AATCC Review

23 June 2024: Received
26 July 2024: Revised
29 August 2024: Accepted
03 October 2024: Available Online

https://aatcc.peerjournals.net/

Original Research Article

Open Access

Estimation of Genetic Variability Parameters in F2 Population of Lathyrus (*Lathyrus sativus* L.)

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ABSTRACT

Lathyrus is crop of prosperity nutritional value. It favours self-pollination so there have been indications that some out crossing occurs due to which precise emasculation and pollination was challenge. The current investigation focused on the study of 21 F_2 crosses in Lathyrus to estimate the genetic parameters in the F_2 population. During the rabi 2017-18 season, the F_2 crosses were cultivated alongside ten parents, with data collected on seven yield and yield-contributing characteristics. The genetic coefficient of variation was notably high for the number of pods per plant and yield per plant. Estimates of heritability (h) in the broad sense indicated a high range for yield per plant (40.12-92.14%) and a moderate to high range for the number of pods per plant (21.89-85.70%). Significant genetic advancement was anticipated across all F_2 populations, particularly for plant height at maturity (15.88-26.83), the number of pods per plant (10.72-47.49), and yield per plant (4.22-13.62). Fourteen crosses were identified based on their elevated means, genotypic coefficient of variation, broad-sense heritability, and genetic advances for economically significant traits, such as the number of pods per plant and yield per plant.

Keywords: *Lathyrus, heritability, genetic advance, genetic coefficient of variation, phenotypic coefficient of variation, variability*

I. INTRODUCTION

Lathyrus (*Lathyrus sativus* L.) also known as grass pea, khesari, Indian pea, blue sweet pea, white pea and chickling pea. Lathyrus has 130 species occurring all over temperate region of northern hemisphere and the higher altitude of tropical Africa. The most probable origin of lathyrus is Europe and Western Asia. In India lathyrus crop can be cultivated in Maharashtra. Bihar, Chhattisgarh, M.P. and West Bengal as reported by[2].

Designing efficient and desirable plant type requires the existence of genetic variability in the material. To incorporate desirable characters to maximize economic yields, the information on the nature and extent of genetic variability present in population for desirable characters, their association and relative contribution to yield constitute the basic requirement. F_2 generation provides an active breeding material from which desirable plant may selected. There have been varying reports about the reliability of early-generation selection. Therefore, the present study was planned and undertaken to find genetic variation.

The experimental material comprised of twenty-one F_2 crosses selected based on different yield contributing characters from F_1, and their ten parents in which seven lines (female) viz. NLK-06, NLK-48, NLK-12, NLK-73, NLK-17, LL-14-2.LL-14-5 and three testers (male) viz., Ratan Prateek, NLK-40 were crossed in a line x tester mating design in rabi 2015. This material was grown during rabi 2017- 2018 in randomized complete block design with three replications.

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DOI: https://doi.org/10.21276/AATCCReview.2024.12.03.366

Five rows of each F_2 cross and one row of each parent were allotted during sowing. These rows sown with 45 cm x 15 cm spacing consisted of twenty plants in each row. Data were recorded on two hundred plants from each individual cross and five randomly selected plants from each parent for seven characters i.e. days to first flower. days to maturity, plant height at maturity, number of primary branches per plant, number of pods per plant, 100 seed weight and seed yield per plant. The data recorded were subjected to various statistical and biometrical viz. Analysis of variance [4], estimation of genetic parameters ie. genotypic and phenotypic coefficient of variability, heritability in broad sense [3].

