PERFORMANCE EVALUATION OF CAULIFLOWER CULTIVARS IN MID-HILLS OF NEPAL FOR WINTER SEASON PRODUCTION

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ABSTRACT

Cauliflower (Brassica Oleracea botrytis) is one of the most popular and demanded vegetables in Nepal. Five cultivars: Barkha, Girija, Giewont, Whistler and Snow Mystique were transplanted in the first week of October 2016 and 2017 in the mid-hills (Kathmandu valley, 1300 masl) and grown during the winter season with 60X45 cm spacing. Source seed of Snow Mystique was Takii Seed Japan and the rest were Montsanto Seed, India. Crops were fertilized with 200:120:80N.P.K Kg/ha and 15-ton FYM/ha. Insecticide and fungicide were sprayed one time in the early period for crop establishment. The main objective of this experiment was to find out suitable high yielding and insect pest and disease tolerant hybrid cauliflower cultivars for commercial farming in the mid-hills of Nepal. Crops were evaluated with their vegetative, insect pest and disease, yield and farmers' and consumers' response in two consecutive years. Results showed that among the tested cultivars, Barkha was found to be highly uniform, vigorous, less attacked by insect pests and disease, early harvestable (62.7 days after transplanting), efficient per day yield (487.7 kg/ha), preferable average head weight (1039 g), freshness (4.3) and market preference (4.0) as compared to check variety Snow Mystique. On the other hand, Snow Mystique has only yield efficiency (436.2 kg/ha/day), greater insect damage and leaf spot disease, longer days to harvest (101 days), and freshness (3.8), respectively. Hence, Barkha has been selected and recommended for commercial cultivation in the mid-hills of Nepal.

Keywords: Cauliflower, Hybrid cultivars, Insect pest and disease, Mid-hills, Yield

INTRODUCTION

Cauliflower (*Brassica oleracea* Botrytis) is one of the popular vegetables of commercial crops globally because of its wider adaptability to climatic conditions and soil types, ease of production and storage, and its food value. Commercial cultivation of cauliflower is very common due to high market demand. Cauliflower can be cultivated throughout the year if appropriate varieties are selected and planted. It favors a cold climate and soil pH with 5.5 to 6.5. It is grown throughout the country from Terai (plain area) to high hills but planting time might be different. It is a cold season crop and generally cultivated during the winter season. Cauliflower belongs to Brassicaceae family and basically grown with seeds. The white part of the flower is used for culinary purpose. The stalk and surrounding thick, green leaves are used in vegetable broth or can be fed as fodder for livestock. Surrounding the curd are ribbed, coarse green leaves that protect it from sunlight, impeding the development of chlorophyll. The cauliflowers are attached to a central stalk.

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Cauliflower crop is very sensitive to soil and climatic requirement (Nath el al. 1987). Based on climatic requirements and maturity, cauliflower is divided into three types; early maturity, medium maturity and late maturity. Early maturing varieties need long days and warm temperatures, whereas late-maturing varieties can with stand late in the season. Cauliflower varieties are classified based on optimum temperature for curd initiation and availability period viz, early (20-27^0 C and September-October), mid-early (20-25^0 C and October-November), mid-late (16-18^0 C and November-December), and late (12-16^0 C and December-January) (Thamburaj and Sing, 1998). Seedlings are prepared in the nursery and transplanted for crop production. Cauliflower is cultivated in 34,967 ha with a production of 531,944 mt and 15.2 mt/ha productivity in Nepal and ranks first on the basis of area coverage (MOAD, 2016). In terms of sales, the most common commercial vegetables are cauliflower, cabbage and tomato, respectively (MOAD, 2016).

