Advances in Zoology and Botany 11(5): 384-391, 2023
DOI: 10.13189/azb.2023.110506 http://www.hrpub.org

Genetic Variability Studies of 'Flowering Chinese Cabbage (*Brassica rapa* subsp. *Chinensis* var. *parachinensis*)' in Bangladesh

Sadia Tabassum Tanni[1], Md. Nazrul Islam[1], Sharmin Sultana[2], Md. Harun-Ur-Rashid[1], Md. Abdur Rahim[1,*]

[1]Department of Genetics and Plant Breeding, Sher-e-Bangla Agricultural University, Bangladesh
[2]Department of Biochemistry, Sher-e-Bangla Agricultural University, Bangladesh

Received November 2, 2022; Revised February 24, 2023; Accepted April 19, 2023

Cite This Paper in the Following Citation Styles

(a): *[1] Sadia Tabassum Tanni, Md. Nazrul Islam, Sharmin Sultana, Md. Harun-Ur-Rashid, Md. Abdur Rahim, "Genetic Variability Studies of 'Flowering Chinese Cabbage (Brassica rapa subsp. Chinensis var. parachinensis)' in Bangladesh," Advances in Zoology and Botany, Vol. 11, No. 5, pp. 384 - 391, 2023. DOI: 10.13189/azb.2023.110506.*

(b): *Sadia Tabassum Tanni, Md. Nazrul Islam, Sharmin Sultana, Md. Harun-Ur-Rashid, Md. Abdur Rahim (2023). Genetic Variability Studies of 'Flowering Chinese Cabbage (Brassica rapa subsp. Chinensis var. parachinensis)' in Bangladesh. Advances in Zoology and Botany, 11(5), 384 - 391. DOI: 10.13189/azb.2023.110506.*

Abstract Flowering Chinese cabbage also called ‘Caixin’ or “Choy sum” is an annual leafy vegetable of the ‘Brassicaceae’ family. An experiment was conducted with eight flowering Chinese cabbage genotypes using RCBD with three replications at ‘Sher-e-Bangla Agricultural University’ (SAU) to characterize the various yield contributing traits, evaluate genetic variability and interrelationship between various traits. A significant difference was found for different characters among the flowering Chinese cabbage genotypes. Days to maturity, fresh yield per plant, plant height, no. of siliqua per plant and seeds per siliqua displayed higher genotypic variance suggesting the existence of great variability for these traits. High heritability plus high genetic advance in per cent of mean was detected for fresh vegetative yield, no. of silique per plant indicating additive genetic effect. Fresh yield of flowering Chinese cabbage exhibited a significant and positive relationship with length of leaf and plant height while with days to 50% flowering, leaf breadth and no. of siliqua per plant at phenotypic level only. Our results indicate that selection based on these characters could be rewarding. Besides, this is the first report for cultivation of flowering Chinese cabbage in Bangladesh and further improvement can be performed for this crop.

Keywords Genetic Variability, Heritability, Correlation, Fresh Yield, Flowering Chinese Cabbage

1. Introduction

Fruits and vegetables are a significant part of human diet. They are naturally good and rich in important vitamins, minerals and phytochemicals. They are not only keeping us healthy but also helping protect against some diseases. One of such health promoting vegetables is flowering Chinese cabbage (*Brassica rapa* subsp. *chinensis* var. *parachinensis*) which is also commonly called ‘Caixin’ that means ‘the heart of a cabbage’ [1, 2]. It is an annual herbaceous plant belonging to the mustard family ‘Brassicaceae’ (former ‘Cruciferae’) and consisting of the ‘A’ genome (n = 10). Flowering Chinese cabbage is a cool-season crop and low temperatures (15℃ to 25℃) encourage strong stalks and increase sweetness [2]. The flowering Chinese cabbage develops prolonged, delicate, and thick stems with fast bolting [3-5]. Flower buds with growing tender stems and green leaves are mainly used as cooked vegetables and widely cultivated in southern and central China, Indonesia, Malaysia, Thailand and Vietnam [1].

