost fertilizer permits the crop to have a longer phase of vegetative growth and flowering, as well as providing better ground cover and reduce water loss through evaporation, allowing for continued crop growth and development. While the shortest days to maturity was might be due to the lesser availability of nutrients, especially nitrogen to the crop at the later stages of crop growth when the nutrient degenerate and the nitrogen supply falls short of crop requirements during that development phase was changed to early maturity.This finding is in agreement with of Vyas *et al.* (2015) who recorded response of varieties highly affected by the level of fertilizer levels.

Table 4. Days to 90% physiological maturity as affected by interaction effect of soybean varieties and combined NPSB with vermicompost fertilizers

Soybean Variety	Combined NPSB with Vermicompost (kg ha- 1, t ha-1	Days 90%to maturity
Didessa	0 + 0	114[g]
	100 + 0	117d
	75 + 2	118[e]
	50 + 4	118[e]
	25 + 6	118.67[e]
	0 + 8	118.67[e]
Ethioyugoslavia	0 + 0	118[e]
	100 + 0	122.00d
	75 + 2	123.67[c]
	50 + 4	124.33[bc]
	25 + 6	125.00[b]
	0 + 8	126.67[a]
LSD	0.74	0.74
P value	<.0001	<.0001
CV	0.36	0.36

4.2.3. Number of total nodule per plant

The analysis of variance result indicated that total number of nodule per plant was high significantly ($p<0.0001$) influenced by the main effect of NPSB fertilizer with vermicompost was presented in (Appendix Table.2). However, the main effect of the variety and the interaction effect between varieties and combined application of NPSB fertilizer and vermicompost did not show significant ($P<0.16$) and ($p <0.34$) variations on number of total nodules per plant respectively.The highest number of nodules per plant (33.36) and (31.53) were recorded in response to 75 kg NPSB ha^{-1} + with 2 t Vc ha^{-1} fertilizer application and followed by 100kg NPSB ha^{-1} alone respectively.

However, the lowest number of nodules per plant (18) was obtained in the treatment applied with (8 t Vc ha^{-1} alone listed in (Table 5). The nutrients in blended NPSB fertilizer especially N had contributed largely to initiate nodulation and P contributed to increased root development resulting in nitrogen fixation in bean.The results clearly showed that the combination of blended NPSB fertilizer with vermicompost significantly increased total nodulation in soybean, implying that nutrients from organic and inorganic sources, particularly P, have integrated effects on nodule formation and improved root development and N fixation in common bean (Kouas *et al.*, 2005,Dereje *et al.*,

2017).Similarly, application of vermicompost supply necessary nutrients (N, P, S, K and Fe) important for nodules formation and Rhizobia bacteria are sensitive to soil acidity and require P, adequate soil moisture for their multiplication (Bekere *et al.,* 2013, Tigist Adisu *et al*., 2019). According to Zengeni *et al.* (2006), manure/vermicompost/ application increase indigenous rhizobium populations, which serve as a source of C and offer a suitable environment for bacterial proliferation.

As a result, the increase in nodule number could be attributed to improved soil rhizobium condition because of increased P and other micronutrient contents of the soil from vermicompost application. The present finding is in agreement with the findings of Argaw (2017) and Fatima *et al.* (2018) who reported a significantly high nodule number as a result of the application of integrated application of organic and inorganic fertilizer for lentil and peanut, respectively.

The application 100kg NPSB ha^{-1} alone, followed by combined application inorganic NPSB and vermicompost the total nodules per plant show an increasing trend as the rate of NPSB fertilizer increases from the level of the unfertilized treatment (0 to 100kg NPSB ha^{-1}). This might be the reason increased root development with increasing levels of blended NPSB fertilizer, which can increase the number of nodules per plant. Furthermore, the NPSB contains a significant amount of P fertilizer, which legumes require for growth and to promote leaf area, biomass, yield, nodule number and nodule mass.

This finding in line with Deresa (2018) and Bekere *et al*. (2012) found that as the rate of NPS blended increased from 0 to 200 kg NPS/ ha, the total number of nodules per plant increased. On the other hand, number of nodule per plant at high rate of (8 t Vc ha^{-1}) alone fertilizer application was reduced. This might indicates as the rate of vermicompost increasing application rates and thereby attributed to the negative effect of fertilizer- N on nodule formation. This result is in line with the application of high rate of nitrogen (56.58 kg N ha^{-1}), resulted in reduction of nodule number in soybean (Starling, 1998).

4.2.4. Number effective nodule per plant

The analysis of variance result indicated that the number effective of nodule per plant was high significantly ($p < 0.0001$) influenced by the main effect of combined application of inorganic NPSB fertilizer with vermicompost was given in (Appendix Table.2) while the

variety of the main effect and the interaction effect between varieties and combined application of NPSB fertilizers and vermicompost did not show any significant ($p<0.36$) and ($p <0.36$) variation. The maximam number of effective nodules per plant (31.53) was recorded in response to inorganic 75kg NPSB ha^{-1} combined with 2 t Vc ha^{-1} application, while the lowest number of effective nodules per plant (15) was recorded in the treatment applied with NPSB 0kg ha^{-1} combined + 8tha^{-1} vermicompost fertilizer application

The maximam effective of nodule per plant was might be due to combination of organic and inorganic fertilizer provides better soil environment for root growth, nodule formation, availability and absorption of nutrient from soil (Singh *et al*., 2017, Tigist Adisu *et al*., 2017). An increasing in NPSB fertilizer rate from an-unfertilized plot (0 to 100 NPS kgha^{-1}) enhanced the number of effective nodules per plant (Table 5).

Cutting with a sharp blade revealed the colour inside the nodule, which ranged from pink to dark-reddish. The reason increased number of effective nodules with the increase in NPSB nutrient application up to 100 kgha^{-1} might be due to the vital role of phosphorus available in NPSB-fertilizer as an essential ingredient for N-fixing bacteria to increase the number of effective nodules, the size of nodules and the amount of nitrogen assimilated per unit of nodules. This finding is in line with the findings of Dabele *et al*.(2021) who reported the highest number of effective nodules per plant (31.4) was recorded in response to the application of combined 2 t VC ha^{-1} +75 kg NPS ha^{-1}

This result agreement with Begum *et al*. (2015) reported that applying S containing fertilizer increases the number of effective nodules per plant at all stages of soybean growth. This result is in line with fact that legume nodules have dark pink or red centers denoting the presence of leghaemoglobin that is used as an indicator for effectiveness of the nodules and has positive coloration with N2 fixation (Bulter *et al*., 2004). While the lowest effective nodule per plant was (15.67) recorded with application of 0kgNPSB ha^{-1} + with 8tVc ha^{-1}.This shows an increasing vermicompost rates have attributed negative effect on nodule formation. Whereas inactive nodules (non-effective nodules) were black, grey or greenish, white on the inside of nodules (Purcell *et al*., 2014).

