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Per se performance of matromorphic progenies (Mat_3) and their parental lines in garden pea (*Pisum sativum* L.) under subtropical conditions of J&K

Sonali Sharma*, Anil Bhushan, RK Samnotra, Sandeep Chopra, Satesh Kumar, Sanjeev Kumar and Manoj Kumar

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Abstract

Matromorphs or maternals are non-hybrid diploid offspring which originate entirely from the maternal parent and facilitate in obtaining instant homozygous lines from heterozygous base population thereby, shortening the time requirement of conventional breeding method for the production of homozygous lines. *Per se* performance of twelve advanced generations of matromorphs (Mat_3) along with their ten parental lines were evaluated for growth, yield and screening against powdery mildew and rust disease under sub tropical conditions of Jammu & Kashmir under the present study. A field experiment was carried out during the year 2020-2021 at the Experimental farm, SKUAST-Chatha, Jammu. On the basis of overall findings of the present research study, it was concluded that Palam Triloki was the earliest with minimum days to 50% flowering (44.00) followed by three matromorphic progenies viz., Palam Triloki (46.33 days), Palam Triloki x P-89 (44.67 days) and Palam Triloki x AP-1 (46.83 days). Regarding plant height, maximum plant height was recorded in parental line Arka Apoorva (90 cm) followed by Arka Ajit (89.50 cm) and Arka Apoorva x AP-1 (Pl.1) (88.50 cm) and Arka Apoorva x AP-1(Pl.2) (88.30 cm) amongst Mat_3 progenies were found to be superior. Among Mat_3, maximum number of seeds per pod were recorded in Arka Apoorva X P-89 (7.83) followed by Arka Apoorva x AP-1[Pl.2] (6.77) and P-89 (7.18) and Arka Apoorva (6.34) among parents. Maximum number of pod per plant were recorded in matromorphic progenies, Arka Apoorva x P-89 (45.89) followed by Arka Apoorva x AP-1[Pl.2] (44.61), Arka Apoorva x AP-1[Pl.1] (41.83) and among parental lines, P-89 (41.28), Arka Apoorva (35.83) had maximum number of pod. Maximum pod yield per plant was recorded in Arka Apoorva x P-89 (200.38g) followed by Arka Apoorva x AP-1 [Pl.1] (184.37 g) in Mat_3 whereas among parental lines maximum pod yield was recorded in P-89 (174.76g) and Arka Apoorva (145.72g). Based on the screening of genotypes under study, Arka Apoorva x P-89 (Mat_3) was identified as highly resistant genotype against major pea diseases i.e. powdery mildew and rust.

Keywords: Pea, matromorph, evaluation, homozygous, screening, resistance

Introduction

Garden pea (*Pisum sativum* L.) is a cool-season vegetable crop cultivated for its green pods in temperate and sub-tropical climates around the world, belongs to the Fabaceae family. Being a leguminous vegetable crop, it is a key source of proteins (Burstin et al. 2011) containing an extraordinarily varied nutrient profile of health-building chemicals, including vitamins A, B, and C, minerals such as P, Mg and Fe, and lysine (a limiting essential amino acid in cereals). The production and maintenance of homozygous lines constitute the raw material in pea improvement programme due to highly self pollinated nature of the crop. Pure-breeding lines are generated by crossing the two parental lines and then repeated selfing up to the F_6 generation using traditional breeding processes. Breeders and geneticists have attempted various alternative approaches to shorten the time requirement for the production of homozygous lines using traditional breeding procedures. The scientists have found novel technique of matromorphy that facilitates in obtaining instant homozygous lines from heterozygous base population. Matromorphs, also known as maternals, are non-hybrid diploid offspring that are exclusively descended from the maternal parent (Mackey 1972). Matromorphic induction of the seeds occurs without egg fertilization through pollination, which is often false or prickle, is vital in providing the necessary stimulus for the maternal seed to develop. The doubling of the maternal haploid gamete during an early stage of cleavage produces totally homozygous maternals (Robbelen

Division of Vegetable Science & Floriculture, FoA, Main Campus, Chatha, SKUAST-Jammu, J&K
*Corresponding author, Email: sonalisharma241196@gmail.com

1966). There are many single plant homozygous selections among matromorphs which can be of immense potential as variability can be fixed for development of new varieties.

Garden pea is a sensitive crop that is susceptible to a variety of diseases, resulting in significant losses in production and productivity. Powdery mildew (*Erysiphe pisi*) and rust (*Uromyces viciae fabae)* are the most common diseases infecting pea crops in the plains and hills of North India, resulting in significant yield losses for vegetable growers (Mishra et al. 2019; Shroff and Chand 2010). The development of disease-resistant pea cultivars is a significant challenge that must be prioritised. As a result, screening of the available garden pea genotypes against powdery mildew and rust diseases is critical in order to identify resistant sources that can be utilised to transfer resistance to other high-yielding genotypes. Therefore, the present study was conducted to evaluate the available matromorphic progenies (Mat_3) from pea (homozygous/heterozygous) for various horticultural traits and screened against powdery mildew and rust under subtropical conditions of J&K.

