Identification of alternatives to landraces of kale (*Brassica oleracea* group Acephala) for off-season cultivation and seed-to-seed production in Kashmir valley

Abstract

Kale (*Brassica oleracea* group Acephala) germplasm well adapted for July to December cropping season in Kashmir valley was characterized for suitability for year round cultivation. Considering the average performance of two years in terms of leaf yield in tone per hectare, NW-Saag-1 (24.77, 25.08 and 25.01), CITH-KC-16 (28.79, 26.74 and 11.20) and CITH-KC-18 (24.25, 24.14 and 11.91) were found to yield significantly better than local checks *Khanyari* (7.77, 8.47 and 21.31) and *GM Dari* (10.36, 15.98 and 9.65) when transplanted in May, June and July, respectively. Months of April, May, June, July and August were most conducive for normal nursery production followed by May to September transplanting to get economical yields. January sowing of selected genotypes in polyhouse along with added protection from polysheet resulted in vigorous and healthy seedlings. Their transplanting in the second fortnight of March resulted only in short vegetative phase of the crop followed by bolting and seed production. However, this approach came out as an opportunity to produce seed in 7 months (January to July) compared to 1 year normally taken in farmer adopted seed production method.

Keywords: *Brassica oleracea* gp. Acephala, kale, offseason, seed production

Introduction

Kale (*Brassica oleracea* group Acephala) is popularly referred to as the king or queen of leafy vegetables due to its nutritional and non-nutritional health promoting factors. It has large, flat, green or purplish green leaves with cream or purple venation eaten cooked or pickled. Lately, kale has been increasingly becoming popular round the world due to better awareness on its nutritive and health promoting qualities and is now being honored as 'Superfood' (Samec et al 2018). It has high vitamins C and K, folic acid, beta carotene, dietary fibre and polyphenolic contents, and excellent antioxidant and anticarcinogenic properties (Sikora and Bodziarczyk 2012, Becerra-Moreno et al 2013). In India, it is extensively cultivated in Kashmir and to lesser extent in Jammu and Himachal Pradesh. In Kashmir, it is a traditional crop used in heritage dishes as well as a staple vegetable eaten routinely. Referred to as '*haaq*' in vernacular, over time, kale has developed into many landraces popular for their specific traits, for example, *Khanyari* and *Kawdari* for large number of pickings, deep crinkles and meatiness of leaves and better taste at warmer temperatures; *GM Dari* for its large leaves accumulating great taste during winters and high yield per picking; *Anchaari* for succulent petioles suitable for pickling and *Hanz haaq* for small leaves picked several times throughout the winter.

With the mandate of research on temperate vegetable crops, ICAR-Central Institute of Temperate Horticulture, Srinagar has collected, conserved and improved large germplasm of kale from Kashmir valley over several years. Some of the selections have shown promise for greater yield and quality over existing landraces and farmers' varieties. Since local growers now take interest in alternatives to existing cultivars and their offseason production for higher income from vegetable crops in general, these selections were tested at institute's farm with an objective to assess their suitability for offseason cultivation. The outcome of this research will contribute to our efforts in ensuring year long remuneration to the growers from this popular crop.

Material and methods

The germplasm assessed for two consecutive years for its performance during different times of the year comprised 26 genotypes developed and maintained at the institute (Table 1). Their times of sowing and transplanting are given in table 2).

Table 1: Germplasm assessed for cultivation at different times of the year

S. no.	Genotypes	S. no.	Genotypes
1.	NW-Saag-1	**14.**	CITH-KC-20
2.	NW-Saag-4	**15.**	CITH-KC-23-KT
3.	NW-Saag-21 (LR)	**16.**	CITH-KC-26
4.	NW-Saag-23	**17.**	CITH-KC-26 (R)
5.	NW-Saag-27	**18.**	CITH-KC-38
6.	NW-Saag-33	**19.**	CITH-KC-40
7.	NW-Saag-38	**20.**	CITH-KC-48
8.	NW-Saag-42	**21.**	CITH-KC-Sel-3
9.	CITH-KC-8	**22.**	CITH-KC-Sel-5
10.	CITH-KC-11	**23.**	HW-1
11.	CITH-KC-14	**24.**	*Khanyari* (C)
12.	CITH-KC-16	**25.**	*GM Dari* (C)
13.	CITH-KC-18	**26.**	Japanese Green (C)

Randomized Complete Block Design was used with two replicates of each block to lay experiment. Standard package of practices recommended by state agricultural university was followed to grow the crop. Data on yield was taken at several pickings throughout the season and final yield was obtained by summing them up for each genotype. Analysis of variance to compare genotypes for total yield per hectare was done using online OP Stat software for each date of transplanting.