Table 5.Phenological data influenced by combined fertilizer application

Combined NPSB with Vermicompost (kg ha-1, t ha-1)	DF	NTNPP	NENPP	PH (cm)	NPBPP
0 + 0	67.50^{e}	25.33^{c}	24.00^{d}	66.1^{e}	2.5^{d}
100 + 0	69.5^{d}	31.53^{a}	29.16^{a}	96.57^{a}	6.53^{a}
75 + 2	70.83^{c}	33.33^{a}	31.50a	96.30^{a}	6.50^{a}
50 + 4	72.3^{b}	28.50^{b}	25.50^{c}	92.31^{b}	5.13^{b}
25 + 6	72.50^{b}	26.70^{bc}	24.66^{d}	91.29c	5.10^{b}
0 + 8	74.12^{a}	18.20^{d}	1566.00^{c}	85.89d	4.63^{c}
LSD (%)	1.22	1.85	1.44	0.28	0.13
P Value	<0.0001	<0.0001	<0.0001	0.06	<0.0001
Soybean Varieties					
Didessa	68.11^{b}	27.64	25.27	88.08	5.15^{a}
Ethioyugozilavia	74.12^{a}	26.90	24.90	88.08	5.00^{b}
LSD	0.7	1.06	0.84	0.16	0.07
P Value	<0.0001	0.16	0.36	0.06	0.0013
CV (%)	1.43	5.73	4.90	0.29	2.13

Days to 50% flowering, NTNPP = Number of total nodule per plant, NENPP=Number of effective nodule per plant, PH (cm)=Plant height, NPBPP=Number of primary branch per plant

4.2.4. Plant height

The analysis of variance result revealed that plant height was high significantly ($p<0.0001$) influenced by the main effect with combined application of NPSB and vermicompost fertilizer was given in (Appendix Table.2) while the variety and the intraction between varieties and combined application of inorganic NPSB fertilizer and vermicompost did not show any significant ($p<0.06$) and ($p<0.94$) variations on plant height respectively. The tallest plant (96.57cm) recorded from the application of inorganic 100 kg NPSB ha^{-1} + 0 Vc ha^{-1} and followed by (96.31cm) obtained from treatment combined application of 75 kg NPSB ha^{-1} + 2 t Vc ha^{-1} with statically not show any significant variations while the shortest (66.11cm) was obtained from nil fertilizer application in (Table 6).

The maximum plant height was reached at the greatest 100kg NPSB ha^{-1} rate and dropped when NPSB fertilizer rates decreased. The rise in plant height in response to NPSB fertilizer could be due to increased availability of N, P, S and B from blended NPSB, which triggered vegetative growth and cell division, resulting in increased plant height (Tesfaye, 2007) and the combination of fertilizer also clearly indicated the need for adding

vermicompost to the soil conjunctive with inorganic fertilizers, which increased the availability of nutrients considerably resulting in a positive effect on growth parameters.

This finding is agreement with the results of Babalad (1999) who had observed increased plant height, number of trifoliate leaves per plant and number of branches per plant in soybean due to the application of organic manure and inorganic fertilizers. Similarly, Agegn*et al*. (2022) who claimed that the highest soybean plant height was recorded from the application of the maximum rate blended inoragic fertilizer

Likewise, Kisinyo *et al.* (2005) who found that the combined application of N, P, and S components resulted in an increase in common bean plant height. In addition, Sharma *et al*. (2013) reported Boron application resulted in an increase in common bean plant heights as compared to non-B augmented fertilizer sources. This result also coincide with the research findings of Deresa *et al*. (2018) who found that increasing rates of blended NPS fertilizer (0–150 kg ha-1) observed progressive increase in plant height of common bean (Phaseolus vulgaris L.).

4.2.5. Number of primary branches per plant

The analysis of variance result indicated that the number of primary branches per plant was high significantly (P<0.0001) influenced by main effect with combined application of NPSB fertilizer and vermicompost was given in (Appendix Table .2) while the variety of the main affected significantly (0.0013) on number of primary branch per plant. However, the interaction between variety and combined application of inorganic NPSB fertilizer and vermicompost not show any siginificant (0.49) variation on number of primary branch per plant.

The maximam primary branches per plant (6.5) was recorded from the application of inorganic 75 kg NPSB ha^{-1} +2 t Vc ha^{-1} and followed by 100 kg NPSBha^{-1} alone with statically insignificant difference respectively listed in (Table.6).However, the smallest (2.5) number of primary branches per plant had obtained from the un-fertilize treatment. According to Tesfaye *et al. (*2007) report increasing number of primary branches with increased rate of (P) shows the importance of P for cell division, leading to the increase in plant height and number of branches.

Similarly, increase in number of primary branches per plant in response to application of blended NPSB fertilizer indicates higher vegetative growth of the plants due to N, P, S and

B availabilities. This finding in line with the result of Deresa (2017) reported that NPS application significantly increase the number of primary branches per plants of common bean. Likewise, Dubey *et al*. (1997) reported that S increased the number of primary branches per plant linseed up to 40kg S ha-1. This finding in contrast to Chala and Obsa (2017) reported that combining P and FYM had no influence on the number of branches per plant in chickpea. The maximum primary branch (5.15) was recoded from variety Didessa while the minimum (5.00) primary branch was obtained from variety Ethio-ugozilavia in (Table 6). The difference observed among the varieties might be attributed to the fact that primary branch per plant due to the genetically controlled and individual variety trait is different.

4.3. Yield and Yield Components

4.3.1. Number of pods per plant

The analysis of variance result showed that the both number of pods per plant and variety were high significantly ($p<0.0001$) influenced by the main effect with combined application of inorganic NPSB fertilizer with vermicompost were given in (Appendix Table.3) However, the interaction between varieties and combined application of NPSB fertilizers with vermicompost did not show any siginificant (0.81) variation on number of pods per plant. The maximam number of pod per plant (55.76) was recorded with regards to 75kg NPSB ha^{-1} +2 t Vc ha^{-1} and followed by 100 kg NPSB ha^{-1} with statically did not show any siginificant variations. However, the lowest number of pods per plant (29.53) was recorded from un-fertilized treatment (Table.6).This might be because of the presence of macro (N, P, and S) and micro-nutrients (viz. boron) in blended and vermicompost fertilizer which highly involved in pod initiation and formation in legume plants.