In recent years, hybrid cauliflower cultivation has been increasing. Due to the availability of heat-tolerant cultivars, cauliflower can be grown in summers as an off-season vegetable. Varieties also differ in temperature requirement for curd initiation (Saini 1990). In the high mountain area with a colder climate, it is grown during spring and summer. Cauliflower contributes positively in humal health. The plant was used for medicinal purposes to treat gout, stomach problems, deafness, headache and hangovers in the early days. Regular consumption of cauliflower reduces certain types of cancer risks. Cauliflower aids in weight loss management and promotes heart health, builds healthy immune system, lowers blood cholesterol levels, detoxifies the body system, and boosts vitamin K and calcium content. Cauliflower is a rich source of minerals and is also good for skin health. Curd is the edible part of the cauliflower, and the major nutrients available are vitamins, protein and minerals. Regular consumption of curds can save from cancers and heart diseases and helps maintain a healthy level of cholesterol and immune system in the human body (Keck, 2004).

The main objective of this experiment is to find out suitable high yielding and insect pest and disease field tolerant hybrid cauliflower cultivars for commercial winter season production in the mid-hills of Nepal.

MATERIALS AND METHODS

Five hybrid cultivars of cauliflower were evaluated at NHRC farm Khumaltar where four hybrid cultivars for testing were collected from Monsanto Holding Pvt. Ltd. India through Nepal Agrocenter Janakpur, and one widely grown cultivar in Nepal (Snow Mystique) collected from the market, as a check variety. Three-week-old seedlings were transplanted in the first week of October in 2016 and 2017 consequent years in mid-hills (Kathmandu valley, 1300 masl) and grown during the winter season with 60X45 cm spacing. One dose of insecticide and fungicide was sprayed during the crop establishment stage. The standard recommended dose of fertilizers (200:120:80 NPK kg/ha + 15 ton FYM/ha) was applied, and pesticide and fungicide were minimized. Plants were top-dressed with urea after 25 days of transplanting. Irrigation was done as needed with pipe irrigation. Vegetative, insect pest and disease, and yield parameter data were recorded during the crop growing season. Insect damages on leaves was scored on 1 to 9 score where 1 is no any damage and 9 is highly damaged. Likewise, leaf spot disease was also recorded on 1 to 9 score where 1 is no any symptom

and 9 is dead due to heavily infested. Per day yield efficacy is one of the parameter for the varietal selection that tends to become higher as the earlier and higher yielding varieties. It was calculated by using following formula:

$$\text{Per day yield efficacy} = \frac{\text{Yield kg/ha}}{\text{Days to harvest}}$$

RESULTS AND DISCUSSION

VEGETATIVE PARAMETER

No significant difference was observed in plant uniformity and plant vigor in both the years among the tested varieties. However, cv. Barkha showed more plant uniformity in both the years followed by Snow Mystique. Cumulative plant uniformity mean of the two years was 4.6 score in Barkha and 4.4in Snow Mystique out of 5 score. Giewont had the least plant uniformity (4.1) in both years (4.1) (Table 1). Cumulative mean of plant vigor was highest in Snow Mystique (4.7 score) followed by Barkha (4.5 score out of 5) but not significantly different. In 2017, all the varieties showed vigorous growth in early-stage compared to 2016, but it did not correlate with curd formation (Table 1).

The effect of varieties on plant size was not significant in both the years on its area coverage length. Cv. Girija and Barkha had the longest plant spreading length in 2016 (42 cm) and 2017 (50.6 cm) with a mean 50.6 cm followed by Girija, which had plant length in 2016 (42 cm) and 2017 (50.8 cm) with a mean 46.4 cm. Whistler had the least plant length (41.7 cm) (Table 1). Likewise, the combined mean plant width was widest in Barkha (38 cm), which was 22 cm in 2016 and 54.1 cm in 2017.All the cultivars were more vigorous in 2017 due to timely rainfall. It also reflected in its yield performance; all the cultivars had a better curd yield in 2017 (Table 2).

Plant spreading size was highest with Barkha (50.6x38 cm), followed by Girija (46.4x36.8 cm) and Snow Mystique (46.3x36.7 cm) and least spreading size was with Giewont (40x22 cm) in 2016. It showed that early maturing varieties generally have fast vegetative growth and loose type of curd compared to late maturing varieties.