Results and discussion

Time of sowing

Sowing of each genotype throughout the year yielded information on relationship between time of sowing and success in recovering seedlings suitable for transplanting. The proportion of seedlings suitable for transplanting increased steadily from sowings attempted from March to July. Beyond July, seedling emergence was considerably reduced. Emergence ceased completely from October onwards in both the years. Open field sowing in October to February months of both the years resulted in complete failure in obtaining transplantable seedlings. However, in the second year, sowing was attempted in January keeping in mind the probability to transplant the crop in March. Additional protection received from covering the nursery of *Khanyari*, *GM Dari*, Japanese Green, *Hanz Haaq* and Siberian kale with a polysheet (same as used to clad polyhouse) inside a polyhouse induced congenial environment to produce healthy and vigorous seedlings suitable for transplanting in open field during March when temperature rose enough to support normal plant growth.

Time of transplanting

Transplanting of seedlings of all genotypes obtained from each month of sowing resulted in steady increase followed by reduction in total yield, as the year progressed. However, there were few individual differences among genotypes with respect to the month when the highest yield was achieved. The graphical patterns originating from mean yields of whole germplasm and those from genotypes that most consistently performed better than others across different dates are presented in figures 1 and 2, respectively.

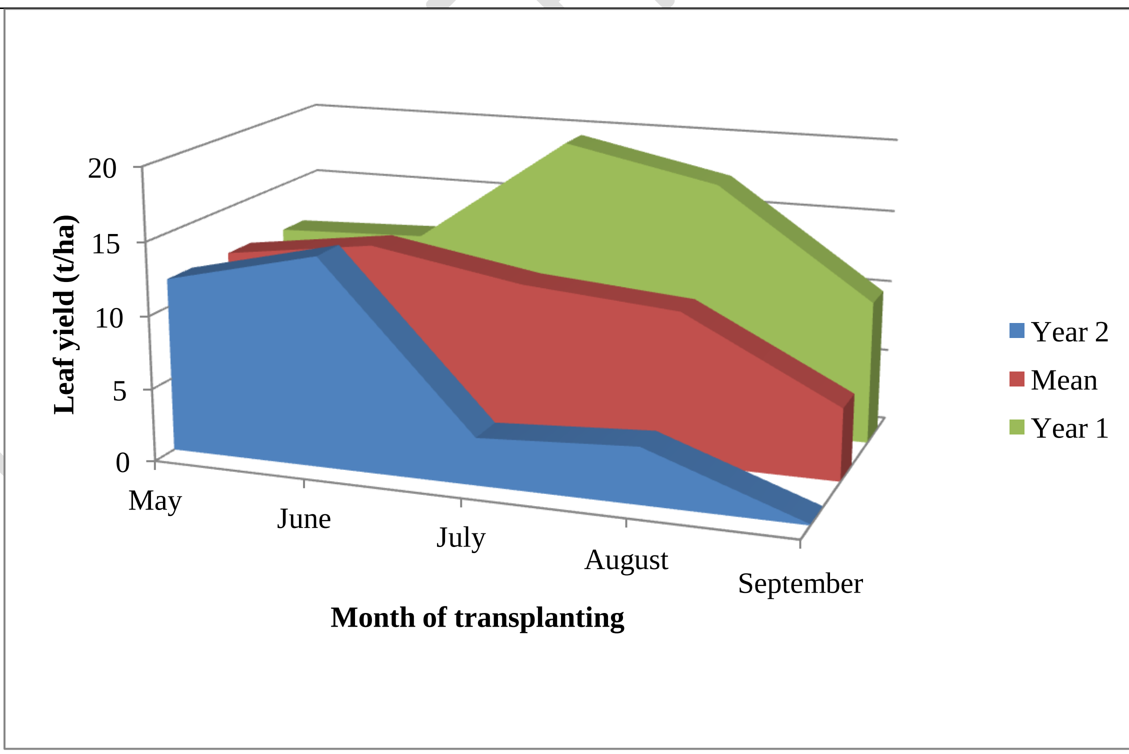
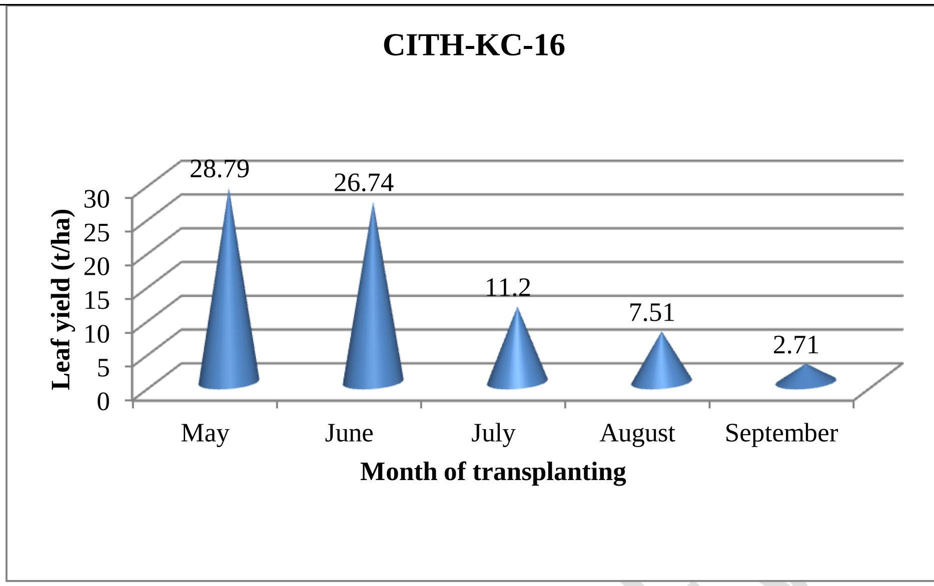
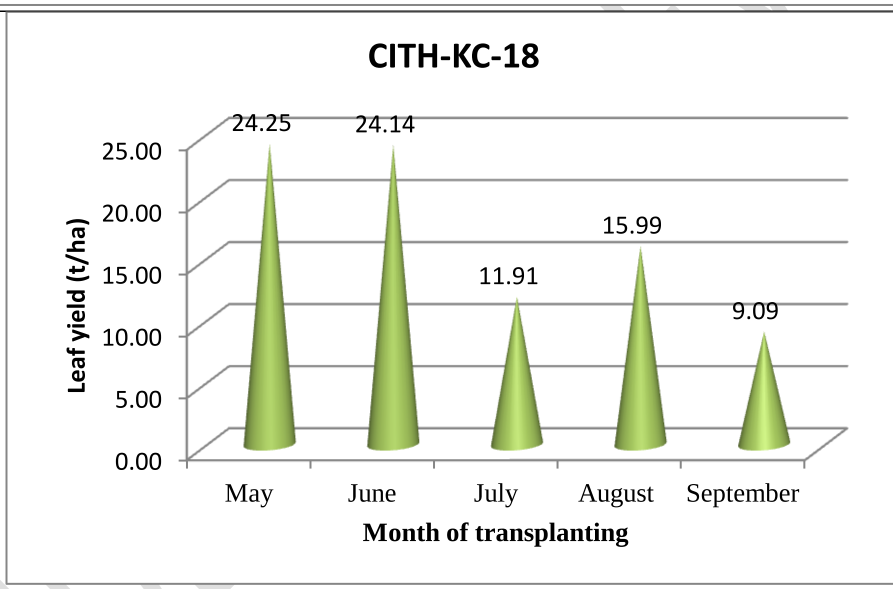


Fig. 1: Yearly and mean leaf yield (t/ha) of germplasm with respect to months of transplanting


CITH-KC-16
Leaf yield (t/ha)
0
5
10
15
20
25
30
28.79
26.74
11.2
7.51
2.71
May
June
July
August
September
Month of transplanting


CITH-KC-18
Leaf yield (t/ha)
0.00
5.00
10.00
15.00
20.00
25.00
24.25
24.14
11.91
15.99
9.09
May
June
July
August
September
Month of transplanting

