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Performance of garden pea (*Pisum sativum* L.) genotypes for growth and yield characters at Dailekh, Karnali Province, Nepal

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ABSTRACT

Fourteen garden pea genotypes (13 improved genotypes and 1 was standard released variety) were evaluated for their morpho-agronomic characters, powdery mildew (PM) disease resistant, and yield performance. The genotypes were evaluated in randomized complete block design with three replications at Horticulture Research Station (HRS), Dailekh in 2018 and 2019. The results revealed that genotypes were significantly (P<0.01) different for pod length (cm), pod diameter (mm), green pod plant^{-1} (no.), green pod weight plant^{-1} (g), seed pod^{-1} (no.), dry pod plant^{-1} (no.), dry seed weight plant^{-1} (g), hundred seed weight (g) and seed yield (mt ha^{-1}) except days to 50% flowering, plant height (cm) and branch/plant (no.). Green pod weight was significantly (P<0.01) higher in genotypes HRSDGP-11-18-10 (233.1 g plant^{-1}) and HRSDGP-11-18-1 (224.1 g plant^{-1}) than Sikkim Local (198.3 g/plant). Genotypes HRSDGP-11-18-10, HRSDGP-11-18-13 and HRSDGP-11-18-1 showed moderate resistant (3.0) reaction to PM disease. Green pod weight plant^{-1} showed significant (P<0.01) positive correlation with seed number/plant (r=0.74**), dry pod number/plant (r=0.52**), dry seed weight (r=0.58**) and seed yield (r=0.57**). Genotypes HRSDGP-11-18-10, HRSDGP-11-18-1 and HRSDGP-11-18-13 showed 32.3%, 20.5% and 2.9% seed yield advantage over the standard variety, Sikkim Local. Based on this result, HRSDGP-11-18-10, HRSDGP-11-18-1 and HRSDGP-11-18-13 are selected as high yielding and PM resistant genotypes which can be used for commercial production as well as breeding lines for garden pea improvement program.

Keywords: Garden pea, growth, morpho-agronomic characters, powdery mildew, yield

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INTRODUCTION

Pea (*Pisum sativum* L.) is an important crop of Leguminoseae family and it is the third largest family of flowering plants having more than 450 genera, and over 1200 species. The genus *Pisum* is comprised of five species: *P. fulvum*, *P. abyssinicum*, *P. sativum* L., *P. humile* and *P. elatius*. Among these 5 species *P. sativum* L. is cultivated (Verhinin et al 2003). Pea is predominantly found in Mediterranean region and West Asia. Pea (*P. sativum* L.) is the third most widely grown legume crop in the world (Smykal et al 2011). *P. sativum* is a short-lived, herbaceous annual plants which climbs by leaflet tendrils. In Nepal, it is grown in winter in terai, autumn in mid hills and summer in high hills (Poon et al 2004). In general, immature fresh pod is consumed as green vegetables while dry seeds are commonly used to prepare

curry and soups. Dry seeds are also used to prepare pickles in household and hotels. Garden pea is an important income generating crop particularly for farmers of mid and high hills. Pea is a short duration crop and fits in crop rotation, and it enriches the soil fertility by fixing atmospheric nitrogen into the soil.

In Nepal, pea covers about 8,275 ha of the total arable land with the total production of 72,557 mt and productivity of 8.7 mt ha^{-1}. However, it is limited in 512 ha with a total production of about 4,333 mt and productivity of 8.4 mt ha^{-1} in Karnali Province (MoALD 2019). These data suggesting that there is huge potentiality to grow pea in Karnali Province. There are many constraints for further scaling up and sustainable production of pea in Nepal such as lack of high yielding, early maturing, powdery mildew resistant and smooth seeded variety (Luitel et al 2021). Powdery mildew caused by *Erysiphe pisi*, a fungus is one of the serious diseases in pea which is characterized by a white powdery coating on surface of leaves, stems and pods (Kazmi et al 2002). Powdery mildew reduces the yield up to 47% (Munjal et al 1963, Nisar et al 2006) and it also reduces the seed quality. Use of resistant cultivars is the effective and economically best approach to control powdery mildew disease (Janila et al 2001). Analysis of correlation co-efficient among the yield traits is necessary to know the direction of selection and enhance the yield of genotypes. Correlation among the quantitative traits in garden pea genotypes was studied by previous researchers (Pandey et al 2017, Luitel et al 2021).

HRS, Dailekh has received the mandate of pea research in Karnali Province, thus has been collecting different pea genotypes, developing breeding lines and evaluating for high yield, earliness, and resistant variety to powdery mildew since 2010 (ARS 2014). Earlier, two pea varieties, Sikkim Local and Sarlahi Arkel were released from Nepal Agricultural Research Council (CPDD 2014). However, these two varieties could not appropriately fulfill the demand of pea growers. High yielding, earliness and powdery mildew resistant varieties are the present needs of pea growers (Luitel et al 2021). Pea genotypes developed at research station may perform differently under different agro-climatic condition. Cultivars of same species grown even in same environment have differences in the yield (Bairwa et al 2018). Yield is a complex character which depend on genetic and environmental factors (Singh 1990). In the past, studies were carried out in the evaluation of different pea genotypes in Nepal (Poon et al 2004, Poudel et al 2017 and Luitel et al 2021), still the selection of pea genotypes with regard to powdery mildew disease and yield have not been undertaken. Therefore, the present study was conducted to select high yielding and powdery mildew resistant pea genotypes under the sub-tropical climatic condition at Dailekh, Karnali Province.

