

**VARIABILITY AND HERITABILITY ANALYSIS IN SHORT
DURATION AND HIGH YIELDING *Brassica rapa* L.**

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Abstract

The experiment was carried out with 32 genotypes of *Brassica rapa* including two commercially cultivated varieties as checks to study their inter-genotypic variability, heritability, GCV, PCV, genetic advance, and CV percent considering 10 morphological characters at the experimental farm of SAU, Dhaka during November 2009 to February 2010. Significant variation was observed among the genotypes for all the characters studied except thousand seed weight. High GCV and PCV values were observed for number of secondary branches/plant. High heritability values along with low genetic advance in percentage of mean were obtained for 1000-seed weight, number of secondary branches/plant, seeds/siliquae, and siliquae length. Highly significant positive association of seed yield per plant was observed with number of primary branches/plant, number of secondary branches/plant and number of siliquae/plant. Considering variability among the genotypes, heritability, genetic advance, percent co-efficient of variance, and field performances, the genotypes G-15, G-19, G-1, G-3, G-4, G-10, G-18, G21, and G-24 were found suitable for future breeding programme.

Keywords: Variability, heritability, *Brassica rapa* L.

Introduction

Rapeseed-mustard is a major oilseed crop in Bangladesh. It contributes a lion share to the total edible oil production of the country. Most of the developed varieties take long duration to mature except a few. As a result, they do not fit well in the existing T.aman – Mustard - Boro cropping pattern. *Brassica* have great economic and commercial value and play a major role in our daily diet. Fat and oil are vital components of the human diet because they are important sources of energy and act as a carrier of fat soluble vitamins. Poor intake of fat and oil reduce the availability of fat soluble vitamins and cause dietary imbalance and food wastage. In a balanced diet, 20-25% of calories should come from fats and oils and the average need of fats and oils is about 37 g/day (Rahman, 1981). The seeds of *Brassica rapa* contain 42% oil and 25% protein (Khaleque, 1985). There is limited scope of horizontal expansion of cultivation of mustard. So, for increasing mustard production, yield must be increased per unit area. High

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yielding and short duration rapeseed mustard varieties should be developed to fit into the existing cropping pattern. Thus F₇ generations have been generated through different inter varietals crosses of *Brassica juncea*. The present study was conducted to find out the variability, character association and the direct and indirect effects of different characters on yield per plant which will give an opportunity to select the desired plant types to meet the existing demand. Information on genetic variability is necessary for initiating a successful breeding programme (Behl *et al.*, 1992). Genetic variability is a prerequisite for a successful breeding programme of any crop species and a critical survey of genetic variability is essential before initiating an improvement programme aiming to develop high yielding varieties (Falconer, 1989). The genetic variability in a population along with heritability gives an idea of genetic advance to be expected from selection for a given character (Burton, 1952; Johanson *et al.*, 1955).

Materials and Method

The present experiment was conducted at the experimental farm of Sher-e-Bangla Agricultural University (SAU), Dhaka-1207 during November 2009 to February 2010. A total number of 32 materials were used in this experiment where two were parents and 30 were F₇ segregating lines (Table 2). The crop was fertilized at the rate of 10 tons of cowdung, 250 kg urea, 175 kg triple super phosphate (TSP), 85 kg muriate of potash (MoP), 250 kg gypsum, 3 kg zinc oxide, and 1 kg boron per hectare. The half amount of urea and total amount of cowdung, TSP, MoP, gypsum, zinc oxide, and Boron were applied during final land preparation. The rest amount of urea was applied as top dressing after 25 days of sowing. The experiment was laid out in randomized complete block design (RCBD) with three replications. The total area of the experiment was 37m × 11m = 407 m². Each replication size was 37 m × 2.7 m and the distance between replication to replication was 1 m. The spacing between line to line was 30 cm. Seeds were sown in lines in the experimental plots on 4 November 2009. The seeds were placed at about 1.5 cm depth in the soil. Intercultural operations, such as weeding, thinning, irrigation, pest management, etc. were done uniformly in all the plots as and when necessary. Aphid infection was found in the crop during the siliquae development stage. To control aphids, Malathion-57 EC @ 2ml/liter of water was applied. Harvesting was done from 4th to 15th February 2010 depending upon the maturity of the genotypes.

