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Participatory Variety Selection of Field Pea (Pisum sativum L.) and Tools to Understand Farmer's Selection Criteria in Major Field Pea Producing Areas of South Eastern Arsi Zone of Ethiopia

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Abstract

Field pea is one of the grain food legumes contributing an enormous amount of protein to the human diet in Arsi zone. It is a long time ago that field pea crop improvement started in which more than 16 new varieties released those are selected primarily for yield potential, but there is a trait left considered as a very import by majority of farmers. The current study intended to identify traits that farmers consider most important when deciding which varieties to grow. The study was conducted at south eastern Arsi of Ethiopia, representing five major field pea producing location, in one growing season, using a participatory variety selection approach. A total of nine improved and one local check field pea varieties are used. Majority of farmers' were found around fourteen traits that can influence the selected varieties across all locations. There are also some traits those are more sensitive to gender difference. Among fourteen traits, nine were considered particularly important in one or all the location in a growing season. Unfortunately, there are preferred traits that are not given high priority by the current field pea breeding program in Ethiopian. This study indicated that there is no field pea variety possesses all desirable characteristics that meet the diverse farmers' selection criteria that adapted to varied location and a growing season. It is better if farmers' preference traits would be considered in breeding program for a country Ethiopia where the crop is consumed as a stable food.

Introduction

Field pea (*Pisum sativum* L.) is the one which is grown widely in many countries and currently lines among the four anterior pulse crops with cultivated areas of 7.8 million hectares. In Ethiopia, the crop is widely grown in mid to highland and ranks fourth per the area coverage attainment of 8,141,031 ha with an annual production of 3, 481, and 44.631 [1]. It is the major food legumes with valuable and cheap sources of protein having extended essential amino acid (21-26%) that have high nutritional values for resource poor households [2, 3]. The crop has important ecological and economic advantages in in the highland of Ethiopia, as it plays a significant role in soil fertility restoration and serves as a break crop suitable for rotation to minimize the negative impacts of cereals based on mono cropping [4-6]. It also used as sources of income for the farmers and foreign currency for the country [7, 8]. Having all these multiple benefits in the economic lives of the farming communities, however, the average yield of the crop is only 1.7t ha^{-1} in Ethiopia (CSA, 2019/20). Still, it fluctuates and beneath the potential as compared to the World production of 2t per hectare (FAOSTAT, 2017). Poor participation of farmers in the selection process is the main problems behind in sufficiency of improved varieties with wider adoption rate, agronomic practice, diseases, and insect pests. In other hand to meet the needs of smallholder farmers some improved field pea varieties has been released by the different regional and federal research centers as a country level since 1979 ((Ministry of Agriculture [9].

Those varieties were selected based on four major criteria – high yield potential, good ascochyta blight resistance, good powdery mildew resistance, and wide adaptation – and targeted the main rainy season (known as Meher), where ascochyta blight, powdery mildew is the primary production constraint. With respective of this, several factors may account for the limited adoption of new varieties. First, breeders' selection criteria may not match the needs and preferences of growers. Small farmers consider multiple traits to satisfy their diverse needs [10]. noted that farmers' selection traits are multivariate in nature. At present the major variety selection criteria of breeders in Ethiopia are limited to specific traits near different agro-ecological zones. For a crop like field pea, endogenous subjective traits were also helping to determine the acceptance of a variety. These traits can be a challenge for breeders to meaningfully assess unless there is a close collaboration with farmers and social scientists [11, 12]. The variation in altitude, temperature, rainfall, soil type and ecological settings leads to the need of a wide range of varieties which may not be provided by the current breeding

program [13]. There is a case in which variability of farmer's preference and limited success of breeding programs resulted due to environmental variation [14] and season [15]. In Ethiopia crop improvement has been targeting the Meher season, when rainfall is abundant that is the reason for missing some farmers preference traits like drought resistance and others. Similarly [16] noted that breeders often don't prioritize traits important for marginal environments. In addition limited seed supply and dissemination system were also pointers poor adoption of the new varieties. Understanding farmers' preferences across different agro-ecologies and growing seasons is an important first step for breeding programs who seek to develop acceptable varieties by farmers [14].

