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Growth and Yield of Late Season Cauliflower (*Brassica oleracea* var. *botrytis* L.) Varieties in Mid-hill Region of Nepal

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ABSTRACT

Background: Cauliflower production during the late winter season has major problems including the requirement of long duration for its maturity, lower yield and poor postharvest quality, especially in the mid-hill region of Nepal. A field experiment was conducted to access the growth, crop maturity and yield of late-season cauliflower varieties at Puranchaur, Kaski in the mid-hill region of Nepal.

Methods: The experiment was arranged in a randomized complete block design (RCBD) with toal eleven late-season cauliflower varieties in which nine were hybrid varieties *viz.* Freedom, Titan, Ravella, Artica, Bishop, Casper, Indam 9803, NS 106 and Snow Mystique while two were open pollinated varieties *viz.* Amazing and Snowball 16. The experiment was conducted from November 2016 to March 2017 with four replications.

Result: Significantly shorter period for final curd initiation of 76 days was recorded in NS 106 and Indam 9803 which was statistically similar with Amazing. Significantly shorter period for final curd maturation of 90 days was recorded in Amazing which was statistically similar to Bishop and NS 106. Similarly, the highest curd yield of 50 mt/ha was produced by Bishop at 91 days after transplanting (DAT) while the lowest crud yield of 19 mt/ha was recorded in Snowball 16 at 113 DAT. Finally, it was concluded that Bishop found the best hybrid variety for higher curd yield and short duration for maturation while Amazing performed higher yield than Snowball 16 and early maturing variety in the mid-hill region of Nepal.

Key words: Cauliflower, Curd initiation, Curd maturity, Growth, Late season.

INTRODUCTION

Cauliflower (*Brassica oleracea* var. *botrytis* L.) is considered as the high quality and prestigious vegetable crop in urban and rural areas of Nepal which can be grown effectively from inner Terai to the high hills (Pandy and Pokhrel, 2000). Curd is the edible part and is consumed as cooking vegetables, curry, raw as salad, pickle and widely used in preparing fried snacks, burgers and sandwiches in restaurants (Ashraf *et al*., 2017). Cauliflower is rich in sources of vitamins and minerals which can protect against heart disease and also helps to maintain the cholesterol level (Keck, 2004).

Cauliflower is highly sensitive to climatic factors that play an important role in the initiation and growth of the curds. In Nepal, early varieties require a higher temperature than mid and late-season varieties for curd initiation of cauliflower. Fuzzy, riceyness and loosed curds could be produced due to higher temperatures above 20°C in the late winter season (Fujime, 1983; Swiader *et al*., 1992). Initiation of curds in cauliflower also depends on the genetic characteristics of the varieties (Saini, 1996). Early varieties of the cauliflower require higher temperature (20-25°C) for curd initiation while late varieties require low temperature (10-16°C) (Bose and Som, 1993; Chatterjee, 1993).

The commercial hybrid varieties in Nepal were introduced from various countries. According to Krishi Diary (2017), common early cauliflower varieties in Nepal are Pusa Deepali, Silver Cup 60, NS 60, Snow Crown, White Top, White Flash and Sweta. Similarly, popular mid-season varieties in Nepal are NS 90, Snow Queen, Snow King, Kathmandu Local and Jyapucauli while commerciallate-season varieties in Nepal are Kibo Giant, Madhuri, Snowball 16, Snow Mystique and NS 106. Long duration for curd initiation and curd maturity are the major problems faced by the commercial growers such as production of low yield and poor quality curds due to higher temperature during during late winter season (Bose and Som, 1993). Indeed, the unavailability of suitable varieties for better quality and higher yield is the major challenges tackled by the commercial vegetable growers from the mid-hills region of Nepal (HRD, 2013). Because of the increase in temperature, insect activities also increase during the late winter season. Identification of short duration with high yielding cauliflower varieties during the late winter season can mitigate the negative effects of higher temperature and its impacts on

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incidence of the insect as well as the production of poor quality curds. Therefore, a field experiment was conducted to identify such short matured cauliflower varieties with higher yield to be suitable in the late winter season focusing at Puranchaur, Kaski in Mid-hill region of Nepal.

MATERIALS AND METHODS

An experiment was conducted at a farmer's field in Puranchaur, Kaski, Nepal, situated at 28.32° North latitude and 83.99° East longitude with an elevation of 900 meters above sea level that falls in the mid-hill region of Nepal. This experiment was carried out from November 2016 to March 2017 to access the growth, maturity and yield of the late-season varieties of cauliflower. The weather data, such as maximum temperature, minimum temperature, total rainfall and relative humidity (RH) during the cauliflower growing period from November 2016 to March 2017 was recorded from Puranchaur meteorological station in Puranchaur, Kaski.