This result is in line with findings of Khanam et al. (2016) who reported that the number of pods per plant of soybean was increased (51.14) with the increase in phosphorous and other micronutrient fertilizer rate. Similarly, findings also by Xiang et al. (2012) who found that the increment of number of pods per plant of soybean is due to increasing amount of blended macro and micro nutrient fertilizer application from 0 to 112.5 kg ha-1. The highest mean number of pods per plant was recorded (47.67) by varity Didessa while variety Ethio-ugozilavia produced the lowest mean number of pods per plant (45.88) (Table.6).The difference observed between the varieties might be attributed to the fact that

number of pods per plant due to the genetically controlled and individual variety trait is different.

4.3.2. Number of seeds per pod

The analysis of variance result indicated that the number of seed per pod was high significantly ($p<0.0001$) influenced by the main effect of combined application of NPSB fertilizer with Vermicompost was given in (Appendix Table.3) However, the main effect of variety and the interaction between varieties and combined application of NPSB fertilizers and vermicompost not show any siginificant (0.32) and (0.12) variations on seed perpod. The maximum number of Seeds per pods (3.2) was observed 100kg NPSB ha^{-1} alone and followed by combined application of 75Kg NPSB ha^{-1}+ 2 t Vc ha^{-1} fertilizer. However, the lowest number of Seeds per pods (2.50) was recorded from unfertilized treatments (Table 6).

The results showed increasing trends of seed perpod with the increase in rate of blended fertilizer rate from (0 to 100 kg ha^{-1}). Number of seeds per pod increased with the increased application of NPSB rates which might have been due to high N is in NPSB rates and changed to vegetative part and the combined application of vermicompost with inorganic fertilizer might be create favorable envaroment for the crops. The result is agreed with the finding of Agegn *et al*.(2020) reported increasing number of soybean seed per pod as increasing blended NPSZnB fertilizer fertilizers. Begum *et al.* (2015) observed that number of seeds pod^{-1} increased with the increase of phosphorus application. Similarly, Morya *et al*. (2018) reported combined application of organic and inorganic significantly influence the numbers of seed perpod of soybean and Raj *et al*. (2021)reported integrated nutrient management increases number of seed per pods of soybean.

Likewise, findings of Shubhashree (2007) who observed the number of seeds per pod of soybean was increased significantly due to increased rates of multi-nutrient blended fertilizers. This finding is dis agreement with that of that of finding of Bekele *et al*. (2016) reported the number of seeds per pod was not significantly affected by the main and interaction effects of soybean varieties and nitrogen rates. It also dis agreement with that findings of Dame and Tasisa (2019) who reported blended NPS fertilizer had no significantly influenced the number of seeds per pod of soybean.

4.3.3. Hundred seed weight

The analysis of variance result indicated that hundred seed weights was found to be highly significantly (P<0.0001) influenced by main effect with combined application of NPSB fertilizer with vermicompost given (Appendix Table.3).However, the main effect of the variety and the interaction between variety and combined application of NPSB and vermicompost fertlizers not show any siginificant (P<0.95) and (P<0.18) variations on hundred seed weight respectively.The heaviest (16.78g) hundred seed weight was obtained with the application of 0 kg NPSB ha^{-1}+ 8t Vc ha^{-1} fertilizer; while the lowest (12.95g) hundred seed weight was recorded with nil fertilizer application listed in (Table.6) This clearly indicates that Vermicompost application delayed leaf senescence and this might be the reason for increased seed weight increment. This finding is in agreement with that of Devi *et al.* (2013) who reported vermicompost application delayed leaf senescence and this that is the reason for increased seed weight.

This finding is in agreement with that of Devi *et al.* (2013) who report vermicompost application delayed leaf senescence and the reason for increased seed weight. Simiraly optimum level of nitrogen nutrient in the soil enhances seed weights in crop plants and also seed sterility is reduced (Fageria Baligar, 2005).Likewise, Agegnehu (2005), reported a larger number of seeds per pod due to the treatment of 8 t FYM·ha^{-1}. Phosphorous fertilized crop produced more pods per plant which were better filled with heavier seeds than control (Mfilinge *et al.*, 2014).This finding is dis agree with the findings of Mandal et al. (2009) who reported the highest 100 seed weight of soybean was obtained at combined application of NPK fertilizer with farmyard manure than at nil application of NPK fertilizer.

4.3.4. Above ground dry biomass yield

The analysis of variance result indicated that aboveground dry biomass yield was found to be highly significantly (P<0.0001) influenced by main effect with combined application of in organic NPSB fertilizer with vermicompost presented in (Appendix Table.3). However, the main effect of variety and the interaction effect between varieties and combined application of inorganic NPSB fertilizers with vermicompost not indicated any siginificant (P<0.10) and (P<0.32) variations on aboveground dry biomass respectively.The maximam above ground dry biomass (8.89 t ha^{-1}) and (8.83 t ha^{-1}) were recorded due to the application of in organic 75 NPSB $kgha^{-1}$ + 2Vc t ha^{-1} fertilizer and followed by

inorganic 100kg NPSB ha^{-1} alone with statically not indicate siginificant variation. However, the lowest aboveground dry biomass (5.34 t ha^{-1}) was obtained from the zero fertilizer application rate (Table.6).

These results showed increasing trends of biomass yield with the increase in rate combined application of 75kg NPSB ha^{-1}+2 t Vc ha^{-1}fertilizer and from(0 to 100 kg ha^{-1}). This might be due to sufficient availability inorganic NPSB fertilizer with combined with vermicompost to the soybean increased significantly the vegetative part of the plant (plant height, number of primary branches, etc.) and this directly related to increments of production of aboveground biomass yield. This result was in agreement with the findings of Dame and Tasisa (2019) who observed the maximum (8718 kg ha^{-1}) aboveground dry biomass yield at the rate of 200 kg ha^{-}1 blended NPS fertilizer application and the minimum(6910 kg ha^{-1}) biomass yield was produced at nil NPS fertilizer application on soybean.

According to Rotaru (2010) reported that both biomass production and nutrient contents in soybean increased with higher Phosphorus application level. Getachew and Rezene (2006) also reported that the total aboveground dry biomass yield of faba bean significantly increased with increased rate of phosphorus fertilizer application.