For studying different genetic parameters and inter-relationships, 10 characters were taken into consideration. The data were recorded on randomly 10 selected plants for each of the parental lines and F₈ progenies on the following traits- days to 50% flowering, days to 80% maturity, plant height (cm), number of primary branches/plant, number of secondary branches/plant, number of

siliquae/plant, siliquae length (cm), number of seeds/siliquae, 1000-seed weight (g), and seed yield/plant (g). The data were analyzed for phenotypic and genotypic variances Johnson *et al.* (1955). Heritability and genetic advance were measured using the formulae given by Singh and Chaudhary (1985) and Allard (1960). Genetic advance in percentage of mean were calculated as suggested by Johnson *et al.* (1955).

Results and Discussion

The mean, range, and CV (%) of seed yield and yield contributing characters of 32 genotypes of *Brassica rapa* along with checks are presented in Table 1. Variations were observed among the lines for all the characters studied. Days to 50% flowering ranged from 30.33 to 36.00. Genotype G17 and G19 showed the lowest days to flowering, the highest was in genotype G1. Plant height ranged from 74.33 to 118.33 cm. Genotype G19 showed the highest (118.33 cm) and genotype G23 was the lowest in (74.33 cm) plant height. Number of primary branches/plant ranged from 4.20 to 9.40. Genotype G10 and genotype G23 showed the highest (9.40) and the lowest (4.20) number of primary branches/plant, respectively. Number of secondary branches/plant ranged from 1.33 to 8.47. Genotype G8, genotype G16, and G19 showed the highest (8.47) and the lowest (1.33) number of secondary branches/plant, respectively. Number of siliquae/plant ranged from 68.33 to 228.00. The highest was recorded in the genotype G3 (228.00) and the lowest was in G16 (68.33). Length of siliquae ranged from 4.34 to 6.93 cm. The highest was observed in genotype G15 (6.93 cm) and the lowest was in G14 (4.34 cm). Days to 80% maturity ranged from 86.33 to 97.33. Genotype G8 showed the lowest (86.33) and genotype G1 was the highest (97.33) days to maturity. Number of seeds/siliquae ranged from 12.30 to 24.33. Genotype G21 showed the highest (24.33) number of seeds/siliquae and genotype G14 was the lowest (12.30). Thousand seed weight ranged from 3.11 to 4.50 g. Genotype G19 was the highest (4.50g) and genotype G25 was the lowest (3.11g). The highest (9.87g) seed yield/plant was recorded in Genotype G15 and the lowest (5.23g) was recorded in G5 (Table 1).

The highest co-efficient of variation (CV%) was recorded in the character number of secondary branches/plant (53.77) followed by number of siliquae/plant (27.11), and 1000-seed weight (20.61g). Minimum variation was observed in the character days to 80% maturity (1.36) (Table 1). Considering the plant height, number of secondary branches/plant, siliquae/plant, maturity duration, seed yield and other yield contributing characters, the genotypes G8, G3, G17, G19, G10, G15, and G21 were selected for future breeding programme.

Table 1. Mean Range and CV (%) of seed yield and yield contributing characters of 32 genotypes of *Brassica rapa*.

Characters	MS	Mean	Range	CV (%)	SE
DTF	5.58	32.30	30.33-36.00	4.02	0.18
PHT	275.83	96.89	74.33-118.33	7.22	1.14
NPB	4.2	6.13	4.20-9.40	18.24	0.15
NSB	12.67	4.83	1.33-8.47	53.77	0.31
NSP	4599.79	153.28	68.33-228.00	27.11	5.26
PLH	0.68	5.51	4.34-6.93	8.16	0.06
DEF	19.94	90.50	86.33-97.33	1.36	0.28
SPS	18.66	16.61	12.30-24.33	15.66	0.34
TSW	0.39 ns	3.57	3.03-4.50	20.61	0.07
YPP	4.95	7.61	5.23-9.67	20.42	0.19

DTF = Days to 50% flowering, PHT= Plant height (cm), NPB =No. of primary branches/plant, NSB = No. of secondary branches/plant, NSP = No. of siliquae/plant, PLH = Length of siliquae (cm), DEF = Days to 80% maturity, SPS= No. of seeds/siliquae, TSW = 1000 seed weight (g) and YPP = Seed yield per plant (g), ns= Not significant.

