

Evaluation of Growth and Yield Characters of Garden Pea Genotypes at Dailekh, Mid-Western Nepal

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Abstract

Knowledge of phenotypic variation among the germplasm is important for the breeding program of garden pea. This study was conducted to evaluate the growth and yield traits of garden pea genotypes and to identify high yielding, and powdery mildew resistant genotype at Horticulture Research Station (HRS), Dailekh, Mid-western Nepal. Eleven garden pea genotypes were evaluated in the main production season (2018-2019) and compared with 'Sikkim Local' as standard variety, and the experiment was laid out in randomized complete block design with three replications. The analysis of variance revealed that genotypes had significant variation for all the traits studied except few insignificant traits. Significantly higher number of green pod/plant, green pod yield/plant, seed number/pod and seed yield/plant were recorded in genotypes DGP-12-18-2 and DGP-12-18-1 as compared with other studied genotypes. Genotype DGP-12-18-2, and DGP-12-18-1 exhibited resistant (2) to powdery mildew disease and these genotypes showed 45.8% and 16.6% yield advantage over the standard check 'Sikkim Local' variety. Therefore, genotypes DGP-12-18-2 and DGP-12-18-1 can be recommended to produce for fresh green pod and seed yield at on-farm condition of Mid-Western Nepal.

Keywords: Breeding, genotypes, on-farm, phenotypic variation, pod yield

Introduction:

Pea is an important annual herbaceous legume belonging to the family Fabaceae which is the third largest family of flowering plants having more than 450 genera and over 1200 species. Pea (*Pisum sativum* L.) is one of the world's oldest domesticated crops and the third most widely grown legume crop worldwide (Smykal et al., 2010). The six *Pisum* species reported so far are *P. sativum* L., *P. arvense*, *P. elatius* Stev., *P. abyssinicum* Braun, *P. humile* Boiss and Noe and *P. fulvum* Sibth and Sm. Among them, cultivated *Pisum* is dominated by *P. sativum* but *P. sativum* ssp *abyssinicum* is an independently derived cultivated type. In Nepal, garden

pea (*P. sativum* L.) is grown commonly in cool season for fresh green seeds, tender green pods, and dried seeds.

Garden pea is an important legume, widely grown in terai, mid-hills and high hills of Nepal. Green immature pod, immature seeds and dry seeds are mostly preferred by consumers and there is high demand of peas in market. Also, the tradition of making pickles using dried peas seeds in household is increased its demand. In addition, it is a good source of protein, carbohydrates, vitamin A, and C, calcium, phosphorus (Ofga, 2019). This is an important vegetable crop to farmers for cash earning and it also contributes to cope the food and

nutritional security of the people especially in hills of Nepal. Since pea is a cool season crop, it is grown in winter season in terai, autumn season in mid hills and summer season in hills (Poon et al., 2004). Besides its nutritional importance, pea being a legume crop; it enriches the soil by adding significant amounts of nitrogen through nitrogen fixing.

According to a report (MoALD, 2019), pea is cultivated in 8,275 ha of land with a total production 72,557 mt and productivity of 8.7 t/ha in Nepal but in Karnali Province, it is limited in 512 ha, with total production of 4,333 mt and the productivity of 8.4 t/ha. Despite its importance, the average national productivity is very low than the yield potential of the cultivar. With increasing demand of fresh pod and dry seed, the present production couldn't meet the galloping demand of market. Lacking of high yielding, early maturing, powdery mildew resistant and quality preferably smooth seeded variety are the major limiting constraints of pea production in Nepal. Powdery mildew caused by *Erysiphe pisiis* one of the most destructive and widely prevalent diseases and this disease occur every year in Dailekh. This disease reduces the yield and seed quality. Suneetha et al. (2014) reported 33 to 69% of pea foliage to be infected with powdery mildew. Yield losses up to 47% had been reported to powdery mildew by different researchers (Munjal et al., 1963; Nisar et al., 2006). Use of resistant cultivar reduce the use of chemicals and eliminates their negative effects (Chaudhary and Banyal, 2017).