Table1: Combine mean of plant uniformity and plant vigor of Cauliflower for the 2 year test on Khumaltar (2016 & 2017)

Cultivars	Plant uniformity[x] (1-5)			Plant vigor[x] (1-5)		
Year	2016	2017	C Mean	2016	2017	C Mean
Girija	4.5	4.0	4.3	4.5	4.0	4.3
Barkha	4.5	4.7	4.6	4.5	4.8	4.5
Giewont	4.2	4.0	4.1	4.2	4.3	4.3
Whistler	4.2	4.4	4.3	4.2	4.6	4.4
Snow Mystique	4.5	4.4	4.4	4.7	4.7	4.7
CV%	11.92	11.2	4.81	13.7	9.33	5.57
F-test	ns	ns	ns	ns	ns	ns

[x] 1: unacceptable, 5: excellent

Table 2: Combined mean of plant length and width of hybrid varieties of Cauliflower at Khumaltar (2016 & 2017)

Cultivars	Plant length (cm)			Plant width (cm)		
Year	2016	2017	C Mean	2016	2017	C Mean
Girija	42	50.8	46.4	26	47.6	36.8
Barkha	42	59.2	50.6	22	54.1	38.0
Giewont	40	49.4	44.7	22	48.3	35.1
Whistler	41	42.5	41.7	23	49.9	36.4
Snow Mystique	40	52.7	46.3	23	50.4	36.7
CV%	8.15	10.48	8.88	5.64	13.98	7.21
F-test	ns	ns	ns	*	ns	ns

The longest leaf length (41 cm) was found in Barkha, which was significantly longer than the rest of the cultivars, followed by Girija and Snow Mystique (36.9 cm), but the widest leaf was measured in Girija (23.1 cm) followed by Snow Mystique (22.5 cm) (Table 3).

Table 3: Combined means of leaf length and width of hybrid varieties of Cauliflower at Khumaltar (2017)

Cultivars	Leaf length (cm)	Leaf width (cm)
Year	2017	2017
Girija	36.9	23.1
Barkha	41.0	22.3
Giewont	34.1	21.6
Whistler	37.2	22.4
Snow Mystique	36.9	22.5
CV%	5.52	6.79
F-test	*	ns
LSD (0.05)	3.87	

Plant height up to leaf tip was highest in Whistler and Snow Mystique (48 cm) followed by Barkha (47 cm) whereas plant height up to curd tip was highest in Whistler (23.1 cm) followed by Snow Mystique and Girija (22.3 cm) even though significantly not different. Plant height up to curd top was higher in the year 2017 than in 2016 because of timely rain fall in the second year (Table 4).

Table 4: Plant height (cm) up to leaf tip and up to curd top of hybrid varieties of Cauliflower at Khumaltar

Cultivars	Height upto leaf tip (cm)	Height upto curd top (cm)		
Year	2016	2016	2017	Mean
Girija	46	18	26.6	22.3
Barkha	47	19	24.8	21.9
Giewont	46	16	27.6	21.8
Whistler	48	19	27.2	23.1
Snow Mystique	48	17	27.7	22.3
CV%	6.95	9.3	5.47	7.21
F-test	ns	ns	ns	ns

INSECT AND DISEASE PARAMETER

Insect damage was not significantly different among the cultivars; however, all the tested cultivars were less damaged by an insect (< 2.5 scores) than check Snow Mystique. Leaf spot (*Alternaria cruciferae*) disease was noticed in both years, where Girija and Barkha had significantly lower leaf spots (0.5 and 1.7 score) in 2017 and also had a low cumulative mean (<2.5), whereas Snow Mystique had a 3.0 score. Insect damage was due to the occurrence of an aphid, cabbage butterfly and diamondback moth. (Table 5).