Like other Brassicaceous vegetables (broccoli, cabbage, spruce sprout), flowering Chinese cabbages are rich in various health-promoting sulfur compounds and bioactive secondary metabolites such as glucosinolates, phenolics, carotenoids, flavonoids, anthocyanins, vitamin C and E, which have antioxidant properties and defensive properties against inflammation, heart-and age-related diseases [6]. Flowering Chinese cabbage is the richest source of folic acid (Vitamin B9) and carotenoid [7, 8].

Natural interspecific crossing is occurring among - *Brassica* species such as *B. napus*, *B. rapa* as well as *B. juncea* [9]. Yellowseed of *B. napus* characterized by higher oil and protein contents with less fiber has been introduced from *B. rapa* [10, 11]. The flowering Chinese cabbage starts flowering (bolting) at a very early stage when there are seven to eight leaves or when the plant is about 8 inches (20 cm) tall [2]. Besides, Hong-Di et al. [12] reported a new medium maturing hybrid flowering Chinese cabbage cultivar 'Youlü 702 Caixin' which takes around 37–40 days from sowing to harvest. Moreover, it can bolt and flower easily without exposure of low temperature (vernalization) [13]. The cultivation and seed production of this novel vegetable would be possible in agro-climatic conditions of Bangladesh. Considering the health promoting properties, during 2021 our research group started research with flowering Chinese cabbage for the first time at Department of Genetics and Plant Breeding of SAU in Bangladesh (https://samakal.com/health/article/2203103258).

Genetic variability and heritability are crucial to distinguish suitable characters for effective crop improvement programs via phenotypic selection [14]. Evaluation and characterization of introduced germplasm are the basic requirement for any plant breeding program. The assessment of interrelationships among morpho-physiological traits of the population is a valuable mean for genetic enhancement [15]. Thus, it is crucial to characterize and asses the variability for yield and its contributing traits for this novel vegetable "Flowering Chinese cabbage" in Bangladesh conditions.

2. Materials and Methods

The plant material consisted of seven flowering Chinese cabbage and one mustard genotypes (Table 1). The seeds of these genotypes were collected from 'Department of Genetics and Plant Breeding', SAU, Dhaka. The research was conducted at SAU, during November 2021 to March 2022 according to a 'randomized complete block design (RCBD)' following 3 replications. The 3 m long 3 rows were considered for each genotype while the spacing was 30 cm × 15 cm. The chemical fertilizers ('Urea', 'TSP', 'MP' @ 55, 160, 160 Kg/ha, respectively) and cowdung were applied in the experimental area. The standard agronomic practices were performed during the experiment. Harvesting was done at 35 DAS ('days after sowing') for fresh yield. The siliqua was harvested at 80% maturity. The data were collected on ten arbitrarily chosen plants each genotype for days to fifty percent flowering, days to maturity, no. of leaves per plant, length of leaf of leaf, leaf breadth of leaf, plant height, fresh yield, no. of branches per plant, no. of siliqua per plant, no. of seeds per silique, 1000-seed weight as well as seed yield per plant. Furthermore, the data were statistically analyzed with 'RStudio'. The variances (phenotypic as well as genotypic) were estimated following the formula of Johnson et al. [16]. Broad sense heritability and genetic advance were determined as per Singh and Chaudhury [17].

Table 1. List of flowering Chinese cabbage genotypes used in this study

Genotype	Accession no.
G1	Fcc/19/GPB-001
G2	Fcc/19/GPB-002
G3	Fcc/19/GPB-003
G4	Fcc/19/GPB-004
G5	Fcc/19/GPB-005
G6	Fcc/19/GPB-006
G7	Fcc/19/GPB-007
G8	BARI Sharisha-14

