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Field Pea Variety Development for Yield and Disease Resistance for Potential Areas - Registration of a Field Pea Variety Named '*Bursa*'

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Abstract

Field pea (pisum sativum L.) variety 'Bursa', with a pedigree (EH 04053 × EH 04051) and breeder ID designation of 'EH05027-2' was released in 2015 for highland areas of the country. The variety has been registered by Kulumsa Agricultural research center and it was tested at better representative environments (Kulumsa, Bekoji, Asassa, Kofele, Adet, Adadi, Jeldu and Sinana) representing mid-highland and highland (1800 to 3000 mean above sea level) agro-ecologies during 2012- to 2013- cropping season. The variety produced 2.78% and 3.09% seed yield advantage over the standard checks Burkitu and Letu, and produced 8% seed size advantage over the shiro-type standard check Letu respectively. It also had comparable resistance/tolerant level to major field pea diseases as checks. The variety is mainly characterized by superior mean grain yield as compared from standard check both Burkitu and Letu based on different yield measurement and stability testing parameters across location and over year yield recorded data from national variety trials.

Keywords: Disease resistance, Grain yield, National yield trail, Preliminary variety trial, Seed size, Pisum sativum L.

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Contents

Contribution of this paper to the literature
The study was conducted across environment and years to exploit the genetic potential of different genotypes and finally succeeded with the new field pea variety named '*Bursa*' that have better performance on yield and known field pea disease as compared to the local cultivars.

1. Introduction

Field pea (*Pisum sativum* L.) is a cool season and an annual climbing, herbaceous plant, showing very considerable variation in form and habit. Field pea is diploid species (2n= 2x=14) belonging to the Leguminosae family, a self-pollinating crop [1]. It is the fourth most important legume crop in Ethiopia in terms of both area and total amount of production accounts for 13% of the total grain legume production [2]. According to Central Statistical Agency (CSA) [3] field pea is grown by 1,639,756 households on 212,530.56 hectares of land from which produced 3,481,44.631 tons of grain with the national average of 1.638 t/ha. It requires evenly distributed a rainfall (800-1000 mm/annual) with altitudes ranges 1800-3000 m.a.s.l and cultivated in wide range of soil type with PH range 5.5- 6.5 provided that the drainage is good [4]. Field pea is nutritious food staff when fully matures and they are valuable food legume in different forms particularly in Ethiopia Central Statistical Agency (CSA) [3]. Asfaw, et al. [5] indicated that field pea is a 'break' crop with the cereal rotation, especially with barley and wheat, which serves to restore soil nitrates and minimize weeds, insect pest and disease of cereals. Field pea crop plays a great economic role for both commercial and local crop producers by selling to local markets and exporting to foreign markets and gain currency to the country economy. But less improved technology available which is widely adopted, lack of emphasis and other factors resulted for less field pea productions and economic benefits. Currently in Ethiopia this all factors makes the productivity of the crop were low 1.6 t/ha as a recent Central Statistical Agency (CSA) [3] report, and even if the potential yields of the crop extends up to 2.5-7.5 t / ha [3, 6-9]. The development of cultivars, which are adapted to a wide range of diversified environments, is the ultimate aim of plant breeders in a crop improvement program [10]. The adaptability of a variety over diverse environments is commonly evaluated by the degree of its interaction with different environments in which it is grown. A variety is considered to be more stable if it has a high mean yield but a low degree of fluctuation in yielding ability when planted over diverse environments [11]. The main objective of this paper was to develop field pea cultivar which is productive, tolerant/resistant to different production constraints and suitable under different agro-ecologies of the country.

2. Materials and Methods

2.1. Experimental sites at National Variety Trail

Table-1. Experimental location and their description.