Materials and Methods

The experiment was carried out at the Experimental Farm-I, Division of Vegetable Science and Floriculture, SKUAST- Jammu (J&K) during winter season (2020-21) situated at 32Ú40' N latitude and 74Ú58' E longitude, at an elevation of 332 m above mean sea level, and falls within the plains of Jammu and Kashmir. The experimental material comprised of 22 garden pea genotypes [12 matromorphic progenies (Mat_3) and 10 parental lines] were laid out in the Randomized Complete Block Design (RCBD) with each treatment replicated thrice with a spacing of 45 × 10 cm. All the production practices were followed as per the recommendations given in package of practices of the university. The observations were recorded from five randomly selected plants of each treatment for horticultural traits viz., days to 50% flowering, node at which first flower appears, plant height (cm), number of primary branches per plant, internodal distance (cm), number of pod per node, pod length (cm), pod width (cm), number of seed per pod, number of pod per plant, days to first picking, average pod weight (g), pod yield per plant (g) and shelling percentage. The data on various observations recorded from the field were subjected to statistical analysis as described by Sheoran et al. (1998).

Screening of pea genotypes under study was done for reaction to powdery mildew and rust when the disease was at peak period i.e. during pod development stage of crop in mid-February. The visual assessment of percent leaf area affected by powdery mildew was done on a 0 to 9 scale given by Saari and Prescott (1975) and according to the plant disease severity scale for rust given by Mayee and Datar (1986). Disease Incidence (DI) for powdery mildew and rust was calculated for each parental line and matromorphic progeny (Mat_3) using the following formula:

$$\text{DI (\%)} = \frac{\text{No. of infected leaves on the main branch}}{\text{Total no. of leaves on the main branchr}} \times 100$$

Percent Disease Index (PDI) for powdery mildew was calculated using the formula:

$$\text{PDI (\%)} = \frac{\text{Sum of all disease rating}}{\text{Maximum disease gradei x Total number of observed plants}} \times 100$$

Plant disease severity scale for powdery mildew (Saari and Prescott 1975)

Rating	PDI (%)	Disease reaction
0	0	Highly resistant
1	0.1-10	Resistant
3	10.1-30	Moderately resistant
5	30.1-50	Moderately susceptible
7	50.1-75	Susceptible
9	75.1-100	Highly susceptible

Plant disease severity scale for rust (Mayee and Datar 1986)

Rating	Description	Disease reaction
0	No symptoms on leaf	Immune
1	1% or less	Resistant
3	1-10%	Moderately resistant
5	11-25%	Moderately susceptible
7	26-50%	Susceptible
9	51% or more	Highly susceptible

Results and Discussion

Days to 50% flowering: Among the genotypes under study, significant differences were observed which ranged between 44.00 to 75.00 days as presented in Table 1. Significantly early flowering was recorded in four genotypes viz., three matromorphic progenies Palam Triloki, Palam Triloki x P-89, Palam Triloki x AP-1 (46.33, 46.67 and 46.83 days) and parental line VLAM-7 (46.97 days) among all the genotypes. However, AP-1 took maximum number of days (75.00 days) to 50% flowering. The variation in days to 50% flowering has been reported by Kumar et al. (2021) while evaluating 109 diverse garden pea along with 6 checks. Similar results have been reported by several workers across different parts of India viz., Devi et al. (2021); Azam et al. (2020) and Kanwar et al. (2020).

Node at which first flower appears As evident from the data presented in Table 1, the mean results exhibit wide variation ranging from 5.50 to 12.47. The results further revealed that among all the genotypes, two matromorphic progenies *i.e.,* Palam Triloki, Palam Triloki x AP-1 (5.50 and 7.93, respectively) and parental line Palam Triloki recorded the lowest value for node number (7.87) whereas AP-1 recorded the highest value for node number (12.47). The observations by several workers *viz.,* Devi et al. (2021); Yathish et al. (2021) and Kalapchieva et al. (2020) supported the findings of the present study.