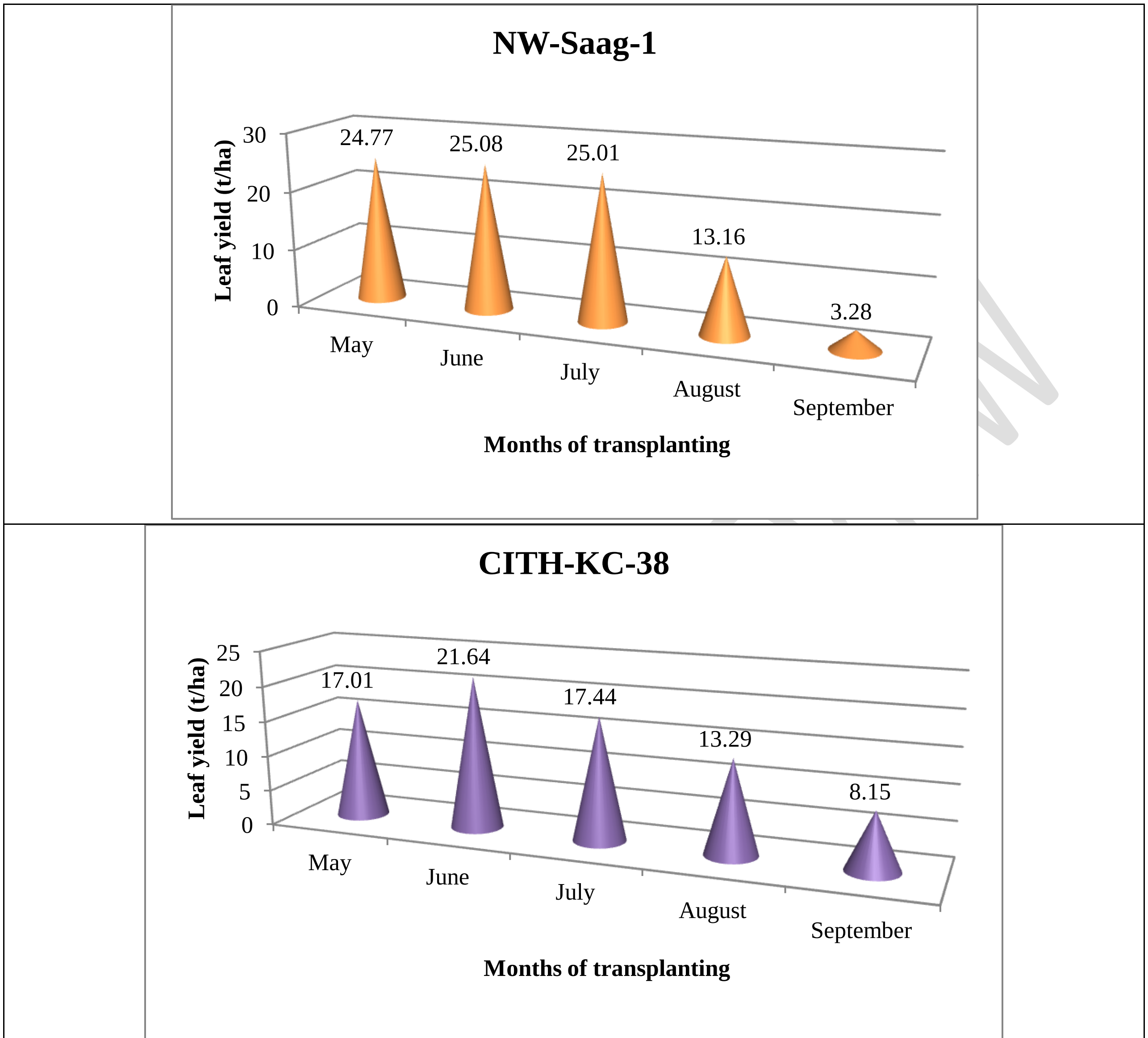


Fig. 2: Mean leaf yield (t/ha) of top performing genotypes over two years with respect to months of transplanting

Suitable genotypes for offseason cultivation

There were significant differences among studied genotypes for yield performance tested at all transplanting times in first as well as the second year (Table 2).

