INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 13, No. 5, p. 327-340, 2018

RESEARCH PAPER OPEN ACCESS

Genetic diversity of pea (*Pisum sativum* L.) landraces using morphological markers

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Key words: *Pisum sativum,* Peas, Morphological Markers, Cluster, PCA.

http://dx.doi.org/10.12692/ijb/13.5.327-340 Article published on November 28, 2018

Abstract

These studies were conducted during 2015and 2016 at the University of Poonch Rawalakot. The present study aim to screen the diverse landraces of peas under agro-ecological conditions of Rawalakot. Mean values for germination percentage ranged from 70% to 90%. Maximum value was recorded for M-25, M-102, M-91 and M-72 (90%). Maximum plant height (80 cm) was observed in genotype L-29 followed by L-30 (78 cm), L-28 (74 cm) and L-30 (75 cm). Maximum pods per plant were found in L-29 (18) followed by L-22, L-27, L-28, and L-30 (17.0). Means values for seed per pod ranged from 4-8. Landraces L-35, L-36, L-37, L-38, L-39, L-40, L-41, L-42, L-43, L-44, and L-46 excelled in seeds per pod (8.0) followed by L-11, L-12 and L-13 (7.0). Highly significant differences were also observed among landraces for 100- seed fresh weight. Maximum 100-seed fresh weight (g) was noted in M-83 (29.6 g) followed by M-91 (28.3 g) and Check variety (28.2 g). Highly significant variation in yield was observed among different landraces. Landraces M-83 had maximum yield (kg) (19.73 kg/ha) followed by M-25 and M-07 (18.13 kg/ha) and M-91 (18.8 kg/ha). Genotypes Check, L-10, M—83, M-07, L-47, M-86 L-33, L-64, L-71, L-23 and L-24 were showing maximum variability and were outliers for the cluster. Knowledge obtained from morphological characterization of populations of *Pisum sativum,* the present study could be used as a benchmark for future studies.

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Introduction

Legumes are important crops worldwide, and they have major impacts on agriculture, the environment and animals and human nutrition (Vance *et al.*, 2003). Pea (*Pisum sativum* L.), a leguminous crop, belongs to family *Leguminoseae*. It has an important ecological advantage because it contributes to the development of low-input farming systems by fixing atmospheric nitrogen and it serves as a break crop which further minimizes the need for external inputs. Legumes constitute the third biggest group of flowering plants, involving in excess of 650 genera and 18,000 species (Lock *et al.*, 2005). Economically, legumes represent the second most the second most essential group of crop plants after *Poaceae* (grass family), representing around approximately 27% of the world's crop production (Vance *et al.*, 2003). Peas contain higher amount of protein having fundamental amino acids especially lysine (Nawab *et al.*, 2008).

Cultivars perform differently under various agro-climatic conditions and different cultivars of same species grown even in same condition and environment often have yield differences. Yield and quality of crop are very complex characteristics depending on certain biological alignments between environment and heredity. The characteristics of a cultivar as well as combination of traits differ according to climatic conditions of the localities (Khokar *et al.*, 1998). Unimproved varieties, local populations, shows high degree of genetic diversity, thus, great differences occur with respect to morphological traits, time to maturity, pod size and type, seed attributes, and yield (Santalla *et al.*, 2001). These properties can be improved by selection so that yield performance can be increased. Pea crop has promising future and attempt should be made to improve yields through the development of high yielding landraces which are adaptable to our climatic conditions. These studies were carried with following objectives: To evaluate the landraces of pea cultivated in Azad Kashmir at morphological, biochemical and molecular levels. To identify suitable and high yielding summer landraces of pea to be used for further crop improvement.

Material and methods

These studies were conducted during 2015 and 2016 at the University of Poonch Rawalakot. The landraces were collected from different locations of district Poonch (Banjosa, Devi gali, Jandali, Dhoke, and Rawalakot), Bagh (Harigal, Sudhan Gali, Mallot, and Dirkot), Sudhnoti (Trarkhal, Mang, Bloch, and Plandri), Mirpur and NARC (PGRI) Islamabad. Seventy five landraces of field peas (*Pisum sativum* L.) were planted in the field following augmented design and one local check variety (Meteor) was used for the comparison of germplasm and planted 5 times after every 20 landraces.

Studied parameter

The experiment was carried out in Augmented design for the morphological studies: Germination percentage, Plant height (cm), Number of leaves plant^{-1}, Leaf area (cm^2), Leaf length (cm), Leaf width (cm), Days to flowering initiation, Days to flowering completion, Days to pod formation, Number of pods plant^{-1}, Pod length (cm), Pod width (cm), Number of seed pod^{-1}, 100-seed weight (g), Seed yield (kg ha^{-1}).

Statistical analysis

The collected data for morphological traits were analyzed to determine the phenotypic correlation coefficients among various parameters using SPSS 16.1. Mean values of the agronomic traits for genotypes were standardized and used for computing Euclidean distances between them. Dendrogram was formed by using computer software PAST. Principal component analyses (PCA) and cluster analyses were used to obtain Euclidean distances between genotypes and to characterize the relation to the most discriminating traits.

Results and discussion

Seed germination

Mean values for germination percentage ranged from 70% to 90%. Maximum value was recorded for M-25, M-102, M-91 and M-72 (90%). Minimum value was observed for L-16, L-18, M-86, L-47 and L-48 (70%).All other landraces remained transitional in performance with esteem to this trait. It is evident from the results that the cultivars differed significantly for seed germination percentage. Seed germination and seedling vigor are influenced by physiological age of the seed at harves and subsequent handling (Muehlbauer and McPhee, 1997). The seeds collected 28 days after an thesis accomplished, attained complete viability. If the seed is harvested earlier than the proper maturity stage, it may result in its reduced viability or in other words, younger the seed at harvest, lower will be the viability. Besides harvesting time, harvesting and threshing methods and storage conditions also affect the seed viability which affects the seed germination (Castillo *et al.*, 1992).

Table 1. Following genotypes were selected for morphological studies.