Table 6.Yield and yield componets of soybean affected by combine application of inorganicwith vermicompost fertilizer (HSARC) in 2023 main cropping season

Combined NPSB with Vermicompost (kg ha^{-1}, t ha^{-1})	**NPPP**	**NSPP**	**HSW (g)**	**AGDBY (t ha^{-1})**	**(GY) (t ha$^{-1)}$**	**(HI %)**
0 + 0	29.53^{d}	2.50^{d}	12.95^{c}	5.34^{d}	1.390^{d}	25.59c
100 + 0	55.53^{a}	3.20^{a}	15.35^{b}	8.83^{ab}	3.36^{a}	38.33a
75 + 2	55.76^{a}	3.20^{a}	15.53^{b}	8.89^{a}	3.42^{a}	39.0a
50 + 4	48.50^{b}	2.86^{b}	15.75^{b}	8.39^{c}	2.82^{b}	33.64b
25 + 6	45.73^{c}	2.80^{bc}	15.50^{b}	8.41^{bc}	2.45^{c}	29.20c
0 + 8	45.63^{c}	2.76^{c}	16.78^{a}	8.05^{c}	2.26^{c}	28.24c
LSD	1.24	0.07	0.64	0.419	0.19	1.87
P Value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Soybean Varieties						
Didessa	47.67^{a}	2.90	15.31	8.08	2.64	32.82
Ethio-ugozilavia	45.88b	2.87	15.30	7.88	2.60	31.78
LSD	0.71	0.041	0.36		0.24	1.12
P Value	<0.0001	0.32	0.95	0.10	0.51	0.06
CV (%)	2.23	2.24	3.50	4.43	6.25	4.87

NPSB= inorganic NPSB blended fertilizer, Nppp=Number of pod per plant, NSPP= Number of seed per pod, AGDBY=Aboveground diry biomas yield t ha^{-1}, GY= Grain yield per ha^{-1}, HI%=Harvest indix by percent

4.3.5. Seed yield

Grain yield is a primary concern of farmers (producers) to cultivate soybean crop.The result showed that seed yield was governed by different yield components such as Plat height, primary branch per pant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, harvest index%. The analysis of variance revealed that the seed yield was affected high significantly (P<0.0001) influenced by the main effects of combined application of inorganic NPSB fertilizer with vermicompost (Appendix Table.3). However, the main effect of variety and the interaction effect between varieties and combined application of inorganic NPSB and vermicompost fertilizer not show any siginificant (P<0.51) and (P<0.38) variations on the seed yield respectively. The maximam seed yield (3.42 t ha^{-1}) and (3.36 t ha^{-1}) were recorded due to the application of inorganic 75kNPSB ha^{-1}+ 2t Vc

ha^{-1} vermicompost fertilizer and followed by the inorganic 100Kg NPSB ha^{-1} alone were recorded with statically did not show any significant difference; whereas the lowest seed yield (1.39tons ha^{-1}) was obtained from un fertilizer treatment application of fertilizer rate in (Table 6).

This might be due to blended fertilizer and vermicompost combination increases plant growth and photosynthesis assimilate partitioning of photosynthates from source to sink in post-flowering stage properly performed resulted in highest seed yield. Similarly, finding also reported by Sharma and Singh (2005), who report seed yield increment was recorded due to sulfur fertilization; it maintains the critical balance of other essential nutrients in the crop plant and resulted in increased metabolic processes. It has been reported that increasing soybean seed yield because of S application (Shahrusv and *et al.*, 2020).The increase in yield might be due adequate supply of nutrients, boosted plant growth, enhanced physiological processes, improved yield attributes and better utilization of nutrients by the crop plants. Thus, these favorable effects on yield components are ultimately manifested by the increasing seed yield of soybean. Similarly, Shahrusvand (2020) who reported soybean photosynthesis responses, yield, and seed quality affected by vermicompost and sulfur.

This result is in line with findings of Yamika and Ikawati (2012) found that the combination of inorganic and organic fertilizers can increase the soybean yield up to 3.5t ha^{-1}**.** Similarly, Bako Agricultural Research Center reported during Crop variety registration (BARC/OARI, 2008). Likewise, MoARD (2008) report that soybeans varieties Ethi-ugoslavia and Didessa have potential up to 3.3 t ha^{-1} and 3.5 t ha^{-1} at Research field on Crop variety register issue respectively. On the other hand, the lowest grain yield was due to the lesser availability of nutrients, especially nitrogen to the crop at the later stages of crop growth when the nutrient degenerate and the nitrogen supply falls short of crop requirements during that development phase was changed to early maturity. Similar results were also reported in soybean (Singh and Rai 2004). In line with this result, application of S with or without P recorded significantly higher seed yield up to 40 kg S ha-1on chickpea (Shivakumar, 2001.While the lowest yield recorded with nil fertilizer application.

4.3.6. Harvest index

Harvest index is a measure of the ability of a crop to convert the dry matter in to economic yield. The analysis of variance result indicted that harvest index was high significantly (P<0.0001) influenced by main effect with combined application of inorganic NPSB with vermicompost fertilizer (Appendix Table.3) while the variety of the main effect was siginificant (0.05) influenced by harvest index. However, the interaction effect between varieties and combined application of inorganic NPSB fertilizes and vermicompost not show any siginificant (0.81) variations on harvest index. The highest harvest index (39.00) and (38.33) were recorded due to the combined application of in organic 75kg NPSB ha^{-1}+ 2 t $Vcha^{-1}$ fertilizer rate and followed by with application of inorganic 100Kg NPSB ha^{-1} alone. However, the lowest harvest index (25.59) was recorded from the nil application of fertilizer rate (Table 6).

This is might be due to optimum combined application of inorganic NPSB with vermicompost fertilizer nutrients from the blended fertilizer that enhanced the partitioning of assimilates from different parts of plants to economical yield (seed yield). The present result is in line with the research findings of Malik *et al.* (2006) who reported the harvest index of soybean was significantly affected by the application of blended NPS fertilizer. Higher growth and development might be due to better availability and uptake of macro and micronutrients directly from the applied mineral NPSB and from organic vermicompost on decomposition resulted in higher biomass accumulation and better partitioning of biomass into yield attributing traits in the later growth stages of the crop, which could explain the increase in (HI%) in response to the integrated application of NPSB and vermicompost.

This finding in agreement with Tadesse*et al.*, (2022) reported a significant increase in the harvest index of fababean with increase in the rate of N and P fertilizers, which might be due to better biomass accumulation and higher translocation of dry matter and photo-assimilate to the economic part. On other hand, the lowest harvest index is due might be due to the lesser availability of nutrients, especially nitrogen to the crop at the later stages of crop growth when the nutrient degenerate and the nitrogen supply falls short of crop requirements during that development phase was changed to early maturity reduce biomas yield. Similar results were also reported in soybean (Singh and Rai 2004) .The maximum mean harvest index (32.82) was recorded by variety Didessa while the lowest

mean harvest index (31.78) was obtained from variety Ethioyugoslavia. The difference observed between the varieties might be attributed to the fact that harvest index might be genetically controlled and individual variety trait is different.

