Nepalese Horticulture 18 : 29-35, 2024
ISSN : 2092-1122 | Print : 2542-2936 (Online)
DOI: https://doi.org/10.3126/nh.v18i1.72732

Research Article

OPEN ACCESS

Performance of Cauliflower Genotypes for the Early Season Production in Pokhara, Kaski, Nepal

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Received on: 6 July, 2024 **Revised on:** 6 November, 2024 **Accepted on:** 12 November, 2024

Abstract

A field experiment was conducted from July to November for three consecutive years; 2019, 2020, and 2021 to identify the cauliflower genotypes suitable for early planting under Pokhara conditions. In 2019, the five cauliflower genotypes (Ageni, Khumal Jyapu 1, Khumal Jyapu 2, Terai 1, Terai 2) from the National Horticulture Research Center were evaluated in the non-replicated design with the check variety White Cup (F1), and in the year of 2020 and 2021 five genotypes of Cauliflower named Terai 1, Terai 2, Ageni, Pusa Sarad, and White Cup(F1) were evaluated in a randomized complete block design (RCBD) with four replications. The four-week-old seedlings were transplanted in the field in the first week of August. From the pooled mean of two years (2020 and 2021) of experiments, there were significant differences among the cauliflower genotypes for days to harvest, curd weight, curd diameter, and curd height and yield. The highest curd weight was found for White Cup (405.79 g) which was at par with Terai 2 (396.21 g). The earliest genotype of cauliflower ready for harvest was White Cup (57.75 DAT) which was statistically similar to Terai 1 (60.12 DAT) followed by Terai 2 (65.25 DAT) and the highest yield was found for Terai 2 (18.55 t/ha) which was at par with White Cup (18.14 t/ha) and Terai 1(16.15 t/ha). Based on the three-year results, two open-pollinated genotypes; Terai 1 and Terai 2 are promising for August planting in Pokhara condition.

Keywords : Consecutive, Curd, Design, Promising, Yield

Introduction:

Cauliflower (*Brassica oleracae* var. *botrytis* L., *2n=2X=18*) is a member of the Brassicaceae family. It is an important and popular vegetable crop grown commercially and for kitchen gardens in Nepal. The cauliflower is called the "King of Cole crops" (Poudel *et al*., 2023). The edible part of Cauliflower is immature curd. In Nepal, the cauliflower production area is 39,214 hectares (ha), production is 611015 tons (t) and productivity is 15.58 t/ha (MoAD, 2023). Similarly, the area, production, and productivity of cauliflower, in Gandaki Province is 2087 ha, 28356 t, and 13.58 t/ha respectively. However, the production level does not meet the market demand from domestic production and there is an import of Cauliflower in huge amounts (MoAD, 2021). Cauliflower is an abundant source of proteins, carbohydrates, fibers, minerals, and vitamins (Ara *et al*., 2009).

Cauliflower is a cool season crop and it is sensitive to the temperature. The low temperature helps with curd formation. In Nepal, available cauliflower varieties are categorized as early, mid, and late-season varieties. For the curd formation, the favorable temperature for early varieties is around 25-27 °C, 13-19°C for mid-season varieties, and 10–16 °C for late varieties (Choudhury, 1996). Farmers should have alternatives to select suitable varieties based on temperature requirements having better yields, quality, and resistance to insect pests/diseases (Poudel *et al.,* 2002; Kumar *et al.,* 2019).

In Nepal, the registered cauliflower varieties for the early season are the White Cup, Silver Cup, White Flash, and Sarlahi Depali (Krishi Diary, 2023). Due to the irregular seed supply of these cauliflower varieties, poor taste, and higher market prices for seed, farmers and consumers want alternatives. The existing local open-pollinated cauliflower varieties have preferred cooking abilities and are insect pest resistant however they are not able to grow early from August to November (HRD, 2013).

In the mid-hill region of Nepal, the cultivation of Cauliflower from August to November is off-season. In that time, they will get lower yields as well as many undesirable traits in cauliflower such as curds with a fuzzy texture, brownish and unattractive loose curds, as well as discolored curds, and get lower prices by a producer (Poudel *et.al*., 2023). However, there is a huge demand from August to November, for cauliflower due to major Nepalese festivals celebrated during this period. Farmers also receive higher prices for cauliflower during this off-season (Bhattrai *et al*., 2015; Pradhan *et al*., 2023). From August to November there is an import of cauliflower from India to meet the majority of the domestic market demand in Nepal.