Landraces	Location	Landraces	Location	Landraces	Location
L-1	Meteor	L-26	Trarkhal 3	L-51	Plandri 3
L-2	Banjosa	L-27	Mang	L-52	Plandri 4
L-3	Banjosa 1	L-28	Mang 1	L-53	Harigal 1
L-4	Banjosa 2	L-29	Mang 2	L-54	Harigal 2
L-5	Banjosa 3	L-30	Mang 3	L-55	Harigal 3
L-6	Devi gali	L-31	Bloch	L-56	Harigal 4
L-7	Devi gali 1	L-32	Bloch 1	L-57	S.gali
L-8	Devi gali 2	L-33	Bloch 2	L-58	S.gali 1
L-9	Devi gali 3	L-34	Bloch 3	L-59	S.gali 2
L-10	Jandali	M-25	NARC	L-60	Meteor
L-11	Jandali 1	M-116	NARC	L-61	S.gali 3
L-12	Jandali 2	M-102	NARC	L-62	Mallot
L-13	Jandali 3	M-91	NARC	L-63	Mallot 1
L-14	Dhoke	M-07	NARC	L-64	Mallot 2
L-15	Dhoke 1	M-83	Meteor	L-65	Mallot 3
L-16	Dhoke 2	M-22	NARC	L-66	Dirkot
L-17	Dhoke 3	M-72	NARC	L-67	Dirkot 1
L-18	R.kot 1	M-39	NARC	L-68	Dirkot 2
L-19	R.kot 2	M-86	NARC	L-69	Dirkot 3
L-20	Meteor	M-08	NARC	L-70	Mirpur
L-21	R.kot 2	M-79	NARC	L-71	Mirpur 1
L-22	R.kot 3	L-47	NARC	L-72	Mirpur 2
L-23	Trarkhal	L-48	Plandri	L-73	Mirpur 3
L-24	Trarkhal 1	L-49	Plandri 1	L-74	Mirpur 4
L-25	Trarkhal 2	L-50	Plandri 2	L-75	Mirpur 5

Plant height (cm)

Pea's landraces also showed variation in plant height. Maximum plant height (80 cm) was observed in genotype L-29 followed by L-30 (78 cm), L-28 (74 cm) and L-30 (75 cm) (Table 2). Genotype L-20 attained minimum plant height (33 cm) followed by L-6 (34 cm), L-50 (39 cm), -L-18 (40 cm) L-51 (41 cm), CH (41 cm) and L-15 (42 cm). All other landraces remained intermediate in performance with respect to this trait. The difference in plant height might be due to the genetic makeup of these cultivars. The cultivars with minimum height at flowering are considered as not only dwarf but also early flowering. The variation in plant height of the varieties used may be attributed to their variable genetic makeup and response to environmental conditions. Different responses to plant tallness may be because of hereditary characteristic of genotypes and adaptability to a specific situation. Scientists acquired lengths changing in the vicinity of 65.67 and 132 cm (Ceyhan and Avci, 2015), 51.20 and 111.30 cm, 65.67 and 126 cm (Khan *et al.*, 2013).On the other hand, the average (63.64 cm) detailed by Habtamu and Million (2013) is lower than that got in the present work (80 cm). Contrast in plant height may be because of hereditary characteristic of genotypes and adaptability to a particular environment (Khan *et al.*, 2013), particularly that this character is dependent on the environment (Solberg *et al.*, 2015).

Table 2. Mean values for Morphological parameters among 75 pea genotypes.

	G	P	L	LL	LW	LA	FI	FC	PF	P/P	PL	PW	S/P	SW	Y
CH	85	41	39	2.5	2.7	4.92	60	73	65	15	10.5	1.2	8	28.2	18.8
L1	85	55	46	2.2	1.8	2.89	58	70	63	12	5.5	1	4	12.3	8.2
L2	85	58	49	2.5	2.5	4.56	58	70	63	13	4.7	1.1	4	12	8
L3	85	47	41	1.7	1.6	2.1	58	70	64	12	5	1	4	12.9	8.6
L4	80	50	43	2	1.9	2.77	56	70	64	12	4.5	1	4	12.5	8.3
L5	80	52	44	1.9	1.8	2.49	56	69	63	11	5.8	1.2	5	13	8.6
L6	80	34	35	1.7	1.2	2.1	50	62	56	10	5.8	1	5	13.7	9.13
L7	85	47	43	2.8	2.7	5.51	55	70	63	12	6.1	1	5	13	8.6
L8	75	46	37	2.6	2.6	4.93	57	68	62	11	6.5	1	5	13.4	8.9
L9	75	47	42	2.1	2	3.06	57	69	63	12	7.5	1.2	6	17	11.33
L10	75	52	45	3.1	3.1	7.01	57	68	62	10	6.6	1.1	6	17.5	11.6
L11	80	57	50	3.2	3.2	7.47	56	68	61	16	8	1	7	19	12.6
L12	85	43	38	3.3	3.3	7.94	61	75	67	13	8.7	1	7	18.2	12.13
L13	85	44	46	3.6	3.5	9.19	61	74	67	13	8.3	1.1	7	19.2	12.8
L14	85	46	39	3.4	3.3	8.19	60	74	66	12	8.3	1	7	19	12.66
L15	80	42	51	3	3.1	6.78	61	75	68	14	6.6	1.2	6	18.6	12.4
L16	70	47	48	2.9	2.9	6.13	57	67	63	15	7.6	1.2	6	19.2	12.8
L17	75	43	54	2.7	2.8	5.51	57	69	65	14	7.6	1.2	6	18.6	12.4
L18	70	40	36	3.1	3.2	7.24	58	70	66	16	7.1	1.2	6	19	12.6
L19	75	46	37	3	3.1	6.78	59	70	66	13	7.7	1.2	7	21.4	14.2
L20	75	33	30	1.8	1.8	2.36	49	61	58	13	7.9	1.2	7	22	14.6
L21	80	58	53	2.9	2.8	5.92	59	71	65	16	8.2	1.2	7	22.6	15.06
L22	80	59	52	2.8	2.8	5.72	58	71	66	17	8	1.2	7	22	14.6
L23	85	65	65	3.6	3.6	9.46	56	70	67	16	7.6	1.2	6	16.4	10.9
L24	85	68	70	4.1	4	11.9	58	73	68	11	7.6	1.2	6	18	12
L25	80	67	66	3.8	3.7	10.2	58	72	67	13	7.6	1.2	6	18.5	12.3
L26	80	69	65	3.9	3.8	11.1	59	72	66	14	7.5	1.2	6	19	12.66
L27	85	71	68	4.2	4.1	12.5	60	74	67	17	8.5	1.1	7	23.8	15.86
L28	85	74	69	4.3	4.3	13.4	60	74	67	17	8.6	1.2	7	23	15.33
L29	85	80	74	5.1	5	18.6	62	77	69	18	8.7	1.2	7	23.5	15.66
L30	85	78	71	4.7	4.7	16.12	61	75	63	17	8.2	1.2	7	23.5	15.66
L31	80	73	67	4.5	4.4	14.4	59	73	61	14	8.3	1.2	7	23	15.33
L32	80	75	66	4.2	4.2	12.87	59	72	62	11	8.5	1.1	7	23.4	15.6
L33	80	54	58	3.9	3.9	11.1	52	65	57	13	8.6	1.1	7	24.9	16.6
L34	75	49	52	2.8	2.9	5.92	51	64	58	12	8.7	1.1	7	23.2	15.46
A35	90	44	49	2.7	2.7	5.32	51	64	58	14	9	1.2	8	26.8	17.86
A36	85	52	57	2.9	2.8	5.92	54	66	59	16	9.2	1.2	8	27.2	18.13
A37	90	56	62	3.1	3	6.78	55	65	60	15	9.3	1.2	8	26.4	17.6
A38	90	49	57	3	3	6.57	53	65	59	14	9.3	1.2	8	28.3	18.8
A39	85	45	54	2.9	2.8	5.92	53	67	69	16	9.1	1.2	8	27.2	18.13
A40	80	50	56	2.8	2.8	5.72	57	71	63	15	10.1	1.2	8	29.6	19.73
A41	85	53	60	3.1	3.1	7.01	57	70	62	14	9.5	1.2	8	25.8	17.2
A42	90	57	64	3.2	3.1	7.24	58	71	62	15	9.2	1.2	8	26	17.3
A43	85	54	59	3	3.1	6.78	55	69	60	16	9.3	1.2	8	27.3	18.2
A44	70	59	67	3.3	3.3	7.49	57	70	62	15	9.5	1.2	8	27	18
A45	80	55	63	3.2	3.1	7.24	56	69	60	14	8.7	1.2	7	25.3	16.86
A46	85	52	61	3.1	3.1	7.01	56	70	61	14	9.4	1.2	8	26	17.33
L47	70	57	65	3.3	3.2	7.7	58	72	62	13	7.6	1.1	6	19	12.6