Location	Latitude	Longitude	Altitude (masl)	Mean annual rainfall	Tem (°c) (Min)	Tem(°c) (Max)	Soil texture	PH
Asassa	07°12'N	39°20'E	2300	620	5.8	23.6	Clay-loam	6.2
Kulumsa	08°05'N	39°10'E	2200	820	10.5	22.8	Dark-clay loam	6
Bekoji	07°05'N	39°30'E	2780	1010	7.9	16.6	Clay-loam	5
Holetta	08°58'N	38°14'E	2400	975.5	6.05	22.41	Red-clay	4.9
Koffale	7°00'N	38°45'E	2660	1211	7.1	18	Loam	5.1
Holeta	9° 00' N	38°30' E	2400	1144	6°C	22°C	Nitosol/Vertisol	-
Adadi	8°37'57"N	38°30'0"E	-	-	-	-	-	-
Sinana	07°06'12"N	40° 12'40"E	2400	812	9.3	22.9	Clay loam	6.5
Adet	11016'00'N	37°29'00"E	2216	1271	8.8	25.2	clayey	7.5

2.2. Breeding Procedures

Adapted field pea lines/materials 'EH 04053' and 'EH 04051', which was selected from the last stage of variety trial, was crossed together and resulted breeder ID designation of 'EH05027-2' (Bursa). The crossing was done at Holeta Agricultural Research Center during 2002 cropping season. Screen houses were routinely used in the early generations, i.e., F1, F2, F3 and F4, of a breeding cycle. During these phases, selection for traits with high heritability such as; seed size, grain yielding ability, plant habit, time of flowering and resistance to major diseases such as aschokyta blight and powdery mildew were undertaken. Twenty-four elite individual lines selected from the F5 generation were promoted and evaluated for yielding ability, large seed size, disease reaction in a preliminary variety trial (PVT) conducted during the 2010/11 cropping season at multi-locations. From this trial, 13 promising genotypes were promoted and evaluated in a national variety yield trial (NVT) along with two recently released standard checks 'Burkitu and Letu' at multi-locations (Kulumsa, Bekoji, Asassa, Kofele, Adet, Adadi, Jeldu and Sinana) during 2012 and 2013 main cropping seasons. Lastly, EH04048-1 and EH05027-2 were selected as the most promising candidate varieties and evaluated along with two best standard checks 'Burkitu and Latu' on 10 m x 10 m plots by the national variety release technical committee at 8 locations, each one on-station and two on-farm fields during the 2014 cropping season. Ultimately, EH05027-2 was recommended for commercial production and named 'Bursa'.

2.3. Experimental layout

The experimental layout was arranged in RCBD designs with 4 replications across testing locations. Each plot has 4(m) row lengths. Spacing between blocks and plots were 1.5 (m) and 1 (m) respectively. The experimental plots have 4(four) rows and seeds were sown at the rate of 80(seeds) per row with 5(cm) spacing between plants and 20(cm) row to row spacing, have a total of 3.2 (m^2) net harvesting plot size and converted in to hectare as moisture content of the grain was adjusted to the recommended percent 11%. Fertilizer was applied 18 kg N and 46 kg P_2O_5 per hectare in the form of DAP (di ammonium phosphate) only at planting time.

2.4. Statistical Analysis

The data were subjected to analysis of variance (ANOVA) using the proc Glm procedure of SAS version 9.0 [12] to determine the existence of significant differences between field pea genotypes.

3. Result and Discussions

3.1. Varietal Characteristics and Descriptions

The newly released Field pea variety 'Bursa' is characterized by a prostrate growth habit. Its flower color is purple. The seed coat and cotyledon colors are Light Brown and Light Yellow, and with seed character of Wrinkled. It's Pod Character and Pod Color are Full (not constricted) and green. The average number of days required by the variety to reach its 50% flowering and 95% physiological maturity were 68 and 133, correspondingly, with the average plant height being 178 cm Table 4. The average number of pods per plant is 11.29 Table 4. The appropriate planting date for this variety would range from mid-June to early July. For a better harvest the variety must receive 46 kg P2O5 ha-1 and 18 kg ha-1 N at sowing.

As indicated above Table 2, the highest mean grain yield was recorded at Bekoji and Kofele testing locations with 5925 kg/ha and 5688 kg/ha respectively in 2013 cropping seasons. Again in 2012 growing season 4948 kg/ha and 4854 kg/ha were recorded at Bokeji and Sinana testing site. In other side, the lowest mean grain yield was recorded in 2013 growing season at Adet with 2131 kg/ha for the newly field pea released variety 'Bursa'.

