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Adaptation and Performance on Yield and Yield Components of Field Pea (Pisum sativum L.) Varieties at Adiyo District, Southwestern Ethiopia

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Abstract
Field pea (*Pisum sativum* L.) is one of the most important high land pulse mainly used for human consumption in Ethiopia. It is considered as the least expensive source of protein and income for the poor farmers. Its production is constrained by low yielding potential of farmers' varieties that are widely grown in the region. The Ethiopian research system has so far developed over 15 improved varieties. However, the available varieties have not been exposed to farmers and, therefore, there is no information which of the released varieties best fits the existing cropping system in field production niches of the region. Therefore, a field experiment was conducted at Alarigeta testing site of Adiyo distric in Kaffa zone for two years (2012 and 2013) main cropping season to identify and select best performing, high yielding field pea varieties for highland ecologies of Adiyo. Ten improved field pea varieties and one local check were tested by using RCB Design with three replications. The combined analysis of variance (ANOVA) showed significant ($p<0.05$) difference among varieties for all the parameters studied. The varieties Burkitu, Gume, Markos, Letu, URJI, Adi, Megeri and Weyyitu were found to be high yielding with their mean yield of 4169.0, 4052.2, 4019.0, 3918.5, 3765.4, 3756.4, 3629.0, and 3609.7 kg ha^{-1}, respectively. However, based on the objectively measured traits coupled with market related characters and farmers preferences, Burkitu, Gume and Markos were selected as best varieties and recommended for future use in the study area and similar agro ecologies.
Keywords: Grain yield; Adaptation; farmers' preference

1. INTRODUCTION

Field pea (*Pisum sativum* L.) is a cool-season legume crop which grown for different purposes in different parts of the world. It is one of the world's oldest crops, as it was first cultivated with cereals as barley and wheat, 9000 years ago (McPhee, 2003). It is native crop of Syria, Iraq, Iran, Turkey, Israel, Jordan, Ethiopia, and Lebanon. It is also one of the most important food legumes in the world not only for its very old history of domestication, but also for its multipurpose use as vegetables, pulses and forage (Choudhury *et al*., 2006).

Field pea is the most important high land pulse and which is mainly used for human consumption in Ethiopia. It contains high levels of amino acids, lysine and tryptophan, which are relatively low in cereals. It also contains approximately 21-25 % protein and rich in carbohydrates (CSA, 2012). It is widely grown in the highlands of Ethiopia. It performs well at an altitude of 1800 – 3000 meter above sea level. In addition, the crop also better adapted under low rainfall environments as compared to other pulses such as Faba bean, lentil, and chickpea (Mohammed *et al*., 2016). Field pea has moisture requirements similar to those of cereal grains. However, field peas have lower tolerance to saline and water-logged soil conditions than cereal grains. It requires 800-1100 and 700-900 mm rain fall in high and mid altitude areas, respectively for optimum growth and development. The crop is usually sown from mid to June up to the first week of July when there is sufficient moisture (Mohammed *et al*., 2016). The national average yield of field pea under farmers' management is 1.2 ton ha^{-1}(Tilahun *et al.,* 2013). However, it was reported to the maximum up to 4-6 ton ha^{-1} at research fields through using improved production technologies (Mohammed *et al.,* 2016).

It is the second most important pulse crop in area and production in Ethiopia (CSA, 2013). Moreover, it plays a significant role in soil fertility restoration as a suitable rotation crop that fixes atmospheric nitrogen. It is used as source of protein and income for the poor farmers. However, the production of field pea is constrained by low yielding potential of farmers' varieties that are widely grown in the region. In addition, it is also constrained by several factors among which disease, insect pests, frost, poor management practices are the majors (Telaye *et al*., 1994). As a result, the productivity has become low despite the fact that its total harvested area has increased tremendously. This can be attributed to the shortage of improved field pea varieties for different agro-ecologies. Currently, over fifteen improved field pea varieties have been released nationally to be grown under high altitude areas of the country. However, the available varieties have not been exposed to farmers and, therefore, there is no information which of the released varieties best fits the existing cropping system in field pea production niches of the region. Therefore, it is essential to evaluate with farmers the adaptability and yield performance of released field pea varieties to the agro-ecologies of Adiyo district, Kaffa zone, and identify farmers' preferred varieties for further production in the area. Keeping these in view, the experiment was conducted with the objective to identify best performing, high yielding field pea varieties for

highland ecologies of Kaffa zone.