On the other hand, only hybrid varieties are registered in Nepal for early-season cultivation, and we have opportunities to select the open-pollinated varieties that can grow in the early period from our gene pool. Therefore, this study was conducted to identify better open-pollinated genotypes that will be competitive with imported hybrid cauliflower varieties in early production and yield for climates like HRS, Malepatan, and Pokhara.

Materials and Methods:

The experiments were carried out at Horticulture Research Station, Malepatan, Pokhara. which lies in the mid-hill region of Nepal with a subtropical climate at 28° 13' 4" North latitude and 83° 58' 28" East longitude with an altitude of 859 masl. Firstly, in the year 2019, the five cauliflower genotypes (Ageni, Khumal Jyapu 1, Khumal Jyapu 2, Terai 1, Terai 2) from the National Horticulture Research Center were evaluated in the non-replicated design with the check variety White Cup. From the exciting results of these genotypes in the first year, a well-planned experiment for the evaluation of these genotypes was held from July to November for two consecutive years in 2020 and 2021. The required seeds of the cauliflower genotype namely Terai 1, Terai 2, Ageni, and Pusa Sarad were collected from the National Horticulture Research Centre, Nepal Agricultural Research Council, Khumaltar, Lalitpur. Along with the above four genotypes, the White Cup (F1) variety of cauliflower (check variety for early production) was used to make treatments for the research trial. The design of the experiment was a Randomized complete block design (RCBD) having four replications of each treatment. The four-week-old seedlings were transplanted in the first week of August each year. The plot sizes were maintained at 1.8 m × 2.25m (4.05 m^2). The row-to-row and plant-to-plant spacing was maintained at 45×45 cm. accommodating 20 plants per plot. We used the recommended dose of fertilizers (200:120:80 NPK kg/ha + 30 tons FYM/ha) for each treatment. The full doses of phosphorous were applied through di-ammonium phosphate (DAP), potassium was applied through muriate of potash (MOP), and half doses of nitrogen were applied through Urea during field preparation at the time of transplanting. The remaining dose of nitrogen was split two times and the urea was used as the top dressing at 20 days after transplanting (DAT) and 40 DAT. The gap filling was done within a week after transplanting when required. All the inter-cultural operations like weeding, earthing up, and hoeing were carried out uniformly when necessary. Irrigation was provided by pipes and watering cans, from transplanting to the harvesting stage. The plant protection measures, like spraying fungicide (carbendazim) during the early plant establishment stage twice in 15-day intervals were provided after transplanting. Observations on yield and yield attributes like plant height during harvest, number of leaves at harvest, days to first harvest after transplanting, curd weight, curd height, curd diameter, and curd yield were recorded from five sample plants from each experimental unit. The recorded data was systemically arranged in MS Excel. The compiled data was used for Analysis of Variance (ANOVA) and Duncan's multiple Range Test (DMRT) for mean separation. Statistical analysis of recorded data was done through R (version 4.3.2) and R Studio (2024.04.1).

Climatic conditions during field experimentation

Table 1: Monthly temperature, relative humidity, and rainfall during field experiments

Month	Min Temp			Max Temp			Avg. RH%			Avg. Rainfall (mm)		
	Year			Year			Year			Year		
	2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021
Aug	20.9	23.26	22.55	32.9	32.24	29.93	76.4	86.88	82.9	453.5	845.9	1244.9
Sept	18.8	21.19	21.16	29.9	30.72	29.98	83	79	79.98	676.8	1473.8	749.4
Oct	14.7	14.02	18.43	27.8	29.82	28.34	75.3	70.3	80.94	219.2	52.9	541.26
Nov	12.9	9.22	11.5	25.4	24.07	23.21	81.1	76.9	80.01	6.3	0.4	0
Dec	6.8	5.19	6.87	18.7	20.25	19.91	83.8	79.66	84.05	48.1	2	48.98

Source: Office of Hydrology and Meteorology, Pokhara.

Results:

Preliminary trial in 2019

From the result of these six genotypes (table 2), the tested genotypes were found earlier in curd formation as compared to hybrid check White Cup (43 DAT). The Terai 1 (40 DAT) genotype was the earliest genotype for curd formation while Khumal Jyapu (65 DAT) and Khumal Jyapu 2 (65 DAT) required the highest time for the curd formation. The curd weight was also recorded more than the check variety. The highest weight of curd was recorded for the Khumal Jyapu 2(496 g) followed by Terai 2 (419 g) and then White Cup (375 g).