MATERIALS AND METHODS

Location and climate of research site

Field experiments were conducted in Horticulture Research Station, Dailekh. The area is located on 28°50'49.8"N latitude and 81°43'19.4"E longitude and 1, 255 m altitude from the sea level and belongs to sub-tropical climatic region. Mean temperature varied from 7.7°C (January) to 24.3 °C (July), and annual rainfall recorded was above 150 mm and relative humidity ranged from 72.5 (December) to 92.5 % (August) (HRS, 2020). The soil is clay loam type with slight acidic. In 2018-2019, maximum temperature during the cropping

season (October-April) ranged from 18.4˚C (Jan.) to 28.0˚C (April) but in 2019-2020, it

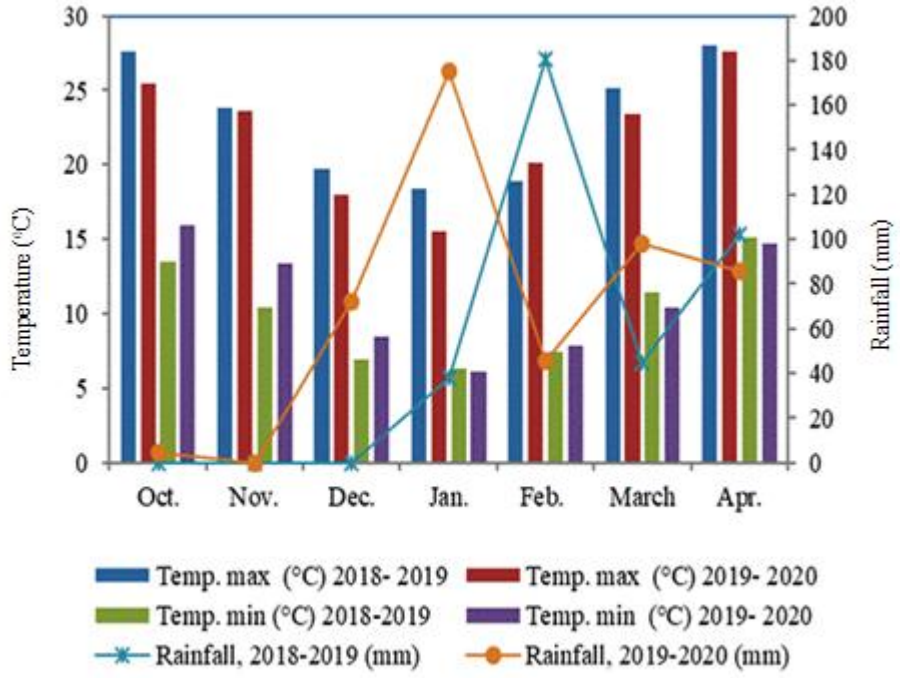

Figure 1. Temperature and rainfall in the production season (October-April) of Garden pea at HRS, Dailekh during 2018-2019 and 2019-2020

ranged from 15.5˚C (Jan.) to 27.6˚C (April). Minimum temperature was the lowest in Jan.-Feb in both years but rainfall distribution was inconsistent in the both years (Figure 1).

Plant materials and field experiments

A total of 40 garden pea genotypes developed from the crossing in 2011 were evaluated in Preliminary Yield Trial (PYT) at HRS Dailekh in 2016 and 2017 for PM resistance and yield characters. Based on PM and yield characters, 13 genotypes were selected for Coordinated Varietal Trial (CVT) to evaluate them at on-station. Genotypes 1.5 (B), 1.5 (C), 2.2 (A), 2.3 (B), 2.4 (D), 2.6 (B), 2.7 (C), 3.1 (A), 4.1 (B), 6.1 (B), 6.5 (A), 6.6 (B), and 6.6 (D) were nomenclatured as HRSDGP-11-18-1, HRSDGP-11-18-2, HRSDGP-11-18-3, HRSDGP-11-18-4, HRSDGP-11-18-5, HRSDGP-11-18-6, HRSDGP-11-18-7, HRSDGP-11-18-8, HRSDGP-11-18-9, HRSDGP-11-18-10, HRSDGP-11-18-11, HRSDGP-11-18-12, and HRSDGP-11-18-13, respectively. Where 'HRS' stands for 'Horticulture Research Station', 'DGP' stands for 'Dailekh Garden Pea', 11 stands for 'crossing year 2011', 18 stands for 'selection year' and remaining 1, 2, and 3…. stands for 'the genotype number'. These 13 indeterminate pea genotypes were further evaluated with standard check variety 'Sikkim Local' for plant, PM disease and yield characters. Experimental field was tilted, pulverized and leveled. Seeds were sown manually by placing two seeds per hill and thinned after emergence to maintain plant population. Seeds were sown in October 14, 2018 and 2019. The inter- and intra-row spacing was maintained at 75 cm and 10 cm, respectively and the experiments was laid out in a randomized complete block design (RCBD) with three replications. Total 24 plants were maintained at each plot and plot size was maintained at 4.5 m^2. Fertilizer was applied at the rate of 30:40:40 kg ha^{-1} $NP_2O_5K_2O$ and well-rotten farmyard manure was applied at the rate of 15 mt ha^{-1}. Full amount of phosphorous, potassium and half amount of nitrogen was applied at planting time and remaining half amount of nitrogen was applied through urea after 40 days of emergence as side dressing. Crop management practices were carried out as desired during crop growing period.