3. Results and Discussion

3.1. Morphological Characteristics

Flowering Chinese cabbage is a tender, succulent and herbaceous plant (Fig. 1). Leaves are alternate, oval, basal-shaped at flowering stage, light to dark green color (Fig. 2). Stem is green, succulent and tender bearing yellow flowers (Fig. 3). All the flowering Chinese cabbage genotypes were late flowering (36-38 days) compared to mustard (32.33 days) (Table 2). Similarly, flowering Chinese cabbage required 81.67-92.67 days for 80% maturity of silique while mustard took only 72 days (Table 2). No. of leaves per plant varied from 11.13 to 14.13 for flowering Chinese cabbage while 11.40 in mustard (Table 2). Length of leaf ranged from 16.37 cm to 18.26 cm in flowering Chinese cabbage and 12.91 in mustard. Flowering Chinese cabbage had broader leaves (7.92-9.76 cm) compared to mustard (5.86 cm). Flowering Chinese cabbage had higher fresh weight of leaves (58.69-114.03) compared to mustard (G8, 58.83 g) at vegetative harvest at 38 days after sowing (Table 2). The minimum plant height of 98.82 cm and maximum of 109.77 cm were observed in flowering Chinese cabbage while in mustard it was 99.45 cm (Table 2). The no. of branches per plant varied from 5.33 (G3) to 7.47 (G2) while in mustard it was 7.73. The flowering Chinese cabbage showed higher no. of siliquae per plant (258.60-331.27) than mustard (120.99). (Table 2). Flowering Chinese cabbage had a lower number of seed per siliqua (13.76-18.75) as compared to mustard (30.91). 1000-seed weight was also lower (1.70-2.19) in flowering Chinese cabbage as compared to mustard (2.76 g) (Table 2). The flowering Chinese cabbage exhibited lesser seed yield per plant (3.44 - 5.23 g) compared to mustard (5.69 g) (Table 2).

Figure 1. A flowering Chinese cabbage plant at harvesting stages (vegetative)