Table 5: Insect and disease parameters of hybrid varieties of Cauliflower at Khumaltar (2016 & 2017)

Cultivars	Insect damage (1-9)			Leaf spot (1-9)		
Year	2016	2017	C Mean	2016	2017	C Mean
Girija	3.7	1.7	2.7	3.2	1.7	2.5
Barkha	3.7	2.3	3.0	3.5	0.5	2.0
Giewont	3.5	1.7	2.6	2.7	2.1	2.4
Whistler	3.5	2.3	2.9	3.2	2.5	2.9
Snow Mystique	3.7	3.0	3.4	3.5	2.5	3.0
CV%	12.51	38.92	12.44	20.45	31.42	27.32
F-test	ns	ns	ns	ns	*	ns
LSD (0.05)					1.104	

YIELD ATTRIBUTING PARAMETER

The day to curd initiation was significantly earlier in Barkha (33 DAT) and Girija (53 DAT), whereas Snow Mystique had 62 DAT. Whistler had late curd initiation (61 DAT) (Table 5). Different varieties have unique genetic characteristics that may cause different duration for curd initiation to the different variety despite the same planting date. These findings were also in line with earlier finding of Pandey *et al.* (1981). Beside this, Barkha had significantly earlier days to harvest (62.7) compared to the rest of all the tested cultivars (Table 6). So, Barkha could fulfill the early market demand of cauliflower with better price opportunity. According to Booij (1990) about 55 % of the variance in the duration of the harvest period of a crop could be explained by the combined effect of variation in the duration of the curd initiation period and temperature during curd growth. Siddikul (2011) reported that days taken for curd maturity of cauliflower were significantly affected by different planting dates and varieties from his experiment. Days taken for marketable curd maturity (days) was 80.50 days in Girija. In this experiment, Girija also had days to marketable curd maturity of 88.7 days, which is quite near.

Likewise, the varietal effect on average curd weight was significant in year 2017,where the cumulative mean was not significantly different. Average curd weight ranged from 1039 g (Barkha) to 1286 g (Giewont) (Table 7). Curd weight for all cultivars was higher in 2017. This might have been due to timely rainfall in the year 2017. However, Barkha had the least average curd weight, 943 g in 2016 and 1135 g in 2017, consumers' preferred size during the early season with high market

price. This is because Barkha has high demand and fetches a good market price in the early season. This finding also supports the Sharma *et al.* (2006), who found that different varieties produced different size curd, which may be due to their genetic characteristics. Kundo and Singh, 2018 found a significant head weight and head diameter difference among the varieties tested.

Table 6: Days to curd initiation and average head weight of Hybrid Cauliflower Varieties at Khumaltar

Cultivars	Days to curd initiation	Days to harvest	Average head wt. (gm)		
	Year		2016	2017	C Mean
Girija	53	88.7	1038	1481	1259
Barkha	33	62.7	943	1135	1039
Giewont	60	113.3	923	1649	1286
Whistler	66	94.7	1021	1467	1244
Snow Mystique	62	101.0	975	1503	1239
CV%	15.2	4.86	9.30	9.85	11.19
F-test	**	**	ns	*	ns
LSD (0.05)	-	18.1	-	268	

The yield difference among the tested cultivars in 2016 was not significant where it ranged from 33.66 t/ha (Giewont) to 37.07 t/ha (Girija). But in 2017, Giewont gave the highest curd yield (55.85 t/ha) followed by Snow Mystique (54.52 t/ha) (Table 7). Even though Giewont have a higher yield, it is not preferred because of very late marketable maturity and very tight curd, which is not easily cookable. Cumulative mean yield ranged from 36.85 t/ha (Barkha) to 44.75 t/ha (Giewont). Yield difference between Girija and Snow Mystique is not significant, where Girija had a higher yield than Snow Mystique in 2016 and at par with Snow Mystique in the second year but the days to marketable harvest is twelve days earlier than Snow Mystique. Besides this Girija had a higher per day yield efficiency (499.7 kg/ha) than Snow Mystique (436.2 kg/ha). Likewise, Barkha had a lower yield in both years but gave per day yield efficiency (587.7 kg/ha) (Table 7). Similarly, in farmers' field conditions, Bhattarai et al. (2014) has also obtained the highest fresh curd yield in Kathmandu Local (41.9 t/ha) followed by HRDCAU005 (29.72 t/ha) and White Flash (28.41 t/ha), where yield range is not much different with this result. In this experiment, the hybrid cultivar's yield is higher than the obtained; it may be due to favorable weather in 2017, better management practices and may be due to potential modern high yielding varieties. However, yield variation was also mentioned by Giri et al. (2018),who recorded the maximum curd yield (55.7 t/ha.) in Bishop at Rampur, but the lowest curd yield (19t/ha) in Snowball16 in varietal evaluation trial. Even in India, different genotypes of cauliflower grown in plains and higher altitude of Kerala in 2018 showed significant differences in cauliflower yield, ranging from 21 – 26.4 kg /1.6 m^2 in hills and 7.8 – 14.3 kg /1.6 m^2 in plains (Elavarasan & Narayanankutty 2014).