II. MATERIALS AND METHODS

The experimental material consisted of twenty-one F_2 crosses, carefully selected based on diverse yield-contributing traits from the F_1 generation, along with ten parents. The seven female lines included NLK-06, NLK-48, NLK-12, NLK-73, NLK-17, LL-14-2, and LL-14-5, while the three male testers were Ratan, Prateek, and NLK-40. A line x tester mating design was employed, and the material was cultivated during the rabi season of 2017-2018 in a randomized complete block design with three replications. For each F_2 cross, five rows were allocated, and for each parent, one row was designated during sowing. These rows, sown with a spacing of 45 cm x 15 cm, comprised twenty plants in each row. Data were collected for two hundred plants from each F_2 cross and five randomly selected plants from each parent, focusing on seven traits, including days to first flower, days to maturity, plant height at maturity, number of primary branches per plant, number of pods per plant, 100-seed weight, and seed yield per plant. The collected data underwent various statistical and biometrical analyses, including Analysis of Variance [4], as well as the estimation of genetic parameters, such as genotypic and

phenotypic coefficients of variability, broad-sense heritability[3] and genetic advance (G.A.) [6]

III. RESULTS AND DISCUSSION

The results of the analysis of variance for the seven characters are presented in Table 1. The mean squares attributed to genotypes (crosses + parents) were found to be significant for all five characters studied, except for the number of primary branches per plant and days to maturity, indicating a substantial genetic variability among the genotypes. This suggests that, except for the number of primary branches per plant and days to maturity, the genetic parameters can be accurately estimated for the remaining five characters, namely days to first flower, plant height at maturity, number of pods per plant, 100-seed weight, and yield per plant. Similar findings were reported by [7], highlighting significant variability among the genotypes (F_2 crosses and parents) for all the mentioned characters in Lathyrus.

Days to first flower

The F_2 cross NLK-06 x Prateek exhibited the earliest flowering at 50.90 days, closely followed by LL-14-2 x NLK-40 (50.93 days), NLK-06 x Ratan (51.05 days), and NLK-17 x NLK-40 (51.05 days). The highest F_2 variance was observed in NLK-06 x NLK-40 (7.24), followed by NLK-06 x Ratan (6.99) and NLK-73 x NLK-40 (6.82). The genotypic coefficient of variation was highest in the F_2 cross NLK-06 x Ratan (4.78%), followed by NLK-06 x NLK-40 (4.77%) and NLK-73 x NLK-40 (4.52%). Moreover, the F_2 cross NLK-06 x NLK-40 exhibited the highest phenotypic coefficient of variation (5.26%), followed by NLK-06 x Ratan (5.18%) and NLK-73 x NLK-40 (5.07%). Regarding heritability estimates, the maximum values were recorded in NLK-06 x Ratan (85.29%), NLK-06 x Prateek (84.25%), NLK-06 x NLK-40 (82.08%), LL-14-2 x Ratan (80.26%), and NLK-73 x NLK-40 (79.50%). Furthermore, the F_1 cross NLK-06 x Ratan displayed the highest genetic advance (4.55), followed by NLK-06 x NLK-40 (4.55) and NLK-06 x Prateek (4.30).

Plant height at maturity (cm)

The maximum F_2 variance was observed in the F_2 cross NLK-06 x Ratan (232.12), followed by NLK-17 x Ratan (220.21) and NLK-06 x Prateek (206.55). Regarding the mean performance of F1 crosses, the highest plant height was observed in NLK-17 x Prateek (74.00 cm), followed by the crosses NLK-06 x NLK-40 (71.59 cm) and LL-14-5 x Ratan (70.80 cm). The genotypic coefficient of variation was found to be the highest in the F_2 cross LL-14-2 x NLK-40 (20.49%), followed by NLK-06 x NLK-40 (19.93%). The phenotypic coefficient of variation was recorded to be the highest in NLK-73 x NLK-40 (23.34%), followed by LL-14-2 x NLK-40 (22.49%) and LL-14-5 x NLK-40 (22.37%). The maximum heritability estimate was observed in the F_2 cross NLK-06 x Ratan (85.12%), followed by NLK-48 x Ratan (84.16%) and LL-14-5 x Ratan (84.09%). Moreover, the maximum genetic advance was recorded in the F_2 cross NLK-06 x Ratan (26.84), followed by NLK-06 x Prateek (24.48) and NLK-48 x Ratan (24.35).