Variability among the genotypes

Out of 32 genotypes the lowest days to flowering was taken by SAU Sharisa-1 S2 (30 days) and F6 × BARI Sharisa-9 P1 followed by BARI Sharisa-9 × BARI Sharisa-6 P3, SAU sarisha-1 S3, BARI Sharisa-9 × F6 P3 (31 days). The highest days to flowering was taken by BARI Sharisa-9 × BARI Sharisa-6 P1 (36.00 days) which was close to F6 × BARI Sharisa-9 P2 (35.00 days) (Table 2). The phenotypic and genotypic variances for this trait were 1.30 and 1.68, respectively. The phenotypic variances appeared to be little bit higher than the genotypic variance suggesting considerable influence of environment on the expression of the genes controlling this trait (Table 3).

The highest plant height was observed in SAU Sharisa-1 S2 (118.33 cm) followed by that of F6 × BARI Sharisa-9 (117.67 cm) and SAU Sharisa-1 S1 (112.67 cm), where as the lowest plant height was observed in BARI Sharisa-9 × BARI Sharisa-6 P5 (74.33 cm) (Table 2). Plant height showed phenotypic variance (75.63) and genotypic variance (48.95) with relatively high difference between them which indicated large genetic influences on this trait (Table 3).

Among 32 genotypes, the highest number of primary branches/plant was observed in F6 × BARI Sharisa 9 (9.40), where as the lowest was in BARI Sharisa-9 × BARI Sharisa-6 P5 (4.20). The number of primary branches/plant in

SAU Sharisa-1 S1, SAU Sharisa-1 S2, BARI Sharisa-6 × R.Tori 7 S4 BARI Sharisa-6 × Tori 7) and Tori 7 × F6 P1 were observed 9.00, 8.47, 7.13, 7.13, 10, and 7.03, respectively (Table 2). Number of primary branches/plant showed low differences between phenotypic variance (1.25) and genotypic variance (0.98) indicating the higher environmental influence on this character (Table 3).

The highest number of secondary branches/plant was observed in SAU Sharisa-1 S3 (8.47) followed by that of BARI Sharisa-6 × R.Tori 7 S4 (8.03) and Tori 7 × F6 P1 (8.00), where as the lowest was observed in SAU Sharisa-1 S2 and BINA Sharisa-6 (1.33) (Table 2). Number of secondary branches/plant showed low difference between phenotypic variance (6.74) and genotypic variance (1.91) indicating high environmental influence on this trait (Table 3).

In the present experiment, the highest variation was found for number of siliquae/plant. The highest number of siliquae/plant was observed in BARI Sharisa-6 × Tori 7 (228.00), whereas the lowest was observed in BINA Sharisa-6 (68.33). The number of siliquae/plant of BARI Sharisa-9 × BARI Sharisa-6 P1, BARI Sharisa-6 × R.Tori 7, F6 × BARI Sharisa-9 and Tori 7 × F6 P2 were 216.00, 215.00, 214.00, and 200.00, respectively (Table 2). The highest phenotypic variance (17.28) and genotypic variance (9.57) was observed for number of siliquae/plant with large environmental influence (Table 3).

The highest siliquae length was observed in SAU Sharisa-1 S1 (6.93 cm) followed by BARI Sharisa-9 × BARI Sharisa-6 P6 (6.33cm), F6 × BARI Sharisa-9 P2 (6.18 cm), and SAU Sharisa 1 S3 (6.03 cm), whereas the lowest was observed in BARI Sharisa-9 × F6 P6 (4.34 cm) (Table 2). Length of siliquae showed minimum difference between phenotypic variance (0.16) and genotypic variance (0.02) indicating that they were less responsive to environmental factors for phenotypic expression (Table 3). The lowest days to maturity was taken by SAU Sharisa-1 S3 (86.33 days) followed by SAU Sharisa-1 S2 (87.67 days).

The highest days to maturity was taken by BARI Sharisa-9 × BARI Sharisa-6 P1 (97.33 days) followed by F6 × BARI Sharisa-9 P2 (95.00 days) and BARI Sharisa-9 × BARI Sharisa-6 P7 (96.33 days) (Table 2). The phenotypic and genotypic variance for days to maturity was observed 6.14 and 1.52, respectively (Table 3) which indicated that the trait expression is highly controlled by genetic parameters.