4.4. Proximate Composition Analysis Result in Soybean Seed

4.4.1. Crude protein content and crude protein yield analysis result

Crude protein content and crude protein yield analysis result indicated that crude protein content and crude protein yield in soybean seed were high significantly influenced by the combined application of inorganic NPSB with vermicompost fertilizer.The maximam protein content (41.77% and 41.58) were recorded from the combined application of inorganic 75kgNPSB ha^{-1} + 2 t Vc ha^{-1} + Ethioyugoslavia and Didessa varieties respectively and the maximum protein yield (1.43 t ha^{-1} and 1.41 t ha^{-1}) were recorded from the application inorganic NPSB 75kg ha^{-1} + 2 Vc t ha^{-1} + Didessa variety and followed by 100kg NPSBha^{-1} respectively with numerically siginficant variation. However, the minimum protein conten of soybean seed (38.27%) was obtained from nil fertilizer application+ Ethio ugoszilavia and the lowest protein yield (0.53 t ha^{-1}) was obtained from unfertilized treatment from Didessaavariety. Due to the combined application of inorganic75kgNPSB ha^{-1} + 2 t Vc ha^{-1}+ fertilizer with Ethioyugoslavia and Didessa varieties the maximum protein contents (9.2%) and (8.6%) were recorded with siginificant difference variation over unfertilized treatment respectively in (Table7).

With regards to application of inorganic 75kg NPSB ha^{-1} + 2 t vc ha^{-1} combination and 100kg NPSB ha^{-1} alone fertilizer application+Didessa varieties the maximum protein yield (169.8% and 166%) were recorded with siginificant difference variation over unfertilized treatment respectively (Table7).The result show that the combined application of inorganic NPSB and vermicompost fertilizer management was high significantly influenced the proteincontents and protein yield in soybean seed. All the treatments were significantly superior over unfertilizer treatments. Khaim *et al. (*2013) reported both N and S nutrients are required for the synthesis of amino acids especially S for cystine, cysteine and methionine which are essential components of protein. This finding agreement with findings of Alam*et al*. (2009) reported using integrated nutrient management soybean seed can be influenced about (40% to 45%) crude protein content.

Likewise, Such increase in these quality parameters by combined application of organic with inorganic nutrient sources was reported by Verma and Aravind (2017) who reported with integration nutrient management application of 75 %kg NPK ha^{-1} + 25 % t ha^{-1}) N ha^{-1} through vermicompost + Rhizobium + PSB recorded significantly higher (maximam) protein content (41.5 %), protein yield (976.8 kg ha^{-1}) while minimam protein (37.3.0%) and protein yield (547.6kg ha^{-1}).Similarly, this result agreement with Singh *et al.* (2020) who observed that the maximam crude protein content (41.39% and the minimam (38.11%) Protein content of soybean seeds was recorded with the use of 100% NPK through inorganic + vermicompost with (2.5 t ha^{-1}) while maximam crude protein yield (1.04 and the minimam 0.27t ha^{-1}) was recorded due to the application of NPK 100% kg ha^{-1} + FYM 5 t $ha^{-1.}$ Likewise Devi *et al.* (2013) reported that integration of 75% RDF with vermicompost at the rate of 1.0 t ha^{-1} produced significantly higher protein content of soybean seed.

The result also indicated that there was difference between Didessa and Ethio-ugozilavia varieties and combined application of inorganic NPSB with vermicompost fertilizer on crude protein content and protein yield were given in (Table 7). This result clearly shows that different soybean varieties have different crude portent content and crude protein yield. This related to genetic constitutes of individual treat. This result also confirmative with Taira and TAIRA (1971) and Rotundo *et al.* (2009) have been reported the genetic improvement in seed protein is associated with assimilate availability per seed and total assimilate supply per plant or unit area which could be associated with seed protein. Likewise McClure *et al. (*2017); Assefa *et al.* (2018); Bellaloui *et al*. (2020) reported soybean seed protein concentration varies among genotypes and environments.

4.4.2. Crude oil and crude oil yield analysis determination

The result indicated that crude oil content in soybean seed were high significantly influenced by the combined application of inorganic NPSB with vermicompost fertilizer was given in (Table7).The maximam oil content (21.12% and 20.98%) was recorded from the application of inorganic 100kgNPSB ha^{-1} alone and 75kg NPSB ha^{-1} +2 t Vc ha^{-1}fertilizer + Didessa variety respectively.However, the minimum oil conten of soybean seed (17.4%) was obtained from nil fertilizer application with Ethiougoszilavia variety. Th maximum oil yield (0.73 t ha^{-1} and 0.71 t ha^{-1}) were recorded from the application of inorganic 75 kg NPSB ha^{-1} + 2 tVc ha^{-1} and followed application of inorganic 100kg

NPSB ha^{-1} + Didessa variety respectively with little numerically siginificant variation while the lowest oil yield (0.24 t ha^{-1}) was obtained from unfertilized treatment from both soybean varieties (Table 7). The oil contents and oil yield in soybean seed were strongly influenced by the application of inorganic 100hg NPSB ha^{-1} alone and followed by inoragic 75 kg NPSB ha^{-1} and 2 t Vc ha^{-1} fertilizer+ Diddessa varieties nutrient management all the treatments were significantly superior over the control treatment(Table 7).

The % change due to the application of inorganic 100kg NPSB ha^{-1} fertilizer alone and the combined application of inorganic kg NPSB75 ha^{-1}+2t Vc ha^{-1} fertlizer ha^{-1} + Didessa variety the maximum oil content% (21.4% and 20.57%) were recorded with siginificant difference variation over unfertilized treatment respectively in (Table7). Similarly, the % change due to the application of inorganic 75 kg NPSB ha^{-1} +2 t Vc ha^{-1} and application of inorganic 100kg NPSB ha^{-1} application fertilizer alone + Didessa varieties the maximum oil yield (204.2% and 195.8%) were recorded with siginificant difference variation over unfertilized treatment respectively(Table 7). The result showed that the application of inoragic 75kg NPSB ha^{-1} +2 t Vc ha^{-1} and the application of inorganic 100kg NPSB ha^{-1} fertilizer management were high significantly influenced the oil content in soybean seed.

The crude oil content in soybean seed high significantly increased in each treatment over control. Increase in oil content might be due to the balanced nutrition of the crop from macro and micro nutrients supplied through NPSB and vermicompost fertilizer helped in synthesis of fatty acids and their esterification by accelerating biochemical reactions in glyoxalate cycle. The present study agreement with Khaim *et al.* (2013) who reported with recommended dose of inorganic 100kg NPK ha^{-1} fertilizer alone recorded maximam oil content (21%) and fallowed by combined application of inorganic 75% NPK ha^{-1} combined with poultry manure 1t Vc ha^{-1} recorded oil content (20.98%)with numerically not show significant variation. Similarly, the maximum oil yield (0.57 t ha^{-1}) was recorded from inorganic 100kg NPK ha^{-1} alone and 75kg NPK ha^{-1} with 25% vermicompost fertilizer with not show difference variation while the minimum oil yield (0.31798 t ha^{-1}).