Considering the first year, in May transplanting, which is about 3 months in advance to main season transplanting (mid August) CITH-KC-16, CITH-KC-18 and NW-Saag-1 were the best yielders and performed statistically better than the best check *GM Dari* (10.30 t/ha). Furthermore, their yields (25.48 to 30.44 t/ha) were *at par* with recommended potential in local package of practices (Package of Practices, SKUAST-K, Shalimar) despite offseason. Similarly, in June transplanting, CITH-KC-16, CITH-KC-18, HW-1, NW-Saag-1 and CITH-KC-38 (25.14 to 20.62) performed best and statistically superior to the best check *GM Dari* (12.72 t/ha). The yields realized were to the tune of main season yields. When transplanting was done in July, *Khanyari* expressed the highest leaf yield (41.90 t/ha). However, breeding lines NW-Saag-42, NW-Saag-1 and NW-Saag-21 LR (37.57 to 33.91 t/ha) performed at par with it. In August, *Khanyari* (30.75 t/ha) and Japanese Green (29.77 t/ha) check varieties yielded the highest but 9 breeding lines with yield potential ranging from 19.97 to 29.52 t/ha also performed at par with them.

The overall analysis of first year trial has shown that NW-Saag-1 made it to the category of most superior yielders at all the 4 dates of transplanting yielding 20.76 to 36.66 t/ha. Genotype CITH-KC-18 (20.98-29.52 t/ha) performed superior at three of the four dates of transplanting.

Table 2: Leaf yield of kale genotypes at different times of transplanting

	Genotype	Year 1					Year 2				
		1st FN May	1st FN June	1st FN July	1st FN August	1st FN Sept	1st FN May	1st FN June	1st FN July	1st FN August	1st FN Sept
1	NW-Saag-1	25.78	22.91	36.66	20.76	6.55	23.75	27.25	13.35	5.56	0
2	NW-Saag-4	15.85	19.46	25.43	19.97	11.25	17.75	22.43	1.32	3.65	0
3	NW-Saag-21 (LR)	16.25	11.97	17.63	11.98	8.56	16.97	14.31	9.86	2.69	0
4	NW-Saag-23	5.12	9.81	17.53	8.41	3.30	4.44	13.31	2.48	2.52	0.35
5	NW-Saag-27	2.41	3.08	13.01	14.38	5.62	0	3.09	0	0	0
6	NW-Saag-33	3.87	4.67	21.42	13.47	7.93	6.71	9.99	0.45	5.46	0
7	NW-Saag-38	7.33	5.91	20.46	21.58	10.05	8.85	7.94	0.55	9.39	0
8	NW-Saag-42	4.40	8.58	37.57	23.01	7.96	4.96	11.48	0.69	11.12	0
9	CITH-KC-8	5.47	7.95	9.13	4.74	2.15	9.17	10.73	1.91	1.33	0.32
10	CITH-KC-11	3.72	7.29	12.77	9.97	2.65	2.12	10.07	0	0.85	0
11	CITH-KC-14	8.66	9.65	13.37	2.87	1.46	8.98	12.95	1.81	1.71	0.40
12	CITH-KC-16	30.44	25.14	18.58	13.14	5.41	27.13	28.34	3.81	1.88	0
13	CITH-KC-18	25.48	23.89	20.98	29.52	18.18	23.02	24.39	2.83	2.45	0
14	CITH-KC-20	20.61	15.72	13.02	18.93	9.30	22.02	18.22	9.02	5.55	0
15	CITH-KC-23-KT	4.79	4.37	13.00	25.38	16.10	6.41	7.40	0.44	8.91	0
16	CITH-KC-26	4.12	7.14	6.00	10.94	5.06	4.67	6.97	2.52	2.04	0.26
17	CITH-KC-26 (R)	15.63	14.39	33.91	21.69	13.40	16.89	18.99	6.79	3.32	0
18	CITH-KC-38	17.27	20.62	27.85	23.82	16.29	16.75	22.66	7.89	2.75	0
19	CITH-KC-40	2.92	4.18	11.74	17.30	12.92	0	7.80	0	3.35	0
20	CITH-KC-48	11.30	9.96	14.09	8.94	4.03	11.15	9.70	1.11	1.88	0.33
21	CITH-KC-Sel-3	14.35	12.33	13.56	23.99	14.92	20.64	11.44	1.09	8.32	0
22	CITH-KC-Sel-5	10.40	11.73	18.24	7.56	8.72	10.64	14.87	1.22	1.69	0.26
23	HW-1	24.86	23.47	28.38	18.89	9.70	24.21	23.96	9.81	2.60	0
24	*Khanyari* (C)	8.25	8.05	41.90	30.75	9.51	7.29	8.88	0.71	4.29	0