L48	70	51	59	2.9	2.9	6.13	55	68	61	14	7.6	1.1	6	19.2	12.8
L49	75	46	62	3.9	3.9	11.1	54	67	61	14	8.5	1.1	7	20.1	13.4
L50	75	39	44	1.8	1.7	2.23	54	65	59	16	8.6	1.1	7	22.1	14.7
L51	80	41	47	2.1	2.1	3.21	53	67	59	11	8.7	1.1	7	22.5	15
L52	80	42	48	2.3	2.2	3.69	53	67	59	12	8.1	1.1	7	22.3	14.8
L53	85	44	50	2.4	2.4	4.2	55	70	61	12	7.5	1.1	6	21.1	14.06
L54	75	47	51	2.6	2.6	4.93	56	71	62	13	7.6	1.2	6	22.1	14.7
L55	85	44	49	2.3	2.3	3.86	56	69	60	14	8.7	1.2	7	22.9	15.26
L56	75	45	49	2.5	2.4	4.38	55	70	61	11	9.3	1.2	8	24.7	16.4
L57	75	49	53	2.7	2.6	5.12	58	72	63	10	9.8	1.2	8	24.6	16.4
L58	80	53	61	3.1	3.1	7.01	55	70	62	12	8.7	1.2	7	23.5	15.6
L59	80	58	66	3.5	3.4	8.68	56	70	61	13	8.7	1.2	7	22.5	15
L60	85	56	63	3.3	3.3	7.94	56	71	62	11	7.6	1.1	6	20.1	13.4
L61	85	59	64	3.6	3.5	8.94	58	72	62	12	7.6	1.1	6	19.7	13.1
L62	85	61	72	3.8	3.8	10.5	59	73	66	14	8.7	1.2	7	21.8	14.5
L63	75	64	75	3.9	3.9	11.1	58	72	65	15	7.5	1.1	6	18.6	12.4
L64	85	66	76	4	3.9	11.3	59	73	65	11	8.1	1.2	7	23.9	15.93
L65	85	60	71	3.8	3.8	10.5	58	72	64	14	8.2	1.2	7	23.4	15.6
L66	75	57	66	3.5	3.5	8.94	55	69	61	15	7.3	1.1	6	19.5	13
L67	75	54	62	3.1	3.1	7.01	55	69	61	16	7.3	1.1	6	20.3	13.53
L68	75	51	59	2.9	2.9	6.13	54	68	60	11	8.3	1.2	7	24.2	16.13
L69	75	58	63	3.6	3.6	9.46	57	71	63	12	8.2	1.2	7	24.6	16.4
L70	80	61	74	3.9	3.8	10.81	58	70	62	12	8.1	1.2	7	23.8	15.8
L71	80	66	75	4.2	4.1	12.5	59	73	63	11	7.6	1.1	6	18.7	12
L72	75	68	77	4.4	4.3	13.81	59	72	62	14	7.6	1.1	6	19.8	13.2
L73	80	64	73	4	4	11.68	57	70	63	13	8.2	1.2	7	22.9	15.2
L74	75	61	65	3.7	3.7	9.99	56	70	63	12	8.1	1.2	7	22.3	14.8
SD.V	5.22	10.29	11.76	0.75	0.75	3.49	2.66	3.06	2.91	1.95	1.17	0.07	1.02	4.19	2.80
C.V	27.25	105.96	138.36	0.56	0.56	12.18	7.09	9.33	8.49	3.79	1.37	0.00	1.04	17.57	7.85

Number of Leaves per Plant

Highly significant differences were observed in this respect among the landraces. It is clear from the data that L-72 possessed the highest number of leaves (77), closely followed by L-64 (76), L-63 (75) and L-71 (75), while, L-20 had the minimum number of leaves (30) followed by L-6 (35), L-18 (36), L-8 and L-19 (37), L-12 (38), L-14 and CH (39). All other landraces remained intermediate in performance with respect to this trait. It is evident that that all cultivars had similarly more number of leaves than the dwar ones. Vegetative development of pea plant are influenced by both hereditary and natural components, which interact with each other to further modify plan growth. The genetic or hereditary effects include photosynthetic potential, water use efficiency, plant growth rate, leaf area index and seed size etc. The genetic factors are affected by environmental conditions including plant density and climatic conditions (Muehlbauer and McPhee, 1997). Hence, variation in pea cultivars could be due to their genetic makeup and adaptability to prevailing environmental conditions.

Leaf Area

Means values for leaf area ranged from 1.2-18.6 cm². It is clear from the data that L-29 possessed the highest leaf area (18.6 cm²), closely followed by L-30 (16.12 cm²) and L-31(14.4 cm²). These landraces exhibited the maximum vegetative growth. L-3 and L-6 had the shown minimum leaf area (1.2 cm²) followed by L-5 (2.49 cm²), L-4 (2.77 cm²) and L-1(2.89 cm²) (Table 1.2). All other landraces remained intermediate in performance with respect to this trait. Vegetative development of pea plant are influenced by both hereditary and natural components, which interact with each other to further modify plan growth. The genetic or hereditary effects include photosynthetic potential, water use efficiency, plant growth rate, leaf area index and seed size etc. The genetic factors are affected by environmental conditions including plant density and climatic conditions (Muehlbauer and McPhee, 1997). Hence, variation in pea cultivars could be due to their genetic makeup and adaptability to prevailing environmental conditions. Varietal differences in garden pea in leaf area were also reported by Akhter, 2004.

