



**PARTICIPATORY VARIETY SELECTION AND VARIABILITY OF IMPROVED
SOYBEAN (*GLYCINE MAX* (L.) VARIETY FOR ACIDIC SOILS IN BENCH SHEKO
AND KAFFA ZONE SOUTH WEST ETHIOPIA**

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ACRONYMS AND ABBREVIATIONS

CSA	Central Statistical Agency
EIAR	Ethiopian Institute of Agriculture
ESE	Ethiopian Seed Enterprise
FAO	Food and Agricultural Organization of the United Nations
FGDs	Focus Group Discussions
MARC	Melkassa Agricultural Research Center
MoARD	Ministry of Agriculture and Rural Development
MTU	Mizan-Tepi University
PA	Peasant Association
PCI	Participatory Crop Improvement
PPB	participatory plant breeding
PVS	Participatory Variety Selection
PVT	Participatory Variety Trail
RCBD	Randomized Complete Block Design
SRARC	Sirinka Agricultural Research Center
TARC	Tepi Agricultural research center

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ABSTRACT

Participatory Variety Selection and Variability of Improved Soybean (*glycine max* (L.)

Variety for acidic soils in Bench sheko and kaffa Zone South Western Ethiopia

Tewodros Biru and Haile Negash

The field trials were conducted at Chena, Menit Goldia and Shey Bench districts, of South western, Ethiopia during 2020 cropping season with objectives of identify high yielding, adaptable and acceptable varieties of soybean through participatory varietal selection and fifteen varieties were laid out in complete randomized block design and replicated three. The result of the current study clearly showed a significant variation among the released 15 Soybean varieties for most agronomic traits obtained at all districts. Seed yield, and disease resistance were the dominant selection criteria used by the farmers at Chena. Farmers in Shay Bench mainly were focused on seed yield; drought resistance and market demand while, similarly farmers at Menit Goldia used seed yield, earliness and seed size as dominant selection criteria. Seed yield, disease resistance and Number of pods per plant were the dominant selection criteria used by the farmers at three districts. Accordingly, majority of farmers frequently selected Nyala, Pawe 02 (PARC-2013-3) and Pawe 01. The results of combined analysis of variance indicated the existence of significant differences among varieties for all traits tested over location. According Nyala, Pawe 02 (PARC-2013-3) and Pawe 01 gave the highest seed yield of (2385kg ha⁻¹), (2155 kg ha⁻¹) and (2038.3kg ha⁻¹) respectively. In this study the farmers' preferences coincide with the breeders' selection. In conclusion, participatory varietal selection is a viable method to gain greater insight into farmers' perceptions, preferences, knowledge, shortcomings and potentials of improved soybean varieties and development of high seed yielding with disease resistance for the study area can enhance farmers' preference towards improved Soybean varieties. Based on the results of this study the identified and preferred varieties need to be multiplied and distributed to farmers through both formal and informal seed system.

Key words: Farmers' perceptions, Matrix ranking, Selection criteria, Seed System, Seed yield

1. INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) the 'golden bean', as it is an important crop in the worlds in terms of its uses in human food and animal feeds. It belongs to the family *leguminosae* and is self-pollinated crop having chromosome number of ($2n=2x=40$) and considered to be a miracle crop as it is extraordinary rich in proteins (~40) and is also second only to ground nut in terms of oil content (~20). Among food legumes, soybean it highly desirable in the human diet due to it Comprising 85% unsaturated fatty acids and is free from cholesterol (Iqbal *et al.*, 2008).

Being a legume, soybean plants also fix atmospheric nitrogen, which then becomes available for other plants. In addition, soybeans contain numerous compounds that can act as antioxidants and are beneficial to human health, as they diminish the risk of many diseases (Kumar *et al.*, 2014).

Glycine max (L.) Merrill is also a multipurpose crop, which can be used for a variety of purposes including preparation of different kinds of soybean foods, animal feed, soy milk, raw material for the processing industry, and it counter effects depletion of plant nutrients in the soil resulting from continuous mono-cropping of cereals, especially maize and sorghum, thereby contributing to increasing soy fertility (Hailegiorgis, 2010).

In Ethiopia soybean can be grown up to 2200 m.a.s.l altitude and with annual rainfall as low as 500-700mm, but performs best between 1300 and 1800m altitude with annual rainfall of 900-1300mm, an average annual temperature between 20-25°C and a soil pH of 5.5 to 7 (Gurmu, 2007).

According to central statics authority (CSA) 2017/18 in Ethiopia, 12,574,107.33 hectares is covered by the grain production among this about 804,752 hectares are oil seeds and which is 6.40%. It is grown globally producing 329.40 million tone year in the world food basket. Ethiopia is experiencing the rise in the soybean production due to its widespread use in food and feed industry.

Despite the wide range of benefits that soybean could provide to subsistence farmers of sub-Saharan Africa, its productivity is very low (below 2.0 t ha^{-1}) in many of these countries as compared to more than 2.7 t ha^{-1} productivity obtained in some other countries (FAO, 2013).

In Ethiopia, its productivity is far below the from world average, as the national average yield of the crop is less than 2 tons per hectare (CSA, 2015). This is mainly due to lack of appropriate production packages, low productivity of varieties, soil acidity problem, and lack of promotional activities suitable for different cropping systems and agro-ecologies (Urgessa, 2015).

Soil acidity and decline in soil fertility are forms of soil degradation adversely affecting sustainable crop production in Ethiopia in general, and in western Ethiopia in particular (Abdenna, *et al.*, 2007). The application of inorganic P fertilizers is one of the possibilities for addressing the problem of low P availability. However, most farmers of Sub-Saharan African countries have limited capacity to purchase and apply inorganic fertilizers, mainly because of high price, limited availability at the right planting time, and problem of distribution systems (Abush *et al.*, 2011).

Besides, the non-renewable P reserve is estimated to be exhausted from the soil in the coming few decades (Vance *et al.*, 2003). Lime treatment is commonly used approach in ameliorating soil acidity, to a mend the acidity of the soil, and thereby, increasing the availability of applied P. However, due to the large quantities of lime required for such purpose, the approach is highly labor intensive and expensive (Rao *et al.*, 1993).

Moreover, different reports indicated that most cultivated lands of the Ethiopian highlands in general and western parts in particular are prone to soil acidity due to removal of ample amount of nutrients by leaching, crop mining and runoff as compared with grazing and forest lands (IFPRI. 2010) and also an estimated 40.9% of Ethiopian soil is acidic (Mesfin, 2007) while most of the medium to strong acid soils of the country are found in the Western and Southwestern parts of Ethiopia (van Straaten, 2002, Mesfin, 2007).

Besides; Heterogeneous environment, large diversity of farmer's needs, lack of adapted varieties to those diverse agro ecologies facing the formal breeding methods and often fails to meet the needs of farmers and to develop cultivars or varieties showing specific or local adaptation (Desclaux, 2005). That is why most technologies developed without farmers' participation have failed to address the issues of rural poverty appropriately (Pretty *et al.*, 1985)

Participatory Variety Selection (PVS) is a more rapid and cost-effective way of identifying farmer-preferred cultivars if a suitable choice of cultivars exists (Witcombe *et al.*, 2008). Hence, Research costs can be reduced and adoption rates increased since farmers participate in variety testing and selection (Joshi *et al.*, 1996). Researchers learned which genotypes farmers preferred and which they dislike and the reasons for these opinions

Many varieties are officially released, but few are adopted by farmers. In contrast, farmers often grow varieties that have not been officially released, a phenomenon known to be associated not only with an inefficient and biased testing system prior to variety release, but also with breeders using different selection criteria from the farmers and particularly G×E interactions in the case of farmers in marginal environments (Ceccarelli, 2012). That is why in many part of Ethiopia farmers grow their own local varieties (Gebremedhin *et al.*, 2001). This is also true in the case of soybean production in the study area.

Thus In order to increase production and productivity of the farmers in study area, evaluation of released soybean varieties combined with farmers' preference to ease the existing problems of obtaining the desired varieties. Better adaptable and well performing variety (varieties) combined with farmers' preference under low soil p condition could be a sustainable and economical in the study areas. Therefore, this study was under taken with the following objectives.