Preferably the breeding program should work directly with farmers (both genders) in variety selection, jointly evaluating new varieties along with farmers existing local varieties [14], by involving both gender groups in a participatory approach, reported that in cropping systems, breeders identified important selection criteria in marginal environments, some of which differed by gender. Capturing the concerns of both men and women is especially important in Ethiopia since field pea production and value chain involves gender specific roles. It makes easy for breeders to understand the variability in farmers' variety preferences from location to location [14]. So Participatory Variety Selection (PVS) is the basic approach for breeding that brings breeders, social scientists, farmers, and extension personnel together in a field setting to prioritize and target traits of importance. It also helps to identify and assess traits that are important to small scale farmers especially successful in assessing "subjective traits" such as taste, aroma, color, seed size, market demand and other culinary qualities, which are difficult to measure quantitatively [12]. Therefore, this study targeted to identifying traits that farmers consider most important when selecting field pea varieties. The study focused on five location and different growing seasons (main season and off season) in south eastern Arsi zone of Ethiopia, where the crop is widely grown. The study also compares farmers' and breeders' priorities in field pea variety selection.

Materials and Methods

Description of the study areas

This trails were evaluated in 2016/2017 at four Woredas; Hexosa (Oda jila FTC), Digalu Tijo (Haro bilalo FTC), Munessa(Caffa FTC),Cholle (Akiya FTC) and Cholle (Amuma selam bar FTC) in which all locations are found in Arsi, south eastern Ethiopia. All locations were representing highland areas with variable soil type based on soil color chart/indicator i.e. dark clay-loam, clay-loam, Loam, Clay loam and clay loam, respectively. The trial was laid down in a single plot of 5m x 5m size. Each variety was planted in rows with spacing of 0.2m between rows and 1.5m between plots. DAP (P_2O_5- 46% and N-18%) fertilizer was applied at the recommended rate of 100 kg/ha at sowing. Seed rate of 100 kg/ha was used (Table 1).

Nine released field pea varieties comprising *Bursa, Letu, Bilalo, Adi, Burkitu, Gume, Markos* Megery, Tegegnech and one farmer cultivar (local check) was used for the study to seek farmer's preferences through participatory variety selection. Both quantitative and qualitative data were collected through observation, group discussion on field day and data recording sheet by researchers groups and farmers separately. Data like farmer preference on disease and pest's resistance, early maturity, drought tolerant, grain color, and yield data were collected through the prepared data collection sheet/record sheet by organizing mini field day and observation on farmer's field.

Invited participants were gathered at the host farmers' field to assess the field pea varieties at flowering stage, at maturity and at harvest, assisted by scientists, assistants from Kulumsa Research Center and agricultural experts from each Woredas. Out of the 117 participants at districts 31 were women (24.4%). At each stage of evaluation, farmers were asked to level the best and worst varieties, giving reasons in each case. Traits that were mentioned as the reason why farmers liked, or disliked varieties were recorded. Then, traits were organized into lists and farmers asked to rank these traits on a scale of 1 ("less important") to 3 ("very important"). As a special criterion like test evaluation at fresh seed level which they seem directly proportional to the tests of Stew or locally 'Wot' after cooking were also seen. The associations of traits and varieties were computed based on farmers' ratings and agronomic data collected from the field experiment. Traits identified as important by PVS were compared to current targets of the national field pea variety selection program (Table 4). Target traits of the national field pea variety selection program were obtained from the Ethiopian Institutes of agricultural research crop directorate. Finally participant farmers were also asked to give an overall score to each variety.

Data Analysis

Descriptive statistics and frequencies were calculated to identify the highest-ranking traits. SAS-software was used for rank test for each location and gender group.