2. MATERIALS AND METHODS

2.1. Description of Experimental Site

Field experiment was conducted at Alarigeta on station in Adiyo district of Kaffa zone, Southwestern parts of Ethiopia in Southern Nations Nationalities and People's Region (SNNPR). The specific experimental site is located 20 kilometers far from Bonga town, city of Kaffa zone. The site is located at 07^0 17' N latitude and 36^0 22' E longitude at an elevation of 2400 meter above sea level. The topography is characterized by slopping and rugged areas with very little plain land (BARC, 2013).

2.2. Experimental Materials

Ten improved field pea varieties (Burkitu, Tulu-dimtu, Letu, Tegegnech, Weyyitu, Megeri, Adi, Gume, Markos, and Urji) including the local check were tested for their adaptability and performance on yield and yield components for two years in 2012 and 2013 main cropping season. These improved varieties were released by Kulumsa and Sinana Agricultural Research Centers.

2.3. Experimental Design and Procedures

The experiment was carried out in a Randomized Complete Block Design (RCBD) with three replications. The experimental plot consisted of six rows with 20 cm x 4 m length (4.8 m^2) and four rows (3.2 m^2) were used as a net plot. The spacing between blocks (replications) was 1.5 m; whereas plots were spaced 1m apart from each other. The experimental field was prepared following the standard practices for field pea production before sowing. The field was ploughed, leveled, and rows were prepared 20 cm apart from each other. All other recommended agronomic practices were applied uniformly in all experimental plots.

2.4. Data Collected

Agronomic data were collected on plant and plot basis from the experiment. Mean values of these samples were utilized to estimate the performance of each treatment. The data of number of pods per plant, number of seeds per pod, and plant height were taken and evaluated on five plants from the middle four rows of each plot whereas, days to flowering, physiological maturity, hundred seed weight (gm) and the grain yield were recorded from harvestable plot or net plot area. The harvested plants in each plot were threshed dried and then weighed to determine yield and converted to kilogram per hectare before it was subjected to statistical analysis. Matrix ranking was used to compare farmers' preferences on the tested varieties. A total of 20 farmers were selected during evaluation. Accordingly, the selected farmers were invited to visit the experimental plot at maturity stage and asked for their insights on the field pea varieties under evaluation based on the specific evaluation criteria of grain yield, number of pods per plant, number of seeds per pod, seed size and seed color. A scale of 1-5 was used to compare their preferences as: 5 = very poor, 4 = poor, 3= average, 2= good and 1 = very good. Farmers were asked to place 1, 2, 3, 4 or 5 for variety ranking representing a given trait and variety according to the above scales.

2.5. Statistical Analysis

Statistical analysis of the agronomic data was completed by using Analysis of variance (ANOVA) statistical software SAS, 2002. The significant treatment effects were compared using Least Significant Difference (LSD) test at 5% probability level ($P \leq 0.05$) and Coefficient of Variance (CV %) was calculated to reveal the relative measure of variation that exists within the data.

3. RESULT AND DISCUSSION

The combined analysis was carried out for the parameters; grain yield, number of pods per plant, number of seeds per pod, thousand seed weight, days to flowering, days to maturity, and plant height for two years (2012 and 2013) at Adiyo (Table 1). Pooled analysis of variance over years showed significant difference ($p<0.05$) among the varieties for all the parameters studied. In addition, all the parameters except days to flowering showed significant differences ($p<0.05$) among years. However, number of seeds per pod revealed significant difference ($p<0.05$) among variety by year interaction. Most of the parameters in this study were showed inconsistence performance among varieties, years and their interactions. Thus, only number of seeds per pod showed significant difference ($p<0.05$) among varieties, years and their interactions.