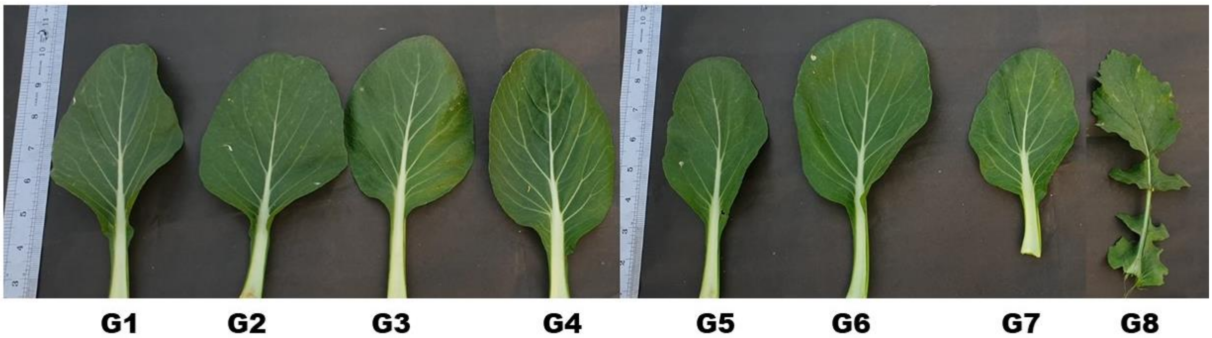

Figure 2. Leaves of flowering Chinese cabbage genotypes used in the study

Figure 3. Flowering Chinese cabbage genotypes at vegetative harvesting stage

3.2. Genetic Variability

Assessment of variability in collected germplasm is essential for genetic improvement of any crop species [18]. The variance analysis of 12 characters, like 'days to 50% flowering (DFF)', 'days to maturity (DM)', no. of leaves per plant (NLP), length of leaf (LL), leaf breadth (LB), fresh yield (FY), plant height (PH), no. of silique per plant (NSP), no. of seeds per siliqua (SS), '1000-seed weight (TSW)', as well as 'seed yield per plant (SYP)' revealed a highly significant variation among flowering Chinese cabbage genotypes (Table 3) which indicated that there is an innate genetic difference for tested traits. Hence, selection would be fruitful for this trait. The result revealed that the phenotypic variances (σ^2p) were greater than the corresponding genotypic variances (σ^2g) for all the traits (Table 3). DM, FY, PH, NSP and SS exhibited higher σ^2g (Table 3) suggesting the prevalence of great genetic variability for these characters. Similarly, PCV ('phenotypic coefficient of variation') was higher than the corresponding GCV ('genotypic coefficient of variation') for all the characters, thus, suggesting both the genotypic and environmental influences on the expression of these traits. The PCV varied from 4.44 to 29.20 while the GCV from 4.09 to 28.32 (Table 3). Rastogi et al. [19] described alike results in Chinese cabbage. Utmost characters showed high broad base heritability apart from NLP and NBP. The highest heritability plus high genetic advance in per cent of mean was detected for FY and NSP (Table 3), suggesting additive genetic effects, hence selection could be fruitful. Venkatesh et al. [20] have described a similar finding for heritability in a leafy vegetable amaranth.

3.3. Correlation Studies

The association of various characters towards yield is crucial for selection in plant breeding program. Yield is a complex trait that is largely influenced by the environment. Therefore, study of interrelationships among several yield attributing characters assists the phenotypic selection rather than the selection based on only yield. The correlation coefficients (genotypic coefficient, r_g; phenotypic coefficient, r_p) between various traits are presented in Tables 4-5. The results showed that the r_g, was higher than the corresponding r_p. DFF had a significantly positive correlation with LL (0.949), LB (0.764) and NSP (0.992) even though a non-significant but positive relationship with DM (0.663), NLP (0.262), FY (0.616) and PH (0.508) at genotypic level (Table 4). It had also a significantly positive correlation with DM (0.604), LL (0.804), LB (0.641), FY (0.558) and NSP (0.895) whereas a non-significant but positive correlation with NLP (0.294) and PH (0.374) at phenotypic level (Table 5). However, it had a significantly negative correlation with NSS at both the genotypic and phenotypic levels (Table 4 and Table 5). Akaneme and Ani [21] reported a similar positively correlation of DFF with leaf length in *Amaranthus hybridus*. DM had a significantly positive correlation with NSSat the genotypic whereas a significantly negative correlation at phenotypic level (Table 4 and Table 5). Moreover, it had also a significantly negative correlation with TSW at both the genotypic and phenotypic levels (Table 4 and Table 5). NLP had a significantly positive correlation with LB (0.484) at phenotypic level only (Table 5). LL had a significantly positive correlation with LB (r_g, 0.813; r_p, 0.807FY (r_g, 0.752; r_p, 0.693) and NSP (r_g, 0.931; r_p, 0.797) at both levels (Table 4 and Table 5). On the other hand, there is a significant negative correlation with NBP (r_g, -0.735; r_p, -0.467) and TSW (r_g, -0.786; r_p, - 0.739) at both levels (Table 4 and Table 5). Arif et al. [22] reported a significantly positive correlation of NLP with LL and LB was reported in spinach. LB had a significant positive correlation with NSP (r_g, 0.752; r_p, 0.640) while a significantly negative correlation with NSP (r_g, -0.817; r_p, -0.744) and TSW (r_g, -0.750; r_p, -0.679) at both levels (Table 4 and Table 5). FY of flowering Chinese cabbage leaves had a significantly positive correlation with LL (0.752) and PH (0.823) and a non-significantly positive correlation with DFF (0.616), NLP (0.458) and LB (0.553) at genotypic level (Table 4). It had a significantly positive correlation with DFF (0.558), LL (0.693) and LB (0.507), PH (0.760) and NSP (0.446) at phenotypic level (Table 5). Cho et al. [23] reported a correlation between leaf weights and LL or LB. A significantly positively correlation of fresh weight with NLP was reported in Indian spinach [24]. Moreover, a significant positive correlation was reported for leaf yield with NLP in red amaranth [25].