General Objective

- To improve the production and productivity of soybean through participatory selection of best adaptable, high yielding and preferable for soil acidity in Bench Shako and kaffa Zones.

Specific Objectives

- To evaluate the performance of improved soybean varieties for soil acidity tolerance.
- To identify farmers' preference and selection criteria for soybean varieties

2. LITERATURE REVIEW

2.1. Origin and Distribution of Soybean

Soybean (*Glycine max* (L.) Merrill) is an old, cultivated crop native to North Eastern China (Hymowitz, 1970). Ngeze (1993) also suggested that soybean is native to Eastern Asia, mainly China, Japan, and Korea, from where it was distributed to America and Europe, and the remaining world in the 18th century. To strength this, the recent findings of Lersten and Carlson (2004) indicated soybean was domesticated around 5000 years ago from *Glycine soja*, its wild progenitor that is found all over East Asia, such as half of China, Korea, Japan, and some part of Russia.

Since its domestication, the *Glycine* is distributed in the Old World and became an established component of world agriculture (Hymowitz, 2008). In Africa, soybean was first introduced in the early 19th century (Ngeze, 1993) and is currently wide spread largely across the continent (Hymowitz, 2008). Evidence indicated that it might have been introduced at an earlier date back in Eastern Africa since that region had a long trade relationship with the Chinese (Shurtleff and Aoyagi, 2016). A similar report stated that soybean has been under cultivation in African particularly in 1907 in Tanzania and 1909 in Malawi. According to Shurtleff and Aoyagi (2009), soybean was introduced to Ethiopia since the year 1950.

2.2. Botanical Description Soybean

(*Glycine max* (L.) Merrill) is a self-pollinated legume crop and it belongs to the botanical family Fabaceae (Leguminosae) and subfamily Papilionideae, tribe Phaseolae, and genus *Glycine* (Shurtleff and Aoyagi, 2009). Taxonomically, the genus *Glycine* is divided into two subgenera, *Glycine* Willd. (perennial) and *Soja* (Moench) F.J. Herm (annual). Subgenus *Soja* again includes two species which economically are very important cultivated soybean (*Glycine max* (L.) Merrill), and its wild annual progenitor, *Glycine soja* Sieb. and Zucc. (Ratnaparkhe *et al.*, 2011).

Both the cultivated *Glycine max* and wild type *Glycine Soja* consists of 40 chromosomes ($2n=2x=40$) and are self-fertile species with less than 1% out-crossing (Norman *et al.*, 1995; Shurtleff and Aoyagi, 2016).

Glycine is a genus name that was originally introduced by Linnaeus in the first edition of his *Genera Plantarum* (Linnaeus, 1957). Currently, the combination *Glycine max* (L.) Merrill.) Was proposed by Merrill in 1917 and has since become the valid name for this useful plant (Merrill, 1917).

The typical cultivated soybean morphology displays a bush-type growth habit with a stout primary stem and sparse branches, bearing various seeds with variable seed coat colors (Ratnaparkhe *et al.*, 2011). It is erect and has prostrate growth and grows up to two meters high. The primary leaves are unifoliate, opposite, and ovate, the secondary leaves are trifoliolate and alternate, and compound leaves with four or more leaflets are occasionally present (Carlson and Lersten, 2004). The flowers are borne in the axillary racemes on peduncles at the nodes, and normally large number of flowers has emerged, but only about two-thirds to three-quarters can effectively produce pods. The developed pods consist of one up to five seeds (Rienke and Joke, 2005).

The root system can be considered as a vegetative morphology which is made up of the main root and secondary roots (Muller, 1981). The development of the root system starts at the soybean seed becomes germinate and reaches the plant's physiological maturity (Muller, 1981). The axillary root can reach a depth of 150 cm, while the secondary measures up to 180 cm (Mitchell and Russell, 1971). The growth habits of the soybean crop variety can be determinate, semi-determinate, and indeterminate (Pratap *et al.*, 2016). The determinate types grow shorter and produce fewer leaves, but produce comparatively more pods, while the indeterminate types grow taller, produce more leaves and more pods right from the stem to shoot (Ngeze, 1993; Pratap *et al.*, 2016).

2.3. Ecological Requirements of soybean

Soybean is a short-day plant and hence flowers more quickly under short days (Criswell and Hume, 1972; Rienke and Joke, 2005). According to Shibles *et al.* (1975) for flowering, the

critical day length ranges from nearly 13 hours for genotypes adapted to tropic areas to 24 hours for photoperiod-insensitive genotypes grown at other latitudinal areas. Consequently, photoperiodism and temperature response is key in determining areas of cultivar adaptation.

The growth duration of the world soybean ranged from 75- 200 days, while in tropical areas, the growth duration of adapted genotypes is commonly 90-110 days, and up to 140 days for the late maturing ones (Liu *et al.*, 2017). Short growth duration is primarily might be related with sensitivity to the day length. Such a situation affects the extent of vegetative growth, flower induction and pollen viability, and flowering duration, pod filling, and maturity characteristics (Norman *et al.*, 1995). Most of the crop legumes for growth and development require a temperature between 17.5 °C and 27.5 °C, optimum being 22 °C and the maximum about 40 °C. The seeds grow well between 15 °C and 40 °C temperatures, but the optimum is about 30 °C (Rienke and Joke, 2005).

Soybean requires an optimum rainfall amount in between 350 and 750 mm and is well distributed throughout the growth cycle (Ngeze, 1993). Rienke and Joke (2005) reported that two periods being critical for soybean moisture demands (sowing to germination and flowering to pod filling periods). The soil moisture should be between 50 and 85% during seed germination. Soybean withstands various soil types but mostly favors warm, moist, and well-drained fertile loamy soils, which supply adequate nutrients (Hans *et al.*, 1997). According to Ngeze (1993) and Singh (2010), soybean performs well in soils with a pH range of 5.5 - 7.0, and it can tolerate acidic soils than other legumes but does not grow well in waterlogged, alkaline, and saline soil areas. Rienke and Joke (2005) also reported that this crop produces high yields in loamy textured soil and that if the seeds can germinate, they grow better in clayey soils.

2.4. Production and Importance of Soybean

Glycine max (L.) Merrill.) is aptly called “golden bean” or “miracle crop” of the 20th century and is one of the most valuable oilseed crops in the globe (Chung and Singh, 2008). It is the foremost important vegetable and oilseed crop having a greater production contribution worldwide (Chung and Singh, 2008). Production of soybeans is rising and is expected to stay to increase as demand for soybean oil for both human consumption and biodiesel and high-

protein meal for animal feed increases in the world. Particularly, the soybean oil is considered as healthiest vegetable oil (Wilson, 2016).

In general, a soybean seed has high nutritional value and is rich in proteins and oil with an average of 40% protein and 20% oil, respectively (Arefrad *et al.*, 2012). However, products of soybean are lacking in the sulfur-containing amino acids such as methionine and cysteine, and currently, the breeders concern goes to enhance their concentrations (Panthee *et al.*, 2006; Krishnan and Jez, 2018). Beyond the nutritional values, soybean is also used as a nitrogen-fixing crop globally for the restoration and maintenance of soil fertility in a sustainable way and consequently contributes much to the improvement of crop yields (Smaling *et al.*, 2008). Herridge *et al.* (2008) reported that soybean requires more nitrogen, and it is estimated that biological nitrogen fixation can cover 60 to 70% of the nitrogen requirements of the plant. Global soybean production is estimated at about 336.71 million tons with productivity of 2.77 tons (FAO, 2019). According to FAO (2019), soybean production is estimated at about 3.09 and 0.126 million tons with the productivity of 1.25 and 2.30 tons per hectare in Africa and Ethiopia, respectively. Production and area cultivated under soybean in Ethiopia have an increasing trend from 2014 to 2020.

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2.5. Genetic Diversity and Variability of Soybean

Plant genetic resources and the genetic diversity present in a particular crop species offer assurance for future genetic progress and insurance to unpredicted threats to agricultural production (Upadhyaya *et al.*, 2008). Traditionally, the evaluation of genetic diversity in soybean has been based on variation detections of morphological and agronomic traits or pedigree information (Ghaffari *et al.*, 2014) which has provided valuable information for

germplasm evaluation. Phenotypic diversity in soybean is extensive and is under the genetic control of qualitative and quantitative traits (Oliveira *et al.*, 2017).