Leaf length

Means values for leaf length ranged from 1.7-5.1 cm. It is clear from the data that L-29 possessed the highest leaf length (5.1 cm), closely followed by L-30 (4.7 cm) and L-31(4.5 cm). These landraces exhibited the maximum vegetative growth. L-3 and L-6 had the shown minimum leaf area (1.7 cm) followed by L-50 (1.8 cm), and L-5(1.9 cm). All other landraces remained intermediate results. This can be clarified by photosynthesis which is more critical when the size of stipules and leaflets are large, hence the yields are higher. Basaran *et al.* (2012) and Basaran *et al.* (2013) noticed a strong correlation between leaflet length and weight of 100 seeds in grass pea.

Table 3. Simple Correlation coefficient for morphological traits among 75 peas landraces.

	Ger	PH	NOL	LL	LW	LA	DFI	DFC	PF	PP	PL	PW	NOSP	SW	YIELD
Ger	1														
PH	.178	1													
NOL	.113	.821**	1												
LL	.116	.822**	.798**	1											
LW	.096	.795**	.781**	.994**	1										
LA	.118	.831**	.777**	.989**	.985**	1									
DFI	.129	.526**	.295*	.527**	.516**	.526**	1								
DFC	.179	.569**	.409**	.587**	.576**	.584**	.923**	1							
PF	.139	.346**	.155	.382**	.378**	.376**	.754**	.748**	1						
PP	.137	.262*	.227*	.279*	.296**	.288*	.197	.139	.260*	1					
PL	.148	.057	.284*	.272*	.291*	.235*	-.038	.025	-.105	.322**	1				
PW	.011	.211	.356**	.220	.241*	.206	.061	.078	.139	.303**	.529**	1			
NOSP	.170	.015	.228*	.227*	.249*	.190	-.089	-.041	-.127	.328**	.960**	.559**	1		
SW	.170	.092	.336**	.241*	.264*	.211	-.127	-.060	-.196	.351**	.912**	.621**	.935**	1	
YIELD	.172	.091	.334**	.239*	.262*	.209	-.127	-.061	-.196	.355**	.912**	.621**	.934**	1.000**	1

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

Where; G= Germination % age, PH= Plant Height, NOL= Number of Leaves, LL= Leaf Length, LW= Leaf Width, LA= Leaf Area, DFI= Days to Flower initiation, DFC= Days to Flowering completion, PF= Pod formation, PP= Pod per plant, PL= Pod length, PW= Pod width, NOSP=Number of Seed per pods, SW= 100 Seed weight, Y= Yield.

Leaf width

Means values for leaf length ranged from 1.7-5.1 cm. It is clear from the data that L-29 possessed the highest leaf length (5 cm), closely followed by L-30 (4.7 cm) and L-31(4.4 cm). These landraces exhibited the maximum vegetative growth. L-3 and L-6 and L-50 had the shown minimum leaf width (1.7 cm) followed by L-1 (1.8 cm), and L-5(1.8 cm). All other landraces remained intermediate results. This can be clarified by photosynthesis which is more critical when the size of stipules and leaflets are large, hence the yields are higher. Basaran *et al.* (2012) and Basaran *et al.* (2013) noticed a strong correlation between leaflet length and weight of 100 seeds in grass pea.

Days to flowering initiation

The landraces also revealed highly significant differences for days to flowering. Minimum number of days taken for flowering were found in L-20 (49.0) followed by L-6 (50.0) L-34 and M-25 (51.0) (Table 2). Maximum number of days for flowering were noted in landraces L-29 (62.0) followed by L-12, L-13, L-15 and L-30. (61.0). The possible reason of early flowering in certain genotypes indicated adaptability of these genotypes in a particular environment, better and efficient utilization of nutrients in a relatively hostile environment which might have resulted in early termination of vegetative phase and initiation of reproductive stage as compared to genotypes which took longer time to flowering (Ishtiq *et al.*, 1996).

Table 4. The Eigen values for 15 traits of *Pisum sativum* L. genotypes.

PC	1	2	3
Eigenvalue	6.18	4.12	1.46
% variance	41.22	27.52	9.79
Cumulative Eigen Value	41.22	68.74	78.53

Similar results have also been reported earlier (Hussain and Badshah 2002), Singh *et al.* (2004) (Vocanson and Jeuffroy, 2008).

Days to Flowering Competition

The time taken from germination to flower competition revealed significant differences among the landraces. It is evident from result that L-29 took the maximum days (77.0) for flowering competition, closely followed by L-30 (75.0) L-27 and L-28(74.0) and L-24 and L-31(73.0), whereas L-20, L-6, L-34 and M-25 took the minimum number of days to complete flowering (61.0 to 64.0).