Table 1: Mean square values of grain yield and other agronomic traits of field pea varieties for combined analysis of variance over years (2012 and 2013) at Adiyo

SOV	GYD	PPT	SPP	TSW	DTM	DTF	PHT
Variety	6005640.4*	484.4*	48.9**	23674.2**	2388.0*	0.6**	34350.5*
Year	692717.0**	175.5*	0.8**	2751.6**	24.6**	2.1NS	580.6**
Variety*Year	258722.2NS	55.0NS	0.5**	318.6NS	15.9NS	1.0NS	437.8NS
Error	256202.7	85.7	0.2	174.9	13.4	0.5	391.5

SOV = Source of variation; GYD = Grain yield; PPT = Number of pods per plant; SPP = Number of seeds per pod; TSW = Thousand seed weight; DTM = Days to maturity; DTF = Days to flowering and PHT = Plant height.

3.1.1. Days to Flowering:

Based on the result the longest days to flowering was recorded for Markos (74.7 days), Gume (74.5 days) and Letu (74.3 days) while the earliest varieties to mature were Megeri, Weyyitu Burkitu and Tulu-dimtu with respective days to flowering of 72.8, 73.0, 73.3, and 73.5. This difference might have come from genetic variation among the tested varieties. Kumar *et al*. (2013) also reported the presence of difference among genotypes

3.1.2. Days to Maturity:

The result showed that the longest days to maturity was recorded for varieties, Letu, Tegegnech, Markos, Burkitu and Local check, which took 139 (improved varieties) and 138 (Local check) days, respectively. URJI was the earliest to mature or took shorter days to maturity with 133 days. However, URJI was statistically similar with the remaining varieties in the location.

3.1.3. Plant Height:

The combined analysis indicated that variety Letu produced the highest plant height of 223.4 cm; over Megeri (189.0 cm). However, Megeri was not significantly different from all other varieties in the experiment except Adi and Markos. On the other hand, Letu was also significantly different in plant height from varieties Gume, Burkitu and the local check. The observed difference in height between the above varieties may be due to the inherent genetic difference among tested varieties.

3.1.4. Number of Pods Plant^{-1}:

Significant differences ($P<0.05$) were revealed among field pea varieties for number of pods per plant. The highest numbers of pods per plant were recorded for varieties Burkitu, Letu, Adi, Gume and Markos with respective number of pods 40.3, 38.3, 37.8, 37.4, and 36.4. However, the lowest number of pods per plant was recorded for Local check (25.5), Tegegnech (27.4), Tulu-dimtu (27.6), Megeri (28.1) and Weyyitu (29.4) (Table 2).

3.1.5. Number of Seeds Pod^{-1}:

The number of seeds per pod is one of the most important yield determining traits in crop (pulses) production. There was significant difference among varieties in producing number of seeds per pod. The highest number of seeds per pod was recorded for varieties; Letu, Markos, Burkitu, Gume, Adi, and Megeri; whereas the lowest was recorded for Weyyitu and Local Check. However, most of the improved varieties had showed better performance as compared to the local check in this study.

3.1.6. Thousand Grain Weight:

Variety Gume produced highest (227.8 gm) thousand grain weight among others (Table 2). However, the lowest 1000-grain weight (145.1gm) was recorded on Megeri. The difference in thousand seed weight among varieties ranged from 145.0 to 227.8 gm. Thus, the seed size of Gume was by far bigger than that of Megeri. The other three varieties; Burkitu, Wyyitu and Markos were produced the highest grain weight next to Gume. The observed differences in thousand grain weight among varieties might be due to inherent genetic differences among the varieties (Ceyhan and Ali Avci, 2015).

3.1.7. Grain Yield:

The highest grain yield was produced by varieties Burkitu, Gume, Markos, Letu, URJI, Adi, Megeri and Weyyitu with the grain yield of 4170, 4050, 4020, 3918.5, 3770, 3760, 3630, and 3610 kg ha^{-1}, respectively. However, Local check and Tegegnech were produced the lowest grain yield of 2950 and 3470 kg ha^{-1}, respectively. Most of the improved varieties were recorded statistically similar yields as compared to the local check in this study. The observed difference among improved varieties might have come from genetic variation. This is in agreement with the results of Mohammed *et al*. (2016) who reported the existence of genetic difference among varieties in producing grain yield. Chernet and Tazebachew (2015) who reported Burkitu and Gume as well adapted and high yielding varieties in their previous study.