3.2. Yield and Quality Performance

The released variety 'Bursa' is primarily characterized by a heavier seed than recently released shiro type standard check 'letu' varieties with the averages of 189 g per 1000 seeds. The seed of this newly released variety has produced 8% seed size advantage over the shiro-type standard check 'letu'. The combined mean grain yield over locations and years of the newly released variety 'Bursa' exceeded the average yield of both standard checks 'burkitu' and 'letu' by 2.78% and 3.09% seed yield advantage respectively Table 3.

For 1000 seed weight, the highest seed weight were recorded at Jeldu(225gm) in 2013 growing season and the lowest seed weight also recorded in the same growing season (2013) at Adadi(139gm) for this new variety 'Bursa'. In addition to this, comparison of overall means of 1000 seeds weight of this newly released variety (Bursa) 189gm, in both over location and year shows better performance with the recent released Shiro-type check 'Letu' 175gm.

The combined statistical analysis of variance result shows that, based on mean square values of grain yield and thousand seed weight parameters have highly significant difference ($p \leq 0.01$) among treatment, location and interaction as well, shown below in the ANOVA Table 5.

3.3. Reaction to Major Diseases

Improving of a field pea cultivars with high yielder, resistant or tolerant to major diseases such as Ascokyta blight (*Mycosphaerella pinodes*) Powdery mildew *(Erysiphe polygoni) and* for wider adaptation areas are among the major objectives of the national field pea breeding program. Ascokyta blight and powdery mildew diseases, was a very serious problems for field pea crops. The values recorded for both diseases based on (1-9) scale were converted to pre-transformed percentage values, which were then used to determine the reaction of the released variety 'Bursa' to major diseases [13]. Consequently, the released variety 'Bursa' showed an average reaction of 32% and 30.5% for Ascokyta blight and powdery mildew respectively Table 4, and is characterized as moderately resistant to these major diseases.

The combined analysis of Variance (ANOVA) for both traits (Ascokyta blight and Powdery Mildew) based on Mean square values of all sources of variation shows highly significant level at ($p \leq 0.01$) except the interaction of Entry(genotypes) with location for a trait ascokyta blight Table 7.

3.4. Performance Stability and Adaptation Domain

The variety 'Bursa' was released for high altitude agro-ecologies of the country receiving 700-to-1100 mm average annual rainfall. It is well adapted to an altitude range of 1800 to 3000 meters above sea level such as Holleta, Bokeji, Jeldu, Kofele, Sinana, and similar agro-ecologies. Based on most stability parameters, 'Bursa' showed relatively comparable performance stability across a range of environments Table 8.

3.5. Variety Maintenance

The breeder and foundation seed will be maintained by Kulumsa and Holeta Agricultural Research Center.

4. Conclusion

Ever-increasing grain yield is the primary trait of interest and a prime objective in field pea breeding programs for a long times. Further improvement for yield, other major constraints and wider adaptation areas are considered as major objectives of the national field pea breeding program. This is helps to widen the adoptability of a field pea to a major disease and generally improving the productivity of field pea for wider potential areas. This point to levels in response to the current move to meet the demand for enough yield and seed quality particularly for the development of a variety resistant to major disease of field pea. In spite of of this, only few Shiro-type field pea varieties that combine adopted, high yielder and comparable resistant to disease have been released since the beginning of field pea breeding program in the country. The recent variety, *Bursa*, has almost 8% and 3.09% % seed size and yield advantages over the widely cultivated field pea varieties, Latu. Regardless of the high demand of widely adapted high yielding shiro-type field pea varieties by majority of the smallholders in the country, Bilallo and Letu is the only shiro-type field pea varieties ever released nationally. Therefore, the newly released field pea '*Bursa*' varieties are expected to take one step forward in the efforts made to fulfill this gap.

Table-2. Mean grain yield (kg/ha) of 15 field pea genotypes tested over 12 environments during (2012-2013) cropping season.