Data collection and analysis

Out of the four rows, two rows (or 12 plants) were used to record plant and green pod yield characters, and PM and grain yield were recorded in remaining two rows. Days to 50% flowering was recorded when 50% of the plant population in each plot produce flower. Plant height (cm) at physiological maturity was measured in five plants from the ground level to the tip of the longest branch and averaged it. Number of branches plant^{-1} was counted at first pod maturity stage. Green pod was first harvested on March 17th for both years (2019 and 2020) and additional two harvests were done for green pod. The numbers of green pods and yield were recorded at commercial maturity stage from five randomly selected plants. The average length (cm) and diameter (mm) of pod was measured at commercial maturity stage using scale and vernier caliper, respectively. For PM, the diseased area represents colonies on the upper surface of pea leaflets. Disease areas were drawn to cover 0, 5, 10, 15, 20, 33, 46, 60, 73, 86, and 100% of leaf surface which corresponds 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 score (Fallon et al 1995). In general, 0 represents highly resistant (no disease symptoms), 2 = resistant, 3 and 4 = moderately resistant and above 5 was considered as susceptible to PM. Five readings were taken on March 26th in both years (2019 and 2020) at each plot for powdery mildew and averaged it. Dry pod was harvested first in April 10th for both years (2019 and 2020) and two more additional harvests were done. The number of seeds were counted for each pod of the five plants at physiological maturity and averaged over the number of pods. The seed yield plant^{-1} (g) was measured on five plants at physiological maturity. The weight of 100 seeds was selected randomly from five plants plot^{-1} and averaged it. Seed yield (g) of each plant was measured on clean, dried seed and the measured seed yield value (g) was converted to mt ha^{-1} for analysis. Seed shape, surface and color were recorded as described by Santos et al (2019). The data were processed and analyzed using GenStat Release 10.3 DE Software (VSN International Ltd.). Pearson's correlation coefficient of characters was done by IBM SPSS Statistics (Version 19). To find influence of genotypes on plant and yield characters, analysis of variance (ANOVA) and LSD test were used for any significant differences at the P<0.05 level between the means.

RESULTS

ANOVA on plant and green pod characters

Genotypes showed highly significant (P<0.01) differences in plant height, branch number plant^{-1}, pod length, pod diameter, green pod number plant^{-1}, and green pod weight plant^{-1} (Table 1). Year affected significantly on days to fifty percent flowering, plant height, branch number plant^{-1}, and pod length but it showed non-significant effect in pod diameter, green pod plant^{-1} and green pod weight plant^{-1}. Interaction of genotype and year showed significant effect on pod length but it showed non-significant in remaining traits.

Table 1. Mean square value of plant and green pod characters of Garden pea genotypes for combined analysis of variance over two years (2018 and 2019)

Source of variation	DF	DFFL	PHT	BPPNT	POD	PD	GPP	GPWT
Genotypes (G)	13	97.99^{ns}	1895.0^{ns}	0.77^{ns}	2.03**	7.53**	1437.7**	9244.0**
Year (Y)	1	10142.01**	47576.0**	16.29**	9.07**	0.28^{ns}	616.8^{ns}	8080.0^{ns}
G x Y	13	77.27^{ns}	554.0^{ns}	0.38^{ns}	0.36*	1.20^{ns}	336.2^{ns}	4340.0^{ns}
Error	54	63.34	1163.0	0.47	0.17	1.15	219.1	2431.0

ns; non-significant; *P<0.05, **P<0.01, DF; Degree of freedom, DFFL; Days to 50% flowering, PHT; Plant height (cm), BPPNT; Branch plant^{-1} (no.), POD; Pod length (cm), PD; Pod diameter (mm), GPP; Green pod plant^{-1} (no.), and GPWT; Green pod weight plant^{-1} (g)

ANOVA on powdery mildew and seed yield characters

Genotypes affected significantly (P<0.05) in powdery mildew but it exhibited highly significant (P<0.01) differences in seed number pod^{-1}, dry pod number plant^{-1}, dry seed weight, hundred seed weight and seed yield (Table 2). Year showed highly significant (P<0.01) difference in powdery mildew, hundred seed weight, and seed yield. The interaction between genotype and year showed non-significant effect in all the traits.

Table 2. Mean square value of powdery mildew and seed yield of Garden pea genotypes for combined analysis of variance over two years (2018 and 2019)

Source of variation	DF	PM	SPP	DPP	DSWT	HSWT	SYLD
Genotypes (G)	13	3.40*	1.29**	1071.3**	769.5**	84.68**	2.27**
Year (Y)	1	39.77**	0.28 ^{ns}	979.8 ^{ns}	49.6 ^{ns}	94.01**	5.13*
G x Y	13	0.97 ^{ns}	0.57 ^{ns}	274.4 ^{ns}	162.2 ^{ns}	9.93 ^{ns}	0.45 ^{ns}
Error	54	2.11	0.39	352.4	179.6	7.63	0.54

ns; non-significant, *P<0.05, **P<0.01. DF; Degree of freedom, PM; Powdery mildew (1-10 score), SPP; Seed pod^{-1} (no.), DPP; Dry pod plant^{-1} (no.), DGWT; Dry seed weight plant^{-1} (g), HGWT; Hundred seed weight (g), and SYLD; Seed yield (mt ha^{-1}).

Plant and green pod yield characters

Days to 50% flowering and plant height were non-significant (P<0.05) but genotypes affected significantly in branch number plant^{-1}, pod length, pod diameter, green pod number plant^{-1}, and green pod weight plant^{-1}. Year showed non-significant effect in number of branch plant^{-1}. Genotypes HRSDGP-11-18-3, HRSDGP-11-18-5, HRSDGP-11-18-9 and HRSDGP-11-18-10 exhibited the highest (4.0 plant^{-1}) number of branch. The combined result showed the longest pod (8.5 cm) in HRSDGP-11-18-7 but it was statistically similar to HRSDGP-11-18-8 (8.4 cm) and HRSDGP-11-18-13 (8.3) and the shortest pod length (6.9 cm) was measured in HRSDGP-11-18-4, HRSDGP-11-18-5, HRSDGP-11-18-6, HRSDGP-11-18-7 and HRSDGP-11-18-10 (Table 3).