Farmers' were also participated on variety selection processes. Their selection criteria were grain yield, number of pods per plant, number of seeds per pod, seed size and seed color. The evaluation of total value for each variety ranged from 7 to 23. The evaluations of varieties through ranking based on the insight of the farmers are presented in Table 3. It is clear that farmers have the potential to select well-adapted and preferred

varieties under their circumstances using their own selection criteria. Accordingly, they preferred and ranked Burkitu, Gume, Markos, Adi, URJI, Letu, Weyitu, Megeri, Tegegnech, Tulu-dimtu and the local check at the first to eleventh position. Likewise, McKay *et al.* (2003) also stated that the selection of appropriate field pea variety in a given environment should consider the variations that exist among varieties.

Table 2: Combined mean values of grain yield and yield components of field pea varieties

Varieties	Mean values						
	GYD (kg ha^{-1})	TPPL	SPP	TSW (gm)	PHT (cm)	DTF	DTM
Burkitu	4169.0^{a}	40.3^{a}	6.0^{ab}	206.4^{b}	197.3^{bc}	73.3^{def}	138.7^{a}
Tulu-dimtu	3559.0^{b}	27.6^{bcd}	5.8^{bc}	170.8^{de}	206.4^{abc}	73.5^{def}	136.3^{ab}
Letu	3918.5^{ab}	38.3^{ab}	6.3^{a}	182.6^{cde}	223.3^{a}	74.3^{abc}	139.3^{a}
Tegegnech	3466.6^{bc}	27.4^{cd}	5.7^{bc}	169.0^{e}	206.5^{abc}	73.8^{bcd}	139.0^{a}
Weyitu	3609.7^{ab}	29.4^{bcd}	5.0^{d}	194.2^{bc}	206.7^{abc}	73.0^{ef}	135.3^{ab}
Megeri	3629.0^{ab}	28.1^{bcd}	5.9^{ab}	145,0^{f}	189.0^{c}	72.8^{f}	136.7^{ab}
Adi	3756.4^{ab}	37.8^{abc}	5.9^{ab}	180.7^{cde}	212.7^{ab}	73.8^{bcd}	135.7^{ab}
Gume	4052.2^{ab}	37.4^{abc}	6.0^{ab}	227.8^{a}	196.3^{bc}	74.50^{ab}	135.3^{ab}
Markos	4019.0^{ab}	36.4^{abc}	6.1^{ab}	194.2^{bc}	216.2^{ab}	74.67^{a}	139.0^{a}
URJI	3765.4^{ab}	30.5^{abcd}	5.9^{b}	185.7^{cd}	210.5^{abc}	73.8^{bcd}	133.0^{b}
Local check	2945.5^{c}	25.5^{d}	5.4^{cd}	177.8^{de}	199.7^{bc}	73.67^{cde}	137.7^{a}
Means	3719	32.61	5.82	184.94	205.87	73.76	136.89
CV (%)	13.94	21.51	6.62	6.96	9.31	0.94	2.68
LSD(P≤ 0.05)	604.0	10.77	0.45	15.01	22.32	0.81	4.27

GYD = grain yield, TPPL= Total pods per plant, SPP = Number of seeds per pod, DTM = days to flowering, DTM = days to maturity, LSD = Least significant difference, CV = coefficient of variation. Means followed by the same letter are not significantly different at 5% level of significance.