			Year_2012						Year_2013				
Entry	**Kulumsa**	**Bekoji**	**Asassa**	**Kofale**	**Adet**	**Sinana**	**Bekoji**	**Asassa**	**Kofale**	**Adadi**	**Jeldu**	**Adet**	**Mean**
Burkitu	2466	5136	4814	4290	3220	3614	5473	5914	5620	4691	4882	1745	4322
EH05027-2	3094	4948	4349	4398	3805	4854	5925	4220	5688	4499	5396	2131	4442
EH05024-4	2067	5879	3695	3783	3213	5203	5673	5221	5055	5100	3449	1252	4132
EH05034-1	2697	5471	4755	4100	2780	4495	4818	5224	4659	3769	4218	1420	4034
EH05050-1	2687	5111	3779	4745	3242	3621	4893	4669	5715	5023	5517	1414	4201
EH05048-3	2877	5515	4232	4101	3491	4231	5269	5790	4745	3967	4939	1720	4240
EH04052-1	2439	5572	5013	4618	3147	4604	4908	5673	4006	5297	3516	1831	4219
EH05031-1	2255	4750	3591	3483	2731	3833	4684	4207	3853	4662	4086	1388	3627
EH05016-4	3307	6390	3596	4544	3056	4469	5057	5471	5084	6081	3208	1805	4339
EH05024-3	2445	4877	2631	3847	2545	3682	4007	3967	3561	4200	3358	1605	3394
EH05029-2	2386	5068	3529	3665	1917	4090	4876	3221	3244	4645	4194	1438	3523
EH05014-5	2064	5631	3967	3202	2989	4587	5058	3775	4137	3630	2952	1482	3623
EH04027-1	2791	5393	4966	4254	3977	4429	5198	5897	4046	4806	4716	1650	4344
EH04048-1	3112	6011	4661	4938	3716	4774	4995	6315	4290	4646	4502	2279	4520
Letu	2334	5720	4246	4363	3480	4165	5490	4385	5166	4222	5609	2534	4309
Mean	2601	5431	4122	4155	3154	4310	5088	4930	4591	4616	4303	1713	4085
CV (%)	23.90	9.92	20.58	17.26	23.52	10.98	10.42	19.49	26.75	17.50	29.87	22.10	18.92
LSD (<0.05)	889	774	1218	1027	1065	680	756	1371	1753	1146	2756	540	316

Keys; DTF = Days to flowering, DTM=Days to maturity, PHT=Plant height (cm), PPP=Pods per plant, SPP=Seeds per pod, TSW = Thousand seed weight (g), GYDH=Grain yield (kg/ha), AB=Ascochyta blight (1-9) scale, PM=Powdery mildew (1-9) scale.

Table-3. Mean 1000 seed weight (g) of 15 field pea genotypes tested over 12 environments during (2012-2013) cropping season.

			Year_2012						Year_2013				
Entry	**Kulumsa**	**Bekoji**	**Asassa**	**Kofale**	**Adet**	**Sinana**	**Bekoji**	**Asassa**	**Kofale**	**Adadi**	**Jeldu**	**Adet**	**Mean**
Burkitu	210	227	190	193	205	230	210	180	198	170	216	196	202
EH05027-2	185	225	179	192	180	220	220	150	193	139	225	162	189
EH05024-4	175	188	156	166	165	190	180	158	175	144	207	143	170
EH05034-1	223	244	193	212	210	256	220	188	203	157	246	174	210
EH05050-1	190	213	174	184	180	208	195	170	193	162	211	162	187
EH05048-3	213	243	195	202	205	232	215	177	208	149	238	180	205
EH04052-1	195	235	185	186	210	215	195	190	205	160	230	168	198
EH05031-1	238	264	203	213	230	256	250	215	218	194	286	190	230
EH05016-4	165	183	127	159	150	159	153	145	163	157	186	146	158
EH05024-3	213	237	178	191	190	222	203	190	200	152	235	176	199
EH05029-2	188	216	166	192	175	204	193	163	183	141	224	150	183
EH05014-5	170	207	164	167	180	209	188	153	170	135	201	144	174
EH04027-1	205	227	182	208	190	221	208	190	195	139	226	164	196
EH04048-1	205	245	189	206	205	229	223	198	185	162	244	183	206
Letu	176	203	156	174	176	199	185	165	178	124	208	160	175
Mean	197	224	176	189	190	217	202	175	191	152	225	166	191
CV (%)	4.12	3.54	6.81	5.35	9.66	4.49	9.84	8.62	8.65	12.42	5.12	8.91	7.51
LSD (<0.05)	11.58	11.34	17.10	14.51	26.32	13.93	28.42	21.80	23.54	26.98	24.74	21.13	5.88

Table-4. Mean grain yield, agronomic traits, quality parameters and disease reaction of 'Bursa' among two standard checks tested in eight environments at varietal verification levels during 2014 cropping seasons.