As presented in Table 3., the majority of the crosses exhibited high values for genotypic coefficient variation, variance of F_2 crosses, heritability, and genetic advance, indicating the potential effectiveness of selection for plant height within these crosses. The crosses demonstrating elevated heritability alongside substantial genetic advance suggest the effectiveness of selection in these particular crosses, in agreement with findings reported by [8] for this trait.

Number of pods per plant

The crosses NLK-46 x Prateek, LL-14-2 x NLK-40, NLK-12 x Ratan, NLK-12 x Prateek, LL-14-2 x Prateek, NLK-06 x NLK-40, NLK-48 x Prateek, NLK-12 x NLK-40, NLK-73 x Ratan, NLK-73 x Prateek, LL-14-2 x Ratan, LL-14-5 x Ratan, and LL-14-5 x NLK-40 exhibited high F_2 variance, genotypic coefficient of variation, heritability, and genetic advance, as presented in Table 3. The notable combination of high heritability with a substantial genetic advance in the aforementioned crosses suggests that the number of pods per plant trait is predominantly governed by additive gene action. Consequently, it is indicated that directional phenotypic selection for this trait in genetically diverse genotypes or segregating populations could be effective for the desired genetic improvement.

The crosses NLK-06 x Ratan, NLK-73 x NLK-40, NLK-17 x NLK-40, and LL-14-5 x Prateek exhibited low heritability alongside low genetic advance, coupled with low genotypic coefficient of variation and F_2 variance. Conversely, the crosses NLK-48 x Ratan, NLK-48 x NLK-40, and NLK-17 x Ratan demonstrated low genetic advance despite the presence of high heritability. This pattern could be attributed to non-additive gene effects and the presence of high genotype by environmental interaction, suggesting that simple selection may not yield substantial rewards. Similar observations were also reported by [7] concerning F_1 crosses exhibiting high heritability coupled with high genetic advance selections based on the number of pods per plant.

100 seed weight (g)

The F_2 cross LL-14-5 x Ratan exhibited the highest 100-seed weight at 8.06 g, followed by NLK-12 x Ratan (7.96 g) and NLK-12 x Prateek (7.86 g). The highest F_2 variance was observed in the F_2 cross NLK-17 x Ratan (2.03), followed by LL-14-5 x Ratan (1.69) and LL-14-5 x Prateek (1.68). Moreover, the genotypic coefficient of variation was found to be the highest in the F_2 cross NLK-17 x Ratan (18.30%), followed by NLK-73 x NLK-40 (16.06%) and LL-14-5 x Prateek (15.31%). The F_2 cross NLK-17 x Ratan recorded the maximum phenotypic coefficient of variation at 19.84%, followed by LL-14-5 x Prateek (17.56%) and LL-14-2 x Ratan (17.04%). Maximum heritability was recorded in NLK-73 x NLK-40 (89.41%), followed by NLK-12 x NLK-40 (85.44%) and NLK-17 x Ratan (84.92%). Additionally, the maximum genetic advance was observed in NLK-17 x Ratan (2.49), followed by NLK-73 x NLK-40 (2.37) and LL-14-5 x Ratan (2.21)

The findings pertaining to 100-seed weight presented in Table 4. indicated that although several crosses exhibited high genetic coefficient variation and heritability, the genetic advance was observed to be low, suggesting the influence of non-additive gene action. The observed high heritability was attributed to favorable genetic effects of the environment rather than the genotype, leading to the conclusion that selection for 100-seed weight in such crosses within the F_1 segregating generation may not yield significant rewards. Similar conclusions regarding non-additive gene effects and the presence of high genotype by environment interaction for 100-seed weight were reported by [10] in their analysis of F_2 crosses.