Days to fifty percent curd formation and days to first harvest from days after transplanting (DAT)

There were significant differences (P<0.01) among the tested genotypes of cauliflower for the days to fifty percent curd formation after transplanting in 2020 (Table 3). The earliest genotypes of cauliflower for days to 50% curd formation were found for the White Cup (55.25 DAT) and Terai 2 (55.25 DAT) and the longest days to 50 percent curd formation was found for the Ageni (72.25 DAT).

Likewise, the mean data on days to the first harvest were significant differences (P<0.001) among the genotypes (Table 3). The genotype of cauliflower ready for earliest harvest was White Cup (57.75 DAT) which was at par with Terai 1 (60.12 DAT) followed by Terai 2 (65.25 DAT) and the highest days required for the harvest was found for the genotype Pusa Sarad (73.5 DAT) which was significantly similar with Ageni (73.37 DAT).

Table 2: Preliminary evaluation for the performance of early cauliflower genotypes at HRS, Malepatan, 2019

Genotypes	Fifty % Curd Formation (DAT)	First harvesting (DAT)	No. of leaves at harvest	Plant height at harvest (cm)	Weight of curd (g)	Curd diameter (cm)	Curd height (cm)
Ageni	55	67	17.25	42	279	15.2	11.6
Khumal Jyapu 1	65	76	27.2	62.8	430	16.5	14.25
Khumal Jyapu 2	65	84	27.5	64	496	15.5	13
Terai 1	40	58	17.5	20.5	105	8.25	4.75
Terai 2	43	58	27.4	43.4	419	14	10.6
White Cup (F1) (Check)	43	58	21	33.4	375	15.8	10.2

Pooled analysis of 2020 and 2021

Table 3: Effect of cauliflower genotypes on days to 50% curd formation and days to first harvest at HRS Malepatan in 2020 and 2021.

Genotypes/variety	Days to 50% curd formation (DAT)	Days to first harvest (DAT)		
	Year	Year		
	2020	2020	2021	Mean
Ageni	72.25[a]	78.00[a]	68.75[a]	73.37[a]
Pusa Sarad	65.50[a]	78.00[a]	69.00[a]	73.50[a]
Terai 1	55.25[b]	64.75[b]	55.50[b]	60.12[c]
Terai 2	66.75[a]	74.50[a]	56.00[b]	65.25[b]
White Cup	55.25[b]	58.25[b]	57.25[b]	57.75[c]
Grand mean	63	70.7	61.3	66
SEM ±	35.06	25.72	2.72	6.11
LSD0.05	9.12**	7.81***	2.54***	3.8***
CV%	9.39	7.17	2.69	3.74

Means followed by common letter (s) are not significantly different among each other based on DMRT at a 5% level of significance. SEM±= standard error of means, LSD= least significant difference, CV= coefficient of variance, '***' Significant at 0.1%(p<0.001) '**' Significant at 1% (p< 0.01)

Table 4: Effect of cauliflower genotypes on no. of leaves per plant during harvest and plant height at HRS Malepatan in 2020 and 2021

Genotypes/ Variety	No. of leaves per plant at harvest			Plant height at harvest (up to the tip of the leaf)		
	Year			Year		
	2020	2021	Mean	2020	2021	Mean
Ageni	19.07[c]	21.27[d]	20.17[c]	60.73[a]	61.77[a]	61.25[a]
Pusa Sarad	19.70[c]	25.38[b]	22.54[b]	53.25[b]	50.99[b]	52.12[b]
Terai 1	19.71[c]	24.40[bc]	22.06[b]	38.14[c]	33.42[c]	35.78[c]
Terai 2	27.31[a]	32.17[a]	29.74[a]	52.56[b]	50.03[b]	51.30[b]
White Cup	21.99[b]	22.12[cd]	22.06[b]	52.82[b]	45.53[b]	49.18[b]
Grand mean	21.55	25.07	23.31	51.5	48.34	49.92
SEM ±	0.7	3.21	0.95	9.26	11.47	4.66
LSD0.05	1.29***	2.76***	1.5***	4.68***	5.21***	3.32***
CV%	3.88	7.14	4.18	5.91	7.04	4.32

Means followed by common letter (s) are not significantly different among each other based on DMRT at a 5% level of significance. SEM±= standard error of means, LSD= least significant difference, CV= coefficient of variance, '***' Significant at 0.1%(p<0.001)

Number of leaves per plant and plant height during harvest

From the pooled mean of two years, there was a highly significant difference (P<0.001) among the tested genotypes for the number of leaves per plant during harvest (table 4). The highest number of leaves per plant was found for the genotypes Terai 2 (29.74) followed by White Cup (22.06), Terai 1 (22.06), and Pusa Sarad (22.54). The lowest number of leaves was found for the genotype Ageni (20.17).