Likewise, Verma and Aravind (2017) who reported with integration nutrient management application of NPK 75 % kg ha^{-1}+25% t ha^{-1} N ha^{-1} through organic vermicompost +

Rhizobium + PSB recorded significantly higher oil content (20.1 %), and oil yield (476.2 kg ha^{-1}) while min oil (18.9%)and oil yield (273.4kg ha^{-1}).The result also indicated that the difference between Didessa and Ethio-ugozilavia varieties and combined application of inorganic NPSB and vermicompost fertilizer on oil content and oil yield were given in (Table 8). This result clearly shows that different soybean varieties have different oil content and crude yield. This related to genetic constitutes of individual treat. McClure *al. (*2017); Assefa *et al.* (2018); Bellaloui *et al*. (2020) reported soybean seed oil conten and oil yield concentration varies among genotypes and environments.

4.4.3. Crude Ash Analysis Determination

The result show that crude ash content in soybean seed was shows significantly variations by combined application of inorganic NPSB with vermicompost on ash content of soybean seed.The maximum ash content(4.75%)was recorded by the application of inorganic50kg NPSBha^{-1} + 4 t Vc ha^{-1} fertilizer while the minimum ash conten(4.4%) was obtained from the treatment fertilized by 75kg NPSB ha^{-1} +2 t Vc ha^{-1} fertilize + Didessa variety(Table7).This might be the conjoint application of inorganic 50kg NPSB ha^{-1} 4 t Vc ha^{-1} fertilizer nutrient increase the ash content in soybean grain; this is more related (4tVc vermicompost combined with 50 kg NPSBha^{-1} encourage ash content in soybean grain. This combination of inoragic and vermicompost increased ash content by (7.9%) recorded over control treatment (Table 7).

This result show that the combined application of inorganic NPSB and vermicompost nutrient management has influenced on ash content in soybean seed. The standard ash content was recorded with the combined application of 75kg NSB ha^{-1}+2tVc ha^{-1} is the revealed that the optimum ash for human consumption

Table 7. Proximate composition of soybean seed influenced by combined fertilizer

Soybean varieties	Combined NPSB withVermicompost (kg ha-1, t ha-1)	Soybean Quality parameters						
		CP (%)	CPY (t ha^{-1})	%CO	COY (t ha1)	CA (%)	CF (%)	T.C.H (%)
Didessa	0 + 0	38.38	0.53	17.63	0.24	4.84	5.85	30.94
	100 + 0	41.26	1.41	21.12	0.71	4.5	6.65	24.81
	75 + 2	41.58	1.43	20.98	0.73	4.61	6.34	24.62
	50 + 4	41.40	1.22	20.2	0.59	4.75	7.15	25.44
	25 + 6	40.54	1.10	19.57	0.53	4.67	5.86	27.11
	0 + 8	41.09	0.92	19.72	0.44	4.65	6.64	26.33
Ethio ugozilavia	0 + 0	38.27	0.54	17.4	0.24	4.64	6.33	31.48
	100 + 0	41.23	1.39	21.05	0.71	4.61	5.85	24.90
	75 + 2	41.77	1.39	20.97	0.69	4.4	7.15	24.55
	50 + 4	40.98	1.10	20.3	0.54	4.58	5.94	25.93
	25 + 6	39.93	0.91	18.12	0.41	4.56	6.64	29.18
	0 + 8	39.94	0.69	19.59	0.34	4.67	5.85	27.69

NPSB=Inorganic NPSB fertilizer, Vc= Vermicompost (t ha^{-1}), Didessa and Ethioyugoslavia Soybean Varieties).CP =crude protein, CO= crude oil, CPY=crude protein yield (t ha^{-1}),COY=Crude oil yield(t ha^{-1}).,CA=Crude Ash, CF= Crude fiber, TCH=Total carbohydrate.

4.4.4. Total carbohydrate analysis determination

The result show that total carbohydrate content in soybean seed was did not influenced by combined application of inorganic and vermicompost. The maximum total carbohydrate content (31.48%) was recorded from the control unfertilized treatment + Ethioyugoslavia variety while the minimum total carbohydrate content (24.62%) from inorganic 75kg NPSB ha^{-1}+2 t Vc ha^{-1}fertilizer (Table7).The data result showed that as the level of inorganic NPSB fertilizer decreases the total carbohydrate content show increasing fashion and as the level of vermicompost fertilizer increases the total carbohydrate content show an increase fashion. This shows that nutrient, which is increase protein and oil content decrease carbohydrate conten in soybean seed. The preset study the maximam total carbohydrate in soybean seed is agreement with finding of Hou *et al.* (2009) who reported proximate composition of carbohydrates (33%) in soybean seed

4.4.5. Crude fiber analysis determination

The physiological effects of dietary fiber are what make it of interest to the consumer, food nutritionists and regulators. Soybean fiber contains both soluble and insoluble fiber and has been shown to lower blood levels of cholesterol and to improve bowel function. The result of laboratory data shown soybean crude fiber content in soybean seed was significantly influenced by combined application of inorganic NPSB and vermicompost fertilizer. The maximum soybean fiber (7.15%) were recorded by the application of combined inorganic 50kg NPSB ha^{-1} +4 t Vc ha^{-1} fertilizer+ with both variety while the minima fiber content(5.8) was obtained from the control treatment. The combined application of inorganic fertilizer and vermicompost could be increased (22.2%) over control treatment (Table.7).

4.5. Economic Analysis

Information on costs and benefits of treatments are a prerequisite to adopt technical innovation by farmers. This study assessed economic benefits of the treatments to develop recommendation from the agronomic data. This enhances selection of the best combination of nutriet management by farmers in the study area. The result in this study indicated that the combined application of inoragic 75 kg NPSB ha^{-1}+2 t Vc ha^{-1} obtained treatments resulted in higher net benefits than other treatment (Table 8). The partial budget analysis was done on the basis of costs of inorganic NPSB fertilizer and vermicompost cost and the cost of both inorganic NPSB fertilizer and vermicompost cost of application. The partial budget analysis revealed that the combined application of 75kg NPSB ha^{-1} + 2 t Vc ha^{-1}fertilizer application produced the highest net benefit of 145105.64 Birr ha^{-1} with marginal rate return (1871.5%)(Table8).