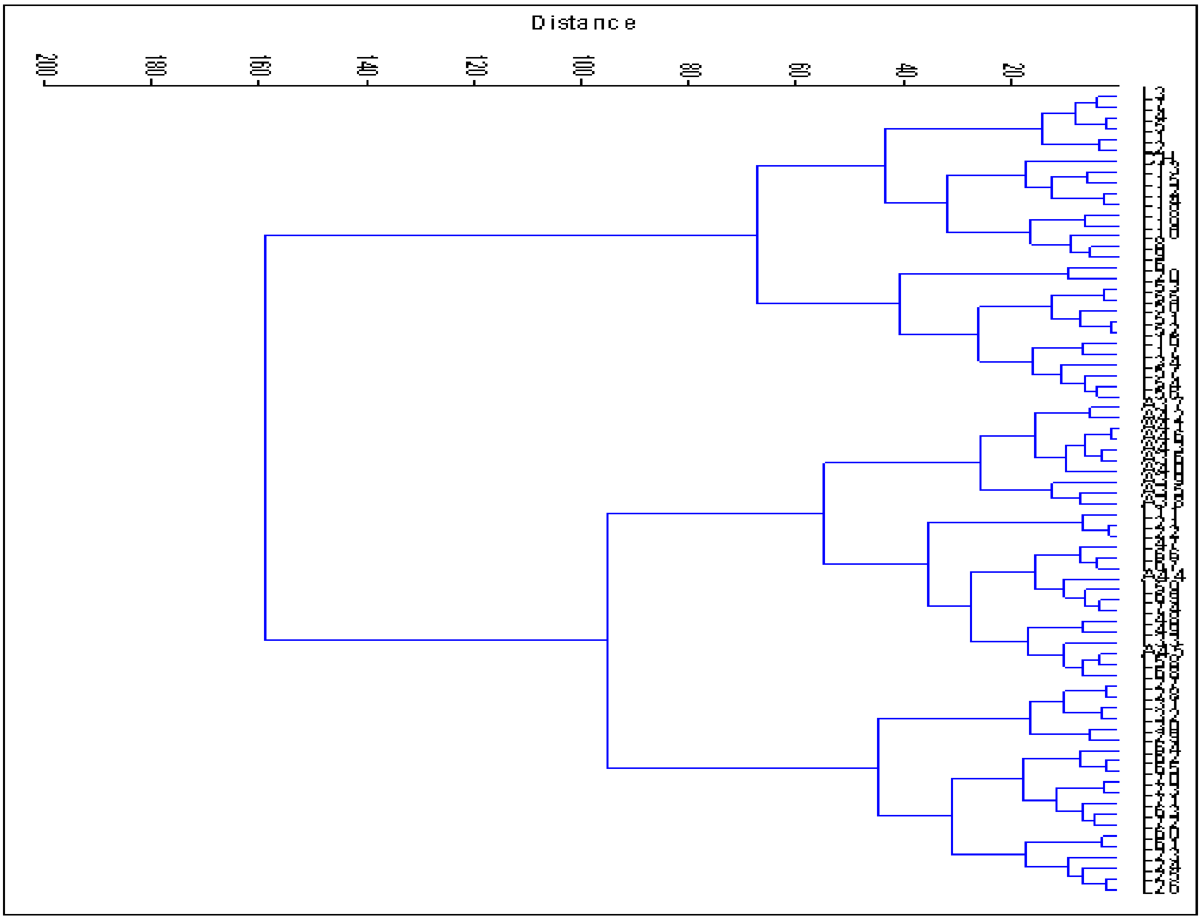

Fig. 1. Dendrogram based on average linkage distance for 75 peas genotypes.

The cultivars taking minimum number of days to flowering are comparatively early maturing than other cultivars, from the farmers point of view such cultivars seem more desirable because early flowering means early crop maturity. According to Makasheva, (1983) pea cultivars have an adequately wide range of duration of vegetative period and their consequent phases (flowering, maturation etc.). The period of vegetative growth corresponds to agro-climatic peculiarities of the area of their cultivation.

Days to Pod Formation

The landraces also revealed highly significant differences for days to pod formation (Table 2).

Maximum number of days taken for pod formation were found in L-29 and L-39 (69.0 each) followed by L-15 and L-24 (68.0 each) and L-12, L-13, L-23, and L-25, (67.0 each). Minimum number of days for pod formation were noted in landraces L-6, (56.0) followed by L-33 (57.0) and L-20, L-34, and M-25 (58.0 each). The cultivars taking minimum number of days to flowering are comparatively early maturing than other cultivars, from the farmers point of view such cultivars seem more desirable because early flowering means early pod formation result in early crop maturity. According to Makasheva, (1983) pea cultivars have an adequately wide range of duration of vegetative period and their consequent phases (flowering, maturation etc.).

The period of vegetative growth corresponds to agro-c1imatic peculiarities of the area oftheir cultivation.

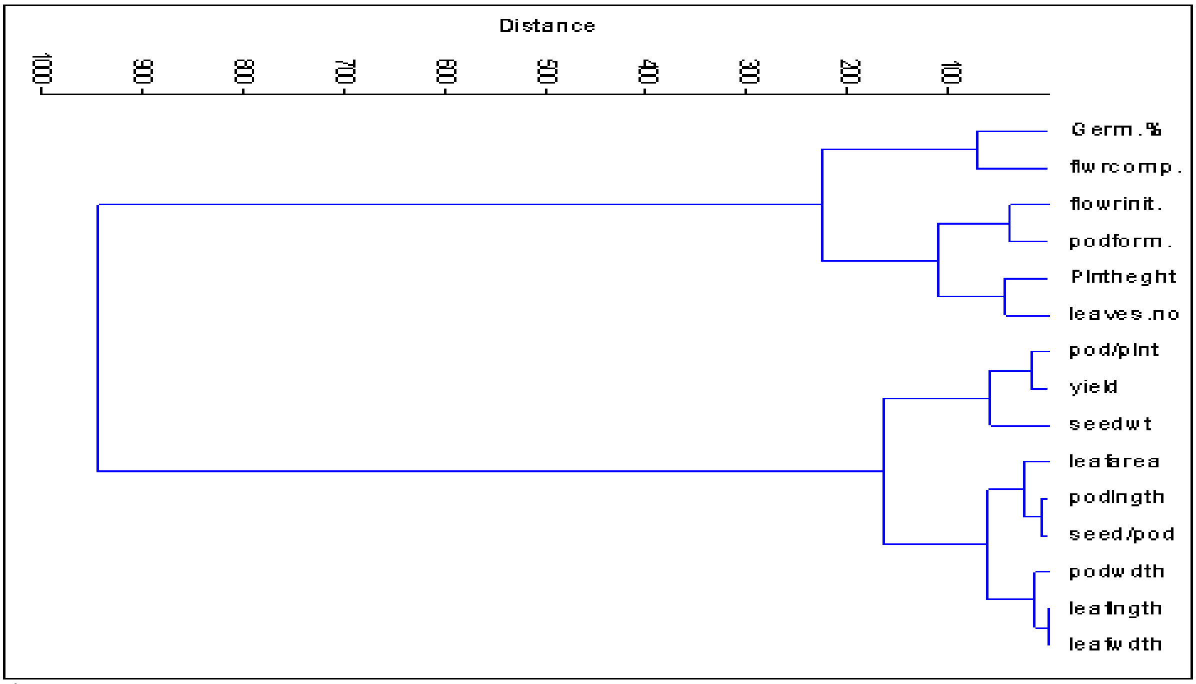

Fig. 2. Dendrogram based on average linkage distance for 15 Traits.

Number of pods per plant

The Number of pods per plantalso revealed highly significant differences among all the landraces. Maximum pods per plant were found in L-29 (18) followed by L-22, L-27, L-28, and L-30 (17.0). Data concerning number of pods per plant indicated significant difference among the landraces. The landraces L-6 and L-57 produced the minimum number of pods per plant (10.0). It indicated that priority could be given to a certain cultivar over others on the basis 'of number of pods per plant, if other parameters were also at optimum level. More number of pods per plant might be because of small pod size as fewer nutrients are required for small pods compared with larger pods (Baginsky *et al.*, 1994). Number of pods per plant identify to plant height. Vigorous varieties produced more pods while number of pods decreased with decrease in plant height, which may be ascribed to hereditary or genetic make up of the plants. Pods per plant have significant and positive correlation with biological yield, grain yield and harvest index. Similar results have also been reported earlier (Hussain *et al.*, 2005; Khokar *et al.*, 1998). Some scientist'sobserved number of pods per plant as the most useful yield component (Javaid *et al.*, 2002).

Pod length (cm)

Data on pod length showed important modifications among the landraces A comparison of means for landraces showed that check variety demonstrated the maximum pod length(10.5 cm) followed by L-40 (10.1 cm), L-57(9.8 cm), and L-41 and L-44 (9.5 cm each). Minimum pod length (4.5 cm) was recorded in

L-4 followed by L-2(4.7 cm).). A number of prior workers have previously reported that pea cultivars differ importantly in size and form of pods and number of seeds per pod (Makasheva, 1983; Muehlbauer and McPhee, 1997).(Shah *et al.*, 1990) have reported comparable outcomes. In general, pod size is a varietal character, yet it is additionally influenced by vigor of plant. More availability of nutrients particularly during pod formation and development stages of more vigorous pea varieties might have translocate most of its reserved food material towards pod formation and development (Arshad *et al.*, 1998; Ishtiaq *et al.*, 1996).