Table 2. Mean performance of flowering Chinese cabbage genotypes used in the study

Genotypes	DFF	DM	NLP	LL	LB	FY	PH	NBP	NSP	SS	TSW	SYP
G1	35.67a	92.33a	11.40b	17.16ab	9.23ab	79.30c	101.07cd	5.67ab	258.60b	16.56bc	1.70c	5.16ab
G2	36.00a	81.67c	11.40b	16.39b	7.97b	80.74c	109.66a	7.47ab	290.84ab	18.75b	2.14b	5.07ab
G3	35.67a	92.67a	12.40ab	16.84ab	7.99b	71.52d	105.37abc	5.33b	291.68ab	17.49bc	1.81c	5.16ab
G4	37.33a	92.00a	11.13b	16.44b	7.92b	58.69e	98.82d	6.13ab	331.27a	17.23bc	2.19b	3.44c
G5	37.67a	86.33b	11.47b	18.26a	8.0b	114.03a	109.77a	5.77ab	313.80ab	15.67bc	2.11b	4.54b
G6	36.67a	92.00a	12.20ab	16.37b	8.31b	79.41c	103.44bcd	6.47ab	285.00ab	13.76c	2.19b	5.23ab
G7	37.33a	83.67c	14.13a	17.54ab	9.76a	100.46b	107.57ab	7.17ab	316.20ab	16.7bc	2.15b	5.04ab
G8	32.33b	72.00d	11.40b	12.91c	5.86c	58.83e	99.45d	7.73a	120.99c	30.91a	2.76a	5.69a
Range	32.33-37.67	72.00-92.67	11.13-14.13	12.91-18.26	5.86- 9.76	58.69-114.03	98.82-107.57	5.33- 7.73	120.99-333.27	13.76-30.09	1.70-2.76	3.44-5.69
Grand mean	36.08	86.58	11.94	16.49	8.13	80.37	104.39	6.47	276.05	18.39	2.13	4.92
CV (%)	2.11	3.94	6.51	3.81	5.62	6.86	1.73	12.76	7.81	7.10	3.60	7.09

DFF, Days to 50% flowering; DM, Days to maturity; NLP, No. of leaves per plant; LL, Length of leaf (cm); LB, Leaf breadth (cm); FY, Fresh yield (g); PH, Plant height (cm); NBP, No. of branches per plant; NSP, No. of silique per plant; SS, No. seeds per siliqua; TSW, 100-seed weight (g) and SYP, Seed yield per plant (g).

Table 3. Estimation of genetic parameters for different traits of flowering Chinese cabbage genotypes

Traits	GMS	σ^2_g	σ^2_P	GCV	PCV	h^2_b (%)	GA	GA (%)
DFF	15.13**	2.72	3.29	4.57	5.03	82.49	3.09	8.55
DM	242.70**	53.23	53.89	8.42	8.48	98.77	14.94	17.25
NLP	4.85**	0.78	1.38	7.37	9.84	56.18	1.36	11.39
LL	19.19**	2.39	2.78	9.37	10.11	85.85	2.95	17.88
LB	18.64**	1.23	1.44	13.66	14.78	85.46	2.12	26.02
FY	2274.84**	364.23	364.72	23.75	23.76	99.87	39.29	48.88
PH	17.76**	18.22	21.48	4.09	4.44	84.82	8.10	7.76
NBP	3.54*	0.58	1.26	11.74	17.34	45.83	1.06	16.37
NSP	28.59**	4270.42	4734.76	23.67	24.93	90.19	127.85	46.31
SS	48.73**	27.12	28.82	28.32	29.20	94.09	10.41	56.59
TSW	49.95**	0.09	0.10	14.54	14.98	94.22	0.62	29.08
SYP	11.21	0.41	0.54	13.09	14.89	77.28	1.17	23.70

DFF, Days to 50% flowering; DM, Days to maturity; NLP, No. of leaves per plant; LL, Length of leaf (cm); LB, Leaf breadth (cm); FY, Fresh yield (g); PH, Plant height (cm); NBP, No. of branches per plant; NSP, No. of silique per plant; SS, No. seeds per siliqua; TSW, 1000-seed weight (g) and SYP, Seed yield per plant (g).
* and ** indicate significant at 5% and 1% level of significance, respectively.