Plant height (cm): The perusal of data presented in Table 1 revealed wide variations among genotypes ranging between 24.27 cm to 90.00 cm. Significantly maximum plant height was observed in five genotypes viz., two parental lines Arka Apoorva, Arka Ajit (90.00 and 89.50 cm, respectively) along with three matromorphic progenies i.e. Arka Apoorva x AP-1 (Pl.1) (88.50), Arka Apoorva x AP-1 (Pl.2) (88.30) and Arka Apoorva x P-89 (87.73) while matromorphic progeny, Palam Triloki recorded the minimum values (24.27 cm) for plant height as compared to all other genotypes. The results are consistent with the findings of several other researchers *viz.,* Aman et al. (2021); Azam et al. (2020) and Thapa et al. (2020).

Number of primary branches per plant: The results observed for number of primary branches per plant show non- significant differences among genotypes as evident from Table 1 and it ranged between 1.67 to 2.80. Three parental lines viz., Arka Apoorva (2.80), Arka Ajit (2.60) and Palam Priya (2.50) recorded the maximum number of primary branches whereas; matromorphic progeny Palam Triloki recorded the minimum number of primary branches per plant (1.67). These results are also confirmed by Thapa et al. (2020) who evaluated 12 pea genotypes and the number of primary branches per plant ranged between 2.21 to 3.68. Our results are in consistence with the findings of other workers *viz.,* Kanwar et al. (2020) and Ali et al. (2019).

Internodal distance: The perusal of data presented in Table 1 revealed significant differences regarding internodal distance among genotypes which ranged between 3.41 to 7.10 cm. Two parental lines viz., Arka Apoorva and Arka Ajit recorded the maximum internodal distance (7.10 and 6.95 cm, respectively) followed by three matromorphic progenies *viz.,* Arka Apoorva x AP-1 (Pl.1) (6.83), Arka Apoorva x AP-1(Pl.2) (6.81) and Arka Apoorva x P-89 (6.47). However, matromorphic progeny Palam Triloki recorded the minimum internodal distance (3.41) among all the genotypes. The results correspond with those of Kalapchieva et al. (2020); Singh et al. (2019) and Yumkhaibam et al. (2019).

Number of pod per node: Among all the genotypes, non- significant differences were observed for number of pod per node ranging from 0.97 to 2.00 (Table 1). It was revealed that parental lines, P-89 and Palam Priya recorded the maximum number of pod per node (2.00 and 1.95, respectively) along with two matromorphic progenies, Arka Apoorva x P-89 (1.96) and Arka Apoorva x AP-1(Pl.1) (1.95) which were found to be superior among all the genotypes. However, Palam Triloki recorded the minimum number of pod per node (0.95). Devi et al. (2018), on the other hand, found multiple flowering in pea genotypes that produced three blooms at multiple flowering nodes.

Pod length (cm): Our results revealed significant differences among the genotypes for pod length during present study ranging from 5.47 to 8.34 cm (Table 1). The maximum pod length was recorded in matromorphic progeny, Arka Apoorva x P-89 (8.34) along with Arka Apoorva x AP-1(Pl.1) (8.00), Arka Apoorva x AP-1(Pl.2) (8.09), Arka Ajit x AP-1 (7.90), Mithi Phali (7.81), Vivek Matar-10 (7.80) and five parental lines viz., P-89 (8.17), AP-1(8.07), Vivek Matar-10 (7.97), Palam Priya (7.83) and Mithi Phali (7.80) whereas, matromorphic progeny, Palam Triloki recorded the minimum pod length (5.47). Our results are consistent with the findings of Aman et al. (2021); Kanwar et al. (2020) and Raj et al. (2020).

Pod width (cm): The results revealed non- significant differences among the genotypes under study for pod width ranging from 1.00 to 1.89 cm (Table 1). The maximum pod width was recorded in matromorphic progeny, Mithi Phali (1.89 cm) along with two parental lines *viz.,* Mithi Phali (1.88) and Arka Apoorva (1.73) whereas Arka Priya (1.00) recorded minimum pod width. Different workers viz., Kanwar et al. (2020); Singh et al. (2019) and Bairwa et al. (2018) have reported similar outcomes.

Number of seed per pod: The quantity of seeds per pod is an important yield contributing factor that has a direct impact on pea crop production. In peas, there is a positive correlation between seed size and yield; the number of seeds per pod increased as the pod length increased (Smitchger and Weeden 2018). Our findings revealed considerable variances in the number of seed per pod among genotypes, ranging from 4.30 to 7.83 (Table 1). The matromorphic progeny, Arka Apoorva x P-89 recorded the maximum value for number of seed per pod (7.83) followed by P-89 (7.18) which were found to be significantly superior compared to all other genotypes. Significant differences among genotypes for number of seeds per pod were reported by researchers viz., Thapa et al. (2020) and Bijalwan et al. (2018).