HRS, Dailekh is a lead centre of pea research in Nepal and it has been collecting different pea varieties, developing breeding lines and genetic materials, and evaluating them particularly for high yield, early maturity, powdery mildew, and fusarium wilt since 2010 (ARS, 2014). Two varieties (Sikkim Local and Arkel) released in pea so far in Nepal are not addressed properly to grow in diverse environment as well as to meet the needs of farmers. In the past, several studies were carried out in order to evaluate plant and yield characters in pea genotypes in Nepal (Poon et al., 2004; Poudel et al., 2017; Lohani et al., 2017). However, study on the selection of high yielding with powdery mildew disease resistance in different pea breeding lines are not undertaken so far. Therefore, this study was designed to select high yielding and powdery mildew resistant pea genotypes at mid-western of hills of Nepal.

Material and Methods:

Description of the experimental site

The experiment was conducted at HRS, Dailekh which is located at 28°13' 6.18" N longitudes and 83°58'27.72" E latitude with an elevation of 1,255m asl. This station represents mid-western hills of Karnali Province and falls under sub-tropical climatic region. This district received an average annual rainfall of 26-150 mm (HRS, 2019) and June to September is the major rainy season. This district receives less annual rainfall as compared to other regions so it can be characterized as dry hill. The dominant soil type is clay loam with slight acidity. In 2018-2019, maximum temperature during the cropping season (Oct.-April) ranged from 18.4°C (Jan.) to 28.0°C (April) but in 2019-2020, it 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 (Fig. 1).

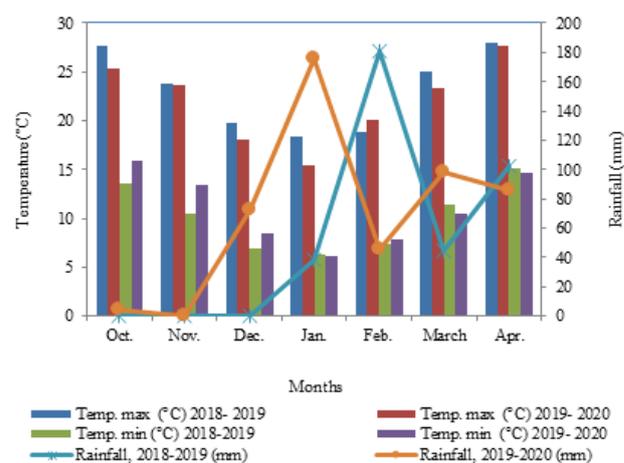


Figure 1. Monthly temperature and rainfall of cropping season (Oct.-April) of Garden pea at HRS, Dailekh during 2018-2019.

Plant materials and experimental design

Altogether, 40 garden pea genotypes developed from the crossing in 2012 and were evaluated as Preliminary Yield Trial (PYT) at HRS, Dailekh in 2016 and 2017 for powdery mildew and yield characters. Based on plant, powdery mildew and yield characters, 12 genotypes were selected in Coordinated Varietal Trial (CVT) to evaluate as on-station. Genotypes 13.04.14 (A-1), 14.4.14 (C-2) LGW, 37.05.1 (C-1)LYR, (2)1.3(A-2)RR, 18.05(C-2) LYW, 5.01.4(A-2) LGR, 39DCP-4(4.12B), 27.4.4(A-1)YW, 22.05.19(A), 40.1.4(A-1)YR, 36.8.6(B-2)RR, and 25.6.5 (A)YR were selected and nomenclatured

as DGP-12-18-1, DGP-12-18-2, DGP-12-18-3, DGP-12-18-4, DGP-12-18-5, DGP-12-18-6, DGP-12-18-7, DGP-12-18-8, DGP-12-18-9, DGP-12-18-10, DGP-12-18-11 and DGP-12-18-12, respectively. Where, DGP stands for 'Dailekh Garden Pea', 12 stands for crossing year '2012', 18 stands 'selection year' and remaining '1, 2, 3...' stands 'the genotype number'. These 12 selected genotypes (indeterminate type) were further evaluated along with 'Sikkim Local' as a check variety for their plant, powdery mildew and yield at on-station during two years (Oct. 2018-April, 2019, and Oct. 2019-April, 2020). The experiment was laid out in randomized complete block design with three replications. Seeds were sown by hand in Oct. 10, 2018 and 2019 and the intra and inter row spacing were maintained at 10 cm and 75 cm, respectively. Each plot contained 24 plants with each row had six plants. The space between plots within block was 50 cm and blocks within each replication was 1m. Fertilizer was applied at the rate of 30:40:40 kg/ha $\text{NP}_2\text{O}_3\text{K}_2\text{O}$ and well-rotten farmyard manure was applied at the rate of 15 t/ha. Half amount of nitrogen, full amount of phosphorus, potassium, and farmyard manure was applied at the land preparation time, and remaining half amount of nitrogen was given through urea as side dressing. Standard agronomic practices were followed in garden pea as recommended by Chalise and Pun (2015).