Experiment design and treatments

The experiment was organized in a randomized complete block design (RCBD); each treatment replicated four times comprised of eleven late-season cauliflower varieties. Out of eleven varieties, nine varieteis were hybrid varieties *viz.* Freedom, Titan, Ravella, Amazing, Artica, Bishop, Casper, Indam 9803, NS 106, Snow Mystique while Snow Mystique was the most popular hybrid late season variety in Nepal. There were two open pollinated varieties *viz.* Amazing and Snowball 16 in which Snowball 16 was the common open pollinated late season variety in Nepal. The size of the individual plot was 7.5 m^2 (3 m × 2.5 m) having 25 plants in each plot. Row to row distance was maintained as 60 cm and plant to plant distance was 50 cm.

Soil properties of the experimental field

The soil samples from each block with 20 cm depth were taken for chemical analysis before the transplanting of seedlings. The air-dried and sieved samples were taken to test total nitrogen, phosphorus, potassium, organic matter, soil pH and soil texture at Agriculture Technological Centre (ATC), Lalitpur. The experimental field was slightly acidic with 5.8 soil pH; low organic matter content, medium nitrogen, low phosphorus, low potash and sandy loam in texture.

Field preparation and analysis

Based on the recommended dose of 30 metric ton farmyard manure (FYM) and 200:120:80 kg NPK per hectare, 22.5 kg FYM, 195 g DAP, 152 g urea and 100 g murate of potash per plot was incorporated in the soil as a basal dose and 98 g urea was supplied 40 DAT as a split dose. The seedlings were transplanted four weeks after the seed sowing and regular water was applied as per need by the crops. Important growth parameters such as plant height and canopy diameter at different growth stages were measured from those randomly selected five plants of each plot. Similarly, the days required for curd initiation (first curd and final curd initiation) and curd maturity (first curd and final curd maturity) were recorded from the whole population, except border plants of each plot. Finally, curd yield and biological yield was recorded from those randomly selected five plants of each plot. Data were recorded and entered into MS-Excel 2016. Statistical tool Genstat 18th edition was used for general analysis of variance (ANOVA), grand mean and standard error of mean . Means were compared using Duncan's multiple range test (DMRT). The significant differences between varieties were determined by using the least significant difference (LSD) test at 5% level of significance (Gomez and Gomez 1984; Shrestha, 2019).

RESULTS AND DISCUSSION

Weather parameters

Maximum temperature, minimum temperature, total rainfall and relative humidity during the cauliflower growing period was recorded from November 2016 to March 2017 in Puranchaur, Kaski (Fig 1). A maximum temperature of 25°C was recorded in November 2016 and March 2017 while the minimum temperature of 6°C was observed in January 2017. Similarly, the maximum and minimum relative humidity of 78% and 60% was found in December 2016 and February 2017, respectively. There was negligible rainfall for the whole experiment period, except 146 mm precipitation during March 2017.

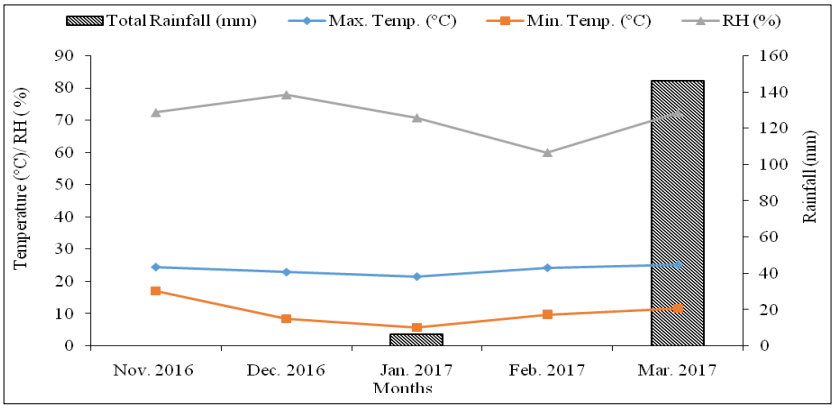


Fig 1: The prevailing weather condition in Puranchaur, Kaski during the cauliflower growing period from November 2016 to March 2017.

Plant height

Plant height at different growth stages of cauliflower was differed significantly at *p<0.01* among the varieties (Table 1). At 25 days after transplanting (DAT), significantly higher plant height was recorded in Snow Mystique and Indam 9803 than other varieties. Similarly, the lowest plant height was produced by Ravella. At 40 DAT, significantly higher plant height was recorded in Indam 9803 and Snow Mystique while the lowest plant height was produced by Casper. At 55 DAT, significantly higher plant height was produced by Indam 9803 and Titan while the lowest plant height was produced by Casper and Snowball 16. At final harvest, significantly higher plant height was produced by Ravella, Freedom, Titan, Snow Mystique and Bishop followed by Amazing, Indam 9803 and NS 106. The lowest plant height was measured for Snowball 16.