However, the lowest net benefit (MRR=207.25%) was obtained from treatment combined with inorganic NPSB 25kg ha^{-1} + 6 t ha^{-1}. This implies that farmers would be better of using the combination of NPSB 75 kg ha^{-1} and 2 t VC ha^{-1} as these increases soybean yields income. Thus, combined application inorganic NPSB75 kg ha^{-1} and 2 t VC ha^{-1} with Didessa variety is profitable and recommended for the farmers in the study areas and other areas with similar agro-ecological conditions. According to Zahid *et al.* (2016) reported a 173.8% increase in grain yield over the control due to the integration of NPK and FYM. For example, Fouda *et al*. (2017) recorded the highest grain yield values of

1681.12 (g) per plot (m^2) for common bean following an integrated application of NPK 100% + compost.

Table 8. Partial budget analysis of influence of combined NPSB with Vermicompost fertilizers on two soybean varieties

Soybean varieties	**Combined NPSBwith Vermicompost kg ha-1, t ha-1**	**Fertilizer kg ha^{-1}**	**Verm co.t ha^{-1}**	**Grain Yield kg ha^{-1}**	**Adjusted Yield (-0.1%) kg ha-1**	**Gross BenefitETB ha^{-1}**	**Total Variable CostETB ha^{-1}**	**Net Benefit ETB ha^{-1}**	**MRR %**
Didessa	0 + 0	0	0	1388.6	1288.60	57987	0	57987	-
	100 + 0	100	0	3408.33	3308.33	148875	4609.14	144265.86	1800
	75 + 2	75	2	3472.22	3372.22	151750	6644.35	145105.64	1871.5
	50 + 4	50	4	2958	2858.00	128610	8679.57	119930.43	D
	25 + 6	25	6	2722	2622.00	117990	10714.79	107275.21	207.25
	0 + 8	0	8	2249	2149.00	96705	12602	84103	D
Ethioyugoslavia	0 + 0	0	0	1416	1316.00	59220	0	59216	D
	100 + 0	100	0	3333.33	3233.33	145500	4610.14	140889.86	D
	75 + 2	75	2	3377.78	3277.78	147500	6646.36	140853.64	D
	50 + 4	50	4	2694	2594.00	116730	8680.57	108049.43	D
	25 + 6	25	6	2291	2191.00	98595	10716.79	87878.21	D
	0 + 8	0	8	1749	1649.00	74205	12604	61601	D

NPSB=44.59 Birr/kg, Vermicompost = 1.5 Birr/kg, NPS application = 150 Birr/ha, Vermicompost application = 625 Birr/ha

5. SUMMARY AND RECOMMENDATION

Soybean crop production has been practiced in Kellem and Western Wollega Zones in western Ethiopia, but the average yield is below the potential yield of the crop. The major yield limitation are decline soil fertility due to nutrient depletion and escalating inorganic fertilizer prices and less availability is the basic root cause for low rate of soybean yield for poor small holder farmer becoming unaffordable inorganic fertilizer is concern for most parts of Ethiopia. The study was conducted at Haro Sabu Agricultural Research Center during the 2023 main cropping season western Oromia. This study was carried out with objectives of to evaluate the influence of combined use of different rates of inorganic NPSB fertilizers and vermicompost on seed yield, yield attributes, seed quality, varietal response of soybean, soil properties and economically visible rates of NPSB and vermicompost fertilizer treatments(s) on soybean (*Glycine max* (L).(*Merrill*)varieties in Dale Sadi district, western Ethiopia.

The treatments were laid out in factorial combination of six inorganic NPSB fertilizer combined with vermicompost (0+0, 100+0, 75+2, 50+4, 25+6 and 0 kg +8 tones ha^{-1}) with two soybean varieties (Didessa and Ethioyugoslavia) were arranged in factorial arrangement of completely randomized block design (RCBD) with three replications. The soil result after harvest analysis showed the maximum pH value (5.57) was recorded from inorganic 50 kg NPSB ha^{-1}+ 4 t Vc ha^{-1} fertilizer application with Didessa variety while the minimum soil pH (5.50) was obtained from unfertilized treatment with Ethioyugoslavia variety. The (%) change in soil reaction pH over composite soil result on soil pH (3.72%), on soil organic matter by (18.9%), on total nitrogen by (16.7%) and on phosphorus (15%) were recorded due the combined fertlizer application of this treatment.

The result of treatment obtained 75kg NPSBha^{-1} +2 t Vc ha^{-1} was recorded maximum total nodule per plant (33.36), number of effective nodule per plant (31.53), number of pod per plant (55.76), number of seed perpod(3.2), plant height (96.31cm), number of primary branch per plant(6.5), The longest days to 50% was recorded(74.12 days) due to 0kg ha^{-1} +8 t Vc. While the earler(67.50) was obtained from control.The longest mean period of days to 50% flowering (74.12) was recorded from Ethioyugoslavia while the earlier period of (68.11 days) was obtained from variety Didessa. The longest period of days to 90% physiological maturity (126.67dyas) was recorded from the application of 0kg ha^{-1} +8 t Vc ha^{-1} with Ethioyugoslavia variety while the earlier period of (118 days) was obtained

from the control with Didessa variety. The maximum aboveground dry biomas yield (8.89 t ha^{-1}) was recorded from combined application of inorganic 75 kg NPSB ha^{-1} + 2 t Vc ha^{-1} while, the minimum aboveground dry biomas yield (5.34 t ha^{-1}) was obtained from control treatment.

Similarly, the maximum seed yield (3.42 t ha^{-1}) was recorded from the combined application of 75 kg NPSB ha^{-1} and 2 t Vc ha^{-1} while, the lowest seed yield (1.39 t ha^{-1}) was obtained from control treatment. The proximate composition in soybean seed result showed that the maximam protein content and protein yield (41.77% and 1.43t ha-1) were recorded from the application of 75kg NPSB ha^{-1}+2t VC ha^{-1} with Ethioyugoslavia variety andDidessa variety respectively.However, the lowest protein content and protein yield (38.27% and 0.53 t ha^{-1}) were obtained from control treatment with Ethioyugoslavia variety and Didessa variety respectively. The %change in protein content and protein yield (9.2% and 169.8%) due combined fertilizer application. Likewise, the maximum oil content and oil yield (21.12%and 0.73 t ha^{-1}) were recorded from 100kgNPSB ha^{-1} alone and 75kg NPSB ha^{-1} +2 t Vc ha-1+ Didessa variety while the minima oil content and oil yield (17.4%and 0.24t ha^{-1}) were obtained from control treatment with Ethioyugoslavia variety and both varieties respectively.