Data collection and analysis

Thirteen quantitative and three qualitative traits were measured in the studied genotypes. Two rows were used to record the data on green pod yield and remaining two rows were used to take dry pod yield. Days to 50% flowering was recorded when 50% of the plant population in each plot produce flower. The number of branch/plant was counted. Plant vigor was rated on 1-5 scale (1= poor, and 5 = Excellent). Plant height (cm) was measured from the ground level to the top of the plant. Green pod was first harvested on March, 17th for both years (2019 and 2020) and additional two harvests were done for green pod collection. The numbers of green pods and yield were recorded at commercial maturity stage from five randomly selected plants. The average length (cm) and diameter of pod was measured at commercial maturity stage using scale and vernier caliper, respectively. For powdery mildew, 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 = tolerant and above 5 was considered as susceptible to powdery mildew. 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 to complete the data. The number of seeds were counted for each pod of the five plants and averaged over the number of pods. The seed yield /plant (g) was measured on the five plants at physiological maturity. The weight of 100 seeds was selected randomly from five plants/plot and averaged it. Seedyield (g) of each plant was measured on clean, dried seed and the measured seed yield value (g) was converted to ton/ha for analysis. Seed shape, surface and color were recorded based on visual observation. The experimental data were processed and analyzed using GenStat Release 10.3 DE Software (VSN International Ltd.). Correlation analysis (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 characters and green pod yield

Genotypes had non-significant effect on days to 50% flowering and branch number/plant but it affected significantly on plant vigor, plant height, green pod number/plant and green pod yield/plant (Table 1). The influence of year on days to 50% flowering and branch number/plant remained non-significant whereas it showed significantly different in plant vigor, plant height, and green pod/plant. The variation in temperature and rainfall during the cropping season might influence the plant vigor, plant height and pod number/plant. The interaction of genotype and year showed non-significant effect in all the studied traits except plant height. The average maximum temperature during crop growing period (October to April) in 2018-2019 was 23.7°C whereas it was the lowest (21.9°C) in 2019-2020. In case of precipitation, it was highest (68.8 mm) in 2019-2020 but the lowest (46.8 mm) precipitation was noted in the year 2018-2019 and this might be attributed to cause the variation in plant height.

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

Source of variation	DF	DFFL	BPPNT	PVIG	PHT	GPP	GPYLD
Genotypes (G)	12	105.47 ^{ns}	1.08 ^{ns}	2.55 ^{**}	2839.6 ^{**}	525.8 [*]	14891.0 ^{**}
Year (Y)	1	10200.82 ^{ns}	0.37 ^{ns}	6.06 ^{**}	24977.7 ^{**}	867.6 [*]	96.00 ^{ns}
G x Y	12	127.5 ^{ns}	0.61 ^{ns}	1.29 ^{ns}	904.3 [*]	86.4 ^{ns}	1635.0 ^{ns}
Error	50	96.44	0.66	0.72	423.6	206.5	4624.0

ns, *, ** non-significant or significant at 5% and 1%, respectively. DF = Degree of freedom, DFFL = Days to 50% flowering, BPPNT = Branch/plant (no.), PHT = Plant height (cm), PVIG = Plant vigor (1-5), GPP = Green pod/plant (no.), and GPYLD = Green pod yield/plant (g)

ANOVA on pod characters, powdery mildew disease and seed yield

Genotypes affected significantly on pod length, powdery mildew, seed number/plant, seed yield/plant, hundred grain weight and seed yield/ha. Similarly, year revealed the significant variation in all the traits except pod length. In contrast, the interaction effect between genotypes and years was non-significant in all the characters studied (Table 2).