25	*GM Dari* (C)	10.30	12.72	14.89	12.06	16.70	10.41	19.24	4.40	3.22	0.33
26	Japanese Green (C)	3.25	6.78	4.36	29.77	24.66	4.86	6.65	0	3.81	0
	CD (p<0.05)	*5.09*	*4.73*	*11.17*	*11.11*	*6.31*	*7.09*	*6.09*	*4.00*	*4.41*	-

Table 3: Leaf yield of kale genotypes at different times of transplanting

	Genotype	**Mean leaf yield over two years**				
		May	**June**	**July**	**August**	**September**
1	NW-Saag-1	24.77	25.08	25.01	13.16	3.27
2	NW-Saag-4	16.79	20.94	13.38	11.81	5.62
3	NW-Saag-21 (LR)	16.61	13.14	13.74	7.33	4.28
4	NW-Saag-23	4.78	11.56	10.01	5.46	1.82
5	NW-Saag-27	1.20	3.08	6.51	7.19	2.81
6	NW-Saag-33	5.29	7.33	10.93	9.47	3.96
7	NW-Saag-38	8.09	6.93	10.50	15.48	5.03
8	NW-Saag-42	4.68	10.03	19.13	17.06	3.98
9	CITH-KC-8	7.32	9.34	5.52	3.03	1.24
10	CITH-KC-11	2.92	8.68	6.39	5.41	1.32
11	CITH-KC-14	8.82	11.30	7.59	2.29	0.93
12	CITH-KC-16	28.78	26.74	11.20	7.51	2.71
13	CITH-KC-18	24.25	24.14	11.90	15.98	9.09
14	CITH-KC-20	21.31	16.97	11.02	12.24	4.65
15	CITH-KC-23-KT	5.60	5.88	6.72	17.14	8.05
16	CITH-KC-26	4.39	7.05	4.26	6.49	2.66
17	CITH-KC-26 (R)	16.26	16.69	20.35	12.50	6.70
18	CITH-KC-38	17.01	21.64	17.87	13.28	8.15
19	CITH-KC-40	1.46	5.99	5.87	10.32	6.46
20	CITH-KC-48	11.22	9.83	7.60	5.41	2.18
21	CITH-KC-Sel-3	17.50	11.89	7.32	16.15	7.46

22	CITH-KC-Sel-5	10.52	13.30	9.73	4.63	4.49
23	HW-1	24.53	23.71	19.10	10.74	4.85
24	*Khanyari* (C)	7.77	8.46	21.30	17.52	4.75
25	*GM Dari* (C)	10.35	15.98	9.65	7.64	8.52
26	Japanese Green (C)	4.06	6.72	2.18	16.79	12.33
	CD (at 5% LoS)	*3.148*	*2.727*	*1.593*	*1.186*	*NS*

Table 4: Mean leaf yield (t/ha) of kale germplasm over two years at different times of transplanting

	1st FN May	**1st FN June**	**1st FN July**	**1st FN August**
Year 1	11.64	11.99	19.46	17.24
Year 2	11.91	14.35	3.23	3.86

During the second year of study, there was unexpected heavy snow in the first week of November, which was much sooner than expected and affected the crop adversely. Had the weather been regular during second year of study, mean performance of whole germplasm as well as individual genotypes would have been higher. Nevertheless, yields were taken into consideration because it would not change the comparative performance of genotypes among themselves, even though absolute values of yield are lower than the genotypes' potential. Additionally, it gave an estimate of performance of these genotypes in the event of temperature stress.