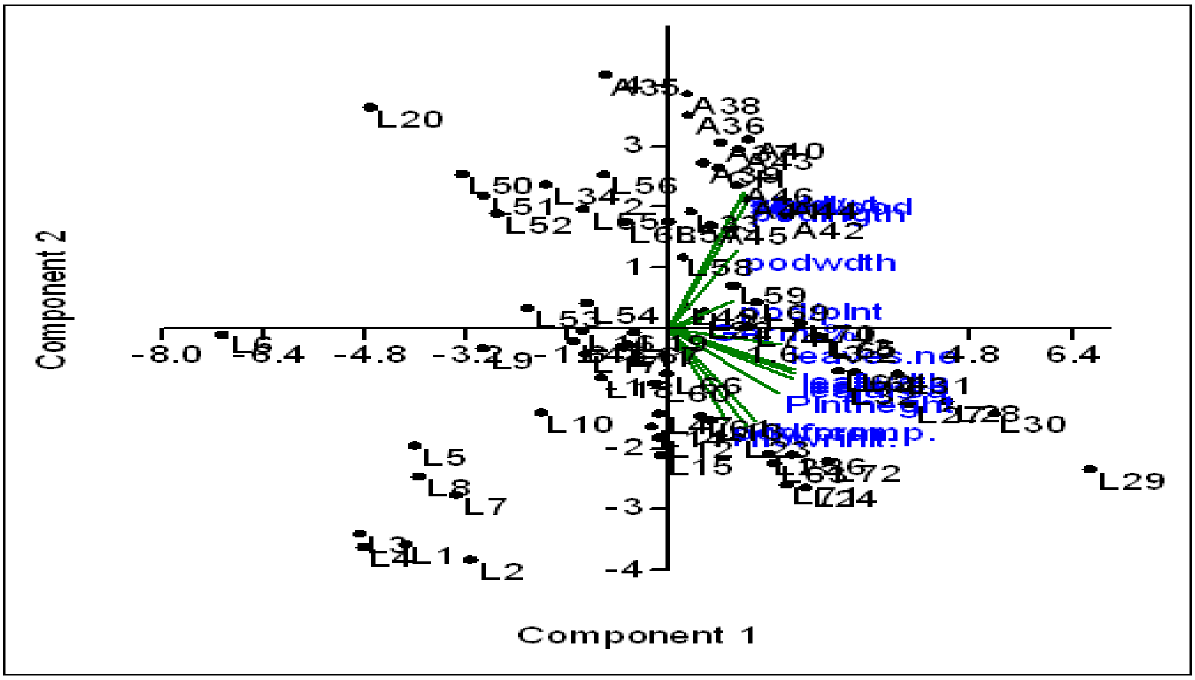

Fig. 3. Scatter Biplot diagram of 75 landraces of Peas on the basis of morphological characterization.

Pod width

Means values for leaf length ranged from 1-2.1 cm. All the landraces except L-1, L-3, L-4, L-6, L-7, L-8, L-11 and L-12 produced nearly the same pods width. The landraces L-1, L-3, L-4, L-6, L-7, L-8, L-11 and L-12 produced the minimum pods width (1cm).

In general, pod size is a varietal character, yet it is additionally influenced by vigor of plant. More availability of nutrients particularly during pod formation and development stages of more vigorous pea varieties might have translocation most of its reserved food material towards pod formation and development (Arshad *et al.*, 1998; Ishtiaq *et al.*, 1996).

Number of seeds per pod

Means values for seed per pod ranged from 4-8.Landraces L-35, L-36, L-37, L-38, L-39, L-40, L-41, L-42, L-43, L-44, and L-46excelled in seeds per pod (8.0) followed by L-11, L-12 and L-13 (7.0),whereas landraces L-1, L-2, L-3,and L-4 produced the lowest (4.0) number of seeds per pod. According to Makasheva, (1983)the number of seeds in a pod is variable depending upon the cultivar The number of seeds per pod depends mostly on the cultivar and on the natural conditions yet has additionally been recorded to be influenced by plant density.

The average number of seeds per pod was inversely related to plant population. These outcomes are similar to those of (Arshad *et al.*, 1998) who expressed that numbers of seeds are correlated with pod length. The more is the pod length, the more is number of seeds and vice versa. The environmental and genetic factors of different cultivars may have affected process of fertilization. Qasim *et al.* (2001). The number of seeds pod^{-1} is an important yield component and contributes to the final yield. Decrease in seeds pod^{-1} may result due to the genetic characteristics or environmental unsuitability, which may hinder the process of pollination, fertilization or cause abortion. The possible reason of less number of seeds per pod may be that environmental condition was not appropriate at the season of pollination and fertilization (Ali *et al.*, 2002).

100-Seed fresh weight (g)

Highly significant differences were also observed among landraces for 100- seed fresh weight. Maximum 100-seed fresh weight was noted in M-83 (29.6 g) followed by M-91 (28.3 g) and Check variety (28.2 g). L-2 gave minimum 100-seed fresh weight (12.0 g) followed by L-1 (12.3 g), L-4 (12.5 g) and L-3 (12.9 g). All other landraces remained intermediate in performance with respect to this trait. Different ecological conditions enable the seed to be filled to its genetic potential. With increased plants per area, each plant has fewer resources available which could convert into smaller seeds. In a few circumstances, plants can abort flower sites so that all fertile seeds can fill to larger sizes. The reduction in the number of pods per plant, seeds per pod and seed weight at the higher densities may be because of increased inter plant competition. The results suggest a strong relationship between source and sink and maximum translocation of food material from vegetative to reproductive portion in good environmental condition which cause higher seed weight (Ali *et al.*, 2002). The rate of acclimatization of genotypes may be considered the possible cause of this variation. Moreover, this variation might be due to genetic variability of different genotypes (Hatam and Amanullah, 2001).