Table 2. Mean square values of pod characters, powdery mildew disease and seed yield of pea genotypes for combined analysis of variance over two years (2018 to 2019).

Source of variation	DF	PL	PD	PM	SPP	SYPP	HSWT	SYLD
Genotypes (G)	12	7.95 ^{**}	8.50 ^{ns}	8.06 ^{**}	4.08 ^{**}	800.0 ^{**}	73.28 ^{**}	2.893 ^{**}
Year (Y)	1	0.15 ^{ns}	162.21 ^{**}	50.88 ^{**}	4.60 [*]	2421.3 ^{**}	135.92 ^{**}	24.07 ^{**}
G x Y	12	1.04 ^{ns}	7.22 ^{ns}	1.92 ^{ns}	1.05 ^{ns}	148.0 ^{ns}	15.26 ^{ns}	0.57 ^{ns}
Error	50	1.09	11.24	2.03	1.09	299.8	14.45	1.115

ns, *, ** non-significant or significant at 5% and 1%, respectively. DF = Degree of freedom, PL = Pod length (cm), PD = Pod diameter (mm), Powdery mildew (1-10 score), SPP = Seed/pod (no.), SYPP = Seed yield/plant (g), HGWT = hundred seed weight (g), and SYLD = Seed yield (t/ha).

Mean performance of genotypes for plant and green pod yield characters

The combined mean over two years on plant and yield characters of pea genotypes are given in Table 3. Genotypes did not show any significant differences in days to 50% flowering and branch number/plant. But plant vigor was highly significantly different among the genotypes. Genotype DGP-12-18-1, DGP-12-18-2 and Sikkim Local showed the highest (4) in plant vigor whereas the lowest (2) plant vigor was observed in genotype DGP-12-18-3, DGP-12-18-3 and DGP-12-

18-8. The tallest plants were measured in Sikkim Local (200.9 cm) followed by genotype DGP-12-18-7 (179.6 cm) but it was the lowest (127.9cm) in genotype DGP-12-18-4. The number of green pod/plant showed the significant differences among the genotypes. Genotype DGP-12-18-2 produced the maximum (49.0) number of green pod/plant followed by DGP-12-18-1 (47.0) and DGP-12-18-7 (42.0). Green pod yield/plant produced the highest (240.5 g) in DGP-12-18-2 followed by DGP-12-18-1 (219.0 g) but it was the lowest (64.6 g) in genotype DGP-12-18-4.

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

Pea genotypes	DFFL	BPPNT	PVIG	PHT	GPP	GPYLD
DGP-12-18-1	80.0	3.0	4.0	168.3	47.0	219.0
DGP-12-18-2	77.0	4.0	4.0	159.4	49.0	240.5
DGP-12-18-3	85.0	2.0	2.0	130.4	23.0	124.9
DGP-12-18-4	80.0	3.0	2.0	127.9	20.0	64.6
DGP-12-18-5	85.0	3.0	3.0	142.0	26.0	128.3
DGP-12-18-6	69.0	3.0	3.0	132.6	25.0	119.7
DGP-12-18-7	75.0	3.0	3.0	179.6	42.0	124.6
DGP-12-18-8	80.0	3.0	2.0	149.2	26.0	96.1
DGP-12-18-9	81.0	3.0	3.0	163.5	38.0	162.3
DGP-12-18-10	82.0	3.0	3.0	132.6	29.0	103.4
DGP-12-18-11	77.0	3.0	3.0	167.0	31.0	152.8
DGP-12-18-12	80.0	2.0	3.0	150.9	29.0	92.7
Sikkim Local (Check)	82.0	3.0	4.0	200.9	37.0	165.3
Mean	79.4	3.0	3.05	154.2	32.5	138.0
P Value	0.386	0.109	<0.001	0.001	<0.010	0.002
LSD (0.05)	11.39	0.94	0.99	23.87	16.66	78.85
CV (%)	12.4	26.1	28.0	13.3	34.3	39.3

DFFL = Days to 50% flowering, BPPNT = Branch/plant (no.), PHT = Plant height (cm), PVIG = Plant vigor (1-5), GPP = Green pod/plant (no.), and GPYLD = Green pod yield/plant (g)

Mean performance of genotypes for pod characters, powdery mildew disease and seed yield