The highest number of seeds/siliquae was observed in BINA Sharisa-6 (24.33) followed by SAU Sharisa-1 S1 (21.67) and SAU Sharisa-1 S2 (19.67), whereas the lowest was observed in BARI Sharisa-9 × F6 P6 (12.30) (Table 2). The phenotypic variances and genotypic variances for this trait were 6.77 and 3.96, respectively (Table 3).

Table 2. Mean performances of 32 genotypes of *Brassica rapa*.

Genotype		DTF	PHT	NPB	NSB	NSP	PLH	DEF	SPS	TSW	YPP
BARI 9 × BARI 6 P1	G₁	36.00	105.47	6.90	6.10	216.07	5.63	97.33	15.60	3.60	8.63
F6 × BARI 9 P2	G₂	35.00	93.00	5.33	6.50	168.00	6.18	96.33	19.67	3.40	7.93
BAR I 6 × Tori 7	G₃	33.33	103.33	7.13	7.10	228.00	5.73	92.00	18.00	3.33	8.43
BARI 6 × R.Tori 7	G₄	34.67	100.33	7.03	8.03	215.00	5.67	94.00	15.00	3.17	9.53
BARI 9 × BARI 6 P7	G₅	33.67	91.57	5.50	5.67	147.00	5.77	95.00	17.97	3.40	7.32
BARI 9 × F6 P2	G₆	32.67	88.80	5.40	2.70	125.00	4.97	93.33	13.50	3.59	6.38
BARI 9 × BARI6 P4	G₇	32.33	92.67	5.80	4.10	135.00	5.47	88.00	14.67	3.43	6.80
SAU Sharisa 1 S3	G₈	31.00	99.00	5.57	8.47	157.00	6.03	86.33	16.00	4.23	7.50
BARI 9 × BARI 6 P3	G₉	34.33	100.30	4.30	4.27	153.67	5.28	89.00	14.97	4.05	7.83
F6 × BARI 9	G₁₀	32.00	117.67	9.40	5.23	214.67	5.67	89.67	17.67	3.20	9.03
BARI 9 × F6 P8	G₁₁	32.67	92.70	6.10	3.57	191.33	5.23	88.00	16.19	3.38	6.69
BARI 6 × Tori 7	G₁₂	31.33	93.00	5.60	4.60	143.67	5.83	90.00	18.33	3.27	8.23
BARI 9 × F6 P2	G₁₃	33.00	95.00	5.50	4.30	137.67	5.16	91.33	16.03	3.11	6.15
BARI 9 × F6 P6	G₁₄	33.00	98.30	5.57	3.47	145.17	4.34	88.67	12.30	3.48	5.83
SAU Sharisa 1 S1	G₁₅	31.00	112.67	9.00	2.33	140.67	6.93	88.00	21.67	3.80	9.87
BINA Sharisa 6	G₁₆	33.00	99.33	6.27	1.33	68.33	5.77	92.33	20.00	4.00	6.30
F6 × BARI 9 P1	G₁₇	30.33	87.33	4.97	6.57	174.67	5.17	90.67	14.67	4.10	7.03
Tori 7 × F6 P2	G₁₈	33.00	106.67	6.30	6.23	200.00	5.43	88.00	15.67	3.50	7.87

Table 2. Cont'd.