Table 4. Genotypic correlation among different traits of flowering Chinese cabbage genotypes

	DFF	DM	NLP	LL	LB	FY	PH	NBP	NSP	SS	TSW
DFF											
DM	0.663										
NLP	0.294	0.026									
LL	0.949**	0.687	0.312								
LB	0.764*	0.604	0.635	0.813*							
FY	0.616	0.064	0.458	0.752*	0.553						
PH	0.508	-0.060	0.445	0.603	0.354	0.823*					
NBP	-0.503	-0.990**	0.298	-0.735*	-0.441	-0.176	0.013				
NSP	0.992**	0.727*	0.318	0.931**	0.752*	0.469	0.490	-0.636			
SS	-0.936**	0.847**	-0.282	-0.926**	-0.817*	-0.510	-0.421	0.703	-0.927**		
TSW	-0.548	-0.816*	-0.129	-0.786*	-0.750*	-0.290	-0.263	0.899**	-0.648	0.748*	
SYP	-0.697	-0.474	0.217	-0.428	-0.177	0.032	0.154	0.439	-0.689	0.415	0.172

DFF, Days to 50% flowering; DM, Days to maturity; NLP, No. of leaves per plant; LL, Length of leaf (cm); LB, Leaf breadth (cm); FY, Fresh yield (g); PH, Plant height (cm); NBP, No. of branches per plant; NSP, No. of silique per plant; SS, No. seeds per siliqua; TSW, 1000-seed weight (g) and SYP, Seed yield per plant (g).
* and ** indicate significant at 5% and 1% level of significance, respectively.

Table 5. Phenotypic correlation among different traits of flowering Chinese cabbage genotypes.

	DFF	DM	NLP	LL	LB	FY	PH	NBP	NSP	SS	TSW
DFF											
DM	0.604**										
NLP	0.294	0.009									
LL	0.804**	0.635**	0.278								
LB	0.641**	0.562**	0.484*	0.807**							
FY	0.558**	0.064	0.333	0.693**	0.507*						
PH	0.374	-0.054	0.232	0.551**	0.330	0.760**					
NBP	-0.367	-0.675**	-0.034	-0.467*	-0.229	-0.128	0.056				
NSP	0.895**	0.667**	0.185	0.797**	0.640**	0.446*	0.396	-0.305			
SS	-0.823**	-0.827**	-0.199	-0.837**	-0.744**	-0.493 *	-0.345	0.489*	-0.834**		
TSW	-0.468*	-0.796**	-0.078	-0.739**	-0.679**	-0.281	-0.224	0.634**	-0.575**	0.738**	
SYP	-0.570**	-0.426*	0.318	-0.367	-0.163	0.023	0.100	0.264	-0.601**	0.399	0.158

DFF, Days to 50% flowering; DM, Days to maturity; NLP, Number of leaves per plant; LL, Length of leaf (cm); LB, Leaf breadth (cm); FY, Fresh yield (g); PH, Plant height (cm); NBP, Number of branches per plant; NSP, Number of silique per plant; SS, Seeds per siliqua; TSW, Thousand seed weight (g) and SYP, Seed yield per plant (g).
* and ** indicate significant at 5% and 1% level of significance, respectively.

Therefore, fresh yield could increase through indirect selection via length of leaf breadth as well as plant height in Bangladesh condition.

4. Conclusions

We characterized various fresh yield and seed yield elements, and their yield attributing characters in flowering Chinese cabbage were previously introduced by our research team in Bangladesh. The results exhibited significant variations for different characters. The high heritability together with high genetic advance in per cent of mean was detected for fresh vegetative yield, no. of silique per plant indicating additive genetic effects, thus selection could be fruitful. Fresh vegetative yield showed significantly positive relationships with leaf length and plant height whereas with days to 50% flowering, leaf breadth and no. of silique per plant at phenotypic level only. These results revealed that the genetic improvement of this novel crop would be possible via phenotypic selection for these characters. Moreover, flowering Chinese cabbage can be grown in Bangladesh during *Robi* season. More research can be performed following the present results for the genetic enhancement of the flowering Chinese cabbage in Bangladesh.