Table 1: Mean performance of matromorphic progenies (Mat_3) and their parental lines with respect to different horticultural traits

S. No.	Genotypes	Days to 50% flowering	Node at which first flower appears	Plant height (cm)	No. of primary branches per plant	Internodal distance	No. of pods per node	Pod length (cm)	Pod width (cm)	No. of seeds per pod	No. of pods per plant	Days to first picking	Average pod weight (g)	Pod yield per plant (g)	Shelling percentage
1	Arka ApoorvaX AP-1(Pl.1)	51.33^{fgh}	10.73^{abc}	88.50^{a}	2.13^{efg}	6.83^{ab}	1.95^{ab}	8.00^{ab}	1.64^{abc}	6.74^{bc}	41.25^{bc}	96.00^{abcd}	4.17^{c}	184.37^{b}	48.33^{abcde}
2	Arka ApoorvaX AP-1(Pl.2)	56.20^{def}	10.33^{bcde}	88.30^{a}	2.07^{fgh}	6.81^{ab}	1.92^{ab}	8.09^{ab}	1.69^{abc}	6.77^{bc}	44.92^{ab}	95.00^{bcde}	4.13^{c}	174.27^{bc}	45.00^{bcde}
3	Arka Apoorva X P-89	57.53^{def}	10.47^{bcd}	87.73^{a}	2.13^{fg}	6.47^{bc}	1.96^{g}	8.34^{a}	1.58^{abc}	7.83^{a}	45.89^{a}	96.67^{abc}	6.40^{a}	200.38^{a}	37.67^{ab}
4	Arka Ajit X AP-1	57.07^{def}	10.89^{ab}	71.50^{ef}	2.13^{fg}	5.93^{defg}	1.02^{g}	7.90^{abc}	1.57^{abc}	6.48^{cd}	31.83^{e}	102.00^{ab}	4.03^{cd}	128.33^{e}	50.00^{abcde}
5	Arka Ajit X P-89	59.33^{cde}	8.73^{defg}	61.60^{hi}	1.87^{ij}	5.30^{hijk}	1.00^{ab}	7.05^{abcd}	1.49^{bcde}	6.17^{defg}	41.33^{c}	84.67^{fg}	4.03^{cd}	166.67^{c}	54.33^{ab}
6	Palam Triloki	46.33^{hi}	5.50^{h}	24.27^{l}	1.67^{k}	3.41^{l}	1.07^{g}	5.47^{e}	1.50^{bcde}	4.3^{i}	17.03^{i}	64.00^{ij}	3.33^{hij}	59.37^{m}	45.00^{bcde}
7	Palam Triloki X AP-1	46.83^{hi}	7.93^{g}	59.63^{hi}	1.87^{ij}	5.00^{k}	1.08^{g}	6.60^{cde}	1.40^{bcde}	4.8^{i}	24.89^{gh}	68.00^{i}	3.87^{def}	96.24^{ij}	33.33^{abcde}
8	Palam Triloki X P-89	46.67^{hi}	10.00^{bcdef}	82.27^{bc}	2.13^{fg}	6.22^{cde}	1.03^{g}	6.73^{bcde}	1.47^{bcde}	5.78^{fgh}	22.33^{h}	86.00^{fg}	3.97^{cde}	88.57^{jk}	45.00^{bcde}
9	Arka Priya X AP-1	53.93^{efg}	11.00^{ab}	62.67^{hi}	2.13^{fg}	5.56^{ghij}	1.05^{g}	7.27^{abcd}	1.50^{bcde}	4.83^{i}	29.67^{ef}	97.50^{abc}	4.03^{cd}	119.67^{efg}	50.00^{abcde}
10	Palam Priya X VLAM-7	47.87^{ghi}	10.90^{ab}	64.37^{gh}	1.93^{hij}	5.67^{fghi}	1.66^{d}	6.99^{abcd}	1.49^{bcde}	5.71^{gh}	30.33^{e}	95.00^{bcde}	3.63^{fg}	110.20^{gh}	44.33^{bcde}
11	Mithi Phali	68.67^{ab}	8.47^{fg}	76.57^{de}	2.00^{ghi}	6.05^{cdefg}	1.03^{g}	7.81^{abc}	1.89^{a}	5.61^{h}	18.17^{i}	84.67^{fg}	4.10^{cd}	74.50^{l}	40.00^{de}
12	Vivek Matar-10	56.00^{def}	8.27^{fg}	58.00^{ij}	2.00^{ghi}	5.20^{ijk}	1.05^{g}	7.80^{abc}	1.53^{bcd}	6.31^{cdef}	18.56^{i}	82.00^{gh}	3.23^{ij}	59.98^{m}	44.33^{bcde}
13	Arka Apoorva	70.00^{ab}	10.63^{bc}	90.00^{a}	2.80^{a}	7.10^{a}	1.50^{e}	7.39^{abcd}	1.73^{ab}	6.24^{cdefg}	35.83^{d}	92.25^{cdef}	4.10^{cd}	145.72^{d}	43.33^{a}
14	AP-1	75.00^{a}	12.47^{a}	86.07^{ab}	1.77^{jk}	6.30^{cd}	1.80^{c}	8.07^{ab}	1.40^{bcde}	6.45^{cd}	24.83^{gh}	103.00^{a}	4.03^{cd}	100.15^{hi}	40.00^{abc}
15	P-89	58.67^{cde}	8.60^{efg}	74.37^{de}	2.00^{ghi}	6.03^{cdefg}	2.00^{a}	8.00^{a}	1.18^{ef}	7.18^{b}	41.25^{c}	77.50^{h}	6.10^{b}	174.76^{bc}	53.33^{abc}
16	Arka Ajit	64.83^{bc}	10.83^{ab}	89.50^{a}	2.60^{b}	6.95^{ab}	1.87^{bc}	7.67^{abc}	1.47^{bcde}	6.34^{cde}	24.70^{gh}	88.00^{efg}	3.73^{efg}	91.31^{ijk}	51.33^{abcd}
17	Palam Triloki	44.00^{i}	7.87^{g}	62.30^{hi}	2.20^{def}	4.91^{k}	0.97^{g}	6.29^{de}	1.39^{bcde}	5.86^{efgh}	17.50^{i}	67.67^{i}	3.57^{gh}	60.72^{m}	46.67^{abcde}
18	Arka Priya	71.83^{a}	9.00 ^{cdefg}	53.93^{j}	2.00^{ghi}	5.31^{hijk}	1.00^{g}	7.11^{abcd}	1.00^{f}	5.83^{efgh}	35.34^{d}	95.00^{bcde}	3.13^{ij}	112.43^{fg}	44.33^{bcde}
19	Palam Priya	72.33^{a}	11.17^{ab}	68.33^{fg}	2.50^{bc}	5.74^{efgh}	1.95^{ab}	7.83^{abc}	1.19^{def}	6.28^{cdef}	36.34^{d}	89.00^{defg}	3.37^{hi}	121.94^{ef}	46.67^{abcde}
20	VLAM-7	46.97^{hi}	8.23^{fg}	44.87^{k}	2.33^{cde}	5.22^{ijk}	1.33^{f}	7.18^{abcd}	1.68^{abc}	5.57^{h}	27.34^{fg}	59.00^{j}	3.20^{ij}	87.11^{jk}	41.33^{cde}
21	Mithi Phali	70.67^{ab}	9.60^{bcdefg}	77.00^{cd}	2.37^{cd}	6.07^{cdef}	1.03^{g}	7.80^{abc}	1.88^{a}	5.45^{h}	22.82^{h}	89.00^{defg}	3.77^{efg}	85.54^{k}	39.00^{e}
22	Vivek Matar-10	61.00^{cd}	9.50^{bcdefg}	57.30^{ij}	2.20^{def}	5.15^{jk}	1.87^{bc}	7.97^{abc}	1.37^{cde}	6.34^{cde}	22.84^{h}	85.67^{fg}	3.10^{j}	71.95^{l}	46.33^{abcde}
	SE(m) ±	1.05	0.33	1.00	0.04	0.09	0.02	0.21	0.06	0.11	0.54	1.28	0.06	1.93	2.11
	C.D.(0.05)	3.01	0.96	2.86	0.10	0.27	0.06	0.59	0.18	0.30	1.57	3.65	0.04	5.52	6.03
	C.V. (%)	3.12	6.04	2.48	2.88	2.81	2.51	4.79	7.32	3.05	3.19	2.56	4.10	2.92	7.66