Yield per plant (g)

High heritability with moderate genetic advance was observed for the trait yield per plant in the F_2 crosses, including NLK-06 x Prateek, NLK-12 x Ratan, NLK-12 x Prateek, LL-14-2 x Prateek, LL-14-5 x Ratan, LL-14-2 x NLK-40, LL-14-5 x Prateek, LL-14-5 x

NLK-40, NLK-73 x Prateek, LL-14-2 x Ratan, NLK-12 x NLK-40 and NLK-73 x Ratan (Table 4). The trait was determined to be under the influence of additive gene action, making selection in these crosses a rewarding endeavor. Similar findings regarding the predominance of additive gene action were also reported by [5] in their examination of crosses. Conversely, the crosses NLK-06 x Ratan, NLK-06 x NLK-40, NLK-48 x Ratan, NLK-48 x Prateek, NLK-48 x NLK40, NLK-73 x NLK-40, NLK-17 x Ratan, NLK-17 x Prateek and NLK-17 x NLK-40 exhibited high heritability and low genetic advance, indicating the presence of non-additive gene action. The observed high heritability in these cases was attributed to environmental influence, rendering selection in these crosses ineffective for yield per plant. Similar findings regarding high heritability and the ineffectiveness of selection were also reported by [9] for yield per plant.

V. CONCLUSION

Among the seven characters studied, significant variation was observed in five characters across the twenty-one crosses during the F_2 population study in Lathyrus. Notably, the characters number of pods per plant (22.58%) and yield per plant (13.90%) exhibited high and moderate coefficients of variation, respectively, while days to first flower (0.81%), plant height at maturity (9.81%) and 100-seed weight (6.57%) demonstrated low coefficients of variation. Consequently, for the selection of crosses, only number of pods per plant and yield per plant characters were considered.

From the results of F_2 crosses NLK-06 x Prateek, LL-14-2 x NLK-40, NLK-12 x Ratan, NLK-12 x Prateek, LL-14-2 x Prateek, NLK-06 x NLK-40, NLK-48 x Prateek, NLK-12 x NLK-40, NLK-73 x Ratan, NLK-73 x Prateek, LL-14-2 x Ratan, LL-14-5 x Ratan, LL-14-5 x NLK-40, and LL-14-5 x Prateek were identified for their high mean, genetic coefficient of variation, heritability, and genetic advance for both number of pods per plant and yield per plant, or for at least one of these two traits. Consequently, these fourteen crosses were selected for further advancement.

Table 1. Analysis of variance for seven characters in Lathyrus

Source of variation	Mean square							
	d.f.	Days to first flower	Days to maturity (cm)	Plant height at maturity	No. of primary branches	No. of pods per plant	100 seed weight (g)	Yield per plant (g)
Replications	2	0.309	0.809	144.83	1.089	11.89	0.177	10.62
Genotypes	30	0.289	0.672	98.90	0.17	382.61	0.492	7.24
Error	60	0.172	0.545	46.10	0.365	153.56	0.235	3.54

Note:,**Significant at 5% and 1%*

Table 2. Estimation of genetic parameter in each F_2 cross for days to first flower