Acknowledgements

This research was financially supported by the research grant of ‘Sher-e-Bangla Agricultural University Research System (SAURES) 2021-2022’, Sher-e-Bangla Agricultural University (SAU), Dhaka-1207, Bangladesh.

REFERENCES

[1] Sun R., "Economic/academic importance of *Brassica rapa*," in The *Brassica rapa* Genome, Compendium of Plant Genomes. Springer, Berlin, Heidelberg. pp. 1-15, 2015. https://doi.org/10.1007/978-3-662-47901-8_1

[2] Wang Y., Liu G., "Production Guide for Choy Sum—An Emerging Asian Vegetable in Florida: HS1380, 9/2020." EDIS 2020, no. 5, pp. 1-5, 2020. https://edis.ifas.ufl.edu

[3] Cheng F., Wu J., Wang X., “Genome triplication drove the diversification of *Brassica* plants’” Horticultural Research, vol. 1, pp. 1-8, 2014. https://doi.org/10.1038/hortres

[4] Huang X., Lei Y., Guan H., Hao Y., Liu H., Sun G., Chen R., Song, S., “Transcriptomic analysis of the regulation of stalk development in flowering Chinese cabbage (Brassica campestris) by RNA sequencing,” Scientific Reports, vol. 7, no. 1, pp. 1-14, 2017. https://doi.org/10.1038/s41598-017-15699-6

[5] Wei X., Rahim M. A., Zhao Y., Yang S., Wang Z., Su H., Li L., Niu L., Harun-Ur-Rashid M., Yuan Y., Zhang X., “Comparative Transcriptome Analysis of Early-and Late-Bolting Traits in Chinese Cabbage (*Brassica rapa*),” Frontiers in Genetics, vol. 12, p. 590830, 2021. https://doi.org/10.3389/fgene.2021.590830

[6] Manchali S., Chidambara Murthy K. N., Patil B. S., “Crucial facts about the health benefits of popular cruciferous vegetables,” Journal of Functional Foods, vol. 4, no. 1, pp. 94-106, 2012. https://doi.org/10.1016/j.jff.2011.08.004

[7] Wills R. B. H., Rangga A., “Determination of Carotenoids in Chinese Vegetables,” Food Chemistry, vol. 56, no. 4, pp. 451–455, 1996. https://doi.org/10.1016/j.jff.2011.08.004

[8] Houlihan A., Pyke M., Scheelings P., Graham G., Eaglesham G., O’ Hare T., Wong L., Puwastien P., Jongjitsin W., “Folate content of Asian vegetables,” Project

Report. Rural Industries Research and Development Corporation (RIRDC), 2011. https://rirdc.infoservices.com.au/items/10-167

[9] Bing D. J., Downey R. K., Rakow G. F. W., "Hybridizations among *Brassica napus*, *B. rapa* and *B. juncea* and their two weedy relatives *B. nigra* and *Sinapis arvensis* under open pollination conditions in the field," Plant Breeding, vol. 115, no. 6, pp. 470-473, 1996. https://doi.org/10.1111/j.1439-0523.1996.tb00959.x

[10] Chen B. Y., Heneen W. K., Jonsson R., "Resynthesis of *Brassica napus* L. through interspecific hybridization between *B. alboglabra* Bailey and *B. campestris* L. with special emphasis on seed colour," Plant Breed, vol. 101, no. 1, pp. 52-59, 1988. https://doi.org/10.1111/j.1439-0523.1988.tb00266.x

[11] Rahman M. H., "Production of yellow seeded *Brassica napus* through interspecific crosses," Plant Breed, vol. 120, no. 6, pp. 463-472, 2001. https://doi.org/10.1046/j.1439-0523.2001.00640.x

[12] Hong-Di H. U. A. N. G., Hua Z. H. A. N. G., Yan-Song Z. H. E. N. G., Guang-Guang L. I., Zi-Zhu L. I. U., Jian-Song C. A. O., Yan-Chun Q. I. A. O., "A New Flowering Chinese Cabbage Cultivar 'Youlü 702 Caixin'," Acta Horticulturae Sinica, vol. 39, no. 12, pp. 2539-2540, 2012. http://ahs.ac.cn/EN/abstract/abstract3914.shtml