Yield (kg/ha)

Highly significant variation in yield was observed among different landraces. Landraces M-83 had maximum yield (19.73 kg/ha) followed by M-25 and M-07 (18.13 kg/ha) and M-91 (18.8 kg/ha). Landraces L-2 produced minimum yield (8.0 kg/ha) followed by L-1 (8.2 kg/ha) L-4 (8.3 kg/ha) and L-3 and L-7 (8.6 kg/ha each). Yield is a complex character determined by the interaction of many heritable characters with soil, climate and agronomic conditions (Makasheva, 1983). Maximum yield requires maximum vegetative growth during crop establishment (Muehlbauer and McPhee, 1997). Higher number of leaves means more photosynthesis and ultimately more yield. Mor yields in various genotypes might be because of optimum plant survival, long and more number of seeds per pod, which eventually contributed altogether towards fina yield. The performance ofa cultivar mainly relies upon association of hereditary or genetic makeup and environmental condition. Therefore, these two factors provide an index for selection of cultivars for a specific locality. Similar results have also been reported by Ranalli *et al.* (1992) who observed that dissimilar cultivars varied in their yield competence. Warmer weather condition and storm cases must be responsible for lessening seed yield performance in the second experimental year because high temperature during flowering and pod formation reason for reduction in seed yield pea. Further, optimum temperature and comparative moisture through grain filling period might also be responsible for maximum translocation of photo integrates towards final end product. Positive association of grain yield with plant height, pods per plant and stem girth has also been observed under field or rained conditions by Hatam and Amanullah, (2001).

Simple correlation coefficient

Table 03 represents the correlation coefficients among all the quantitative traits. Yield was showing maximum positive and highly significant correlation with seed weight (1.000**). Leaf length was showing maximum positive and highly significant correlation with leaf width (0.994**) and leaf area (0.989**) followed by leaf area and leaf width (0.985**). Number of seed per pod was having positive and highly significant correlation with pod length (0.960**), seed weight (0.935**) and yield (0.934**), respectively followed by days to flower completion with days to flower initiation (0.923**). Pod length was showing maximum positive and highly significant correlation with seed weight and yield (0.912**). The plant height was showing highly significant and positively correlated with four characters which are: leaf area (0.831**), number of leaves (0.821**), days to flower completion (0.569**) and days to flower initiation (0.526**). Number of leaves was showing highly significant and positive correlation with the traits such as leaf length (0.798**), leaf width (0.781**) and leaf area (0.777**).A highly significant correlation was found between pod width with seed weight and yield (0.621**). Number of pods per plant has a positive significant correlation with leaf length (0.227*), leaf width (0.249*) and number of leaves (0.228*).Yield was correlated with two characters: leaf width (0.262*) and leaf length (0.239*).

This can be clarified by photosynthesis which is more critical when the size of stipules and leaflets are large, hence the yields are higher. Basaran *et al.* (2012) and Basaran *et al.* (2013) noted a strong correlation between leaflet length and weight of 100 seeds in grass pea. Number of seeds per pod was negatively correlated to weight of100 seeds.

A negative significant correlation between these two characters was found by Gatti *et al.* (2011). Stipule length and width leaflet length and width were correlated between themselves.

The same result was obtained by Gatti *et al.* (2011). Number of grain per pod was correlated positively and significantly with pod length. Ali *et al.* (2007) found also a significant positive correlation between these two characters.

Cluster analysis

Average linkage distance among pea's landraces

The dendrogram indicated the expected association among the Peas landraces. Dendrogram was created with computer software PAST, using seventy five landraces showed three main clusters I, II and III at linkage distance of near about 160. Cluster I includes two sub clusters I-A and I-B. Cluster I-A was comprised of 16 landraces namely L-3 and L-7, L-4 and L-5, L-1 and L-2, L-13 and L-15, L-12 and L-14, L-18 and L-19, L-8 and L-9 were correlating each other at same linkage distance. Genotypes Check and L-10 were outliers in this sub cluster (I-A) showing variability. Sub Cluster I-B was comprised of thirteen landraces. Landraces L-16 and L-20, L-53 and L-55, L-51 and L-52, L-16 and L-17, L-54 and L-56 were similar to each other in term of traits studies while landraces L-50, L-57 and L-34 were outliers for this cluster.

Cluster II was also comprised of two sub clusters II-A and II-B. Sub cluster II-A was comprised of two sub clusters II-A1 and II-A2. II-A1 was comprised of ten landraces M-102 and M-72, M-22 and M-79, M-39 and M-116, M-25 and M-91 that were present at same linkage distance while landraces M--83 and M-07 were outliers for this cluster. Sub sub cluster IIA-2 was comprised of 16 landraces, L-21 and L-22, L-66 and L-67, L-69 and L-74, L-48 and L-49, M-08 and L-58 were correlated to each other at same linkage distance whereas L-47, M-86 and L-33 were outliers for the cluster. While sub cluster II-B was containing 20 landraces from which only L-64, L-71, L-23 and L-24 were showing maximum variability and were outliers for the cluster. Landraces L-27 and L-28, L-31 and L-32, L-30 and L-29, L-62 and L-65, L-70 and L-73, L-63 and L-72, L-60 and L-61, L-25 and L-26 were significantly related to each other, respectively.

Average linkage distance among pea's traits based on morphological studies

The cluster analysis exposed as a dendrogram showed the predictable association among 15 Peas traits. Dendrogram was constructed with computer software PAST, using seventy five genotypes showed two main clusters I and II at linkage distance of near about 920. Cluster I was sub divided into two clusters I-A and I-B. I-A was comprised of Germination percentage and Flower completion whereas I-B was comprised of four traits; flower initiation and pod formation, plant height and number of leaves at same linkage distance. Cluster II was subdivided into two sub cluster II-A and II-B. Sub cluster II-A was comprised of three traits including pod per plant and yield at same linkage distance whereas seed weight was outlier in this cluster. Pod length and seed per pod, leaf length and leaf width were correlating each other for sub cluster II-B. Leaf area and pod width were outliers in this cluster**.**

Principal component analysis

Principal components analysis (PCA) has an ability to recognize and eliminate redundant data from experimental results. Using PCA, large number of available data is reduced, which results in different number of the new variables, so called principal components (PC). Principal component (PC) is in fact a linear combination of original variables.

In practice, it is usually sufficient to retain only a few principal components, whose sum includes large percentage of total variable.

There are three Eigenvalues higher than 1 in principal components. Three separated components showed cumulatively 78.53 % of total variability. The first of them accounts for 41.22%, the second for 27.52% and the third for 9.79% of all variations. The principal components (PC1 and PC2) account for 68.74 % of all variations of genotype characteristics. The maximum Eigen value was 6.18 while the minimum was 1.46.

Conclusion

Mean values for germination percentage ranged from 70% to 90%. Maximum value was recorded for M-25, M-102, M-91 and M-72 (90%). Maximum plant height (80 cm) was observed in genotype L-29 followed by L-30 (78 cm), L-28 (74 cm) and L-30 (75 cm). Maximum pods per plant were found in L-29 (18) followed by L-22, L-27, L-28, and L-30 (17.0). Means values for seed per pod ranged from 4-8. Landraces L-35, L-36, L-37, L-38, L-39, L-40, L-41, L-42, L-43, L-44, and L-46 excelled in seeds per pod (8.0) followed by L-11, L-12 and L-13 (7.0). Highly significant differences were also observed among landraces for 100- seed fresh weight. Maximum 100-seed fresh weight was noted in M-83 (29.6 g) followed by M-91 (28.3 g) and Check variety (28.2 g). Highly significant variation in yield was observed among different landraces. Landraces M-83 had maximum yield (19.73 kg/ha) followed by M-25 and M-07 (18.13 kg/ha) and M-91 (18.8 kg/ha). Genotypes Check, L-10, M—83, M-07, L-47, M-86 L-33, L-64, L-71, L-23 and L-24 were showing maximum variability and were outliers for the cluster. Knowledge obtained from morphological, biochemical and molecular characterization of populations of *Pisum sativum,* the present study could be used as a benchmark for future studies.