F_2 crosses/Parents	Mean + $SE_{(m)}$	Range	VF_2	GCV(%)	PCV(%)	h^2(%)	GA
NLK-06 x Ratan	51.05+2.64	14.00(45-59)	6.99	4.78	5.18	85.29	4.55
NLK-06 x Prateek	50.90+2.47	14.00(44-58)	6.15	4.47	4.87	84.25	4.30
NLK-06 x NLK-40	51.16+2.69	12.00(46-58)	7.24	4.77	5.26	82.08	4.55
NLK-48 x Ratan	51.23+2.31	12.00(46-58)	5.36	4.03	4.52	79.47	3.79
NLK- 48 x Prateek	51.12+2.23	10.00(46-56)	4.99	3.89	4.37	79.15	3.64
NLK- 48 x NLK -40	51.38+2.34	11.00(46-57)	5.48	3.95	4.56	74.99	3.62
NLK-12 x Ratan	51.06+2.43	12.00(45-57)	5.95	4.17	4.78	76.12	3.84
NLK-12 x Prateek	51.16+2.42	12.00(46-58)	5.87	4.15	4.73	76.78	3.83
NLK-12 x NLK-40	51.70+2.22	12.00(46-58)	4.94	3.49	4.29	65.77	3.01
NLK-73 x Ratan	51.72+2.22	12.00(46-58)	4.93	3.77	4.29	77.09	3.53
NLK-73 x Prateek	51.40+2.14	10.00(46-56)	4.60	3.66	4.17	76.76	3.39
NLK-73 x NLK-40	51.56+2.61	15.00(45-60)	6.82	4.52	5.07	79.50	4.28
NLK-17 x Ratan	51.07+2.52	12.00(46-58)	6.37	4.38	4.94	78.62	4.09
NLK-17 x Prateek	51.11+2.43	13.00(44-57)	5.94	4.21	4.77	78.06	3.92
NLK-17 x NLK-40	51.05+2.49	12.00(46-58)	6.21	4.19	4.88	73.73	3.78
LL-14-2 x Ratan	51.17+2.26	10.00(46-56)	5.14	3.97	4.43	80.26	3.77
LL-14-2 x Prateek	51.28+2.09		4.37	3.61	4.08	78.17	3.37
LL-14-2 x NLK-40LL-14-5 x Ratan	76.1866.85						
LL-14-5 x Prateek	51.48+2.12	12.00(46-58)	4.50	3.36	4.12	66.69	2.91
LL-14-5 x NLK-40	51.06+2.11	10.00(46-56)	4.46	3.18	4.14	59.03	2.57
NLK-06	51.40	-	-	-	-	-	-
NLK-48	51.47	-	-	-	-	-	-
NLK-12	51.40	-	-	-	-	-	-
NLK-73	50.73	-	-	-	-	-	-
NLK-17	51.73	-	-	-	-	-	-
LL-14-2	51.00	-	-	-	-	-	-
LL-14-5	51.07	-	-	-	-	-	-
Ratan	51.60	-	-	-	-	-	-
Prateek	51.07	-	-	-	-	-	-
NLK-40	52.13	-	-	-	-	-	-
Grand mean	52.26						
SE(m)±	0.24						
CV (%)	0.81						

Table 3. Estimation of genetic parameters in each F_2 cross for plant height at maturity and number of pods per plant