This crop continues to yield marketable leaves till December-January during winter cultivation except *Khanyari* that can yield beyond, although it is predominantly cultivated in summer season (April-October). Hence, the May transplanted crop well entered the month of November as much as the later transplanted crops. Therefore, the sudden stress did play a part in affecting yields at all transplanting dates. In May transplanting, CITH-KC-16 yielded the highest leaf yield (27.13 t/ha) with 5 other genotypes HW-1 (24.21), NW-Saag-1 (23.75), CITH-KC-18 (23.02), CITH-KC-20 (22.02) and CITH-KC-Sel-3 (20.64) performing at par with it. This yield range coincides with the realized yields of kale in Kashmir (reference). This suggests buffering capacity of these genotypes to low temperature stress at later stages of cropping season. On the other hand, traditional varieties *Khanyari* (7.29), *GM Dari* (10.41) and Japanese Green (4.86), which were used as checks yielded sub-optimally under the same conditions. With respect to June transplanting, CITH-KC-16 (28.34) was again the best yielder with NW-Saag-1 (27.25), CITH-KC-18 (24.39) and HW-1 (23.96) again performing at par with it along with CITH-KC-38 (22.66) and NW-Saag-4 (22.43). The check varieties performed statistically inferior to the best genotype CITH-KC-16. In July and August transplanting, the yields obtained were comparatively very low despite being near main cropping season suggesting that sudden lowering of temperature and snow had greater impact on the earlier developmental stage of crop than at later stages (as in the case of May and June transplanting).

Considering the average performance of genotypes over two years, CITH-KC-16 (28.78 t/ha) alone outperformed all other genotypes including landraces and other checks when transplanted in May. In June transplanting, again CITH-KC-16 (26.74) along with NW-Saag-1 (24.77) and CITH-KC-18 (24.14) was the top performer. NW-Saag-1 (25.01) again performed best in July transplanting. With respect to transplanting in August, however, the highest average performance was exhibited by genotypes other than these three. Check Japanese Green (16.79), landrace *Khanyari* (17.52), CITH-KC-23 (17.14) and germplasm line NW-Saag-42 (17.06) were top performers. In September transplanting, however, no significant differences among genotypes were recorded, probably due to extremely skewed yields caused by temperature drop.

Also, it was observed that in August transplanting, which is also the main season of the crop, an introduced variety and a landrace were the top performers substantiating their claim over being the highest performing adapted genotypes. This implies that the germplasm held by CITH is very valuable in terms of the seasons other than the valley's main season along with other traits of importance.

Seed production

The lifecycle of cultivated vegetable kale in the valley comprises embryo (seed) followed in succession by vegetative phase, vernalization, reproductive phase and then embryo (seed) again. In our attempt to cultivate our germplasm across all months, we were unable to achieve transplantable seedlings beyond August sowing in open field conditions. Although, sowing could be done in September till December in protected conditions, transplanting them in open fields during October to February period could not have been possible due to the obvious reason of inhospitable weather. However, sowing of certain genotypes was done in January in naturally ventilated polyhouse with second layer of poly-sheet over the nursery bed. Healthy seedlings were obtained, which were transplanted in mid March in open field. Luxuriant growth was achieved in all of them. However, with rise in temperature in May, bolting occurred, first in Japanese Green followed by others that eventually yielded viable seeds in July. This offseason production of seed is a great opportunity to circumvent vernalization phase that entails *ex-situ* field establishment and its care. This saves time and other resources and simplifies kale cultivation on the whole.

Conclusion

Kashmir is cultivating vegetable kale (*haaq/ hakh*) since antiquity and hosts several landraces and farmers' varieties. However, with time, like all other crops, newer varieties in kale are also being demanded by farmers. Such varieties should have certain merits of relevance to the growers. Varieties with higher yields, better aesthetic quality, pest resistance and offseason production potential are of immense value to farmers. At ICAR-CITH, Srinagar, a large germplasm of kale is being maintained and improved for several years. On evaluating for offseason cultivation across many dates of transplanting, genotype NW-Saag-1 followed by CITH-KC-18 and CITH-KC-16 performed most consistently and better than others including landraces. Consequently, these genotypes have been identified as novel candidates for offseason kale cultivation (transplanting from May to July) that can perform better than their conventional counterparts *Khanyari* and *GM Dari* popularly grown in Kashmir valley. Further, polyhouse seedling preparation during harsh winters followed by mid March transplanting of some of these lines produced seed in seed-to-seed mode saving 5-month time and considerable efforts.

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