Soybeans, has the subgenus Soja and perennial species within the subgenus Glycine. These species are considered as genetic resources for breeding purposes of the soybean crop (Hymowitz, 2004; Oliveira *et al.*, 2017). As reviewed by Oliveira *et al.* (2017) the collected data and updated by the International Plant Genetic Resources Institute (IPGRI), indicated that more than 170,000 accessions of *Glycine max* are maintained by around 160 institutions in about 70 countries in the world.

Genetic diversity investigation of plants provides a key role for developing high-yielding varieties and improvements in other relevant traits in the plant breeding strategies. The screening and selection for crop improvement would be based more likely on the availability of promising genotypes, which depends on the availability of diversity (Gemechu Keneni *et al.*, 2012). Genetic variability is essential for any breeding program, which offers an opportunity to a breeder for the selection of high-yielding and desirable genotypes. Understanding the magnitude of existing variability, proper characterization of key physiological traits and their relationships with yield and yield components would be very helpful in the development of efficient and highly productive genotypes (Aditya *et al.*, 2011).

Tadesse Ghiday *et al.* (2017) reported that the estimates of genotypic coefficient of variation were high for the number of seeds per pod, seed yield per plant, number of pods per plant, seed filling period, number of branches, and plant height. Bisht *et al.* (2018) and Diriba Beyene and Negash Geleta (2021) also found significant genotypic and phenotypic variations of most quantitative traits of 22 and 100 soybean genotypes. Moreover, several authors studied and reported the existence of a wide range of genetic variability and diversity on different yield and yield-related traits of soybean. Dubey *et al.* (2018) and Mishram *et al.* (2018) examined soybean genotypes and reported the presence of sufficient genetic variation and diversity based on the quantitative traits data.

2.6. Soil Acidity and Its Effect on Crop Production

Acid soils (soils with pH < 5.5 in the surface layer) constitute 3,950 million ha or 30% of the world's total ice-free land. In Africa, 22% or 659 million ha of the total 3.01 billion ha land are acid soils (Uexkull and Muter, 1995). The main problems of crop production on acid soils are mineral toxicities related to dissolved aluminum, manganese, and iron, and deficiencies of phosphorus, calcium, magnesium, and molybdenum (Uexkull and Mutert, 1995 and Kochian *et al.*, 2004). Sixty-seven percent of the acid soils of the world have Al-toxicity problem (Eswaran *et al.*, 1997).

The highlands of Ethiopia (areas >1500 m above sea level) are particularly the most affected region by the problem. The cause of soil acidity is high amount of precipitation that exceeds evapo-transpiration, which leaches appreciable amounts of exchangeable bases from the soil surface. As a result, most of the soils have a pH range of 4.50 to 5.5 contain low organic matter (< 20 g kg⁻¹) and low nutrient availability (Temesgen *et al.*, 2011). Increased soil acidity causes solubilization of aluminum (Al), which is the primary source of toxicity to plants at pH below 5.5, and deficiencies of P, Ca, Mg, Mo, N, K, and micronutrients (Kariuki *et al.*, 2007). Theoretically, soil acidity is quantified on the basis of hydrogen (H⁺) and Al³⁺ concentrations of soils.

For crop production however, soil acidity is a complex of numerous factors involving nutrient/element deficiencies and toxicities, low activities of beneficial microorganisms, and reduced plant root growth which limits absorption of nutrients and water (Fageria and Baligar, 2003). However, Al toxicity is one of the major limiting factors for crop production on acid soils by inhibiting root cell division and elongation, reducing water and nutrient uptake (Wang *et al.*, 2006), poor nodulation or mycorrhizal infections (Kochian *et al.*, 2004, Delhaize *et al.*, 2007), leading to poor plant growth and yield of many crops.

Soils of the south Ethiopia including south western Ethiopia have acidity problems (Mesfin Abebe, 2007). Soil acidity and depletion of nutrients negatively affected the performance and yields of soybean in the region. Soybean is an important food crop produced in south parts of Ethiopia. It is a rich source of protein and serves as a cash crop for smallholder farmers. However, the crop yields are below the national average (0.13 t ha⁻¹). Soil nutrient depletion

due to erosion and leaching of basic cations from the agro-ecosystem is also a very widespread crop production constraint in West Ethiopia (Taye Bekele, 2001).

The use of lime, vermicompost and other organic fertilizer sources are recommended to cope with problem of soil acidity. However, these options are constrained by several factors including, strong buffering capacity of most acidic soils in the region against the amendments of lime. Hence, large amount of lime is needed to normalize the pH. Most resource-poor farmers in there are embarrassed by unavailability, transport, and the high cost of the large volumes of lime needed to treat the soils.

In addition, lime has low mobility and its mechanical incorporation in to the subsoil is also often difficult for small holder farmers without tractors and subsoil rippers. Consequently, when surface soils are amended with lime, it fails to increase the pH of the sub-soil, resulting in restricted root growth and, therefore, poor plant growth (Mesfine Abebe, 2007). Limited root growth also increases the vulnerability of plants to drought of even short duration (Foy, 1992). This is particularly important because many acid soils have inherently low water holding capacity (Haynes and Mokolobate, 2001). Soybean as leguminous crop relies on microbial nitrogen fixation as source of N. However, under acid soils, the population of *rhizobia* bacteria is reduced and consequently nodulation and N fixation is impaired. This affects negatively on crop nutrition and yields.

2.7. Participatory Crop Improvement (PCI)

Participatory crop improvement (PCI) is an approach in genetic improvement, first developed to respond to the demands for improved varieties from small-scale farmers situated in poor or marginal areas, for which conventional breeding had generally failed. The approach aims to deepen the involvement of farmers and other actors (in the crop's production chain) in the different stages of variety development. Moreover, the method has a decentralized approach; it takes into account the specific environmental conditions of targeted sites such as climate, soils and farming practices to better control the genotype-by-environment interactions that are frequently very strong in traditional, low-intensity, production systems (Ceccarelli *et al.*, 1996).

2.7.1. Participatory varietal selection (PVS) and its importance

“Participation” includes people’s involvement in decision-making processes, in implementing programmes, their sharing in the benefits of development programmes and their involvement in efforts to evaluate such programmes. Participatory research is a family of approaches that enable participants to develop their own understanding of and control over the processes and events being investigated (Ashby and Lilja, 2004).

PVS is an approach that provides choices of varieties to the farmers for increasing production in their diversity of socioeconomic and agro-ecological condition. It is also a selection process of testing released or promising genotypes. Therefore, the variety that is developed through PVS can meet demand of different stakeholders (Witcombe, 1996).

The rationale behind to use PVS as part and parcel of modern plant breeding is objectives of researchers (e.g. yield maximization) may differ from objectives of farmers (e.g. market, quality and household utilization, farming environment varies according to climate, soil, market access, diseases and pests) and results from conventional research process take a longtime to reach the farmers. PVS also increase the suitability and use of improved technologies as well as widen ownership of new technologies to include farmers (Witcombe *et al.*, 2005).

PVS also provides an opportunity to the farmers to evaluate many kinds of varieties on their own fields; cultivars can be searched according to the needs of the farmers of study areas with some other characters, such as earliness, high yield, disease resistance and other good quality traits; enhance farmer’s access to crop varieties and increase in diversity; increase production and ensure food security; help to disseminate the adoption of pre and released varieties in larger areas; allow varietal selection in targeted areas at cost-effectiveness and also in less time and as a consequence help seed production and scaling-up at community based (de Boef and Ogliari, 2008).

Participatory Variety Selection (PVS) can effectively be used to identify farmer-acceptable varieties and thereby overcome the constraints that cause farmers to grow old or obsolete varieties (Joshi and Witcombe, 1996; Witcombe *et al.*, 1996). Moreover, participatory

research increases the job efficiency of the scientists (Bellon, 2001) and farmers' knowledge that enables to be retained effectively from year to year (Grisley and Shamambo, 1993). Research costs can be reduced and adoption rates increased if farmers are allowed to participate in variety testing and selection. In addition, production increases when farmers adopt new varieties identified in participatory research.