Results and Discussion

Farmers' Field pea variety selection criteria

Records for fifteen traits those are important across five locations, one growing season and two gender groups were detailed in (Table 2). Seven of these traits are agronomic, five reflect biotic and abiotic stress tolerance, and three are related to utilization and marketability. Farmers are clearly considering many traits when choosing which field pea variety

Table 1: Lists of faba bean varieties.

Variety	Year of release (G.C)	Days to maturity	Seed size(gm)	Character	Altitude	Adaptation eminence
Bursa	2015	134-157	189	Shiro-type	1900-3000	Nationally released
Letu	2010	130-165	178	Shiro-type	1800-3000	Nationally released
Bilalo	2012	118-170	224	Kick-type	1900-3000	Nationally released
Adi	1995	120-150	209	Kick-type	2300-3000	Nationally released
Burkitu	2009	110-160	208	Kick-type	1800-3000	Nationally released
Gume	2006	100-149	201	Kick-type	1800-3000	Nationally released
Tegegnech	1994	120-150	215	Shiro-type	2000-3000	Nationally released
Megery	2006	95-150	136	Shiro-type	2300-3000	Nationally released
Markos	1995	120-130	188	Kick-type	1800-3000	Nationally released
Local check	-	-	129	Shiro-type	1800-3000	Locally available

to grow. This is consistent with several other studies, in other crops (maize, Potato and sorghum), which stressed that small farmers consider multiple traits for variety selection [17-19]. It is also reliable with the reflection that most field pea producer farmers in Ethiopia grow more than one variety as one variety rarely meets all needs.

The relative importance of the farmers' (each gender group) variety selection traits

All considered relative importance traits are rated in each agro-ecology by using a 1 to 3 scale (1 = less important, 2 = somewhat important, 3 = especially important). Accordingly, the mean rate values revealed as, more than 60% of the farmers across all location preferences considered nine traits as a ''especially important'' (Table 2). Two of the nine were biotic and abiotic tolerance traits-Powdery mildew and drought tolerance. Four of the nine were agronomic traits- yield, pod per plant, seed per pod and early maturity date. All traits related to utilization is an incredibly special behind the farmers'– suitability for boiling, stew, and market demand - were considered "very important" by farmers in all locations. So it is exceedingly difficult to do adoption for new field pea varieties that lack any of these traits.

For the remaining traits there is a possibility that was either considered especially important by only a few farmers or was related to other traits of importance in each location. Low fertility adoption from biotic and abiotic tolerance is considered ''especially important'' behind a specific farmer at some location because of less capacity to afford chemical fertilizers cost. Aphid was also considered as a "very important" for farmers at some location especially those have low moisture that favors the occurrence of aphids. Among agronomic traits early flowering (and correlated early maturity) were important traits for breeders seeking to develop new varieties for off season production, majority of the farmers did not consider the traits "very important" because they can adjust the varieties, they grow each year depending on when the rain starts [20]. When there is early rainfall in the growing season, they plant late maturing varieties and vice versa. Plant height for high biomass content that could be used as an animal feed was considered as a "very important" behind individual farmers for some location.

How location influences field pea variety selection

From this study farmers' variety choices for at least some traits are revealed variation among agro-ecological and cropping season difference (Table 2). Drought tolerance, adaptation to low soil fertility, and Ascochyta blight and aphids were among the abiotic and biotic stress tolerance traits those are varied in values of rating rank between agro ecological zones. From (Table 2) above, location represented by FTC-3 and FTC-4 (sub-moist agro ecology) showed as drought is more severe than the rest location those are mostly moist agro ecology. At locations (FTC-2, FTC-3 and FTC-5) low fertility adaptation is considered more important.