The plant height at harvest was found highly significant (P<0.001) difference among the tested genotypes of cauliflower. The highest plant height was found for the genotype Ageni (61.25 cm) followed by Pusa Sarad (52.12 cm) which was at par with Terai 2 (51.3 cm) and White Cup (49.18 cm). The shortest genotype was Terai 1 (35.78 cm).

Curd weight, Curd diameter, and curd height

From the pooled mean of two years of experiments,

Table 5: Effect of cauliflower genotypes on curd weight, curd diameter, and curd height at HRS Malepatan in the year of 2020 and 2021.

Genotypes/ variety	Curd weight (g)			Curd diameter (cm)			Curd height (cm)		
	Year			Year			Year		
	2020	2021	Mean	2020	2021	Mean	2020	2021	Mean
Ageni	381.91^{b}	303.73	342.82^{bc}	18.46^{a}	18.04^{a}	18.26^{a}	9.66^{a}	10.39^{a}	10.02^{a}
Pusa Sarad	404.06^{ab}	216.98	310.52^{c}	15.79^{b}	13.14^{b}	14.46^{bc}	7.93^{bc}	7.57^{b}	7.75^{b}
Terai 1	403.81^{ab}	270.01	336.91^{bc}	12.77^{c}	14.02^{ab}	13.40^{c}	6.85^{c}	9.50^{ab}	8.18^{b}
Terai 2	483.37^{a}	309.04	396.21^{ab}	14.35^{bc}	16.91^{ab}	15.64^{b}	8.68^{ab}	9.90^{a}	9.29^{ab}
White Cup	476.77^{a}	334.81	405.79^{a}	14.37^{bc}	16.98^{ab}	15.68^{b}	8.88^{ab}	9.42^{ab}	9.15^{ab}
Grand mean	429.98	286.91	358.45	15.15	15.82	15.49	8.4	9.35	8.88
SEM ±	2547.53	2568.54	1482.22	1.89	6.28	1.68	0.93	1.77	0.92
LSD0.05	77.76*	NS	59.31*	2.11***	NS	1.99**	1.48*	NS	1.48*
CV%	11.37	17.66	10.74	9.08	15.84	8.37	11.47	14.24	10.81

Means followed by common letter (s) are not significantly different among each other based on DMRT at a 5% level of significance. SEM±= standard error of means, LSD= least significant difference, CV= coefficient of variance, '***' Significant at 0.1%(p<0.001) '**' Significant at 1% (p< 0.01) '*' Significant at 5% (p<0.05) NS= Non-significant

Table 6: Effect of cauliflower genotypes on plant stand per plot during harvest and yield at HRS Malepatan in the year of 2020 and 2021.

Genotypes/ variety	Plant stand per plot during harvest			Yield (t/ha)		
	Year			Year		
	2020	2021	Mean	2020	2021	Mean
Ageni	18.00	19.25	18.62	16.97^{b}	14.43	15.70^{ab}
Pusa Sarad	16.25	19.00	17.62	16.13^{b}	10.24	13.18^{b}
Terai 1	19.50	19.25	19.37	19.41^{ab}	12.90	16.15^{ab}
Terai 2	18.75	19.25	19.00	22.41^{a}	14.68	18.55^{a}
White Cup	17.50	18.75	18.12	20.67^{ab}	15.60	18.14^{a}
Grand mean	18	19.1	18.55	19.12	13.57	16.34
SEM ±	2.19	1.86	1.13	7.77	8.86	5.35
LSD0.05	NS	NS	NS	4.29*	NS	3.56*
CV%	8.22	7.15	5.73	14.58	21.92	14.15

Means followed by common letter (s) are not significantly different among each other based on DMRT at 5% level of significance. SEM= standard error of means, LSD= least significant difference, CV= coefficient of variance, '*' Significant at 5% (p<0.05) NS= Non-significant

there were significant differences among the cauliflower genotypes for curd weight (P<0.05), curd diameter (P<0.01), and curd height (P<0.05). The highest curd weight was found for White Cup (405.79 g) which was at par with Terai 2 (396.21 g) followed by Ageni (342.82 g) which was at par with Terai 1(336.91 g) and the smallest curd was found for the genotypes Pusa Sarad (310.52 g).