References

Akhter N. 2004. Morphological change of garden pea (Pisum sativum L.) under different reducing light level. M.Sc. Thesis, Dept. Crop Botany BSMRAU, Gagipur, Bangladesh.

Ali ST, Tekeli EA, Ates E. 2007. Yield and its components in field pea (Pisum arvense L.) lines. Journal of Central European Agriculture **4,** 313-317.

Ali I, Rub A, Ali S. 2002. Performance of pea germplasm for seed yield and yield components under Peshawar conditions. Sarhad Journal of Agriculture **18,** 39-43.

Arshad M, Hussain SA, Ali SAN, Muhammad N, Ziaullah. 1998. Screening of pea (Pisum sativum L.) cultivars in Kohat valley. Sarhad Journal of Agriculture **14,** 559-562.

Baginsky C, Faiguenbaum H, Krarup C. 1994. Pre and post-harvest evaluation of six pea cultivars. Horticultural Abstracts **64,** 70-81.

Basaran UH, Mut O, Asci Gulumser E, Acar Z, Ayan I. 2012. Variation in seed yield and morphological traits in Turkish grass pea (Lathyrus sativus L.) genotypes. Options méditerranéennes: serie A. Sémi-méditerranian **102,** 145-148.

Basaran U, Akar Z, Karacan M, Onar AN. 2013. Variation and correlation of morpho-agronomic traits and biochemical contents (protein and B-ODAP) in Turkish grass pea (Lathyrus sativus L.) landraces. Turkish Journal of Field Crops **18,** 166-173.

Castillo AG, Hampton 1G, Bear PC. 1992. Effect of time and method of harvest on seed vigour in garden peas (Pisum sativum L.). Journal of Applied Seed Production **10,** 31-36.

Ceyhan E, Avci MA. 2015. Determination of some agricultural characters of developed pea (Pisum sativum L.) lines. International Journal of Biology, Biomolecules, Agriculture and Food Biotechnology, p **9,** 12.

Gatti I, Esposito MA, Almiron P, Cravero VP, Cointry EL. 2011. Diversity of pea (Pisum sativum L.) accessions based on morphological data for sustainable field pea breeding in Argentina**.** Genetics and Molecular Research **10,** 3403-3410.

Habtamu S, Million F. 2013. Multivariate analysis of some Ethiopian field pea (Pisum sativum. L) genotypes. International Journal of Genetics and Molecular Biology **5,** 78-87.

Hatam M, Amanullah. 2001. Grain yield potential of garden peas (Pisum sativum L.) germplasm. Journal of Biological Sciences **1,** 242-244.

Hussain SA, Badshah N. 2002. Study on the adaptive behavior of exotic pea (Pisum sativum L.) varieties under local condition of Peshawar. Asian Journal of Plant Sciences **1,** 567-569.

Hussain SA, Hussain M, Qasim M, Hussain B. 2005. Performance and economic evaluation of pea varieties at two altitudes in Kaghan Valley. Sarhad Journal of Agriculture **21,** 587-589.

Ishtiaq M, Ahmad Z, Shah A. 1996. Evaluation of exotic cultivars of pea in Peshawar valley. Sarhad Journal of Agriculture **12,** 425-431.

Javaid Ghafoor A, Anwar R. 2002. Evaluation of local and exotic pea (Pisum sativum L.) germplasm for vegetative and dry grain traits. Pakistan Journal of Botany **34,** 419-427.

Khan TN, Ramzan A, Jillani G, Mehmood T. 2013. Morphological performance of peas (Pisum sativum L.) genotypes under rainfed conditions of potowar region. Journal of Agriculture Research **51,** 51-60.

Khokar KM, Khan MA, Hussain SI, Mahmoodand T, Rehman HU. 1998. Cooperative evaluation of some foreign and local pea cultivars. Pakistan Journal of Agricultural Research **9,** 549-551.

Lock M, Mackinder B, Schrirer B, Lewis G. 2005. Legumes of the World; Royal Botanical Gardens: Kew, UK.

Makasheva RK. 1983. The Pea. Oxonian Press Pvt. Ltd. New Delhi, India. p 78-107 .

Muehlbauer EJ, McPhee KE. 1997. Peas: In The Physiology .of Vegetable Crops (Ed. H.C. Wein). CAB International, Wallingford, UK. p 429–459.

Nawab NN, Subhani GM, Mahmood K, Shakil Q, Saeed A. 2008. Genetic variability correlation and path analysis studies in garden pea (Pisum sativum L.) Journal of Agricultural Research **46,** 333-340.

Qasim M, Zubair M, Wadan D. 2001. Evaluation of exotic cultivars of pea in Swat valley. Sarhad Journal of Agriculture **17,** 545-548.

Ranalli P, Giordano I, Ziliotto U, Lomabrcho GM, Pirami V, Lahoz E, Bcuonaccorso V, Talluri P, Bottozzi P, Lucque G, Rosoe D, Ruaro G, Casrini B, Re P. 1992. Yield potential of pea for dry seed in different Italian environments. Sementi Elette **38,** 15-43.

Santalla M, Amurrio JM, Ron AM. 2001. Food and feed potential breeding of green dry and vegetable pea germplasm. Canadian Journal of Plant Science **81,** 601-610.

Shah A, Lal SD, Shah A. 1990. Comparative performance of some pea cultivars under rainfed conditions of U.P. hills. Progressive Horticulture in India, **22,** 121-124.

Singh UP, Sarma BK, Singh DP, Bahadur A. 2002. Plant growth promoting rhizobacteria-mediated induction of phenolics in pea (Pisum sativum L.) after infection with Erysiphe pisi. Current Microbiology **44,** 396-400.

Solberg SO, Brantestam AK, Olsso K, Leino MW, Weibull J, Yndgaard F. 2015. Diversity in local cultivars of (Pisum sativum L.) collected from home gardens in Sweden. Biochemical System and Ecology **62,** 194-203.

SPSS. 1999. Base9.0 for Windows Users Guide. SPSS. Inc, USA.

Vance CP, Graham PH. 2003. Legumes: Importance and constraints to greater use. Plant Physiology **131,** 872–877.

Vocanson A, Jeuffroy MH. 2008. Agronomic performance of different pea cultivars under various sowing periods and contrasting soil structures. Journal of Agronomy **100,** 748-759.