The pod length was varied from 7.6 cm (DGP-12-18-4) to 10.9 cm (DGP-12-18-1) with the average of 9.28 cm. Pod diameter was non-significant among the genotypes. Powdery mildew disease was significantly varied among the tested genotypes. Genotypes DGP-12-18-1, DGP-12-18-2, and DGP-12-18-9 showed the resistant (2.0) to powdery mildew disease whereas DGP-12-18-7 (3.0), DGP-12-18-11 (3.0), Sikkim Local (3.0), DGP-12-18-3 (4.0), DGP-12-18-5 (4.0), and DGP-12-18-8 (4.0) revealed the tolerance to powdery mildew (Table 4). The number of seed/pod was ranged from 5.0 to 7.0 with the average of 6.42. With respect of seed yield/plant, it produced the highest (57.2 g) in DGP-12-18-2 which was statistically at par with DGP-

12-18-1 (45.6 g), DGP-12-18-11 (44.2 g), DGP-12-18-9 (40.4 g) and Sikkim Local (39.6 g) but DGP12-18-8 produced the lowest (15.1 g) seed yield/plant. The hundred seed weight also exhibited the significant differences among the genotypes. Sikkim Local gave the highest hundred seed weight (31.3 g) followed by DGP-12-18-11 (28.7 g) and DGP-12-18-1 (27.1 g) and the lowest (18.0 g) was produced in genotype DGP-12-18-7. As for seed yield, it was produced the highest (3.5 t/ha) in DGP-12-18-2 which was statistically similar to DGP-12-18-1 (2.8 t/ha), DGP-12-18-9 (2.4 t/ha) and Sikkim Local (2.4 t/ha). Seed shape was varied from elliptic to rhomboid and except the genotype DGP-12-18-8, all the genotypes contained smooth seed surface. Seed color was varied from cream yellow, light green, yellow green to brown in the studied genotypes (Table 4).

Table 4. Means of genotypes over pod characters, powdery mildew disease, and dry pod yield of pea genotypes and seed characters for combined analysis of variance over two years (2018 to 2019)

Pea genotypes	PL	PD	PM	SPP	SYPP	HSWT	SYLD	SSH	SS	SC
DGP-12-18-1	10.9	15.6	2.0	7.0	45.6	27.1	2.8	E	S	CY
DGP-12-18-2	10.6	13.3	2.0	7.0	57.2	25.2	3.5	E	S	LG
DGP-12-18-3	9.8	13.9	4.0	7.0	28.5	24.3	1.8	E	S	YG
DGP-12-18-4	7.6	11.6	5.0	7.0	26.1	22.3	1.6	Rh	S	B
DGP-12-18-5	10.8	15.2	4.0	7.0	29.3	22.2	1.8	E	S	LG
DGP-12-18-6	9.2	13.5	6.0	6.0	21.5	24.7	1.3	E	S	LG
DGP-12-18-7	7.9	11.9	3.0	6.0	30.8	18.0	1.8	E	S	LG
DGP-12-18-8	9.4	13.7	4.0	5.0	15.1	21.4	0.9	Rh	R	LG
DGP-12-18-9	8.8	12.4	2.0	7.0	40.4	22.0	2.4	E	S	CY
DGP-12-18-10	9.6	13.2	5.0	6.0	24.7	21.4	1.5	E	S	CY
DGP-12-18-11	10.1	14.2	3.0	7.0	44.2	28.7	2.7	E	S	B
DGP-12-18-12	8.4	13.1	4.0	5.0	28.4	23.9	1.7	E	S	CY
Sikkim Local (Check)	7.8	12.1	3.0	5.0	39.6	31.3	2.4	E	S	LG
Mean	9.28	13.35	3.86	6.42	33.2	24.04	2.03			
P Value	<0.001	0.691	<0.001	<0.001	0.008	<0.001	0.009			
LSD (0.05)	1.215	3.88	1.65	1.212	20.08	4.40	1.22			
CV (%)	11.3	25.1	36.9	16.3	32.2	15.8	32.1			

PL = Pod length (cm), PD = Pod diameter (mm), Powdery mildew (1-10 score), SPP = Seed/pod (no.), SYPP = Seed yield/plant (g), HSWT = Hundred seed weight (g), and SYLD = Seed yield (t/ha), SSH = Seed shape; E = Elliptical, Rh = Rhomboid, SS = Seed surface; S = smooth, R = Rough; SC = Seed color, CY = Cream yellow; LG = light green; YG = Yellow green, B = Brown,