Canopy diameter

Canopy diameter at different growth stages of cauliflower was differed significantly at *p<0.01* among the varieties (Table 2). At 25 DAT, a significantly higher canopy diameter was recorded by Indam 9803, Titan, Amazing, Artica, NS 106 and Snow Mystique. At 40 DAT, a significantly higher canopy diameter was recorded in Indam 9803 than other varieties while the lowest canopy diameter was measured

Table 1: Plant height at different growth stages of cauliflower in Puranchaur, Kaski during November 2016 to March 2017.

Treatments	Plant height (cm)			
	25 DAT	40 DAT	55 DAT	Final harvest
Freedom	19.5^{cd}	32.2^{abcd}	42.7^{bc}	64.3^{a}
Titan	20.1^{bcd}	33.2^{ab}	46.0^{a}	66.3^{a}
Ravella	15.8^{e}	30.9^{bcde}	42.8^{bc}	66.5^{a}
Amazing	22.0^{ab}	32.8^{abc}	45.2^{ab}	57.8^{b}
Artica	21.3^{abcd}	31.2^{bcde}	42.3^{bc}	56.0^{bc}
Bishop	19.2^{d}	30.1^{cde}	44.8^{ab}	64.6^{a}
Casper	19.9^{bcd}	29.2^{e}	41.6^{c}	52.3^{c}
Indam 9803	22.5^{a}	34.6^{a}	46.8^{a}	57.0^{b}
NS 106	21.1^{abcd}	32.3^{abcd}	45.1^{ab}	58.0^{b}
Snow Mystique	23.1^{a}	34.5^{a}	45.3^{ab}	62.4^{a}
Snowball 16	21.7^{abc}	29.6^{de}	41.6^{c}	47.5^{d}
Grand mean	20.62	31.92	44.06	59.36
F-test	**	**	**	**
$LSD_{0.05}$	2.04	2.58	2.74	4.02
CV%	6.9	5.6	4.3	4.7

Means with same letter in column are not significantly different at p=0.05 by DMRT. *Significant at 5% (p<0.05) and **Significant at 1% (p<0.01). LSD = Least significant difference, CV = Coefficient of variance and DAT = Days after transplanting.

Table 2: Canopy diameter at different growth stages of cauliflower in Puranchaur, Kaski during November 2016 to March 2017.

Treatments	Canopy diameter (cm)			
	25 DAT	40 DAT	55 DAT	Final harvest
Freedom	23.8^{b}	38.3^{bcd}	51.1^{bcd}	64.3^{a}
Titan	27.9^{a}	41.3^{abcd}	53.9^{ab}	63.2^{ab}
Ravella	19.2^{c}	31.6^{e}	49.6^{cd}	63.1^{ab}
Amazing	27.7^{a}	40.9^{abcd}	48.8^{d}	60.9^{bc}
Artica	29.0^{a}	39.8^{bcd}	49.2^{d}	60.4^{c}
Bishop	24.3^{b}	37.9^{cd}	53.0^{abc}	64.2^{a}
Casper	26.3^{ab}	41.0^{abcd}	48.2^{d}	58.0^{d}
Indam 9803	29.7^{a}	44.7^{a}	54.4^{ab}	65.3^{a}
NS 106	28.4^{a}	42.5^{abc}	55.8^{a}	64.4^{a}
Snow Mystique	28.0^{a}	43.1^{ab}	54.0^{ab}	64.4^{a}
Snowball 16	23.5^{b}	37.6^{d}	48.2^{d}	48.5^{e}
Grand mean	26.22	39.39	51.53	61.54
F-test	**	**	**	**
$LSD_{0.05}$	3.16	4.23	3.41	2.20
CV%	3.5	2.7	4.2	3.9

Means with same letter in column are not significantly different at p=0.05 by DMRT. *Significant at 5% (p<0.05) and **Significant at 1% (p<0.01), LSD = Least significant difference and CV = Coefficient of variance.

Table 3: Curd initiation and curd maturity of cauliflower in Puranchaur, Kaski during November 2016 to March 2017.