2.7.2. Participatory varietal selection in Ethiopia

In Ethiopia, participatory varietal selection (PVS) is on the way of extending to participatory plant breeding (PPB) on the assumption that if it is desirable to involve farmers in selection of cultivars, then why wait until there are finished products? Moreover farmers can be involved at a much earlier stage whilst material is still segregating. However, PPB is more resource consuming than PVS, and hence, the first recourse should be to the least expensive method. Moreover, several countries of east Africa including Ethiopia are probably the best-known examples for the successful application of PVS work of bean varieties which have fueled bean crop improvement (Weltzien *et al.*, 2003).

Participatory plant breeding has to be used when PVS has been tried and failed, or when the research process has failed to identify any suitable candidate cultivars (Witcombe *et al.*, 2005 and Ortiz-Ferrara *et al.*, 2007). The approach of participatory varietal selection in Ethiopia has begun on many crops including common bean (Firew, 1997; Assefa *et al.*, 2005; Asrat and Fitsum, 2008; Mekonnen *et al.*, 2010), sorghum (Eshetu and Ketema, 2001), maize (Eshetu and Habtamu, 2002, Girma, 2003), tef (Getachew *et al.*, 2006), barley (Fetien *et al.*, 2008 and Yetsedaw *et al.*, 2010) and wheat (Alebachew, 2012).

Participatory varietal selection (PVS) and participatory plant breeding (PPB) are techniques for integrating clients' or end-users' needs and including environments in the crop improvement process. Molla, 2010 indicated that farmers identified their selection criteria of improved varieties of finger millet as: yield related traits (effective number of tillers, number of fingers per ear, plant height, finger length, stand and uniformity at maturity, days to maturity and biomass yield), seed color and blast disease reaction.

PVS work of Getachew *et al.*, (2006), indicated that seed color, driven by market forces, are the overriding selection criteria of tef varieties by farmers of the major tef growing woredas of Ethiopia. Now a day in Ethiopia, there is a progress that farmers are increasingly participating in agricultural research as scientists and development workers become more aware of the philosophy of farmer first and its effectiveness. Many farmer participatory approaches are possible in farmer participatory research for improved crop cultivars by farmers' priority through participatory varietal evaluation.

Mekonen *et al.*, 2010 in PVS work conducted on common bean showed that farmers identified disease resistance, pod length, pod load, seed size, seed color, and seed yield. They gave the highest weight to seed yield, followed by pod load and seed color. Farmers' preference ranking indicated that Hawassa Dume, Nasir, and Dimtu (which are high yielders and red beans) were the best varieties for their area. More over from small-scale traders' evaluation seed color and size were important traits for variety selection.

Alebachew in 2012 also reported that grain yield and earliness were proposed as very important criteria followed by Disease resistance, feed palatability and tillering ability as less important criteria in participatory evaluation of bread wheat varieties at Tigrie region.

When farmers are exposed to the basket of choices of a range of new cultivars in a participatory selection program, the outcome in a specific region may be an increase or a reduction in biodiversity. The situation is complex and changes in biodiversity depend on existing variability in farmers' fields, the variability in the new cultivars offered to farmers and their acceptability, and the variability in the target environment, both physical and socioeconomic.

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The experiments was conducted during the 2020 main cropping season at three locations with representing various agro-ecologies of Bench Shako and kaffa zone, South Western Ethiopia where soybean is grown and were characterized by strong to moderate soil acidity and low P availability. Detail description of the study sites is given in Table 1.

Table 1: Descriptions of Altitude, Temperature, Rainfall, latitude and longitude of testing locations

Location	Altitude (m.a.s.l)	Average rainfall	Average temperate	Global positions	
				Latitude	Longitude
Shay Bench	1400-2485	1547.7mm	22-29 °c	5 ⁰ 30'' - 7 ⁰ 00'' N	34 ⁰ 00'' - 36 ⁰ 00'' E
Chena	500-3350	1600 –2200mm	18 – 21 °c	6 ⁰ 24' - 7 ⁰ 70' N	35 ⁰ 69' - 36 ⁰ 78' E
Menit Goldiya	700-2200	1700-2000	23 - 32	6 ⁰ 25' N	35° 16' 0' E

3.2 Experimental Materials

Sixteen released soybean varieties that expected to perform better in the areas was used for the study. The varieties are selected based on average yield performance and agro ecological adaptation and obtained Jimma and Hawassa Agricultural Research centers (Table 2).

Table 2: Description of released soybean varieties for the study

S.N	Variety	Maturity Type	Altitude (m.a.s.l.)	Maintainer	Year of Release
1	Gizo(TGX-1885-33F)	Medium	520-1800	PARC/EIAR	2010
2	Gishama(PR-143-(26))	Medium	520-1800	PARC/EIAR	2010
3	BOSHE(IAC-13-1)	Medium	1200-1900	BARC/OARI	2008
4	Dhidhessa(PR-143-81-EP-7-2)	Medium	1200-1900	BARC/OARI	2008
5	AFGAT(TGX-1892-10F)	Medium	750-1800	AwARC/SARI	2007
6	KORME(AGS-129-2)	Medium	1200-1900	BARC/OARI	2011
7	KATTA(PR-145-2)	Medium	1200-1900	BARC/OARI	2011
8	Wello(TGX-1895-33F)	Medium	520-1800	SARC/ARARI	2012
9	Belessa-95(PR-149)	Late	520-1800	AwARC//SARI	2003
10	Wegayen(TGX-1998-29F)	Late	520-1800	PARC/EIAR	2010
11	Gazale	NA	800-1700	AwARC and PARC	2015
12	Pawe 01 (PARC-2013-2)	NA	520-1800	PARC/EIAR	2015
13	Pawe 02 (PARC-2013-3)	NA	460-1600	PARC/EIAR	2015
14	Nyala	Medium	NA	AwARC and ARC	2014
15	Hawasa-04(AGS-7-1)	Medium	NA	AwARC	2012

Source: MOANR (2016), NA=Not available Where: MARC=Melkassa Agricultural Research Center, BARC= Bako Agricultural Research Center, OARI = Oromia Agricultural Research Institute, SRARC=Sirinka Agricultural Research Center and NA = Not Available.

3.3. Laboratory analysis

An initial soil sample at a depth of 0-30 cm was taken from randomly selected diagonally across the experimental field using Auger before sowing from each site and was composited and send for analysis of selected chemical and physical soil properties, i.e organic matter, total N, soil pH, available phosphorus, and exchangeable acidity. Total nitrogen: The total nitrogen in the soil was determined by using Kjeldahl (Jackson, 1973) method. Available phosphorus: Phosphorus content of was by Bray method (Bray, 1945). Cation exchange capacity (CEC) was extracted by saturating the sample with 1N NH₄OAc. Organic carbon: was determined using (Wakley and Black method., 1954). Soil organic matter content (%): It was estimated before planting using wet oxidation method. PH: Soil pH was determined by Jakson method by preparing 1:2.5 soil water suspensions and measuring by Digital Systronics pH meter (Jakson, 1973).

3.4. Experimental Design and Trial Management

The experiment was laid out using randomized complete block design (RCBD) with three replications and the plot size was six rows of 3.6 m length with 1.2 m width i.e. 1.2 m x 3.6 m = 4.8 m². A spacing of 60 cm x 5 cm was maintained between rows and plants respectively, while 1m and 0.5 m was maintained between blocks and plots, respectively.

Planting was done in accordance with the on-set of the rain in the area. A seed rate of 25Kg/ha was used. A uniform dose of 18 kg N ha⁻¹ was applied at planting to all plots as a starter. All crop management practices/activities was carried out as per the time schedule and existing conditions of the study area. The central four rows were harvested for grain yield and biomass yield from each plot leaving boarder rows to avoid boarder effects.

3. 5. Data Collection

3.5.1 Crop phenology

Days to 50% flowering: It was determined, as the number of days from sowing to the time when 50% of the plants had started flowering through visual observation.

Days to 90% physiological maturity: Days to maturity was determined as the number of days from sowing to the time when the plants had reached at 90% physiological maturity based on visual observation. It was identified by the senescence of leaves and yellowing of pods.