The highest curd diameter was found for the Ageni (18.26 cm) followed by White Cup (15.68 cm), Terai 2 (15.64 cm), and the lowest diameter of curd was found for the Terai 1 (13.4 cm). Similarly, the highest curd height was found for the genotype Ageni (10.02 cm) which is at par with Terai 2 (9.29 cm) and White Cup (9.15 cm). The smallest curd height was found for the Pusa Sarad (7.75 cm) and Terai 1(8.18 cm).

Final plant stands per plot and yield

The analysis of variance for the final plant stand per plot was found non-significant among the tested genotypes. The pooled mean from two years of experiments, there was significant differences (P<0.05) in the yield among the tested genotypes. The highest yield was found for the Terai 2 (18.55 t/ha) which was at par with White Cup (18.14 t/ha) and Terai 1(16.15 t/ha). The lowest yield was found for the Pusa Sarad (13.18 t/ha).

Discussions:

Cauliflower is very sensitive to the temperature during vegetative growth and curd formation (Giri *et al.,* 2020). The temperature required for curd formation of cauliflower genotypes differs significantly, the suitable temperature range for early varieties is around 25-27 °C, for mid-season varieties is 13-19°C and for late varieties is 10–16 °C (Pradhan *et al.,* 2023). The results of our research found that White Cup and Terai 2 were superior for curd formation and curd maturity in the early planting in Malepatan condition. Similar results were also obtained for curd formation and maturity under the Khumaltar condition when the genotypes were transplanted on the 5th of August. However, the economic yield was significantly the lowest for these genotypes (Pradhan *et al.,* 2023).

The variation in the yield and other growth parameters in different growing seasons is due to the different genotypic responses to climatic factors like temperature and rainfall, which is reported by several researchers and by Pradhan *et al*., (2023). The height of the curd was significantly affected by genotypes. This difference in curd height due to genotype is supported by many researchers (Poudel *et al*., 2017; Pradhan *et al*., 2023; Poudel *et al*., 2023). Due to unfavorable growing conditions in the early season, the performance of genotypes also differs and there may arise many physiological disorders like riceyness, buttoning, fuzziness, and monetary loss (Singh *et al.,* 2013).

There were significant differences for parameters like number of leaves, plant height, days to first harvest, curd weight, curd diameter, and yield among the tested genotypes. The variation found in genotypes might be due to different genes present and their expression with environment and management practices. The statement about the variation occurring by different genes is supported by Santhosa *et al.,* (2014), Singh *et al.,* (2010), Mehra & Singh (2013), and Pradhan *et al*., (2023). The plant height, leaf number, and curd initiation varied significantly for different varieties. These results coincide with Giri (2020), Ara *et al*., (2009), and Poudel *et al*., (2023). Hossaina *et al*. (2020) reported that variation in the number of leaves and yield among genotypes. Likewise, Poudel *et al*., (2017) found significant differences in plant height and yield for different early-season varieties.

The days to curd initiation and maturity are determined by environmental factors and genetic traits (Poudel *et al*., 2023). To select the early cauliflower genotypes, we should give priority on parameters like days to 50% curd initiation, days to harvest, number of leaves, and yield (Bhattarai *et al*., 2015; Pradhan *et al*., 2023). The productivity of cauliflower significantly differs from each other. The difference in yield between the tested genotypes is due to genetic characteristics and growing conditions like temperature, moisture, and the nutrients in the field. Poudel *et al*., (2023) and Ara *et al*., (2009) also reported differences in curd yield in different varieties.

Conclusion:

The evaluation of these genotypes in HRS, Malepatan reveals that different genotypes perform differently for the vegetative and yield parameters. Based on the three-year results, the open-pollinated genotypes like Terai 1 and Terai 2 are the promising lines for the early season production, which is generally off-season production when transplanted in August in Pokhara condition. The maturity period from the transplanting date and the yield of these genotypes can compete with the imported hybrids for commercial cultivation. However, further evaluation is required for these genotypes through multi-location trials and farmer field trials in different agroecological conditions for variety release or registration.

Acknowledgments:

We all authors would like to acknowledge all staff of the Horticulture Research Station for their kind cooperation in conducting and completing research trials. They also acknowledge the Nepal Agricultural Research Council for providing research funds.

Declaration of conflict of interest and ethical approval:

The role of Santosh Lohani was to prepare the research design and the conduction of field experiments, data recording, analysis of data, and draft preparation. Saroj Adhikari and Yubraj Bhusal were involved in the research concept, design, and analysis. Sujan Subedi and Navin Gopal Pradhan were helpful with the seed source and other technical support. S Ranabhat was involved in the field experiment and data collection. The authors have no relevant financial or non-financial interests during the research period, manuscript preparation, and publication.

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