Genotype		DTF	PHT	NPB	NSB	NSP	PLH	DEF	SPS	TSW	YPP
SAU Sharisa 1 S2	G₁₉	30.33	118.33	8.47	1.33	132.00	5.50	87.67	19.67	4.50	8.07
BARI 9 × F6 P5	G₂₀	32.67	87.67	6.60	7.33	172.33	5.20	91.33	16.67	3.63	9.20
BINA Sharisa 6	G₂₁	32.00	105.00	6.17	1.50	69.00	5.60	92.00	24.33	3.13	7.23
BARI 9 × F6 P3	G₂₂	31.00	101.67	5.37	3.33	134.67	5.33	88.00	15.67	3.50	7.43
BARI 9 × BARI 6 P5	G₂₃	31.33	74.33	4.20	4.17	115.33	5.53	89.00	15.33	3.77	5.23
Tori 7 × F6 P1	G₂₄	32.00	96.33	7.13	8.00	197.00	4.57	91.67	15.33	3.13	9.67
SS 75 × Tori 7 P2	G₂₅	31.33	95.00	5.00	4.17	134.67	5.37	91.00	16.33	3.03	6.07
BARI 9 × F6 P4	G₂₆	31.00	102.00	6.70	6.57	177.33	5.33	89.00	14.67	3.73	7.40
SS 75 × Tori 7 P3	G₂₇	32.33	103.33	6.27	3.57	114.33	5.57	90.00	18.33	3.63	7.07
BARI 6 × Tori 7	G₂₈	31.33	87.00	6.27	5.53	119.00	5.60	89.67	17.33	3.47	6.00
BARI 9 × F6 P7	G₂₉	31.33	85.00	6.00	2.80	114.67	5.43	88.33	14.33	3.73	5.80
BARI 9 × BARI 6 P6	G₃₀	32.00	87.00	5.10	6.40	146.67	6.33	90.33	14.67	3.07	8.60
BARI 9 × F6 P1	G₃₁	31.00	86.33	5.43	5.17	145.67	5.13	90.00	14.33	3.80	8.90
SS 75 × Tori 7 P1	G₃₂	31.67	94.33	5.83	5.10	171.67	5.63	90.00	16.67	3.57	9.33
Grand mean		32.30	96.89	6.13	4.83	153.29	5.51	90.50	16.61	3.55	7.61

DTF = Days to 50% flowering, PHT= Plant height (cm), NPB =No. of primary branches/plant, NSB = No. of secondary branches/plant, NSP = No. of siliquae per plant, PLH = Length of siliquae (cm), DEF = Days to 80% maturity, SPS = No. of seeds per siliquae, TSW = 1000 seed weight (g) and YPP = Seed yield per plant (g).

Thousand seed weight was found maximum in SAU Sharisa 1 S2 (4.50 g), followed by SAU Sharisa 1 S3 (4.23 g), whereas the minimum was found in SS 75 × Tori 7 P2 (3.03 g) (Table 2). The phenotypic and genotypic variances for this trait were 0.43 and 0.02, respectively (Table 3).

The highest amount of yield per plant was observed in SAU Sharisa-1 S1 (9.87 g) followed by that of Tori 7 × F6 P1 (9.67 g), BARI Sharisa-6 × R. Tori 7 S4 (9.53 g), and SS 75 × Tori 7 P1 (9.33 g), whereas the minimum yield per plant was observed in BARI Sharisa-9 × BARI Sharisa-6 P5 (5.23g) (Table 2). The phenotypic variance and genotypic variance were 2.42 and 0.83, respectively (Table 3).

Table 3. Estimation of some genetic parameters in 32 genotypes of *Brassica rapa*.

Characters	Genotypic variance	Phenotypic Variance	GCV	PCV	Heritability (%)	Genetic Advance (1%)	Genetic Advance in % Mean (1%)
DTF	1.30	1.68	3.53	5.34	43.56	1.99	6.15
PHT	48.95	75.63	8.98	11.52	60.17	17.89	18.46
NPB	0.98	1.25	16.16	24.37	43.98	1.74	28.30
NSB	1.91	6.74	28.60	60.97	22.05	1.71	35.46
NSP	9.57	17.28	20.19	33.81	35.65	48.78	31.82
PLH	0.02	0.16	7.26	10.92	44.22	0.70	12.75
DEF	1.52	6.14	2.74	3.06	80.11	5.85	6.47
SPS	3.96	6.77	11.98	19.72	36.92	3.19	19.22
TSW	0.02	0.43	3.67	18.09	84.23	0.07	1.97
YPP	0.83	2.42	11.95	23.86	25.48	1.21	15.93

DTF = Days to 50% flowering, PHT= Plant height (cm), NPB =No. of primary branches/plant, NSB = No. of secondary branches/plant, NSP = No. of siliquae/plant, PLH = Length of siliquae (cm), DEF = Days to 80% maturity, SPS = No. of seeds/siliquae, TSW = 1000 seed weight (g) and YPP = Seed yield per plant (g). GCV = Genotypic co-efficient of variation, PCV= phenotypic co-efficient of variation.