Table 7: Yield Parameter of hybrid Cauliflower varieties at Khumaltar.

Cultivars	Total yield (t/ha)			Per day yield efficiency (kg/ha)
Year	2016	2017	C Mean	
Girija	37.07	51.58	44.32	499.7
Barkha	34.04	39.66	36.85	587.7
Giewont	33.66	55.85	44.75	395.0
Whistler	35.50	51.96	43.73	461.8
Snow Mystique	35.60	54.52	44.06	436.2
CV%	10.65	11.31	10.28	
F-test	ns	*	ns	
LSD (0.05)		10.80		

FARMERS PREFERENCES

Response from the invited farmers showed that Barkha and Girija were highly preferred due to their size, color, freshness, plant appearance, market value and yield. Based on size, shape, freshness, market value, yield, insect damage and disease infection, the early maturing varieties; Barkha and Girija were more preferred than late-maturing varieties; Giewont and Mystique (Table 8).

Table 8: Farmers and consumers responses to hybrid Cauliflower varieties at Khumaltar in 2017

Cultivars	Farmers response[y] (1-5)								
	Size	Shape	Color	Freshness	Plant appearance	Market value	Yield	Insect	Disease
Girija	4.0	3.7	4.0	4.0	4.7	4.0	3.7	3.6	3.5
Barkha	4.3	3.7	4.2	4.3	4.3	3.3	4.0	3.6	3.6
Giewont	4.0	4.0	4.0	4.2	4.0	3.3	4.0	3.4	4.0
Whistler	4.0	4.0	4.0	4.0	4.3	4.0	4.5	4.0	4.1
Snow Mystique	3.3	3.0	3.8	3.8	3.5	3.8	3.7	3.3	4.2
CV%	11.37	14.94	8.54	7.61	13.33	14.8	12.92	10.89	10.95
F-test	ns	ns	ns	ns	ns	ns	ns	ns	ns

[y] 1: unacceptable, 5:excellent

Barkha *Girija* *Snow Mystique*

Figure 1.Curd structure of Barkha, Girija and Snow Mystic varieties of cauliflower

Barkha *Girija* *Snow Mystique*

Figure 2. Internal structure of Barkha, Girija and Snow Mystique

CONCLUSION

Based on overall characters, cv. Barkha was found to be highly uniform, vigorous, less attacked by insect pests and disease, significantly early harvestable (62.7 days after transplanting), per day yield efficiency (487.7 kg/ha), preferable average head weight (1039 g), freshness (4.3) and market preference (4.0) as compared to check Snow Mystique, the most widely grown cultivar. Barkha has high demand and fetches a good market price in the early season. On the other hand, Cultivar Snow Mystique has only yield efficiency (436.2 kg/ha/day), higher insect damage and leaf spot disease, longer days to harvest (101 days), and freshness (3.8), respectively. It is followed by Girija as a medium marketable maturity cultivar. Yield difference between Girija and Snow Mystique is not significant, where Girija had a higher yield than Snow Mystique in 2016 and at par with Snow Mystique in the second year but the days to marketable harvest is twelve days earlier than Snow Mystique. Besides this Girija had a higher per day yield efficiency (499.7 kg/ha) than Snow Mystique (436.2 kg/ha). Hence, Barkha is selected and recommended for winter season commercial farming in the mid-hills of Nepal.

AKNWOLEDGMENTS

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