	Plant Height at maturity							Number of pods per plant						
F_2 crosses/Parents	Mean ±SE(m)	Range	VF_2	GCV%	PCV%	h^2 (%)	GA	Mean ±SE(m)	Range	VF_2	GCV%	PCV%	h^2 (%)	GA
NLK-06 x Ratan	68.40 ± 15.23	94.50 (24.58-119)	232.12	12.59	22.27	85.12	26.84	48.32 ± 23.76	150(10 - 160)	564.94	23.02	49.19	21.89	10.72
NLK-06 x Prateek	69.02 ± 14.37	77.00 (35 - 112)	206.55	18.93	20.82	82.68	24.48	54.75 ± 30.81	169(18 - 187)	949.63	39.01	56.28	48.04	30.49
NLK-06 x NLK-40	71.59 ± 13.86	72.00 (38 - 110)	192.95	17.22	19.37	78.99	22.56	52.29 ± 26.61	156(13 - 169)	708.60	31.44	50.91	38.13	20.91
NLK-48 x Ratan	69.52 ± 14.04	65.00 (49 - 104)	197.30	18.54	20.21	84.16	24.35	47.49 ± 19.89	105(15 - 120)	395.97	27.18	41.91	42.08	17.25
NLK- 48 x Prateek	66.24 ± 14.07	82.00 (30 - 112)	198.00	19.37	21.24	83.13	24.09	53.07 ± 25.83	139(19 - 158)	667.52	37.02	48.69	57.82	30.77
NLK- 48 x NLK - 40	69.82 ± 13.48	71.00 (32 - 103)	181.89	17.18	19.32	79.10	21.98	47.88 ± 19.32	109(14 - 133)	373.64	25.33	40.37	39.37	15.68
NLK-12 x Ratan	67.78 13.90	70.00 (34 - 104)	193.42	17.79	20.52	75.14	21.53	57.91 ± 26.89	197(12 - 209)	723.51	47.06	50.84	85.70	47.49
NLK-12 x Prateek	67.70 ± 13.57	71.00 (31 - 102)	184.40	17.11	20.06	72.76	20.35	52.65 ± 27.86	195(11 - 206)	776.70	47.33	52.93	79.95	45.90
NLK-12 x NLK-40	65.72 ± 12.20	70.00 (34 - 104)	148.95	14.76	18.57	63.18	15.88	45.44 ± 19.45	100(14 - 114)	378.37	36.67	42.80	73.39	29.41
NLK-73 x Ratan	66.66 ± 13.29	68.00 (36 - 104)	176.85	17.04	19.95	72.92	19.98	47.49 ± 23.57	175(12 - 187)	555.62	35.42	49.63	50.93	24.73
NLK-73 x Prateek	60.82 ± 13.18	77.00 (26 - 103)	173.81	18.29	21.68	71.21	19.34	47.24 ± 24.90	186(12 - 198)	620.05	36.37	52.71	47.60	24.42
NLK-73 x NLK-40	60.84 ± 14.20	73.00 (31 - 104)	201.71	19.93	23.34	72.91	21.33	44.71 ± 19.30	106(12 - 118)	372.87	22.70	43.19	27.63	10.99
NLK-17 x Ratan	66.51 ± 14.83	75.00 (34 - 109)	220.21	19.78	22.21	78.61	24.03	53.18 ± 27.18	174(12 - 186)	739.20	29.11	51.13	32.41	18.15
NLK-17 x Prateek	74.00 ± 13.80	69.00 (37 - 106)	190.65	16.07	18.66	74.17	21.09	46.40 ± 20.86	117(10 - 127)	435.30	------	44.97	-------	-------
NLK-17 x NLK-40	67.74 ± 12.87	66.00 (38 - 104)	165.79	15.62	19.01	67.52	17.91	51.67 ± 26.46	156(12 - 168)	700.28	27.61	51.21	29.06	15.84
LL-14-2 x Ratan	64.48 ± 12.64	68.00 (39 - 106)	190.03	17.56	19.61	80.23	20.90	44.70 ± 26.13	246(11 - 257)	682.83	47.88	58.46	67.08	36.11
LL-14-2 x Prateek	62.87 ± 13.78	78.00 (32 - 110)	165.79	19.88	21.93	82.24	23.35	48.65 ± 26.92	187(12 - 199)	725.21	43.52	55.36	61.80	34.28
LL-14-2xNLK-40	67.74 ± 12.87	66.00 (38 - 104)	165.79	15.62	19.01	67.52	17.91	51.67 ± 26.46	156(12 - 168)	700.28	27.61	51.21	29.06	15.84
LL-14-5 x Prateek	60.18 ± 12.51	79.00 (27 - 106)	156.74	18.86	20.80	82.19	21.19	47.42 ± 19.77	118(14 - 132)	390.91	21.67	41.67	27.04	11.01
LL-14-5 x NLK-40	57.91 ± 13.10	79.00 (28 - 107)	171.71	20.37	22.63	81.06	21.88	49.54 ± 24.84	144(12 - 156)	617.37	39.67	50.15	62.76	32.13
NLK-06	80.40	-	-	-	-	-	-	94.53	-	-	-	-	-	-
NLK-48	75.87	-	-	-	-	-	-	69.67	-	-	-	-	-	-
NLK-12	76.13	-	-	-	-	-	-	41.20	-	-	-	-	-	-
NLK-73	75.47	-	-	-	-	-	-	70.93	-	-	-	-	-	-
NLK-17	75.07	-	-	-	-	-	-	73.07	-	-	-	-	-	-
LL-14-2	73.47	-	-	-	-	-	-	62.40	-	-	-	-	-	-
LL-14-5	76.60	-	-	-	-	-	-	68.67	-	-	-	-	-	-
Ratan	75.13	-	-	-	-	-	-	65.93	-	-	-	-	-	-
Prateek	75.93	-	-	-	-	-	-	63.27	-	-	-	-	-	-
NLK-40	71.73	-	-	-	-	-	-	51.87	-	-	-	-	-	-
Grand mean	69.19	-	-	-	-	-	-	54.87	-	-	-	-	-	-
SE +	03.92	-	-	-	-	-	-	07.15	-	-	-	-	-	-
CV (%)	09.81	-	-	-	-	-	-	22.58	-	-	-	-	-	-