The importance of agronomic traits was also showed a little bit variation between agro ecologies (Table 2). But majority of the traits importance are similar rate value rank across location that might be resulted due to the communal interests of farmers on the considered traits importance. For such situation, breeders can easily meet the interests of all farmers living in different agro ecologies at once through improving the considered ''especially important traits". There is no difference among the relative importance of utilization traits; - suitability for boiling, suitability for stews and market demand due to agro ecologies (Table 2).

Table 2: Average ranks of field pea variety based on trait importance by location/district and gender.

	FTC-1			FTC-2			FTC-3			FTC-4			FTC-5			Location Mean		
Biotic and abiotic tolerance																		
Traits	Male	Female	**Rank**	Male	Female	**Rank**	Male	Female	**Rank**	Male	Female	**Rank**	Male	Female	**Rank**	Male	Female	**Rank**
DT	2.6	2.2	**3**	2.3	2.4	**4**	2.5	2.5	**2**	2.5	2.6	**2**	2.3	2.2	**4**	2.44	2.38	**2**
LFA	2.3	2	**5**	2.5	2.3	**3**	2.4	2.5	**3**	2.0	2.2	**4**	2.6	2.5	**2**	2.36	2.3	**3**
AB	2.9	2.6	**1**	2.1	2	**5**	2.1	2.2	**4**	2.4	2.3	**3**	2.4	2.2	**3**	2.38	2.26	**4**
PW	3	2.5	**2**	2.7	2.6	**1**	2.6	2.4	**1**	2.9	2.5	**1**	2.8	2.7	**1**	2.8	2.54	**1**
A	2.4	2.4	**4**	2.8	2.5	**2**	2.1	1.7	**5**	1.6	1.4	**5**	1.9	2.1	**5**	2.16	2.02	**5**
Agronomic Traits																		
EFD	2.6	2.4	**6**	2.5	2.4	**7**	2.6	2.7	**5**	2.7	2.3	**5**	2.3	2.6	**7**	2.54	2.48	**6**
EMD	2.9	2.8	**5**	2.6	2.5	**5**	2.6	2.6	**6**	2.7	2.5	**4**	2.7	2.2	**6**	2.7	2.52	**5**
PH	2.3	2.1	**7**	2.5	2.0	**6**	2.8	2.1	**7**	2.3	2.2	**7**	2.7	2.8	**5**	2.51	2.24	**7**
SPP	3	2.9	**3**	2.8	3	**3**	3	3	**2**	3	3	**3**	3	3	**3**	2.96	2.98	**3**
PPPL	3	3	**2**	3	3	**2**	3	3	**1**	3	2.9	**1**	3	3	**2**	3	2.99	**2**
SS	2.8	2.9	**4**	2.7	2.6	**4**	3	2.5	**4**	2.5	2.6	**6**	3	2.7	**4**	2.8	2.66	**4**
YLD	3	3	**1**	3	3	**1**	3	3	**3**	3	3	**2**	3	3	**1**	3	3	**1**
Utilization																		
SFB	2.1	2.9	**3**	2.3	2.8	**3**	2.2	2.7	**3**	2.3	2.9	**3**	2.5	2.8	**3**	2.28	2.82	**3**
SFS	2.8	3	**1**	3	3	**1**	2.7	2.8	**2**	2.7	2.9	**1**	2.5	2.9	**1**	2.74	2.92	**1**
MD	2.6	2.8	**2**	2.7	3	**2**	2.5	3	**1**	2.9	2.8	**2**	2.4	2.9	**2**	2.62	2.9	**2**

FTC-1, 2,3,4,5 is representing Oda jila, Haro bilalo, Chafa, Akiya and Amuma salam bar kebeles. Ratings are on a scale of 1 to 3, where 1 is less important and 3 is especially important which also indicated the ranks of the traits. Traits: DT; drought tolerance, LFA; low fertility adoption, AB;ascochyta blight,PW; powdery mildew, A; aphid, EFD; early flowering date, EMD; early maturity date, PH; plant hight, SPP; seed per pod, PPPL; pod per plant, SS; seed size, YLD; yield, SFB; suitability for boiling, SFS; suitability for stew and MD; market demand.