Correlation among the plant and yield characters

The simple correlation of phenotypic traits among garden pea genotypes is presented Table 5. Days to 50% flowering showed weak negative correlation with green pod yield/plant and moderate significant negative correlation with seed yield/ha. There was a significant positive weak correlation with seed yield/plant, seed yield/ha with branch number/plant. Plant vigor had a weak significant positive correlation with green pod/plant, green pod yield/plant, seed yield/plant and seed yield/ha. But the plant height showed the moderate significant positive association with green pod number/plant, seed yield/plant and seed yield/ha.

The number green pod/plant had a strong significant positive correlation with green pod yield/plant and it showed the positive significant association with seed yield/plant and seed yield/ha. Similarly, significant positive phenotypic correlation between green pod yield/plant and seed yield. The number of seed/pod had a significant positive correlation with seed yield/plant and seed yield/ha. The strong and significant positive correlation was observed between seed yield/plant and seed yield/ha. But hundred seed weight exhibited weak phenotypic correlation with seed yield.

Table 5. Pearson's correlation coefficient analysis among phenotypic traits of pea genotypes during 2018 -2019 at HRS, Dailekh

Variables	DFFL	BRNPP	PVIG	PHT	GPPT	GPYLD	PL	PD	PM	SPP	SYPP	HSWT	SYLD
DFFL	1.0	-.05	.25*	-.44**	.03	.37**	-.13	.01	-.27*	.25*	-.31**	-.17	-.42**
BRNPP		1.0	.42**	0.12	0.21	.28*	.07	.01	-.17	.12	.36**	.09	.31**
PVIG			1.0	.21	.34**	.38**	.05	.15	-.12	-.01	.38**	.18	.29**
PHT				1.0	.40**	.27*	-.09	-.29**	-.06	-.24*	.45**	.34**	.51**
GPPT					1.0	.84**	.08	-.01	-.10	.22*	.57**	.25*	.54**
GPYLD						1.0	.27*	.14	-.15	.26*	.53**	.35**	.46**
PL							1.0	.35**	-.01	.43**	.13	.09	.14
PD								1.0	-.26*	.30*	.04	-.12	-.08
PM									1.0	-.16	-.10	.15	-.03
SPP										1.0	.48**	-.13	.58**
SYPP											1.0	.33**	.98**
HSWT												1.0	.35**
SYLD													1.0

* and ** significant at 5% and 1%, respectively. DFFL: Days to 50% flowering;); BRNPP: Branch/plant (no.); PVIG: Plant vigor (1-5 score); PHT: Plant height (cm); GPPT : Green pod/plant (no.); GPYLD: Green pod yield/plant (g); PL: Pod length (cm); PD : Pod diameter, PM: Powdery mildew; SPP: Seed/pod (no.); SYPP: Seed yield/plant (g); HSWT: Hundred seed weight (g); and SYLD: Seed yield (t/ha)

Discussion:

In this study, garden pea genotypes showed the significant phenotypic variability for phenology and yield attributes. Except days to 50 percent flowering and branch number/plant, genotypes showed significant differences for plant characters and green pod yield. The genotypic difference in the plant and yield characters indicates the presence of variability for each trait which was also reported by Ofga (2019). Khan et al. (2013) had also reported the variation in plant characters in pea genotypes under rain-fed condition. The mean square due to genotype was significant in green pod number/plant. The number of pod/plant is a variable trait and this result is in agreement with the results of Lakic et al. (2017). Genotypes showed the significant variation in green pod yield/plant which indicates differential response of genotypes of this character. Similar results were reported by previous researchers (Chadha et al., 2010; Khichi et al., 2017; Poudel et al, 2017). In the study of Ei-dakkak (2016), he reported the maximum (215.3 g) green pod yield/plant in genotype of pea but our study showed that the maximum (240.5 g) green pod yield/plant. The significant effect of year on plant vigor, plant height, green pod number/plant and green pod yield/plant due to environmental fluctuation particularly temperature and rainfall during the

cropping season. The average maximum temperature during crop growing period (October-April) in 2018-2019 was 23.7°C but it was lowest (21.9°C) in the cropping season of 2019-2020. In contrast, amount rainfall distribution was higher (68.8 mm) in 2019-2020 than the cropping season of 2018-2020 (46.8 mm) (Fig. 1). The differences in temperature and uneven distribution of rainfall during the cropping season in both years might be influenced the plant and yield traits. The significant interaction between genotype and year on plant height might also be due to environmental condition that affected genetic make-up of the cultivars.