Green pod yield characters and PM disease

The pooled analysis showed the highest pod diameter (14.2 mm) in genotypes HRSDGP-11-18-9 and HRSDGP-11-18-13 but the lowest (10.6 mm) was measured in HRSDGP-11-18-10. Higher number of green pod (56.3 plant^{-1}) produced in 2018 than in 2019. Number of green pod harvested the highest (82.0 plant^{-1}) in HRSDGP-11-18-10 and the lowest (31.0 plant^{-1}) number was harvested in HRSDGP-11-18-8. In contrast, average green pod weight was produced higher (185.4 g plant^{-1}) in 2019 than in 2018. Green pod weight produced the highest (233.1 g plant^{-1}) in HRSDGP-11-18-10 followed by HRSDGP-11-18-1 (224.1 g plant^{-1}) and the lowest pod weight (114.2 g plant^{-1}) was harvested in HRSDGP-11-18-9. Significant (P<0.05) differences in PM disease were observed in garden pea genotypes. Except HRSDGP-11-18-2 and HRSDGP-11-18-3, all the genotypes showed moderate resistant (3 to 4 score) reaction to PM disease (Table 4).

Seed yield characters

Pooled analysis showed that genotypes HRSDGP-11-18-3 and HRSDGP-11-18-7 produced the highest seed number (7.0 pod^{-1}) but genotypes HRSDGP-11-18-8 and Sikkim Local contained the lowest seed number (5.0 pod^{-1}). Significantly higher (58.7 plant^{-1}) pod number was observed in 2019 than in 2018. The highest dry pod number (83.0 plant^{-1}) was recorded in HRSDGP-11-18-1 which was statistically at par with HRSDGP-11-18-10 (80.0 plant^{-1}) and HRSDGP-11-18-13 (61.0 plant^{-1}) and the least pod number was counted in HRSDGP-11-18-8 (37.0 plant^{-1}). Dry seed produced the highest (78.3 g plant^{-1}) in HRSDGP-11-18-10 and the lowest dry seed weight produced in HRSDGP-11-18-8 (38.1 g plant^{-1}). Hundred seed weight measured the highest (31.7 g) in HRSDGP-11-18-8 which was statistically similar to Sikkim Local (28.8 g) but the lowest hundred seed weight (17.1g) was measured in HRSDGP-11-18-5 (Table 5).

Table 3. Means of plant and green pod yield characters of Garden pea genotypes for combined analysis of variance over two years (2018 to 2019)

Pea genotypes	DFFL		Combined	PHT (cm)		Combined	BPPNT (no.)		Combined	POD		Combined
	2018	2019		2018	2019		2018	2019		2018	2019	
HRSDGP-11-18-1	64.0	75.0	70.0	230.0	184.0	206.0	3.0	3.0	3.0	7.4	7.4	7.4
HRSDGP-11-18-2	64.0	93.0	78.0	253.0	198.0	225.0	2.0	4.0	3.0	7.6	7.5	7.5
HRSDGP-11-18-3	68.0	92.0	80.0	247.0	216.0	231.0	3.0	4.0	4.0	7.5	7.4	7.5
HRSDGP-11-18-4	69.0	88.0	78.0	235.0	172.0	204.0	2.0	4.0	3.0	7.5	6.4	6.9
HRSDGP-11-18-5	64.0	95.0	79.0	218.0	205.0	211.0	3.0	4.0	4.0	7.4	6.4	6.9
HRSDGP-11-18-6	68.0	84.0	76.0	249.0	162.0	207.0	3.0	3.0	3.0	7.1	6.8	6.9
HRSDGP-11-18-7	74.0	93.0	84.0	273.0	222.0	248.0	2.0	3.0	3.0	8.9	8.1	8.5
HRSDGP-11-18-8	55.0	85.0	70.0	239.0	195.0	217.0	2.0	3.0	3.0	9.3	7.5	8.4
HRSDGP-11-18-9	64.0	95.0	80.0	236.0	215.0	226.0	3.0	4.0	4.0	8.7	7.5	8.1
HRSDGP-11-18-10	65.0	83.0	74.0	219.0	151.0	185.0	3.0	4.0	4.0	7.3	6.4	6.9
HRSDGP-11-18-11	63.0	91.0	77.0	262.0	207.0	234.0	2.0	3.0	3.0	8.2	7.7	7.9
HRSDGP-11-18-12	68.0	87.0	78.0	273.0	218.0	246.0	2.0	4.0	3.0	8.3	7.7	8.0
HRSDGP-11-18-13	69.0	79.0	74.0	228.0	193.0	210.0	3.0	3.0	3.0	8.5	8.1	8.3
Sikkim Local (Check)	70.0	92.0	81.0	256.0	214.0	235.0	3.0	3.0	3.0	8.3	7.7	7.9
Grand Mean	66.0	88.0	76.99	244.0	196.4	220.0	2.50	3.37	2.93	7.99	7.33	7.66
F-Test			ns			ns			*			**
LSD (0.05)			9.212			39.47			0.799			0.488
CV (%)			10.3			15.5			23.5			5.5

ns; non-significant, *P<0.05, ** P<0.01, DFFL; Days to 50% flowering, PHT; Plant height (cm), BPPNT; Branch plant^{-1} (no.), POD; Pod length (cm).