This confirms that all farmers of each location have a common utilization system of field pea crops i.e. suitability for stew (stable food) makes more sounded crop in Ethiopia.

How gender influences field pea variety selection

Farmers were segregated into gender groups during the process of the PVS experiment to identify important traits at different field pea growth stages. For the biotic and abiotic tolerance traits male group were more concerned than female group in each location and on each trait as shown in rated scale values in table 2. For all agronomic traits, both gender groups showed almost comparable rating scale values that might be resulted due the common national interests of all farmers on the considered traits. Irrespective of this, female groups were more concerned on rate scale values for the utilization traits- suitability for boiling, suitability for stew and market demand than the men group in table 2. In overall this study revealed, the crop improvement like field pea needs gender inclusiveness for releasing the field pea variety that is nationally accepted with important traits.

How field pea varieties are preferred by farmers

During this PVS experiment, twelve characteristics of the varieties were evaluated below (Tables 3). Mainly it is impossible to find one variety that fulfills all the characteristics farmers want [17]; [21] since the accessibility of varieties with different suites of traits allows farmers to satisfy their multiple needs is very scarce. All crops including field pea in Ethiopia is subject to many types of production risks. For these challenges, growing a diverse set of varieties can reduce the risk of crop failure [22, 23] which is more adopted in some areas of Ethiopia like Arsi zone where farmers grow more than one variety of field peas. Twelve important traits were considered to evaluate field pea varieties below (Table 3). Of these varieties, all the improved field pea varieties have mainly negatively associated to the traits like low fertility adoption, early maturity and ascochyta blight except the one which is used as local check have highly and positively associated to those traits at all locations.

In other side the entire improved field pea varieties have highly and positively associated for the traits pod per plant, seed per pod and seed size, than the local one which has negatively associated to the traits (Table 3). Four of the nine improved varieties are equally accepted behind farmers for agronomic traits- pod per plant, seed per pod and seed size which has direct impact on production increment for food security system. 'Local check' and 'Bursa', a new variety, showed good performance for four and seven of 12 traits, respectively, in all agro ecologies. Comparably all improved varieties have an intermediate to incredibly important behind the farmers for all agronomic traits and utilization traits in all locations. Despite of these field pea varieties especially shiro type (Bursa, Tegegnech, Latu and the local one has highly and positively associated for farmers for all utilization traits-soak ability, suitability to stew and market demand in all locations. Since it has good taste when boiled, is suitable for stew, and the market acceptance of this variety by traders is higher than the kick type varieties. Moreover, 'local checks' is an early maturing and low fertility adoption variety at all locations and is better adapted to off season production than the other varieties.

This study revealed the trait importance variation among participatory variety selection (PVS) and current breeding targets of the national field pea program. Twelve traits were especially important for field pea variety selection by farmers in the PVS at all locations per in at least one growing season. Nine traits were considered by national field pea breeding program (Table 4) in main growing season only. Two traits were revealed less important by participatory variety selection farmers, but no traits were considered as less important rather two traits considered as not important in current breeding program in a main season. In other side there is entire traits those are considered as somewhat important by participatory variety selection farmers and current breeding program in both cropping seasons. Moreover there is a trait those are considered as not important especially by current breeding program in main season (seed color and seed shape) off season (acidity tolerance, low fertility adoption, seed color, seed shape, soak ability, suitability for stew and market demand) in which the traits are considered at least somewhat important to especially important traits behind the farmers at least in one season in all locations.

One of the especially important traits, "wide adaptation" was not mentioned as important by farmers in the PVS experiment. Further, the difference in the number of traits deemed important by PVS and the national program was partly due to a difference in target seasons. Our PVS experiment asked about both seasons while the current breeding program targets Meher season only with a specific trait those are not fulfills the

Table 3: Association of local and new cultivars with the 12 important variety traits studied under PVS.