The analysis of variance showed significant differences among the genotypes for all the characters. The ranges were high for most of the traits also. In order to obtain a clear understanding of the pattern of variations, the phenotypic variances were partitioned into genotypic and environmental variances. The highest genotypic, environmental, and phenotypic variances were found in plant height. The lowest variances were found in length of siliquae followed by 1000-seed weight. The phenotypic co-efficient of variations (PCV) were higher than the genotypic co-efficient of variations (GCV) for all the characters studied indicating the presence of environmental influence in the phenotypic expression of the characters. The difference between PCV and GCV was remarkably low for days to flowering. The difference between PCV and GCV was high for number of secondary branches/plant (Table 3).

Heritability and genetic advance

The knowledge of heritability of a character helps the breeder in predicting the behaviour of the succeeding generation and making desirable selections. Days to 50% flowering exhibited intermediate heritability (43.56%) with low genetic advance (6.15%) (Table 3). As a whole, the low heritability and the consequent low genetic advance indicated the lower possibility of selecting genotypes. This results support the reports of Malik *et al.* (1995).

Days to maturity exhibited high heritability (80.11%) with low genetic advance (6.47%) which revealed higher possibility of selecting genotypes that would mature earlier. In some of the crosses the frequency of the segregating plants showing reduced maturity was comparatively high than the other crosses.

Plant height showed medium heritability (60.17%) with good genetic advance (18.46%) (Table 3). The medium heritability and the consequent intermediate genetic advance indicated the higher possibility of selecting genotypes. Varshney *et al.* (1986) found high heritability for plant height.

Number of primary branches/plant exhibited low heritability 43.98% with high genetic advance (28.30%). As a whole, the low heritability and the consequent low genetic advance indicated the lower possibility of selecting genotypes. Number of secondary branches/plant exhibited low heritability 22.05% with low genetic advance (35.46%). The low heritability and the consequent low genetic advance indicated the lower possibility of selecting genotypes. Katiyar and Singh (1974) reported low heritability for this trait.

Number of siliquae/plant exhibited low heritability (35.65%) with low genetic advance (31.82%). The low heritability and the consequent low genetic advance indicated the lower possibility of selecting genotypes for this character. This result supports the report of Paul *et al.* (1976).

Thousand seed weight showed high heritability (84.23) with low genetic advance (0.07%). These results revealed the possibility of predominance of both additive and non-additive gene action in the inheritance of this trait. Kwon *et al.* (1989) and Rao (1977) reported high heritability for this trait. Yadava *et al.* (1982), Sharma (1984) and Kakroo and Kumar (1991) reported low to medium heritability for this trait. Number of seeds/siliquae showed low heritability (36.92%). Malik *et al.* (1995) reported high heritability ($h^2_b > 90\%$) for this trait.

1000-seed weight exhibited high heritability (84.23%) with low genetic advance (1.97%). This trait is governed by non-additive genes. Liang and Walter (1968) reported that moderate values of heritability and low genetic advance may be due to non-additive gene action which includes dominance and epistasis. Johnson *et al.* (1955) reported that heritability estimates along with genetic gain were more useful in prediction selection of the best individual. Seed yield/plant

showed low heritability (25.48%) with low genetic advance (15.93%). These results support the reports of Liang and Walter (1968), but Singh *et al.* (1987) found high heritability for this trait.

Genotypic co-efficient of variation together with high heritability and genetic advance are considered as good estimates of genetic gain to be expected in making selection of superior genotypes on the basis of phenotypic performance. Johnson *et al.* (1955) mentioned that high heritability along with high genetic gain are more successful than the heritability alone to select desirable genotypes with higher yield. Panse (1957) stated that high value of heritability with low genetic advance indicated that the heritability was probably due to the effect of non-additive gene action. The characters with high values of GCV, PCV, and heritability accompanied by high genetic advance in percent of mean might be transmitted to their progenies and therefore, phenotypic selection based on these characters would be effective.

High GCV and PCV values were observed for number of secondary branches/plant. High heritability values along with low genetic advance in percentage of mean were obtained for 1000-seed weight, number of secondary branches/plant, seeds/siliquae, and siliquae length. Considering variability among the genotypes, heritability, genetic advance, percent co-efficient of variance, and field performances, the genotypes G-15, G-19, G-1, G-3, G-4, G-10, G-18, G21, and G-24 were found suitable for future breeding programme.

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