Note: *Means of all the characters followed by different letters within a column are significantly different accordingly to Tukey's test ($P < 0.05$).*

Number of pod per plant: The amount of fresh pods generated is directly proportional to the quantity of pods per plant. Genotypes that produce more healthy pods can be used to increase pea output (Yadav et al. 2018). If other characteristics are optimum, a cultivar's number of pod/plant may be given preference over others. Smaller pods require fewer nutrients than larger pods, which could explain why plants have more pods per plant (Javaid et al. 2002). This could be due to favourable environmental conditions including low temperature, low relative humidity, and an ideal photoperiod for luxuriant vegetative development and blooming, all of which promote increased pod production. The perusal of data presented in Table 1 revealed wide genotypic variation among all the genotypes. The matromorphic progenies, Arka Apoorva x P-89 along with Arka Apoorva x AP-1 (Pl.2) recorded maximum value for number of pod per plant (45.89 and 44.61, respectively) which were statistically superior compared to all other genotypes. Parental lines, P-89 and Arka Apoorva, on the other hand recorded 41.25 and 35.83 number of pod per plant. However, matromorphic progeny, Palam Triloki recorded the minimum value (17.03) for number of pod per plant. The findings of other researchers viz., Azam et al. (2020) and Ali et al. (2019) are in harmony with our results.