Varieties	Low fertility adoption	Ascochyta blight	Powdery mildew	Early Maturity	Pod per plant	Seed per pod	Seed size	Seed color	Seed Shape	Soak ability	Suitability for stew	Market Demand
Bursa	*	*	*	-	-	+	+	+	+	+	+	+
Letu	*	*	*	*	+	+	-	+	-	-	+	+
Bilalo	*	*	-	*	+	+	+	-	-	-	-	-
Adi	*	*	-	*	+	+	+	-	-	-	-	-
Burkitu	*	*	*	*	+	+	+	-	-	-	-	-
Gume	*	*	-	*	+	+	+	-	-	-	-	-
Tegegnech	*	*	*	-	-	-	-	+	+	-	+	+
Megery	*	*	*	*	-	-	-	-	-	-	*	-
Markos	*	*	*	*	+	+	-	-	-	-	-	-
Local check	+	-	+	+	*	*	*	+	+	+	+	+

"+" = the variety and the trait are highly and positively associated; ""= the variety and the trait are negatively associated and "-"the variety and the trait have intermediate preference. This is compiled from farmers' ratings and the agronomic data during the PVS experiment.*

Table 4: Traits of importance revealed by Participatory Variety Selection (PVS) compared to current traits of emphasis in the national field pea breeding program.

Traits	Participatory variety selection		Current breeding program	
Cropping season	Main season	Off season	Main season	Off season
Biotic and Abiotic tolerance				
Acidity Tolerance	+		++	Not
Low fertility adoption	++		++	Not
Ascokayta blight	+++		+++	++
Powdery mildew	+++		+++	++
Agronomic Traits				
Early Maturity	+++	Depends on rain fall distribution	+++	+++
Pod per plant	+++		+++	+++
Seed per pod	+++		+++	+++
Seed size	++		+++	++
Seed color	++		Not	Not
Seed shape	+		Not	Not
Yield	+++		+++	+++
Utilization				
Soak ability	+++		++	Not
Suitability for stew	+++		+++	Not
Market demand	+++		+++	Not

Not = Not important; "+" = least important; "++"= somewhat important; "+++"= very important trait.

farmers interest. Nevertheless, even for main season, PVS identified many traits those especially important traits that are common to the all agro-ecological zones but are not currently high priority traits for the current breeding program. Some of the new varieties fall apart when cooked and are not suitable for stew especially the kick type not as good as the shiro one by the farmers. In fact there is a report that some quality traits can be a challenge for breeders to meaningfully assess unless they collaborate closely with farmers [13]. In overall this PVS experiment was structured to identify traits of importance in different location/agro ecologies. So the relative importance of diverse traits in different localities was resulted by the causes of PVS. In conclusion, national field pea breeding program does not seek to develop varieties for specific agro-ecologies, but instead works to develop field pea that are widely adapted.

Conclusion

This study exposed the diverse farmers' variety selection criterion that helps them to fulfill their multiple needs. They are more focuses on biotic and abiotic tolerance traits, agronomic traits and in utilization aspects especially the highly value traits like food value, long term storability, resistance to biotic stresses such as powdery mildew, ascochyta blight, Aphid. Based on this study result, location/agro ecology, cropping seasons, and genders have a lion share on farmers' selection criteria variation. In further, the traits that are considered by farmers at one location may not be similarly getting consideration at other location and cropping season. There is also the variety selection criteria difference for a few but not most traits among the gender group. So Using of the PVS approach with a diverse set of varieties helped us to capture as many farmer traits as possible because of no single variety can meet all farmers' needs. This research also concludes that the existence of unique and important traits in local check varieties that is not present in newer varieties, and these traits have not yet received attention by the national field pea breeding program. Further, the varying needs resulting from differences between location, cropping seasons and gender should also be considered during variety selection. Similar research could also be undertaken in Arsi zones to better add values on the guidance of national field pea breeding program [24-26].

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