Genotypes also affected the pod size particularly on pod length. Pod size is a varietal character but it is also affected by vigor of the plant (Bozoglu et al., 2007) but our study showed the contradictory result in this variable. Powdery mildew is one of major fungal disease that has deleterious effect on yield of pea crops (Fallon et al, 1990). In our study, powdery mildew above five score showed the susceptibility to powdery mildew and most of the genotypes were tolerant to powdery mildew. Identification of resistant cultivars against powdery mildew in pea genotypes was also studied by previous researchers (Fallon et al., 1995; Xue et

al., 2004; Chaudhary and Banyal, 2017). Number of seed/pod is the important yield attributing characters and this showed highly significant differences among the pea genotypes. In the study of Poudel et al. (2017), they reported 6 to 8 seeds/pod which is much close to this finding. Choudhary and Sharma (2004) had also reported the similar findings in the study of pea cultivars. This study reported the maximum (57.2 g) seed yield/plant in DGP-12-18-2 but in the study of Bairwa et al. (2018), they reported the maximum (67.0 g) seed/plant in P-89 pea genotype. Khichi et al. (2017) reported the greatest (59.2 g) seed yield/plant in pea genotypes which is close to our result. Variation in seed yield/plant among the pea genotypes were also reported by many researchers (Orak and Nizam, 2009; Bairwa et al., 2018). Genotypes showed highly significant differences in 100 seed weight and this could be due to the genetic makeup the variety. Genotype DGP-12-18-2 produced the highest (3.5 t/ha) seed yield. Good plant vigor, more number of green pod/plant, green pod yield/plant, good pod size, more number of seed/pod, more seed yield/plant might be attributed for high yield particularly in this genotype. Significant effect of year was noticed in pod size, powdery mildew, seed number/plant, seed yield/plant, 100 seed weight and seed yield/ha which might be due to climatic condition like temperature and rainfall. Seed morphology namely seed shape, color and surface also influences consumer's preferences (personal communication) and generally, these traits depends on genetic make of the cultivar. Phenotypic variation observed in seed of studied pea genotypes helps to study physicochemical properties. Santos et al. (2019) had used seed morphological traits of pea genotypes particularly seed shape, color and surface for the study of physicochemical functional properties.

The association study of yield with plant and yield characters indicated that there was a significant positive correlation of seed yield/ha with plant height, green pod number/plant, green pod yield/plant, seed number/pod, and seed yield/plant. More number of branch/plant, higher number of green pod/plant and number of seed/plant ultimately contributing positively towards yield. In the study of Singh and Singh (1989), 100 seed weight was negatively associated with grain yield but in our study it showed the weak correlation with seed yield. In the study of Ofga (2019), he reported the significant positive phenotypic correlation of 100 seed weight with seed yield. Thus, significant positive correlation

between seed yield and number of characters namely plant height, green pod number/plant, green pod yield/plant, seed number/pod and seed yield/plant indicating that selection for any one of the traits allows to improve seed yield of pea genotypes.

Conclusion:

Genotypes exhibited the significant variation for plant and yield characters which are useful for pea breeding program. The genotype DGP-12-18-2 and DGP-12-8-1 showed the resistant to powdery mildew, and high green pod and seed yield. Plant height, green pod number/plant, green pod yield/plant, seed number/plant, and seed yield/plant showed significant positive correlation with seed yield/ha which indicates the selection of these traits can be used as selection criteria to improve the seed yield of pea cultivars. The candidate genotype DGP-12-18-2 and DGP-12-18-1 had 45.8 and 16.7% yield advantage over the standard checks and hence, these two genotypes can be recommended to grow fresh and seed production at mid-western of Nepal.

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Declaration of conflict of interest and ethical approval:

The authors declare no conflict of interest.

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