Days to first picking: Days to first picking is an important trait which can be used to discriminate between genotypes of early, medium, and late maturity. Our results revealed wide variation among genotypes for days to first picking ranging from 59.00 to 103.00 days. Among the genotypes, VL Ageti Matar-7 took lesser number of days to first picking (59.00) followed by two matromorphic progenies viz., Palam Triloki (64.00) and Palam Triloki x AP- 1(68.00). However, AP-1 took the maximum days (103.00) to first picking. Similar differences in days to first picking have been reported by other researchers *viz.,* Kanwar et al. (2020) and Rahman et al. (2019).

Average pod weight (g): Average pod weight is another significant feature that has a direct impact on the plant's pod yield which is determined by the number of seed in each pod. More the number of seed per pod, higher would be the average pod weight and ultimately resulting in increased pod yield. This could be owing to cultivars' inherent potential as well as their interactions with soil and climate. Pod size is mostly determined by variety, although it is also influenced by plant vigour (Bozoglu et al. 2007). Significant differences were observed for average pod weight among genotypes which ranged from 3.33 to 6.40 g (Table 1). Among all the genotypes, Arka Apoorva x P-89 was found to be significantly superior with highest value for average pod weight of 6.40 g followed by P-89 (6.10). Our results are consistent with the findings of Kanwar et al. (2020) and Sekhon et al. (2019).

Pod yield per plant: The ultimate goal of a pea breeding programme is to increase economic production, which is measured as pod yield per plant. The boost in pod production may have been aided by favourable environmental circumstances such as low temperatures, high relative humidity, and optimal sunshine hours. Our results revealed significant variability among genotypes for pod yield per plant ranging from 59.37 to 200.38 g (Table 1). Significantly maximum pod yield (200.38 g) was recorded in Arka Apoorva x P-89 followed by Arka Apoorva x AP-1(Pl.1) (184.37) and parental line P-89 (174.76). However, matromorphic progeny, Palam Triloki recorded the minimum pod yield (59.37). Our results are consistent with the observations recorded by Kanwar et al. (2020) and Singh et al. (2019).

Shelling percentage: Shelling percentage is an important feature that directly affects seed yield and is critical for processing purpose. Differences in shelling percentages could be attributed to innate traits of different genotypes and genetic setup (Damor et al. 2017).The perusal of data presented in Table 1 revealed wide variation among all the genotypes ranging from 39.00 to 58.33%. The parental lines, Arka Apoorva, P-89, AP-1 recorded the highest values (58.33, 53.33 and 52.33) along with two matromorphic progenies viz., Arka Apoorva x P-89 (55.00) and Arka Ajit x P-89 (54.33). However, Mithi Phali recorded the lowest value (39.00) for shelling percentage. Our results are in harmony with the findings of Kumar et al. (2021); Thapa et al. (2020) and Singh et al. (2019).

Screening against powdery mildew: The development of disease-resistant pea cultivars is a significant task that must be prioritised. As a result, there is a pressing need to screen current garden pea genotypes for powdery mildew resistance in order to identify resistant sources that may be exploited to transfer resistance to other high-yielding genotypes. The available matromorphic progenies (Mat_3) (homozygous/ heterozygous) and parental lines were screened under field circumstances for resistant sources against pea powdery mildew using the Percent Disease Index (PDI) and Percent Incidence (PI) during the present investigation. The genotypes exhibited considerable variation for resistance against powdery mildew disease. The overall percent disease index (PDI) ranged between 0.0 to 27.78. Whereas, percent incidence ranged between 0.0 to 26.18 (Table 2 and Fig.1). Among 22 genotypes screened for reaction to powdery mildew,

Table 2: Screening of pea genotypes against powdery mildew

Number of genotypes	Genotypes	Incidence Range (%)	PDI Range (%)	Disease reaction
1	Arka Apoorva x P-89(0)	0	....	Highly resistant
8	Arka Apoorva(2.22), Arka Ajit(4.81) ,Arka Ajit x P-89(5.93), Arka Priya(6.30), Arka Apoorva x AP-1(Pl.1)(7.78), Arka Apoorva x AP-1 (Pl.2)(8.52), Arka Ajit x AP-1(8.89) and Arka Priya x AP-1(10.00)	6.78-17.56	2.22-10.00	Resistant
13	AP-1(12.96),Mithi Phali(13.70),Palam Triloki(Mat$_3$) (13.70), Palam Triloki x P-89(13.70), VLAM-7(14.81), Vivek Matar-10(15.19), Vivek Matar-10(Mat$_3$) (16.67), P-89(17.04),Palam Triloki x AP-1(18.15), Mithi Phali(18.52) Palam Priya(18.52), Palam Priya x VLAM-7(19.26), and Palam Triloki(19.13)	14.67- 26.18	12.96-19.26	Moderately resistant
0	NIL	....	....	Moderately susceptible
0	NIL	....	....	Susceptible
0	NIL	....	....	Highly susceptible