3.5.2 Growth parameters

Plant height: It was measured at 90% physiological maturity from the ground level to the tip of plant from randomly taken ten plants of harvestable rows.

Number of branches plant⁻¹: It was determined by counting the total number of branches from randomly taken ten plants from harvestable rows at physiological maturity.

3.5.3 Yield components

Number of pods plant⁻¹: It was recorded based on ten randomly pre-tagged plants in each net plot area and the average was taken as number of pods per plant at physiological maturity.

Number of seeds pod⁻¹: The total number of seeds in ten randomly taken pods from the net plot was counted and divided by total number of pods to find the number of seeds per pod.

Hundred-grain weight: The weight of 100 grains was taken from seed of each plot and weighed using a sensitive balance at designated moisture content of 10%.

Aboveground dry biomass: At physiological maturity, from the destructive rows the aboveground dry biomass of randomly ten plants were taken and measured after drying till a constant weight.

Grain yield: Grain yield was taken by harvesting and threshing the grain yield from net plot area and converted to kg ha⁻¹. The yield was adjusted to 10% moisture

Harvest index: Harvest index was calculated by dividing grain yield per net plot area by the total aboveground dry biomass yield per net plot area and was multiplied by 100.

3.6. Participatory Varietal Selection Procedures

Qualitative data on released varieties of soybean for different agro ecologies were collected using focus participatory tools (direct and pairwise matrix ranking) with farmers. Farmers' selection was done based primarily on their experience for growing soybean participation of true representative groups of old, young, men and women and their willingness to participate in the research. Thus a total of thirty farmers (M=21 and F=9) from the three study sites each represented by 10 farmers were used for farmer's selection criteria setting. Matrix ranking gave more detailed evaluations in to the merits and demerits related to the tested varieties. Matrix ranking was particularly useful in identifying the important traits of interest. Pairwise ranking was a useful tool whenever it is important to explore and discuss the criteria for decision making between and among alternatives.

3.7. Statistical Analysis

The data were analyzed using PROC ANOVA in SAS software version 9.3 with treatment and replications as the class variables and the response variables were the traits on which data were collected. Mean separation was carried out using least significant difference (LSD) at 5% probability level. Error variance of the individual location was tested for homogeneity; and the combined analysis of variance over the three locations was performed as per the formula given by Gomez and Gomez (1984).Microsoft Excel was used for the descriptive analysis, preference ranking.

4. RESULTS AND DISCUSSION

4.1. Soil Physico-chemical Properties of the Experimental Sites

Selected physico-chemical properties of the soil of the experimental site was analyzed for composite soil (0-30 cm depth) samples collected from experimental sites before. Based on the soil analysis made, the soil texture of the study area was clay (Table 1.1).

Table 1.1. Physico-chemical properties of the experimental soil before planting

Parameters	Study areas		
	Shebench	Menit Goldia	Chena
pH water	4.27	4.36	4.55
Av.phosphorus (mg/kg)	2.98	4.19	3.62
Total nitrogen (%)	0.28	0.39	0.32
Organic matter (%)	4.68	5.38	5.02
Exch. Acidity meq/100g	6.12	4.63	7.01
CEC meq/100g	29.67	35.43	32.03
Textural class	Clay	Clay	Clay

The analysis showed pH values was (4.27, 4.36 and 4.55) found in range of (very strongly acid) based on Jones, (2003) classification in Shebench, Menit Goldia and Chena districts respectively (Table 1.1). The analysis revealed that the range of available Phosphorus (Av. P) contents (2.98,4.19 and 3.62mg/kg) for Shebench, Menit Goldia and Chena districts respectively, this was in range of low based on Herrera (2005) (Table 1.1). The low concentration of Av. P in all district may be related to acidity of the soil which bring fixation of P. The result of the analysis showed that, TN and OM content (0.28, 0.39 and 0.32%) and (4.68, 5.38 and 5.02 %) in Shebench, Menit Goldia and Chena respectively which is in range of high to very high. The analysis also revealed CEC (29.67,35.43 and 32.03 meq/100g) for Shebench, Menit Goldia and Chena districts respectively which fall in the range of high.

4.2. Performance Evaluation of soybean Varieties for acidic soils

4.2.1. Crop phenology and Growth Parameters

The analysis of variance for the individual location was carried out first and significant differences ($P \leq 0.05$) among varieties were obtained for days to 90% of maturity, plant height (cm), primary branch, and pods per plant and grain yield at all locations (Table 3). Prior to the combined analysis of variance, homogeneity of error variances was tested and all of the traits showed homogeneous error variances (table 3). Having this confirmation, the data were pooled across locations and combined analysis of variance were performed and presented in Table 1. The mean squares obtained in combined analysis of variance were used to separate genotypic effects, location and their interactions.

The mean squares from the combined analysis of variance over the two locations showed statistically significant ($P \leq 0.05$) difference between locations for all the traits studied. The combined analysis of variance over the three locations revealed significant differences ($P \leq 0.05$) among varieties for most of the studied traits. The presence of significant differences among the tested varieties might be due to the existence dissimilarity in genetic composition among them, for that fact characters may be differ in their genetic properties.

Besides, environmental influences might be the possible causes of their significant differences or both. The highly significant differences observed among varieties for some of the studied characters revealed the presence of substantial variability among varieties. Similar results have been reported by Deresse and Gezahegn (2018), who observed significant variation among soybean varieties for most of the characters they measured at different location. Similarly, the existence of variability among soybean genotypes for different traits had been reported by Aditya *et al.* (2011), Akram *et al.* (2016), Guleria *et al.* (2019), and Yechalew Sileshi (2019). In addition, considerable differences and high genetic variability in soybean genotypes for different quantitative traits were also reported by Jain *et al.* (2018) and Shilpashree *et al.* (2021)

Table 3: Mean square of combined analysis for soybean variety and hogeneity test for yield and yield componets of soyabean varieties tested at Chena, Shey Bench and Menit Goldia in 2020/2021 cropping season.

Source of variation	DF	DM	PH	NBPP	NOP	SY
Replication	2	85.478	156.45	12.35	32.45	13452
Variety	14	366.271*	1156.35**	23.05**	126.48**	210193**
Location	2	778.23**	1925.35**	39.45**	45.56*	17852**
Location*variety	28	64.675 ^{ns}	108.23 ^{ns}	4.03 ^{ns}	19.75 ^{ns}	9275 ^{ns}
Error	88	58.45	66.24	2.52	11.45	5758
CV(%)		6.64	6.19	9.32	2.13	3.15
Mean Square of Error (MSE)						
Chena		75.25	64.28	2.59	27.49	5762
Shey Bench		56.45	42.09	1.95	14.23	4557
Menit Goldiya		63.59	54.35	2.16	19.15	5023
F max		1.33	1.52	1.29	1.93	1.26

Remark= **= significant at 0.01 probability level, * = significant 0.05 probability level, DF= Degree of freedom, DM= Days to maturity, PH= Plant height, NBPP= Primary branches per plant, PP= Pods per pant and SY=seed yield

Phenology and Growth parameters

Days to physiological maturity

The combined analysis of variance as shown in table 3 indicates the main effect of variety and location had highly significant on ($P < 0.001$) effects on days to physiological maturity, while their interactions had no significant effect on days to maturity. The late maturity date was recorded from genotypes Gazale (137.67), Wegayen(TGX-1998-29F) (137), Belessa-95(PR-149) (136.67) and Wello (TGX-1895-33F) (135.67) while the early were found from Nyala (108) and AFGAT(TGX-1892-10F) (110.67) (Table 4).The highly significant effect of variety on days to physiological maturity might be due to different maturity group of varieties with early maturing variety Nyala having earliest days to maturity. This result was in agreement with the report of Deresse and Gezahegn (2018) and Habit and Adugna (2018) who reported that, days to maturity were significantly affected by soybean varieties

The existence of wide variation among the tested genotypes for days to maturity provides an opportunity for the development of soybean varieties for different agro-ecologies. Consequently, early and late-maturing soybean varieties can be developed based on the agro ecological conditions which are mainly characterized by rainfall distribution. A similar

finding had been reported by Yechalew Sileshi (2019) on days to maturity among soybean genotypes. Liu *et al.* (2017) also evaluated a total of 512 world soybean varieties and found different maturity groups.