Table 4. Estimation of genetic parameters in each F_2 cross for 100 seed weight and yield per plant

	100 seed weight (g)							Yield per plant (g)						
F_2 crosses/Parents	Mean ±$SE_{(m)}$	Range	VF_2	GCV%	PCV%	h^2 (%)	GA	Mean ±$SE_{(m)}$	Range	VF_2	GCV%	PCV%	h^2 (%)	GA
NLK-06 x Ratan	7.78 ± 1.26	5.9 (5.0 – 10.9)	1.61	14.48	16.29	79.04	2.06	13.96 ± 5.98	40.5 (4.8 – 45.3)	35.87	36.33	42.89	71.74	08.85
NLK-06 x Prateek	7.72 ± 1.18	5.0 (5.2 10.2)	1.41	12.77	15.39	68.83	1.68	13.69 ± 7.38	48.2 (4.8 – 53.0)	54.60	49.54	53.97	84.26	12.83
NLK-06 x NLK-40	7.38 ± 1.15	5.0 (5.2 – 10.2)	1.34	14.05	15.72	79.91	1.91	13.16 ± 5.91	32.5 (4.5 - 37.0)	35.03	30.08	44.98	75.49	09.20
NLK-48 x Ratan	7.22 ± 1.20	6.0 (4.2 – 10.2)	1.46	15.18	16.70	82.59	2.05	12.91 ± 5.00	33.8 (5.3 – 39.1)	26.06	25.05	39.54	40.12	04.22
NLK- 48 x Prateek	7.68 ± 1.15	6.5 (5.4 – 11.9)	1.33	12.85	15.01	73.26	1.44	14.60 ± 6.84	43.8 (5.4 – 49.2)	46.90	39.26	46.92	70.02	09.88
NLK- 48 x NLK - 40	7.67 ± 1.02	6.0 (5.0 – 11.0)	1.05	12.14	13.38	82.28	1.74	13.56 ± 5.73	42.2 (5.8 – 48.0)	32.89	32.01	42.30	57.28	06.77
NLK-12 x Ratan	7.96 ± 1.20	5.7 (5.3 – 11.0)	1.45	13.82	15.14	83.33	2.07	14.27 ± 7.16	51.2 (4.8 – 56.0)	51.40	47.72	50.24	90.20	13.32
NLK-12 x Prateek	7.86 ± 1.17	6.1 (5.0 – 11.1)	1.39	13.05	15.04	75.34	1.83	13.93 ± 6.65	51.6 (45. – 56.1)	44.34	45.87	47.79	92.11	12.63
NLK-12 x NLK-40	7.55 ± 1.10	6.3 (5.3 – 11.6)	1.21	13.44	14.54	85.44	1.93	12.93 ± 5.72	40.5 (4.6 – 45.1)	32.77	41.85	44.28	89.35	10.54
NLK-73 x Ratan	7.75 ± 1.22	5.9 (5.1 – 11.0)	1.51	14.52	15.85	83.95	2.12	13.11 ± 6.50	39.2 (3.9 – 43.1)	42.34	43.18	49.64	75.67	10.14
NLK-73 x Prateek	7.72 ± 1.24	6.3(4.8 – 11.1)	1.56	14.31	16.20	77.97	2.01	13.40 ± 6.76	43..0 (4.0 – 47.0)	45.71	45.37	50.46	80.83	11.26
NLK-73 x NLK-40	7.58 ± 1.28	7.2 (4.8 – 12.0)	1.66	16.06	16.98	89.41	2.37	12.30 ± 5.30	26.0 (4.0 – 30.0)	28.13	35.79	43.12	68.88	07.53