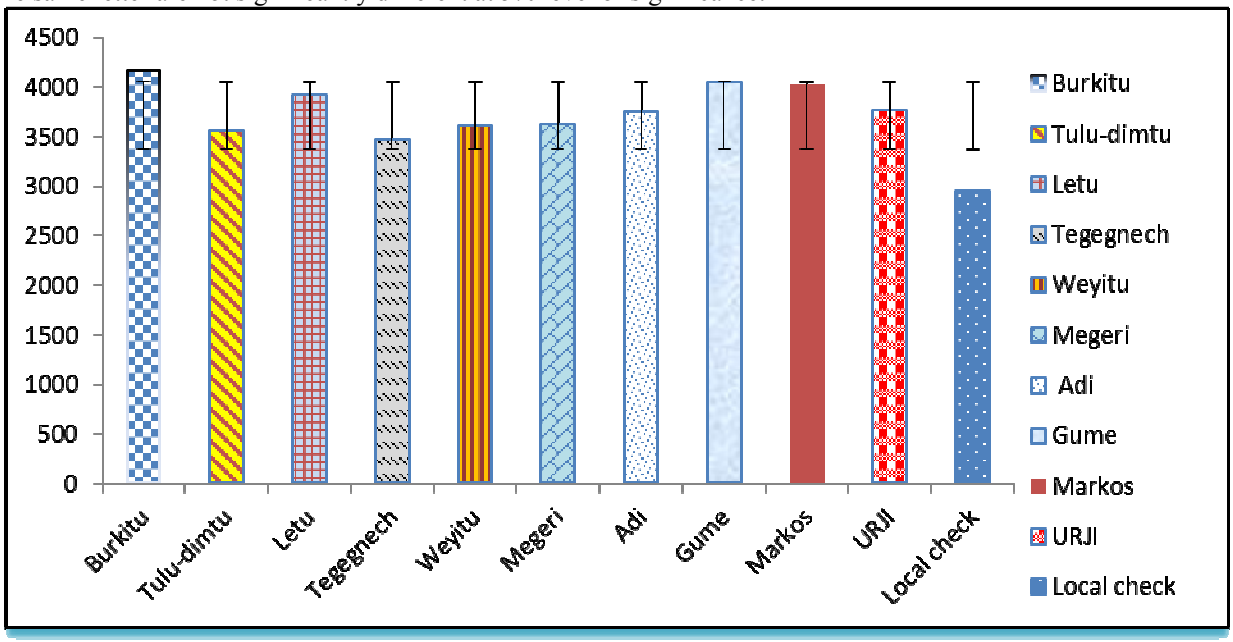

Figure 1. Yield performance of the improved field varieties combined over years

4. CONCLUSION

Ten field pea varieties and a local check were tested for adaptation and yield and yield components in Adiyo districts. Based on the results most the tested improved varieties were produced the highest yield and statistically similar among each other. Farmers were also participated to evaluate and select the tested varieties in the location. Farmers' participation during selection of new varieties is an advantage to exploit their potential knowledge of identifying adapted and high yielding varieties and which can also support the researchers during variety recommendation. However, based on both the researcher's and farmer's selection criteria the varieties Burkitu, Gume and Markos were found to be well adapted, high yielding, good marketability and consumer preferences than others. Therefore, these varieties can be suggested to use for production under Adiyo and

similar agro-ecologies.

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Table 3: Matrix ranking of field pea varieties over years (2012 and 2013) under Adiyo condition
Key: HYLD = High yielding, NPP = Number of pods per plant, NSP = Number of seeds per pod, SSz = Seed size, Sc = Seed color, Rating of the performance of variety for a given criteria 1-5; 5 = very poor, 4 = poor, 3= average, 2= good and 1 = very good.

Field pea varieties	**Farmers Selection Criteria**						
	HYLD	NPP	NSP	SSz	Sc	Total	Rank
Burkitu	1	1	2	2	1	7	1
Tulu-dimtu	4	5	3	4	3	19	10
Letu	3	3	1	4	4	15	6
Tegegnech	4	4	3	4	3	18	9
Weyitu	3	4	2	2	4	16	7
Megeri	2	3	2	5	5	17	8
Adi	2	3	2	3	1	11	4
Gume	1	2	2	1	2	8	2
Markos	1	2	2	2	2	9	3
URJI	2	4	3	3	1	13	5
Local check	5	5	4	5	4	23	11