The % change in oil content and oil yield (21.4% and 204.2%) over control treatment.The combined application of 75kg NPSB ha^{-1} + 2 t Vc ha^{-1} with soybean variety could be increases availability of nutrients, especially phosphorus, total nitrogen, as well as soil organic matter and organic carbon in the soil, which are very crucial for betterment of soybean performance. Therefore, using combined application of inorgainic NPSB fertilizer and vermicompost is the prudent and efficient use of nutrients managements, which is boost soybean production and seed quality in the study area. However, the influence of NPSB and vermicompost on seed yield, seed quality and soil properties on different maturity groups of soybean varieties at different locations and years needs further investigation to come up with conclusive recommendations.

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7. APPENDIX

Appendix Table 1. Mean of Meteorological data of study Area.

Monthly average rainfall (mm), and mean maximum and minimum temperature of Alem Tefere/Dale sadi District (/HsARC (1996-2010)

Months	Meteorological data (5 years)(2000,2001, 2003,2004and 2010)	Meteorological data (5years)(1993,2001, 2003,2004and2006)	Meteorological data (5years)(1996,2001, 2003,2004and2006)
	RF(mm)	**Tmin (^{0}C)**	**Tmax (^{0}C)**
January	3.44	12.84	32.12
Feburary	19.42	12.92	32.72
March	26.06	12.98	32.56
April	51.34	11.88	32
May	275.28	11.54	29.96
June	314.1	13.28	27.92
July	397.2	14.9	26.02
August	322.46	14.38	25.96
September	312.68	15.82	27.28
Mean	**166.39**	**14.86**	**29.64**

Source: Ethiopian Metrology, RF: Rainfall, Tmin: Minimum temperature, Tmax: Maximum temperature of study Area(HSARC)/Alem Teferi/

Appendix Table 1. Analysis of variance (ANOVA) of agronomic parameters influenced by NPSB combined with vermicompost on two soybean varieties

Source of Variation	DF	Mean Squares					
		DTF	**NTNPP**	**NENPP**	**DM**	**PH(cm)**	**NPBP**
NPSBVc	5	36.3***	171.83***	178.16***	19.38***	786.47***	13.19***
Var	1	318***	4.98^{NS}	1.29^{NS}	0.44*	0.0004^{NS}	0.16*
Rep	2	0.67	3.1	1.10	0.028	0.148	0.0033
NPSBVc*Var	5	0.42*	2.83^{NS}	1.73^{NS}	52.9***	0.18^{NS}	0.01*
Error	22	22	22	22	22	22	22
CV		1.26	5.62	4.82	0.36	0.29	2.14

NPSBVc= NPSB fertilizer combined with vermicompost, Var= Soybean variety, DF =Degree of freedom DTF= days to 50% flowering, NTNPP=number of total nodule per plant, NENPP=Number of effective nodule per plant. DM = 90% days to phsilogical maturity, PH (cm)= Plant height in centimeter, NPBP = Number of primary branch per plan. Means followed by the same letters within columns and rows for a variable are not significantly different at 5% level of significance

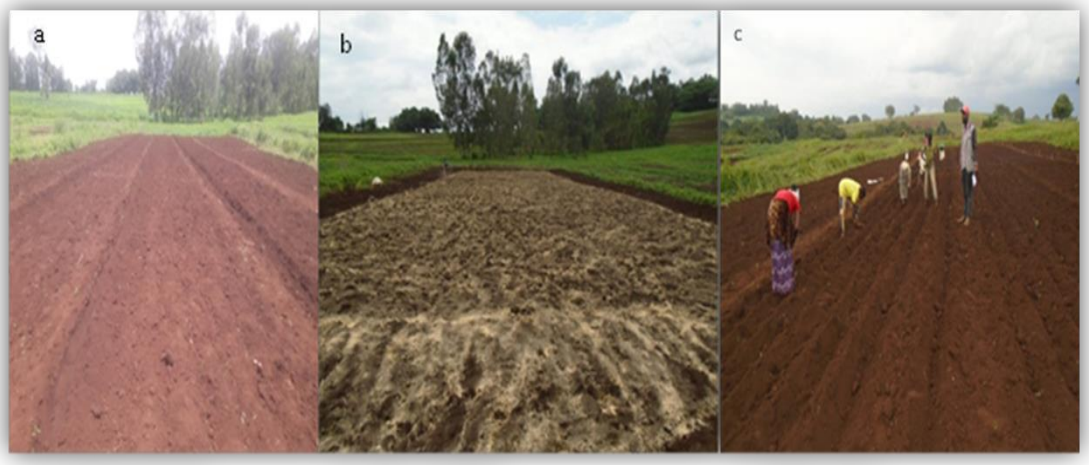
Appendix Table 2. Analysis of variance (ANOVA) of seed yieldand yield components influenced by NPSB fertilizer with vermicompost on two soybean varieties

Source of variation	DF	Mean Squares					
		NPP	**NSPP**	**HSW**	**AGDBY**	**GY**	**HI**
NPSBVc	5	552.24***	0.44***	9.63***	10598958.81***	3.44***	181.87***
Var	1	28.80***	0.0044^{NS}	0.0011^{NS}	345972.70^{NS}	0.012^{NS}	9.73*
Rep	2	1.34	0.015	0.56	166944.93	0.0009	0.87
NPSBVc*Var	5	0.543^{NS}	0.0071^{NS}	0.43^{NS}	148657.89^{NS}	0.03^{NS}	1.33NS
Error	22	22	22	22	22	22	22
CV		2.36	2.058191	3.29	4.336017	6.12	5.12

NPSB = inorganic fertilizer, Vc= vermicompost, Var= soybean variety, NPP = Number of pod Per plant, NSPP= Number of seed per pod, HSW (g) =Hundred seed weight, AGDBY=Aboveground dry biomass yield(t ha^{-1}), GY= Seed yield t ha^{-1}, HI=Harvest Index(%)

Appendix Figure 1. Photo taken during composite sample and planting at HSARC-2023

a. Composite soil b. Vermicompost c. vermicompost



a. Land prepared b. Lime applied c. plating time

Appendix Figure 2. Photo taken during crop management at HSARC-2023

Appendix Figure 3. Photo taken during nodule data and evaluation at HSARC-2023

Appendix Figure 4. Photo taken during harvesting and recording data at HSARC -2023

a. Data record b. Sample size c. During measurement

Appendix Figure 5. Photo taken during harvesting, post soil sapling at HSARC -2023

C. Soil sample prepared.

D. During sample preparation

Appendix Figure 6. Photo taken during sample for quality prepared at HSARC -2023

E&D: Ethioyugoslavia soybean varieties

B. sample prepared

Appendix Figure 7. Soybean Seed quality influenced by combined fertilizer application