Figures in parenthesis are corresponding Percent Disease Index Values (PDI)

only one matromorphic progeny i.e. Arka Apoorva x P-89 was found to be highly resistant whereas eight genotypes viz., Arka Apoorva, Arka Ajit, Arka Ajit x P-89, Arka Priya, Arka Apoorva x AP-1(Pl.1), Arka Apoorva x AP-1 (Pl.2), Arka Ajit x AP-1 and Arka Priya x AP-1 were found to be resistant. Rest of the remaining thirteen genotypes were found to be moderately resistant and none of the genotype(s) was found to be moderately susceptible, susceptible or highly susceptible. Our results are in agreement with the findings of Assen (2020) who also reported considerable variation among genotypes for resistance against powdery mildew disease. Other researchers viz., Azam et al. (2020); Ikram (2020); Mishra et al. (2019) and Nag et al. (2018) also reported similar results while screening different genotypes for powdery mildew resistance.

Screening against rust: One of the devastating diseases, pea rust is found in severe form in all of India's major pea growing locations (Shroff and Chand 2010). The pea cultivars released for general cultivation in India are known to be sensitive to rust. As a result, improving rust resistance in pea cultivars is a serious concern that must be addressed as soon as possible. During the present investigation, 22 pea genotypes were screened against rust disease under subtropical conditions of Jammu region. The results revealed significant differences among genotypes with PDI value ranging between 0.67 to 53.33 and PI between 6.78 to 51.76 (Table 3 and Fig. 1). Among all the genotypes, four genotypes viz., Arka Apoorva x P-89 (Mat$_3$), Mithi Phali (Mat$_3$), Arka Apoorva and Mithi Phali were found to be the resistant genotypes, six genotypes *viz.,* Arka Priya, Arka Ajit, P-89, Arka Apoorva x AP -1 (Pl.2), Arka Apoorva x AP-1(Pl.1) and Arka Ajit x P-89 fall under the category of moderately resistant, seven genotypes, *viz.,* Vivek Matar-10, Palam Triloki (Mat$_3$), Arka Priya x AP-1, VLAM-7, Palam Triloki, Palam Triloki x P-89 and Vivek Matar-10 (Mat$_3$) were found to be moderately susceptible whereas rest of the remaining five genotypes fall under the category of susceptible. However, none of the genotype was found to be immune against rust. Our findings are consistent with those of Singh et al. (2020); Das et al. (2019); Nongmaithem et al. (2017) and Upadhyay et al. (2017).

Table 3: Screening of pea genotypes against rust disease

Number of genotypes	Genotypes	Incidence Range (%)	PDI Range (%)	Disease reaction
0	NIL	....	....	Immune
4	Arka Apoorva x P-89(0.67),Mithi Phali(0.74), Arka Apoorva(0.74) and Mithi Phali(0.76)	5.10-10.87	0.67-0.76	Resistant
6	Arka Priya(8.37),Arka Ajit(8.37) , P-89(8.52)Arka Apoorva x AP -1(Pl.2)(9.33),Arka Apoorva x AP-1(Pl.1)(9.37) and Arka Ajit x P-89(9.63)	8.37-25.43	8.37-9.63	Moderately resistant
7	Vivek Matar-10(21.85),Palam Triloki (Mat$_3$) (22.96),Arka Priya x AP-1(23.33), VLAM-7(23.70),Palam Triloki(24.44),Palam Triloki x P-89(24.81) and Vivek Matar-10(Mat$_3$)(24.81)	46.67- 48.65	21.85-24.81	Moderately susceptible
5	Palam Priya(47.04),AP-1(48.52),Arka Ajit x AP-1(49.63),Palam Priya x VLAM-7(49.63) and Palam Triloki x AP-1(53.33)	50.35-51.76	47.04-53.33	Susceptible
0	NIL	....	....	Highly susceptible

Figures in parenthesis are corresponding Percent Disease Index (PDI) values

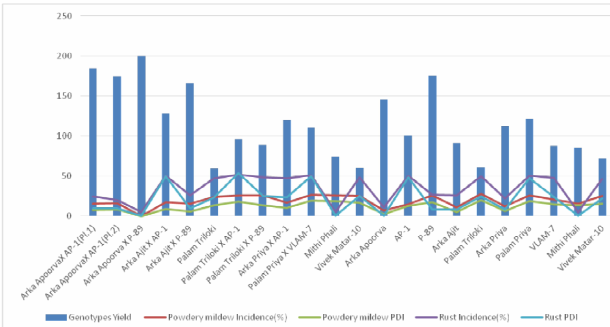

Fig: 1 Genotypic variation for pod yield per plant (g), disease incidence (%) and PDI (Powdery Mildew and Rust)