Table 4. Means of green pod yield characters and powdery mildew disease reaction of Garden pea genotypes for combined analysis of variance over two years (2018 and 2019)

Pea genotypes	PD (mm)		Combined	GPP (no.)		Combined	GPWT (g)		Combined	PM (0-10 score)		Combined
	2018	2019		2018	2019		2018	2019		2018	2019	
HRSDGP-11-18-1	12.4	12.4	12.4	67.0	78.0	72.0	178.9	269.3	224.1	4.0	3.0	4.0
HRSDGP-11-18-2	12.4	12.3	12.4	55.0	56.0	55.0	196.1	243.0	219.6	5.4	3.6	5.0
HRSDGP-11-18-3	12.7	12.5	12.6	61.0	63.6	62.0	150.7	270.7	210.7	6.3	4.0	5.0
HRSDGP-11-18-4	11.9	10.9	11.5	51.0	38.4	45.0	130.4	123.5	127.0	2.9	2.3	3.0
HRSDGP-11-18-5	10.8	11.4	11.1	70.0	58.0	64.0	136.9	164.5	150.7	3.6	3.3	4.0
HRSDGP-11-18-6	11.2	11.1	11.1	65.0	47.0	56.0	155.5	159.3	157.4	4.6	3.0	4.0
HRSDGP-11-18-7	12.1	12.4	12.2	39.0	44.0	41.0	160.2	167.6	163.9	4.3	3.0	4.0
HRSDGP-11-18-8	12.5	13.7	13.1	30.0	32.0	31.0	133.5	121.4	127.5	5.6	2.3	4.0
HRSDGP-11-18-9	13.9	14.5	14.2	49.0	20.0	34.0	142.8	85.6	114.2	3.9	2.3	3.0

HRSDGP-11-18-10	10.8	10.3	10.6	82.0	83.0	82.0	194.2	271.9	233.1	3.0	3.0	3.0
HRSDGP-11-18-11	12.4	11.9	12.2	67.0	28.0	48.0	197.1	145.8	171.4	4.6	3.0	4.0
HRSDGP-11-18-12	12.7	13.1	12.9	39.0	40.0	39.0	139.8	174.0	156.9	3.4	2.0	3.0
HRSDGP-11-18-13	13.0	15.3	14.2	75.0	70.0	72.0	227.6	179.6	203.6	3.4	2.0	3.0
Sikkim Local (Check)	14.3	13.0	13.6	41.0	54.0	48.0	177.1	219.6	198.3	3.2	2.0	3.0
Grand Mean	12.3	12.4	12.43	56.3	50.9	53.6	165.8	185.4	175.6	4.16	2.79	3.47
F-Test			**			**			**			*
LSD (0.05)			1.24			17.13			57.07			1.48
CV (%)			8.7			27.6			28.1			24.1

*P<0.05, ** P<0.01, GPP; Green pod plant^{-1} (no.), GPWT; Green pod weight plant^{-1} (g), PM; Powdery mildew (0-10 score), 0; highly resistant (no disease symptoms), 2; resistant, 3 and 4; moderately resistant, and >5; susceptible

Table 5. Means of grain yield characters of Garden pea genotypes for combined analysis of variance over two years (2018 and 2019)

Pea genotypes	SPP (no.)		Combined	DPP (no.)		Combined	DSWT (g)		Combined	HSWT (g)		Combined
	2018	2019		2018	2019		2018	2019		2018	2019	
HRSDGP-11-18-1	6.0	6.0	6.0	68.0	97.0	83.0	68.9	73.2	71.0	24.1	22.0	23.8
HRSDGP-11-18-2	6.0	6.0	6.0	50.0	53.0	51.0	50.3	49.7	50.0	21.8	25.0	23.4
HRSDGP-11-18-3	6.0	7.0	7.0	60.0	58.0	59.0	58.5	56.2	57.3	22.7	20.6	21.6
HRSDGP-11-18-4	6.0	6.0	6.0	55.0	37.0	46.0	47.1	56.7	51.9	23.8	19.7	21.7
HRSDGP-11-18-5	6.0	6.0	6.0	53.0	62.0	58.0	53.8	39.9	46.8	22.4	22.3	22.4
HRSDGP-11-18-6	6.0	6.0	6.0	57.0	62.0	59.0	47.2	49.8	48.5	18.9	15.3	17.1
HRSDGP-11-18-7	7.0	6.0	7.0	39.0	36.0	38.0	43.1	42.6	42.8	22.4	23.3	22.9
HRSDGP-11-18-8	5.0	5.0	5.0	33.0	41.0	37.0	37.0	39.1	38.1	34.7	28.7	31.7
HRSDGP-11-18-9	5.0	7.0	6.0	43.0	51.0	47.0	38.0	45.1	41.6	31.6	27.3	29.5
HRSDGP-11-18-10	6.0	6.0	6.0	68.0	92.0	80.0	74.9	81.7	78.3	24.9	22.7	23.8
HRSDGP-11-18-11	7.0	6.0	6.0	49.0	57.0	53.0	48.8	49.5	49.2	23.7	22.0	22.9
HRSDGP-11-18-12	5.0	6.0	6.0	41.0	70.0	56.0	38.5	64.6	51.5	26.7	27.0	26.8
HRSDGP-11-18-13	7.0	6.0	6.0	66.0	57.0	61.0	73.9	55.6	64.7	25.3	23.0	24.1
Sikkim Local (Check)	5.0	6.0	5.0	45.0	48.0	47.0	56.4	54.2	55.3	31.6	26.0	28.8
Grand Mean	5.80	5.9	5.86	51.9	58.7	55.30	52.6	54.10	53.40	25.3	23.2	24.27
F-Test			**			**			**			**
LSD (0.05)			0.728			21.73			15.51			3.19
CV (%)			10.7			34.0			25.1			11.4

** P<0.01, SPP; Seed pod^{-1} (no.), DPP; Dry pod plant^{-1} (no.), DSWT; Dry seed weight plant^{-1} (g), and HSWT; Hundred seed weight (g)

Seed yield and quality characters

Seed yield showed highly significant (P<0.01) differences among the genotypes. The highest seed yield was recorded in HRSDGP-11-18-10 (4.5 mt ha^{-1}) which showed statistically similar to HRSDGP-11-18-1 (4.1 mt ha^{-1}) and HRSDGP-11-18-13 (3.5 mt ha^{-1}) and the lowest seed yield (2.3 mt ha^{-1}) was in HRSDGP-11-18-9. Most of studied genotypes contained ellipsoid seed shape except HRSDGP-11-18-13 (rhomboid). HRSDGP-11-18-13 contained rough seed surface and remaining genotypes had smooth surface. Seed color varied from yellow green, light green, cream yellow, dark green, green to light green (Table 6).