Plant height

In this study, combined analysis of variance as shown in table 3 indicates the main effects of varieties and location had highly significantly ($P < 0.001$) effects on plant height, while their interactions no significantly effects on plant height. The stud result on table 4 revealed that plant height exhibited high mean ranges from 51 to 119. The tallest plant height (110.67) was observed for variety Gazale followed by Afgat (TGX-1892-10F) (108.67) and Gizo (99) while the shortest (52.67cm) plant height was recorded from variety KATTA (PR-145-2) (Table 4). This variation ascribed to the differences in the growing environment climatic conditions and genetic make-up of the varieties. Hence, under breeding for longer plant height, it is noted that the listed genotype could be considered. In agreement with the present finding, Viotto *et al.* (2020) and Shilpashree *et al.* (2021) found variations in plant height among tested soybean genotypes. Similarly Kibiru (2018) and Simon *et al.* (2020) also reported significantly difference among soybean genotypes.

Number of Primary branches per plant

Primary branches was highly significantly ($P < 0.05$) affected by the main effects of variety and location. However, their interaction effect did not show significant effect. The highest and statistically similar mean number of branches 7.0 and 6.67 per plant were recorded from variety 'Nyala', and Pawe-2, respectively. The lowest number of primary branches per plant (3.0) was recorded from varieties Gishama (PR-143-(26) (table 4) . The difference in number of primary branches among the varieties could be most probably due to the existence dissimilarity in genetic composition among them, for that fact characters may be differ in their genetic properties to response formation of branch. This result was in conformity with the study by Deresse and Gezahegn (2018), who reported that the number of primary branch per plant was significantly differ among tested variety.

4.2.2. Yield and yield components

Number of Pod per plant

The combined analysis of variance as shown in table 3 indicates the main effects of varieties had high significantly ($P < 0.01$) effects while location had significantly ($P < 0.05$) effects and their interactions had no significantly effects on number of pods per plant. The highest mean number of pods per plant (64.67) was recorded for variety Pawe 01 (PARC-2013-2) followed by Pawe 01 (PARC-2013-2) (64.33) and Nyala (61.37) while the lowest number of pods per plant (51.667) was recorded for variety Wegayen(TGX-1998-29F) (Table 4). The difference on number of pods per plant might be due the fact that the number of pods per plant regulated by the genotypes of soybean. This result was in line with Simon *et al.* (2020) who reported that significant difference of pods per plant among soybean varieties.

From the result it was estimated that 625% of the tested genotypes had greater than the grand mean in the number of pods per plant. Consequently, this result verified the existence of genetic variability for these traits, suggesting the possibility of selection among soybean genotypes. Kumar *et al.* (2018) reported variations for the number of branches per plant, number of pods per plant, and number of seeds per pod in soybean genotypes. Kumar *et al.* (2014) and Kumar *et al.* (2014) also found similar results on the variation of such traits of soybean.

Seed yield

The combined analysis of variance of the current study showed the main effects of variety high significant ($P < 0.01$) effect and location had significantly ($P < 0.05$) effect while their interactions no significantly effects seed yield. The highest seed yield (2385kg ha⁻¹), (2155 kg ha⁻¹) and (2038.3kg ha⁻¹) were recorded for varieties Nyala, Pawe-2 and Pawe-1, respectively and the lowest seed yield (1446.7kg ha⁻¹) was recorded for variety Gishama(PR-143-(26)). These higher yielder varieties are relatively recent released varieties when it compared with the other tested varieties. Therefore, the possible reason for the observed the higher yielder varieties might be due to recent released variety gave higher yield than earlier released varieties. In addition, existence dissimilarity in genetic composition among them, for that fact characters may be differ in their genetic properties. Moreover, environmental influences might be the possible causes of their significant differences or both.

The variation of genotypes in producing seed yield indicates the existence of sufficient genetic variability in the tested genotypes and the potential of the genotypes for soybean yield improvement through direct selection. In accordant to the present study, significant variation was reported for seed yield by Kumar et al. (2014), Besufikad Enideg (2018), Deresse and Gezahegn (2018), Yechalew Sileshi (2019), and Diriba Beyene and Negash Geleta (2021).

Table 4: Combined analysis for yield components and mean yield Soybean variety for acidic soils

Variety	DM	PH(cm)	NBP	NPP	SY
Gizo(TGX-1885-33F)	133.00 ^{ab}	99.00 ^b	5.00 ^{bcd}	59.333 ^c	1716.0 ^{fg}
Gishama(PR-143-(26))	137.67 ^a	90.67 ^c	3.00 ^e	52.00 ^g	1446.7 ⁱ
BOSHE(IAC-13-1)	119.67 ^{bcd}	57.67 ^{ef}	5.333 ^{abcd}	58.333 ^{cd}	131.3 ^{fg}
Dhidhessa(PR-143-81-EP-7-2)	116.33 ^{cd}	82.00 ^d	6.00 ^{abc}	59.333 ^c	1923.3 ^d
AFGAT(TGX-1892-10F)	110.33 ^d	108.67 ^a	6.33 ^{ab}	59.333 ^c	1940.0 ^{cd}
KORME(AGS-129-2)	129.00 ^{abc}	82.33 ^d	5.67 ^{abcd}	54.333 ^f	1808.3 ^e
KATTA(PR-145-2)	129.00 ^{abc}	52.67 ^f	5.67 ^{abcd}	59.333 ^c	1700.0 ^f
Wello (TGX-1895-33F)	135.67 ^a	82.67 ^{cd}	4.33 ^{cde}	57.00 ^{ef}	1596.7 ^g
Belessa-95(PR-149)	136.67 ^a	99.67 ^b	4.33 ^{cde}	56.000 ^{ef}	1575.0 ^{gh}
Wegayen(TGX-1998-29F)	137.00 ^a	88.67 ^{cd}	4.00 ^{de}	51.667 ^g	1580.0 ^{gh}
Gazale	137.67 ^a	110.67 ^a	4.00 ^{de}	58.667 ^{cd}	1483.3 ^{hi}
Pawe 01 (PARC-2013-2)	114.00 ^d	61.67 ^e	6.67 ^{ab}	64.667 ^a	2155.0 ^b
Pawe 02 (PARC-2013-3)	112.67 ^d	58.33 ^{ef}	6.33 ^{ab}	64.333 ^a	2038.3 ^c
Nyala	108.00 ^d	58.00 ^{ef}	7.00 ^a	61.667 ^b	2385.0 ^a
Hawasa-04(AGS-7-1)	112.00 ^d	57.67 ^{ef}	6.33 ^{ab}	59.333 ^c	1930.0 ^d
Mean	124.58	79.356	5.33	58.22	1787.3
LSD	13.85	8.21	1.83	1.91	102.88
CV(%)	6.64	6.19	9.32	2.13	3.15

Remark= **= significant at 0.01 probability level, * = significant 0.05 probability level, DF= Degree of freedom, DM= Days to maturity, NBP= number of primary branch, NPP= Primary pod per plant, PH= plant height and SY=seed yield

4.3. Farmers’ Participatory Evaluation of improved soybean Varieties

4.3.1. Farmers’ Participatory Evaluation and Selection Criteria for the Tested Varieties

Participatory evaluation was done at vegetative and physiological maturity stage of soybean varieties with the total number of 7 male and 3 female farmers selected based on their soybean farming background information obtained from DA (Development Agent) for each districts. Prior to the evaluation, discussion was made with the farmers on the plant characters and selection procedure; and then two distinct groups comprising male and female were formed. Accordingly they cited many selection criteria at different stages in three locations: and were agreed on medium maturity, diseases resistance, seed yield, seed per pod, pod per plant, plant height and market demand and suggested these criteria as final selection criteria. Similarly, Mulatu and Zeleke (2002) and Mekonen (2011) stated that, in a refinement exercise using pairwise comparison the excessive criteria list was reduced to the trait, which the majority of the respective village farmers want a crop to have. Such targeted selection efforts have a much higher rate of success and of progress from selection than programs that have to consider multiple traits, for multiple systems as selection criteria.