Entry	**Agronomic traits**						**Disease Reaction (1-9)**		**Quality Parameters**	
	DTF	**DTM**	**PLH(cm)**	**NPPP**	**TSW(gm)**	**Grain Yield (Kg/ha)**	**AB**	**PM**	**ACP (%)**	**Soak-ability (%)**
Burkitu	72	132	157	12	201	37.8	29.8	30	20.96	95
EH05027-2	63	146	178	13	189	40.3	32	30.5	20	90
Bilalo	64	138	163	11	213	38.2	26.1	30.2	20.92	85

Keys: DTF = Days to 50% flowering; DTM = Days to 95% physiological maturity; PHT = Plant height; NPPP = Number of pods per plant; TSW = 1000 seed weight; AB =Ascokyta blight; ACP = Average crude protein; PM=powdery mildew.

Table-5. Summary ANOVA table of grain yield and 1000 seed weight.

	Mean squares	
Source of variation	**Grain yield**	**1000 seed weight**
Location	68438025.3**	29417.47**
Block(Location)	1969885.6**	343.75**
Entry	5757760.7**	14674.6**
Location x Entry	987797.5**	341.97**
Mean	4081.8	190.9
CV (%)	19	7.25
R^2	0.79	0.87

Keys: ** = Highly significant ($p \leq 0.01$), * = Significant ($p \leq 0.05$) ns= Non-significant.

Table-6. Mean ascochyta blight and powdery mildew diseases (1-9) scores of 15 field pea genotypes tested over 8 environments during (2012-2013) cropping season.

	Ascochyta blight (1-9) scale									Powdery Mildew (1-9) scale								
	Year_2012					Year_2013				Year_2012				Year_2013				
Entry	**Kul**	**Bek**	**Asa**	**Kof**	**Sin**	**Bek**	**Asa**	**Kof**	**Mean**	**Kul**	**Bek**	**Asa**	**Kof**	**Sin**	**Bek**	**Asa**	**Kof**	**Mean**
Burkitu	5.25	4.00	4.00	4.00	3.50	3.75	3.25	3.75	3.94	3.75	1.00	1.25	3.75	3.00	6.25	4.75	4.25	3.50
EH05027-2	5.50	4.25	5.00	3.50	4.00	4.25	3.50	4.00	4.25	3.75	1.50	2.00	4.00	3.75	6.00	6.25	4.50	3.97
EH05024-4	5.50	3.75	4.25	4.00	3.75	4.25	3.75	4.25	4.19	4.00	1.50	2.25	4.00	3.25	4.00	4.25	4.50	3.47
EH05034-1	5.50	3.50	4.50	4.00	4.00	3.50	3.75	4.25	4.13	4.00	1.50	2.00	4.25	3.75	6.00	5.75	4.50	3.97
EH05050-1	4.67	4.00	4.67	4.33	4.00	4.00	4.00	4.50	4.27	4.00	1.00	1.67	4.33	3.67	5.75	5.75	4.25	3.80
EH05048-3	5.25	3.50	4.00	4.50	4.00	3.25	4.00	4.25	4.09	4.25	1.50	2.25	3.75	4.00	5.25	5.00	4.50	3.81
EH04052-1	5.75	4.25	4.25	4.00	4.50	4.25	3.75	5.00	4.47	4.00	1.50	2.00	4.50	4.25	5.25	5.50	4.75	3.97
EH05031-1	5.00	4.00	4.75	4.00	4.50	4.25	4.50	4.25	4.41	4.25	1.25	2.75	4.00	4.25	5.50	4.50	4.25	3.84
EH05016-4	5.00	4.00	4.50	3.75	4.50	3.75	4.00	3.50	4.13	4.50	1.00	2.00	3.75	3.75	4.25	3.00	4.25	3.31
EH05024-3	6.00	3.75	4.75	4.00	4.50	4.25	4.25	4.50	4.50	3.25	1.00	2.00	4.50	4.25	6.50	6.50	5.25	4.16
EH05029-2	5.50	3.75	4.50	3.75	5.25	3.75	4.50	3.75	4.34	4.25	1.25	2.75	4.25	4.25	4.75	5.00	4.00	3.81
EH05014-5	5.25	3.75	3.75	3.50	3.50	4.00	3.75	4.00	3.94	5.25	1.00	2.25	4.00	3.50	5.25	5.25	5.00	3.94
EH04027-1	5.50	3.25	4.25	4.00	4.25	3.50	3.75	4.25	4.09	4.50	1.50	2.50	4.25	3.50	5.75	5.00	4.25	3.91
EH04048-1	5.00	3.75	4.25	3.75	4.00	4.25	3.50	4.75	4.16	4.75	1.25	1.50	3.50	3.50	6.00	5.75	4.50	3.84
Letu	5.00	3.80	4.40	3.40	4.40	3.75	4.00	4.50	4.16	4.20	1.40	1.80	3.60	4.20	4.50	4.25	4.00	3.49
Mean	5.31	3.82	4.39	3.90	4.18	3.92	3.88	4.23	4.20	4.18	1.28	2.06	4.03	3.79	5.40	5.10	4.45	3.79
CV (%)	11.3	17.90	11.18	12.31	13.51	14.71	13.99	17.02	13.99	16.92	38.43	32.37	15.01	16.2	10.67	15.82	14.74	17.08
LSD (<0.05)	0.86	0.98	0.70	0.69	0.81	0.82	0.78	1.03	0.29	1.02	0.71	0.96	0.87	0.88	0.82	1.15	0.94	0.32