Table 6. Seed yield and seed quality characters of Garden pea genotypes for combined analysis of variance over two years (2018 and 2019)

Pea genotypes	SYLD (mt ha^{-1})		Combined	SSH	SS	SC
	2018	2019				
HRSDGP-11-18-1	4.3	3.9	4.1	E	S	YG
HRSDGP-11-18-2	3.4	2.6	3.0	E	S	LG
HRSDGP-11-18-3	3.8	2.9	3.4	E	S	LG
HRSDGP-11-18-4	3.8	3.0	3.4	E	S	YG
HRSDGP-11-18-5	3.6	2.1	2.8	E	S	LG
HRSDGP-11-18-6	3.1	2.7	2.9	E	S	LG
HRSDGP-11-18-7	2.8	2.3	2.6	E	S	YG
HRSDGP-11-18-8	2.4	2.1	2.3	E	S	YG
HRSDGP-11-18-9	2.5	2.4	2.5	E	S	CY
HRSDGP-11-18-10	4.4	4.5	4.5	E	S	DG
HRSDGP-11-18-11	3.3	2.6	2.9	E	S	G
HRSDGP-11-18-12	2.6	3.4	3.0	E	S	G
HRSDGP-11-18-13	3.7	3.3	3.5	Rh	R	YG
Sikkim Local (Check)	3.9	2.8	3.4	E	S	LG
Grand Mean	3.42	2.92	3.17	E	S	YG
F-Test			**	E	S	LG
LSD (0.05)			0.855			
CV (%)			23.3			

** P<0.01, SYLD; Seed yield (mt ha^{-1}) SSH; Seed shape; E; Elliptical, Rh; Rhomboid, SS; Seed surface; S; Smooth, R; Rough; SC; Seed color, YG; Yellow green, LG; light green, CY; Cream yellow, G; green, DG; Dark green

Correlation among the phenotypic traits

Days to 50% flowering exhibited positive significant (P<0.01) correlation with branch number $plant^{-1}$ (r=0.48**), but it showed moderate significant (P<0.01) negative correlation with powdery mildew (r=-0.42**) and seed yield (r=-0.35**). Plant height showed moderate significant (P<0.01) positive correlation with pod length (r=0.47**) but negative significant (P>0.01) positive correlation (r=-0.46**) was found between branch number $plant^{-1}$ and pod length. Pod length was positively correlated with pod diameter (r=0.52**), and hundred seed weight (r=0.48*). Green pod $plant^{-1}$ had highly significantly (P<0.01) positively correlated with green pod weight $plant^{-1}$ (r=0.74**), dry pod number $plant^{-1}$ (r=0.52**), dry seed weight $plant^{-1}$ (r=0.58**) and seed yield (r=0.57**). Green pod weight $plant^{-1}$ showed significant (P<0.01) positive correlation with seed number $plant^{-1}$ (r=0.40**), dry pod number $plant^{-1}$ (r=0.51**), dry seed weight (r=0.64**) and seed yield (r=0.50**). Seed number pod^{-1} showed positive association with seed yield (r=0.54**). Likewise, dry pod number $plant^{-1}$ showed significant (P<0.01) positive association with dry seed weight (r=0.74**) and yield (r=0.67**). Dry seed weight showed highly significant strong positive association with seed yield (r=0.89**) (Table 7).

Table 7. Pearson's correlation coefficient among phenotypic traits of Garden pea genotypes during the years 2018 and 2019

Variables	DFFL	PHT	BRNPP	PL	PD	GPPT	GPWT	PM	SPP	DPPT	DSWT	HSWT	SYLD
DFFL	1.0	-0.38**	0.48**	-0.36**	-0.09	-0.23*	-0.01	-0.42**	0.05	-0.07	-0.15	-0.24	-0.35**
PHT		1.0	-0.30**	0.47**	0.25*	0.05	0.05	0.28**	0.12	0.21	-0.04	0.23*	0.15
BRNPP			1.0	-0.46**	-0.13	0.07	0.12	0.23*	0.05	0.18	0.14	-0.20	-0.02
PL				1.0	0.52**	-0.15	-0.02	0.19	-0.03	-0.24*	-0.13	0.48*	-0.02
PD					1.0	-0.10	0.03	-0.13	0.01	-0.14	-0.08	0.29**	-0.09
GPPT						1.0	0.74**	0.19	0.33**	0.52**	0.58**	0.15	0.57**
GPWT							1.0	-0.43**	0.40**	0.51**	0.64*	-0.08	0.50**
PM								1.0	0.06	-0.01	0.01	0.02	0.11
SPP									1.0	0.24*	0.55*	-0.34*	0.54**
DPPT										1.0	0.74**	0.04	0.67**
DSWT											1.0	0.06	0.89**
HSWT												1.0	0.06
SYLD													1.0