NLK-17 x Ratan	7.17 ± 1.42	7.3 (4.3 – 11.6)	2.03	18.30	19.84	84.92	2.49	12.95 ± 6.07	38.2 (4.6 – 42.8)	36.85	37.56	46.88	64.18	08.03
NLK-17 x Prateek	7.64 ± 1.11	5.4(5.4 – 10.8)	1.24	11.94	14.58	67.08	1.54	13.01 ± 6.14	44.5 (4.5 – 49.0)	37.74	39.24	47.20	69.11	08.75
NLK-17 x NLK-40	7.55 ± 1.17	6.3 (5.0 – 11.3)	1.38	14.13	15.55	82.63	1.99	13.84 ± 5.75	27.6 (4.5 – 32.1)	33.15	33.51	41.61	64.86	07.69
LL-14-2 x Ratan	7.20 ± 1.22	7.0 (4.5 – 11.5)	1.50	14.52	17.04	72.62	1.83	12.26 ± 5.84	37.0 (5.0 – 42.0)	34.15	43.59	47.66	83.65	10.07
LL-14-2 x Prateek	7.43 ± 1.24	7.4 (4.2 – 11.6)	1.55	13.69	16.75	66.81	1.71	13.25 ± 7.17	50.2 (4.9 – 55.1)	51.46	51.99	54.16	92.14	13.62
LL-14-2xNLK-40	7.64 ± 1.13	5.1 (5.2 – 10.3)	1.28	12.69	14.83	73.16	1.71	13.60 ± 6.29	39.2 (4.8 – 44.1)	39.59	43.86	46.28	89.81	11.64
LL-14-5 x Ratan	8.06 ±1.30	6.7 (5.3 – 12.0)	1.69	14.68	16.18	82.29	2.21	14.69 ± 3.79	36.0 (5.0 – 41.0)	43.37	42.03	44.96	87.40	10.43
LL-14-5 x Prateek	7.38 ±1.29	6.9 (4.2 – 11.1)	1.68	15.31	17.56	76.03	2.03	12.28 ± 5.74	42.4 (4.0 – 46.4)	33.04	43.93	46.79	88.12	10.43
LL-14-5 x NLK-40	7.61 ± 1.16	6.1 (4.3 – 10.4)	1.35	13.88	15.27	82.67	1.98	13.58 ± 6.22	34.1 (4.0 – 38.1)	38.70	43.43	45.81	89.88	11.52
NLK-06	7.31	-	-	-	-	-	-	14.57	-	-	-	-	-	-
NLK-48	6.55	-	-	-	-	-	-	16.67	-	-	-	-	-	-
NLK-12	7.15	-	-	-	-	-	-	10.01	-	-	-	-	-	-
NLK-73	6.69	-	-	-	-	-	-	15.25	-	-	-	-	-	-
NLK-17	7.07	-	-	-	-	-	-	13.50	-	-	-	-	-	-
LL-14-2	7.17	-	-	-	-	-	-	13.01	-	-	-	-	-	-
LL-14-5	7.25	-	-	-	-	-	-	11.69	-	-	-	-	-	-
Ratan	7.09	-	-	-	-	-	-	14.07	-	-	-	-	-	-
Prateek	6.87	-	-	-	-	-	-	12.62	-	-	-	-	-	-
NLK-40	6.42	-	-	-	-	-	-	11.77	-	-	-	-	-	-
Grand mean	7.38	-	-	-	-	-	-	13.53	-	-	-	-	-	-
$SE_{(m)}$	0.28	-	-	-	-	-	-	01.09	-	-	-	-	-	-
CV (%)	6.57	-	-	-	-	-	-	13.90	-	-		-	-	-

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