Keys: Kul=Kulumsa, Bek.= Bekoji, Asa= Asasa, Kof= kofele, Sin=Sinana.

Table-7. The combined ANOVA table for both traits (AB & PM) of 15 field pea genotypes tested over 12 environments during (2012-2013) cropping season.

Disease type	SV	D f	MS	F-value
Powdery mildew	Location	8	112.1**	276.5
	Block(Location)	27	3.64**	8.98
	Entry	14	1.62**	4
	Entry x Location	110	0.9**	2.22
	Mean		3.71	
	CV (%)		17.14	
	R^2		0.89	
Ascokyta blight	Location	8	15.1**	45.43
	Block(Location)	27	2.1**	6.31
	Entry	14	0.9**	2.7
	Entry x Location	110	0.38^{ns}	1.14
	Mean		4.25	
	CV (%)		13.55	
	R^2		0.65	

Keys; SV =Sources of Variation, Df= Degree of Freedom, MS= Mean Square, ** = Highly significant ($p \leq 0.01$), * = Significant ($p \leq 0.05$) ns= Non-significant.

Table-8. Stability status of the genotypes using ASV, GSI and Fox TOP third environment.

Entry	YIELD	ASV	RY	RASV	GSI	TOP	RANKSUM
Burkitu	4234.49	27.6046	6	7	13	41.6667	15
EH05027-2(Bursa)	4360.10	40.1578	2	13	15	66.6667	13
EH05024-4	4060.21	16.0422	10	3	13	33.3333	20
EH05034-1	3945.79	11.3968	11	1	12	8.3333	13
EH05050-1	4126.35	40.9857	9	14	23	33.3333	21
EH05048-3	4214.68	12.3222	7	2	9	41.6667	10
EH04052-1	4186.07	34.0699	8	11	29	50.0000	15
EH05031-1	3656.80	17.8573	12	5	17	0.0000	14
EH05016-4	4323.76	43.1965	3	15	18	50.0000	18
EH05024-3	3280.44	33.3814	15	10	25	0.0000	21
EH05029-2	3430.67	31.6369	14	9	23	0.0000	26
EH05014-5	3645.99	17.3506	13	4	17	18.1818	22
EH04027-1	4293.06	25.7343	4	6	10	50.0000	9
EH04048-1	4444.81	31.0024	1	8	9	66.6667	5
Letu	4263.56	36.2225	5	12	17	41.6667	18

Key: ASV = AMMI stability value, RY = Yield rank, RASV = AMMI stability value rank, GSI = Genotypic stability index, TOP = % share in the top three high yielding environments based on Fox et al. (1990), VIPC1 = Varietal interaction principal component one, VIPC2 = Varietal interaction principal component 2 and RANKSUM = Rank Sum.

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