* P<0.05, **P<0.01; DFFT; Days to 50% flowering, PHT; Plant height (cm), BRNPP; Branch plant^{-1} (no.); PL; Pod length (cm); PD; Pod diameter, GPPT; Green pod plant^{-1} (no.), GPWT; Green pod weight plant^{-1} (g), PM; Powdery mildew, SPP; Seed pod^{-1} (no.), DPPT; Dry pod plant^{-1} (no.), DSWT; Dry seed weight plant^{-1} (g), HSWT; Hundred seed weight (g), and SYLD; Seed yield (mt ha^{-1})

DISCUSSION

In this study, pea genotypes exhibited highly significant differences in pod characters and pod weight. Significant differences in pod characters in different pea genotypes were also reported by previous researchers (Poudel et al 2017; Lakic et al 2017 and Luitel et al 2021). However, year affected only on days to fifty percent flowering, plant height, branch number plant^{-1} and pod length. This might be due to changing weather condition in the both years (Figure 1). Minimum temperature was higher until February in 2019-20 than in 2018-19. Rainfall in 2019 was consistently increased from November to January. In contrast, meager amount of rainfall was observed until January in 2018 and it was then increased until February. Genotypes exhibited the significant variation in PM, seed number pod^{-1}, dry pod number plant^{-1}, dry seed weight plant^{-1} and seed yield. Ofga (2019) had also reported the variability in morphological traits in field pea varieties. In contrast, year affected significantly on powdery mildew disease scoring, hundred seed weight and seed yield. Variation in temperature and rainfall in both years might influence the powdery mildew disease in the pea genotypes. Generally, high temperature and humid condition (more than 70% relative humidity) favors the powdery mildew outbreak during pod filling and maturation stage and in this study, temperature in March and April was higher in 2018-19 than 2019-20 which tend to be the cause of significant differences in powdery mildew disease in pea genotypes. Atiq et al (2016) had reported that PM disease incidence increased with increased air temperature in pea. In addition, warm temperature and humidity more than 70% in late season during flowering and pod filling stage favors powdery mildew disease development (https://agriculture.vic.gov.au).

Significant variation in branch number plant^{-1}, pod length, pod diameter, green pod number plant^{-1}, and green pod weight plant^{-1} observed in garden pea genotypes. We reported the highest green pod yield (233.1 g plant^{-1}) whereas Ei-dakkak (2016) reported the maximum green pod yield (215.3 g plant^{-1}). Differences in green pod yield in pea genotypes were also reported by many researchers (Khichi et al 2017, Poudel et al 2017, Din et al 2019 and Luitel et al 2021). Significant differences in PM disease, seed number pod^{-1}, dry pod number plant^{-1}, dry seed weight plant^{-1}, hundred seed weight and seed yield were observed in pea genotypes (Table 4, Table 5, and Table 6). Phenotypic variation in pod number plant^{-1}, 100 seed weight and seed yield plant^{-1} had also been reported by Kumar et al (2013). We found the maximum pod number (83.0 plant^{-1}) in genotype HRSDGP-11-18-1 but Haridy et al (2019) reported the maximum number (64.8 plant^{-1}) of pods in Dwarf Gray Sugar. Bairwa et al (2018) reported the highest seed yield (5.3 mt ha^{-1}) in P-89 genotype but our study found the highest seed yield in HRSDGP-11-18-10 (4.5 mt ha^{-1}) and HRSDGP-11-18-1 (4.1 mt ha^{-1}) (Table 6). Haridy et al (2019) reported the highest seed yield (1.4 mt ha^{-1}) in Master B cultivar. Seed shape, surface and seed color varied in pea genotypes and these traits depend on genetic make-up of the cultivar.

Traits including green pod number plant^{-1}, green pod weight plant^{-1}, seed number pod^{-1}, dry pod number plant^{-1} and dry seed weight plant^{-1} showed significant positive association with seed yield (Table 7). This result indicates that as number of green pod plant^{-1} increases, seed yield plot^{-1} also increases. Significant positive association between pod number plant^{-1} and seed yield plant^{-1} was reported by Kumar et al (2013). Significant positive correlation between green pod plant^{-1}, greed pod weight plant^{-1}, seeds pod^{-1} and seed yield was reported by previous researchers (Pandey et al 2017, Luitel et al 2021). Kosev and Mikic (2012) reported the strong positive significant association between number of seed plant^{-1} and seed weight plant^{-1} and similar results were found in this study. Likewise, numbers of pod plant^{-1}

also showed significant positive correlation with seed weight plant^{-1} which also confirmed the findings of Kosev and Mikic (2012).

CONCLUSION

Genotypes HRSDGP-11-18-10, HRSDGP-11-18-1 and HRSDGP-11-18-13 exhibited moderate resistant to powdery mildew disease under field condition and also outperformed for green pod and seed yield. Seed yield showed significant positive phenotypic correlation with green pod number plant^{-1}, pod weight plant^{-1}, seed number pod^{-1}, dry pod number plant^{-1} and dry seed weight plant^{-1} and these characters should be used as selection criteria to improve seed yield. On the basis of powdery mildew and yield evaluation, genotypes HRSDGP-11-18-10, HRSDGP-11-18-1 and HRSDGP-11-18-13 are selected as candidate genotypes for commercial production and as breeding materials for pea improvement program.

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Authors' contribution

BP Luitel designed the experiment and conducted it in the field. BB Bhandari helped to observe the data in experiments. BP Luitel analyzed the data and prepared the whole manuscript.

Conflicts of Interest

The authors have no relevant financial or non-financial interests to disclose.

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REFERENCES

ARS. 2014. Annual Report 2070/71 (2013/2014). Agricultural Research Station (Horticulture), NARC, Kimugaon, Dailekh, Nepal

Atiq MA, A Nawaz, M Younas, M Nasir, A Rashid and M Ehetisham-ul-Haq. 2016. Characterization of environmental conditions conducive to powdery mildew of pea. Advances in Environmental Biology **10**: 243-249

Bairwa DS, DK Rana, P Kumar, S Kumar, V Bhati and D Parihar. 2018. Response of pea varieties on growth, yield attributes and quality under valley conditions. International Journal of Agriculture, Environment and Bioresearch **11**: 585-588.