[13] Li G., Wang J., Liao Y., Jiang D., Zheng Y., Dai X., Ren H., Zhang H., Chen C., "A high-continuity genome assembly of Chinese flowering cabbage (*Brassica rapa* var. *parachinensis*) provides new insights into *Brassica* genome structure evolution," Authorea Preprints, pp. 1-17, 2020. 10.22541/au.159986559.90881792

[14] Vidya C., Oommen S. K., Kumar V., "Genetic variability and heritability of yield and related characters in yard-long bean," Journal of Tropical Agriculture, vol. 40, pp. 11-13, 2006. http://www.jtropag.kau.in/index.php/ojs2/article/view/67

[15] Bello D., Sajo A. A., Chubado D., Jellason J. J., "Variability and correlation studies in okra (*Abelmoschus esculentus* (L.) Moench)," Journal of Sustainable Development in Agriculture and Environment, vol. 2, no. 1, pp. 120-126, 2006.

[16] Johanson H. W., Robinson H. F., Comstock R. E., "Estimates of genetic and environmental variability in soybean," Agronomy Journal, vol. 47, no. 7, pp. 314-318, 1955. https://doi.org/10.2134/agronj1955.00021962004700070009x

[17] Singh R. K., Chaudhary B. D., "Biometrical methods in quantitative genetic analysis," Kalyani Publishers, p. 56, 1985.

[18] Anshebo T., Veeraragavathatham D., Kannan M., "Genetic variability and correlation studies in sweet potato (*Ipomoea batatas* Lam. L.)," Madras Agricultural Journal, vol. 91. No. 7-12, pp. 420-424, 2004.https://worldveg.tind.io/record/36499/

[19] Rastogi K. B., Korla B. N., Joshi A. K., Thakur M. C., "Variability studies in Chinese cabbage (*Brassica chinensis* L.)," Advances in Horticulture and Forestry, Vol. 4, pp. 101-107, 1995.

[20] Venkatesh L., Murthy N., Nehru Manjappa S. D., "Genetic variability, heritability and genetic advance in grain amaranth (*Amaranthus spp.*)," Asian Journal of Bio Science, vol. 9, no. 1, pp. 67-70, 2014.

[21] Akaneme F. I., Ani G. O., "Morphological Assessment of Genetic Variability among Accessions of *Amaranthus hybridus*," World Applied Sciences Journal, vol. 28, no. 4, pp. 568-577, 2013./https://www.idosi.org/wasj/wasj28(4)13/20.pdf

[22] Arif M., Jatoi S. A., Rafique T., Ghafoor A., "Genetic divergence in indigenous spinach genetic resources for agronomic performance and implication of multivariate analyses for future selection criteria," Journal on Science and Technology for Development, vol. 32, no. 1, pp. 7-15, 2013. https://agris.fao.org/agris- search/search.do?recordID=PK2014000146

[23] Cho Y. Y., Oh S., Oh M. M., Son J. E., "Estimation of individual leaf area, fresh weight, and dry weight of hydroponically grown cucumbers (*Cucumis sativus* L.) using length of leaf, width, and SPAD value," Scientia Horticulturae, vol. 111, no. 4, pp. 330-334, 2007. https://doi.org/10.1016/j.scienta.2006.12.028

[24] Varalakshmi B., "Genetic variability in Indian Spinach (*Basella alba* L)," Journal of Horticultural Science, vol. 5, no. 1, pp. 21-24, 2010. https://jhs.iihr.res.in/index.php/jhs/article/view/486

[25] Jangde B., Asati B. S., Sahu P., Tripathy B., "Correlation and path coefficient analysis in vegetable amaranthus (*Amaranthus tricolor* L.)," Journal of Pharmacognosy and Phytochemistry, vol. 6, no. 6S, pp. 409-415, 2017. https://www.phytojournal.com/archives/2017/vol6issue6S/PartI/SP-6-6-95-882.pdf