Conclusion

It can be concluded from the present investigation that the genotypes performed differently for various traits under field conditions, but the overall performance of matromorphic progeny Arka Apoorva x P-89 was found to be best expressed in terms of morphological and yield traits as well as resistance to powdery mildew and rust disease. This genotype can be promoted for further evaluation / cultivation on a large scale in the farmer's field under subtropical conditions of J&K.

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कायान्तरण या मातृ गैर–संकर द्विगुणित संतान है जो पूरी तरह से मातृ (माता–पिता) से उत्पन्न होते हैं और विषमयुग्मजी आधार वाले समूह से तत्काल समरूप वंश प्राप्त करने में सुविधा प्रदान करते हैं, जिससे समरूप वंशों के लिए पारंपरिक प्रजनन पद्धति के समय की आवश्यकता कम हो जाती है। वर्तमान अध्ययन के तहत् जम्मू और कश्मीर की उपोष्ण कटिबंधीय स्थितियों के तहत 12 उच्चीकृत पीढ़ियों में कायान्तरण (मैट3) के प्रदर्शन के साथ–साथ उनकी 10 पैतृक वंशों को मूल्यांकन, विकास, उपज और चूर्णिल आसिता रोग और रस्ट रोग के विरूद्ध छंटनी के लिए शेरे–ई–कश्मीर कृषि एवं प्रौद्योगिकी विश्वविद्यालय, प्रायोगिक प्रक्षेत्र, चट्ठा, जम्मू में वर्ष 2020–2021 क्षेत्र परीक्षण किया गया। वर्तमान शोध अध्ययन के समग्र निष्कर्षों के आधार पर, यह परिणाम प्राप्त हुआ कि किस्म पालम त्रिलोकी न्यूनतम दिनों में 50 प्रतिशत पुष्पन (44.00) के साथ सबसे पहले था, उसके बाद तीन कायान्तरित संतानें जैसे–पालक त्रिलोकी (46.33 दिन), पालम त्रिलोकी x पी.–89 (44.67 दिन) और पालम त्रिलोकी x एपी.–1 (46.83 दिन) का स्थान रहा। पौधे की ऊँचाई के संबंध में, अधिकतम पौध की ऊँचाई पैतृक वंश अर्का अपूर्वा (90.0 सेमी.) में दर्ज की गयी एवं उसके बाद अर्का अजीत (89.50 सेमी.) और अर्का अपूर्वा x ए.पी.–1 (पी.एल.–1) (88.50 सेमी.) और अर्का अपूर्वा x ए.पी.–1 (पी.एल.–2) (88.30 सेमी.) मैट3 संततियों में श्रेष्ठ पाया गया। मैट3 में, अर्का अपूर्वा x पी.–89 (7.83), अर्का अपूर्वा x ए.पी.–1 (पी.एल.–2) (6.77) और पी.–89 (7.18) और अर्का अपूर्वा (6.34) पितरों में प्रति फली अधिकतम बीज पाया गया। फली प्रति पौध की अधिकतम संख्या कायान्तरित संतानों में दर्ज की गयी। अर्का अपूर्वा x पी.–89 (45.89) के बाद अर्का अपूर्वा x ए.पी.–1 (पी.एल.–2) (44.61), अर्का अपूर्वा x ए.पी.–1 (पी.एल.–1) (41.83) पाया गया और पैतृक वंशों में पी.–89 (41.28), अर्का अपूर्वा (35.83) में फली की अधिकतम संख्या प्रति पौधा पायी गयी। अधिकतम फली उपज अर्का अपूर्वा x पी.–89 (200.38 ग्राम) और उसके बाद अर्का अपूर्वा x ए.पी.–1 (पी.एल.–1) (184.37 ग्राम) मैट3 में जबकि पैतृक वंशों में अधिकतम फली उपज पी.–89 (174.76 ग्राम) और अर्का अपूर्वा (145.72 ग्राम) में प्राप्त हुयी। अध्ययन के तहत् प्रभेदों की छंटनी के आधार पर अर्का अपूर्वा x पी.–89 (मैट3) की पहचान मटर में संक्रमण करने वाले रोगों यानी चूर्णिल आसिता और रस्ट के विरूद्ध उच्च प्रतिरोधी प्रभेदों के रूप में पहचान की गयी थी।

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