Based on the result obtained from pair wise matrix farmers at Chena district seed yield had the highest score and ranked 1st and followed by disease resistance, while seed per pod and plant height were the least ranked according to pair wise ranking of the selected criteria (table 9). This is in line with the findings of Seltene *et al.*, (2016) and Hunde D, Tefera G (2018), who found the same selection criteria as the most important in soybean varieties.

Table 5 Pairwise ranking of farmers’ selection criteria at maturity stage at Chena (n = 10) ¥

No.	Selection criteria	SY	PH	DR	MM	SPP	PPP	Total	Rank
1.	SY	-						5	1
2.	PH	SY	-					0	6
3.	DR	SY	DR	-				4	2
4.	MM	SY	MM	DR	-			3	3
5.	SPP	SY	SPP	DR	MM	-		2	4
6.	PPP	SY	PPP	DR	MM	PPP	-	1	5

DR=Disease resistance, SY=seed yield, SPP=seed per pod, PPP=pod per plant, PH=plant height, MM=medium maturity

According to the direct matrix ranking, farmers in Chena identified Nyala variety as the best variety followed by Pawe 01 (PARC-2013-2) and Pawe 02 (PARC-2013-2). The least preferred varieties based on the direct matrix ranking were Gishama (PR-143-(26)), Gazale and Wegayen (TGX-1998-29F) (Table 10).

Farmers' overall evaluation of the soybean varieties based on both direct matrix and pairwise ranking identified the variety Nyala as the best followed by Pawe 01 (PARC-2013-2) and Pawe 02 (PARC-2013-2, while, Gishama (PR-143-(26)) as the least preferred.

Therefore, the result indicated that if seed of the selected variety is available, then farmers will be interesting to produce and benefited from it. In the present study, farmers in Chena District (Table 9), indicated that seed yield was one of the most important traits during soybean varietal selection; next they gave preference to pop per plant pod and disease resistant varieties, this is in agreement with the previous works reported by Mahasi et al. (2010). Therefore, development of high yielding soybean varieties which can resist rust disease and show good performance in yield will enhance farmers' preference to improve soybean varieties at Chena district, this result is in agreement with Seltene *et al.*, 2016, and Hunde D, Tefera G (2018), finding in soybean. The results of the PVS agreed with the ANOVA result in identifying the varieties which suit best for the farmers as well as the environment.

Table 6: Direct matrix ranking of Soybean varieties for the selected traits by farmers at Chena (n=10) Ω

Variety	Relative Weight	Ranking of Selection Criteria for each Variety						Total	Rank
		SY	DR	SPP	PPP	PH	MM		
		3	3	3	2	1	2		
Gizo(TGX-1885-33F)		2(6)	3(9)	2(6)	2(4)	4(4)	3(6)	35	9
Gishama(PR-143-(26))		1(3)	2(6)	1(3)	2(4)	3(3)	3(6)	25	15
BOSHE(IAC-13-1)		3(9)	2(6)	2(6)	2(4)	4(4)	3(6)	35	9
Dhidhessa(PR-143-81-EP-7-2)		3(9)	2(6)	3(9)	3(6)	4(4)	4(8)	42	6
AFGAT(TGX-1892-10F)		4(12)	3(9)	4(12)	4(8)	5(5)	5(10)	56	4
KORME(AGS-129-2)		3(9)	2(6)	2(6)	3(6)	3(3)	4(8)	38	7
KATTA(PR-145-2)		3(9)	2(6)	2(6)	2(4)	3(3)	4(8)	36	8
Wello (TGX-1895-33F)		2(6)	3(9)	1(3)	2(4)	3(3)	2(4)	29	12
Belessa-95(PR-149)		2(6)	2(6)	2(6)	2(4)	4(4)	2(4)	30	11
Wegayen(TGX-1998-29F)		2(6)	2(6)	1(3)	2(4)	2(2)	3(6)	27	13
Gazale		1(3)	2(6)	2(6)	2(4)	5(5)	1(2)	26	14
Pawe 01 (PARC-2013-2)		5(15)	4 (12)	4(12)	5(10)	3(3)	5(10)	60	2
Pawe 02 (PARC-2013-3)		5(15)	4 (12)	4(12)	4(8)	3(3)	5(10)	62	3
Nyala		5(15)	4 (12)	5(15)	5(10)	3(3)	5(10)	67	1
Hawasa-04(AGS-7-1)		4(12)	2(6)	3(9)	4(8)	3(3)	4(8)	46	5

- Ω number of participants =10 (male = 7, female = 3). -Rating of performance of a variety for a selection criteria: 5 = excellent, 4 = very good, 3 = good, 2 = poor and 1= very poor. Relative weight of a selection criteria: 3 = Very important, 2 = important and 1 = less important. -The numbers in the parenthesis indicates the product of relative weight of the selection criterion and the performance of a variety given by farmers. DR=Disease resistance, SY=seed yield, SPP=seed per pod, PPP=pod per plant, PH=plant height, MM=medium maturity

Similarly at Shay Bench district Participatory evaluation was done at vegetative and physiological maturity stage of soybean varieties with the total number of 7 male and 3 female farmers. Prior to the evaluation, discussion was made with the farmers on the plant characters and selection procedure; and then two distinct groups were organized. Key criteria used by farmers to evaluate and select the preferred varieties were seed yield, Drought resistance, market demand, seed per pod and Shattering. Based on farmers' pair wise ranking result seed yield, drought resistance and market demand were proposed as the three most important criteria in descending order as indicated in Table 7. Similarly Hunde D, Tefera G (2018), who found the same selection criteria as the most important in soybean varieties. Buah *et al.* (2018) in participatory evaluation of drought tolerant varieties and Yetsedaw (2019) on participatory evaluation of malt barley reported similar selection criteria by farmers. In addition, Alebachew (2012) found also the same selection criteria while farmers' evaluated wheat

Table 7: Pairwise ranking of farmers' selection criteria at maturity stage at Shey Bench (n = 10) ¥

No.	Selection criteria	SY	DR	MD	SPP	SH	Total	Rank
1.	GY	-					4	1
2.	DR	SY	-				3	2
3.	MD	SY	DR	-			0	3
4.	SPP	SY	DR	SPP	-		2	4
5.	SH	SY	DR	SH	SPP	-	1	5

DR=Drought resistance, SY=seed yield, SPP=seed per pod, MD=market demand, SH =Shattering,

In direct matrix, the total score ranged from 53 to 21. The highest score given to the best variety Pawe 02 (PARC-2013-3) (53) followed by Pawe 01 (PARC-2013-3) (48), Nyala (47) and Hawasa-04(AGS-7-1) (41). Out of the 15 varieties tested Gazale, Wegayen(TGX-1998-29F), and Gishama(PR-143-(26)) were the least preferred with a total score of 21,23 and 24 respectively (table 12). Generally farmers' responded positively to the new varieties they have evaluated. Farmers' evaluation result indicated that there was alignment with researchers' criteria particularly for grain yield and agronomic aspects.