CPDD. 2014. Released and registered crop varieties in Nepal (1960-2013). Communication, Publication and Documentation Division. Nepal Agricultural Research Council, NARC Publication No. 0040-2013/14; **P**.24.

Din M, F Khan, A Karim, Tajuddin and Saifullah. 2019. Evaluation of different varieties of pea under agro-climatic conditions of Gilgit-Baltistan. Adv Food Technol Nutr Sci Open J. **5**: 50-53.

Ei-dakkak AAA. 2016. Genetic improvement for yield and quality characters in pea by using selection. J. Plant Production **7**: 837-842.

Falloon RE, SLH Viljanen Rollinson, GD Coles and JD Poff. 1995. Disease severity keys for powdery and downy mildews of pea, and powdery scab of potato. New Zealand Journal of Crop and Horticultural Science **23**: 31-37.

Haridy AGH, HS Abbas, KA Amein and FE Mahmoud. 2019. Evaluation of some garden pea cultivars for growth and yield characteristics under Assiut conditions. Assiut J. Agric. Sci. **50**: 120-125.

HRS 2020. Annual Report 2076/77 (2019/2020). (Ed. Binod Prasad Luitel), Horticulture Research Station, NARC, Kimugaun, Dailekh, Nepal.

Janila P, B Sharma and SK Mishra. 2001**.** Inheritance of powdery mildew resistance in pea (*Pisum sativum* L.). Ind. J. Genet. Plant Breed. **61**:129–131.

Kazmi MR, G Jeelani and MH Bhatti. 2002. Yield potential of some promising pea cultivars against powdery mildew. Pak. J Agric. Res. **17**: 97-98.

Kosev V and A Mikic. 2012. Assessing relationship between seed yield components in spring-sown field pea (*Pisum sativum* L.) cultivars in Bulgaria by correlation and path analysis. Span J Agric Res. **10**:1075-1080.

Kumar B, A Kumar, AK Singh and GR Lavanya. 2013. Selection strategy for seed yield and maturity in field pea (*Pisum sativum* L. arvense). African Journal of Agricultural Research. **8**: 5411-5415.

Lakic Z, S Stankovic, S Pavlovic, S. Krnjajic and V. Popovic. 2017. Genetic variability in quantitative traits of field pea (*Pisum sativum* L.) genotypes. Czech J. Genet. Plant Breed. **55**: 1-7.

Luitel BP, TB Pun and BB Bhandari. 2021. Evaluation of growth and yield characters of garden pea genotypes at Dailekh, Mid-Western Nepal. Nepalese Horticulture **15**: 1-15.

MoALD. 2019. Statistical information on Nepalese Agriculture 2018/19 (2075/76). Ministry of Agriculture and Livestock Development, Singhadurbar, Kathmandu, Nepal

Munjal RL, VV Chenulu and TS Hora. 1963. Assessment of losses due to powdery mildew (*Erysiphe polygoni*) on pea. Indian Phytopath. **16**: 268-270.

Nisar M, A Ghafoor, MR Khan, and AS Qureshi. 2006. Screening of *Pisum sativum* germplasm against *Erysiphe pisi* syd. Acta. Biol. Cracov. Bot. **48**: 33-37.

Ofga B. 2019. Comparing yield performance and morpho-agronomic characters of landraces and released varieties of field pea (*Pisum sativum* L.) at Agarfa and Goro Woredas, Bale Zone, Oromia Region, Ethiopia. International Journal of Genetics and Genomics **7**:34-49.

Pandey M, VB Singh, GC Yadav, N Tyagi, GS Vishen Sriom, KK Bhargav and P Pandey. 2017. Correlation and path coefficient analysis among diferent characters in genotypes of vegetable pea. Bull. Env. Pharmacol. Life Sci. **6**: 123-130.

Poon TB, HN Regmi, BB Pokhrel, OB Oli and SR Sharma. 2004. Potential of promising varieties of garden pea in relation to determinate characters, the efficiency of green pod yield and monetary returns under the mid-hills environments of Dailekh. In: Agricultural Research for Enhancing Livlihood of Nepalese People (BK Joshi, SL Joshi and KP Paudyal, eds). Proc. 2nd SAD-N Convention, 30 July -1 Aug. 2003, Kathmandu, pp. 111-114.

Poudel K, A Karkee, MK Shah and S Karki. 2017. Performance of garden pea genotypes in eastern hills of Nepal. Journal of Nepal Agricultural Research Council. **3**: 15-18.

Santos CS, B Carbas, A Castanho, MW Vasconcelos, MC Vaz Patto, C Domoney and C Brites. 2019. Variation in pea (*Pisum sativum* L.) seed quality traits defined by physical functional properties. Foods. **8**: 57

Singh BD. 1990. Plant Breeding, principles and methods. Kalyani Publishers, New Delhi. **p**. 110

Smykal P, G Kenicer, AJ Flavell, J Corander, O Kosterin, RJ Redden, R Ford, CJ Coyne, N Maxted, MJ Ambrose and NTH Ellis. 2011. Phylogeny, phylogeography and genetic diversity of the *Pisum* genus. Plant Genetic Resources: Characterization and Utilization **9**: 4-18

Verhinin T, J Noma, and J Nisnitarumozu. 2003. Seed productivity and germinability of various garden pea genotypes collected in Medditerrian region. Memoirs of the Faculty of Agric. Magushima Univ. **34**: 12.