Table 8: Direct matrix ranking of Soybean varieties for the selected traits by farmers at Shey Bench (n=10) Ω

Variety	Relative Weight	Ranking of Selection Criteria for each Variety					Total	Rank
		SY	DR	SPP	MD	SH		
Gizo(TGX-1885-33F)		2(6)	4(12)	2(6)	2(2)	3(6)	32	10
Gishama(PR-143-(26))		2(6)	2(6)	2(6)	2(2)	2(4)	24	13
BOSHE(IAC-13-1)		3(9)	3(9)	2(6)	2(2)	4(8)	34	9
Dhidhessa(PR-143-81-EP-7-2)		3(9)	2(6)	3(9)	3(6)	4(8)	38	6
AFGAT(TGX-1892-10F)		4(12)	3(9)	4(12)	3(3)	2(4)	40	5
KORME(AGS-129-2)		3(9)	3(9)	2(6)	3(3)	3(9)	36	8
KATTA(PR-145-2)		3(9)	3(9)	2(6)	4(4)	3(9)	37	7
Wello (TGX-1895-33F)		2(6)	3(9)	1(3)	2(2)	3(6)	26	11
Belessa-95(PR-149)		2(6)	3(9)	1(3)	2(2)	2(4)	24	12
Wegayen(TGX-1998-29F)		2(6)	2(6)	1(3)	4(4)	2(4)	23	14
Gazale		1(3)	2(6)	2(6)	2(2)	2(4)	21	15
Pawe 01 (PARC-2013-2)		5(15)	4 (12)	4(12)	3(3)	3(6)	48	2
Pawe 02 (PARC-2013-3)		5(15)	4 (12)	5(15)	3(3)	4(8)	53	1
Nyala		5(15)	3 (9)	4(12)	5(5)	3(6)	47	3
Hawasa-04(AGS-7-1)		4(12)	3(9)	4(12)	4(4)	2(4)	41	4

- Ω number of participants =10 (male = 7, female = 3). -Rating of performance of a variety for a selection criteria: 5 = excellent, 4 = very good, 3 = good, 2 = poor and 1= very poor. Relative weight of a selection criteria: 3 = Very important, 2 = important and 1 = less important. -The numbers in the parenthesis indicates the product of relative weight of the selection criterion and the performance of a variety given by farmers. DR=Drought resistance, SY=seed yield, SPP=seed per pod, MD=market demand, SH =Shattering,

At Menit Goldia district Participatory evaluation was done at vegetative and physiological maturity stage of soybean varieties with the total number of 7 male and 3 female farmers. Prior to the evaluation, discussion was made with the farmers on the plant characters and selection procedure; and then two distinct groups were organized. Key criteria used by farmers to evaluate and select the preferred varieties were seed yield, uniformity, seed size, pod per plant and earliness. Based on farmers' pair wise ranking result indicated in table 13 they gave the highest weight to seed yield followed by earliness and seed size. Moreover, pod per plant and uniformity were also selected by farmers' as moderate significance. Similarly, Mekonnen (2019) reported farmers' had identified seed yield, pod per plant and seed color as important criteria in PVS done on common bean varieties. In addition, Seltene *et al.*, 2016, also reported seed yield, pod per plant, seed size and uniformity as a selection criteria in PVS work on soybean.

Table 9: Pairwise ranking of farmers' selection criteria at maturity stage at Menit Goldia (n = 10) \forall

No.	Selection criteria	SY	UN	PPP	SS	ER	Total	Rank
1.	SY	-					4	1
2.	UN	SY	-				1	4
3.	PPP	SY	UN	-			0	5
4.	SS	SY	SS	SS	-		2	3
5.	ER	SY	ER	ER	ER	-	3	2

SY=seed yield, UN=uniformity, PPP=pod per plant, SS=seed size and ER=earliness \forall = Number of participants = 10 (male = 7, female = 3)

As per the direct matrix rankings, the total score (the product of relative weight of each criterion by the relative importance) ranged from 61 to 23. The highest score given to the best variety Nyala (61), followed by Pawe 02 (PARC-2013-3) (58) and Pawe 01 (PARC-2013-3) (56), and Hawasa-04(AGS-7-1) (41). Out of the 15 varieties tested Gishama (PR-143-(26)), Gazale, , and Wegayen (TGX-1998-29F) were the least preferred with a total score of 23,24 and 26 respectively (table 14).

Table 10: Direct matrix ranking of Soybean varieties for the selected traits by farmers at Menit Goldia ($n=10$) Ω

Variety	Relative Weight	Ranking of Selection Criteria for each Variety					Total	Rank
		SY	ER	SS	PPP	UN		
		3	3	3	2	2		
Gizo(TGX-1885-33F)		2(6)	4(12)	2(6)	2(4)	3(6)	34	10
Gishama(PR-143-(26))		2(6)	2(6)	1(3)	1(2)	3(6)	23	15
BOSHE(IAC-13-1)		3(9)	4(12)	3(9)	3(6)	3(6)	42	7
Dhidhessa(PR-143-81-EP-7-2)		4(12)	4(12)	3(9)	2(4)	3(6)	43	6
AFGAT(TGX-1892-10F)		5(15)	4(12)	3(9)	3(6)	3(6)	48	4
KORME(AGS-129-2)		2(6)	4(12)	2(6)	3(6)	3(6)	36	9
KATTA(PR-145-2)		3(9)	3(9)	2(6)	3(6)	3(9)	39	8
Wello (TGX-1895-33F)		2(6)	2(6)	2(6)	2(4)	3(6)	28	11
Belessa-95(PR-149)		2(6)	2(6)	2(6)	2(2)	2(8)	28	11
Wegayen(TGX-1998-29F)		2(6)	2(6)	2(6)	4(4)	2(4)	26	13
Gazale		2(6)	2(6)	2(6)	2(2)	2(4)	24	14
Pawe 01 (PARC-2013-2)		5(15)	4(12)	5(15)	4(8)	3(6)	56	3
Pawe 02 (PARC-2013-3)		5(15)	4(12)	5(15)	4(8)	4(8)	58	2
Nyala		5(15)	5(15)	5(15)	4(8)	4(8)	61	1
Hawasa-04(AGS-7-1)		4(12)	4(12)	3(9)	3(6)	4(8)	47	5

- Ω number of participants =10 (male = 7, female = 3). -Rating of performance of a variety for a selection criteria: 5 = excellent, 4 = very good, 3 = good, 2 = poor and 1= very poor. Relative weight of a selection criteria: 3 = Very important, 2 = important and 1 = less important. -The numbers in the parenthesis indicates the product of relative weight of the selection criterion and the performance of a variety given by farmers. SY=seed yield, UN=uniformity, PPP=pod per plant, SS=seed size and ER=earliness.

5. CONCLUSION AND RECOMMENDATION

Soybean [*Glycine max* (L.) Merrill] is renowned as the "Golden Bean" and "Miracle Crop" of the 21st century and plays significant role to fulfill the world's current and prospective protein and edible oil demands. Varieties suited for resourcepoor farmers existed amongst the released varieties, but farmers had no opportunity to try to produce them in their fields.

The field experiments were conducted at three locations in the southwestern part of Ethiopia at Chena, Menit Goldiya, and Shey Bench District during 2021 main cropping season and aimed to identifying farmers' preferences and selection criteria; high yielding, adaptable and acceptable varieties among the tested fifteen soybean varieties through farmers participation under acidic soils.

The combined results of this study the highest seed yield (2385kg ha⁻¹), (2155 kg ha⁻¹) and (2038.3kg ha⁻¹) were recorded for varieties Nyala, Pawe-2 and Pawe-1, respectively and the lowest seed yield (1446.7kg ha⁻¹) was recorded for variety Gishama. Therefore, it can be concluded that variety Nyala, Pawe-2 and Pawe-1 were well performed and can be recommended for the growers in the study area and similarly agro ecology.

In this study the pair wise matrix analysis and farmers' evaluation explained that farmers in Chena District gave priority to seed yield and disease resistance during Soybean varietal selection and identified Nyala variety as the best variety followed by Pawe 01 (PARC-2013-2) and Pawe 02 (PARC-2013-2). Farmers in Shay Bench mainly were focused on seed yield; drought resistance and market demand three most important criteria for selection and gave high score for variety Pawe 02 (PARC-2013-3) followed by Pawe 01 (PARC-2013-3), Nyala and Hawasa-04(AGS-7-1) pair wise matrix analysis. Similarly farmers at Menit Goldia gave the highest weight to seed yield followed by earliness and seed size and as per the direct matrix rankings The highest score were given Nyala, Pawe 02 (PARC-2013-3) and Pawe 01, and Hawasa-04(AGS-7-1) respectively. These imply that to enhance farmer's preference towards Soybean improvement program, the current breeding program needs to give attention to the aforementioned traits in the three districts.

In general the agronomic and farmers preference data analysis revealed that Nyala variety as the best variety followed by Pawe 01 (PARC-2013-2) and Pawe 02 (PARC-2013-2) has been selected as the best variety at all districts. As a result, this variety needs to be multiplied and disseminated to producers and farmers that are playing a great role in soybean seed system in the area and similar agro ecology.

Therefore, these varieties are recommended for production in the study areas and areas that have similar agro-ecologies to the study areas.

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