Treatments	Curd initiation (DAT)		Curd maturity (DAT)	
	First curdinitiation	Final curdinitiation	First curd maturity	Final curd maturity
Freedom	74^{c}	81^{cd}	86^{cd}	92^{e}
Titan	75^{bc}	83^{c}	92^{b}	97^{c}
Ravella	76^{b}	88^{b}	91^{b}	99^{b}
Amazing	70de	77^{e}	84^{d}	90^{f}
Artica	71^{d}	82^{cd}	91^{b}	97^{c}
Bishop	69de	80^{d}	85^{cd}	91^{ef}
Casper	71^{d}	82^{cd}	87^{c}	95^{d}
Indam 9803	68^{e}	76^{e}	86^{cd}	92^{e}
NS 106	69de	76^{e}	85^{cd}	91^{ef}
Snow Mystique	71^{d}	83^{c}	90^{b}	97^{c}
Snowball 16	94^{a}	103^{a}	106^{a}	113^{a}
Grand mean	73	83	89	96
F-test	**	**	**	**
$LSD_{0.05}$	1.87	2.41	2.52	1.43
CV%	1.8	2.0	1.9	1.0

Means with same letter in column are not significantly different at p=0.05 by DMRT. *Significant at 5% (p<0.05), **Significant at 1% (p<0.01), LSD = Least significant difference and DAT = Days after transplanting.

in Ravella. At 55 DAT, a significantly higher canopy diameter was produced by NS 106 than other varieties. Similarly, a significantly lower canopy diameter was produced by Snowball 16, Amazing, Artica and Casper. At the final harvest, a significantly higher canopy diameter was produced by Indam 9803, Freedom, Bishop, NS 106 and Snow Mystique. In this experiment, higher plant height and canopy diameter was obtained in Bishop, Freedom,Snow Mystique, Titan and Ravella followed by NS106 and Indam 9803 while other remaining varieties produced lower plant height and canopy diameter at different growth stages of the cauliflower. These variations among the varieties were possibly due to the genetic characteristics of the cultivars which were introduced from various countries. The variation on plant height and canopy diameter of cauliflower varieties were found significantly among the varieties from the beginning of the transplanting to the final harvest. Similar findings were also reported by; Poudel *et al*., (2017), Pun *et al*. (2003) and Yadav *et al*. (2013).

Curd initiation and curd maturity of cauliflower

Curd initiation and curd maturity of cauliflower was differed significantly at *p<0.01* among the varieties (Table 3). A significantly shorter period for first curd initiation of 68 days after transplanting was recorded in Indam 9803. A significantly shorter period for final curd initiation of 76 days after transplanting was recorded in Indam 9803, NS 106 and Amazing. A significantly shorter period for first curd maturity of 84 days after transplanting was recorded in Amazing while Freedom, Bishop, NS 106 and Indam 9803 did not differ from Casper or Amazing. Similarly, a shorter period for final curd maturation of 90 days after transplanting was recorded in Amazing. Snowball 16 recorded a significantly longer period for curd initiation and curd maturity than other varieties. The late-season varieties introduced from the USA and India performed longer duration for curd initiation and curd maturity which was due to variation in weather parameters and management practices. The days to curd initiation and curd maturity of cauliflower in the mid-hill region of Nepal was differed significantly due to the genetic characteristics of cultivars. Similar findings were also reported by Booij, (1990) and Wurr *et al*. (1996). The longest period for curd initiation and curd maturity was performed by Snowball 16 as a similar finding was also reported by Pandey, (2003).

Table 4: Curd yield and biological yield of cauliflower in Puranchaur, Kaski during November 2016 to March 2017.

Treatments	Curd yield (t/ha)	Biological yield (t/ha)
Freedom	40.5^{cd}	79.0^{cd}
Titan	44.5^{bc}	91.6^{ab}
Ravella	42.0^{bc}	82.5^{c}
Amazing	36.9^{d}	72.9^{d}
Artica	46.0^{ab}	82.3^{c}
Bishop	50.0^{a}	85.6^{bc}
Casper	44.6^{bc}	78.5^{cd}
Indam 9803	45.1^{bc}	82.5^{c}
NS 106	44.9^{bc}	85.2^{bc}
Snow Mystique	45.0^{bc}	93.7^{a}
Snowball 16	19.0^{e}	42.2^{e}
Grand mean	41.73	79.69
F-test	**	**
$LSD_{0.05}$	4.16	6.32
CV%	6.9	5.5

Means with same letter in column are not significantly different at p=0.05 by DMRT. *Significant at 5% (p<0.05) and **Significant at 1% (p<0.01). LSD = Least significant difference, CV = Coefficient of variance and DAT = Days after transplanting.

Curd yield of cauliflower

The curd yield and biological yield of cauliflower were differed significantly at *p<0.01* among the varieties (Table 4). A significantly higher curd yield of 50 mt/ha was recorded in Bishop. A significantly higher biological yield of 93.7 mt/ha was produced by Snow Mystique while the lowest curd yield and biological yield was recorded in Snowball 16. In this experiment, hybrid varieties produced higher curd yield and biological yield than open-pollinated varieties. Significant variations in curd yield and biological yield were found among the late-season varieties of cauliflower. A similar finding was also reported by Yadav *et al*., (2013) and Kumar *et al*., (2011). The yield of cauliflower is polygenic in nature, as it could be influenced by environmental factors and various management practices (Meena *et al*., 2010), as a similar finding was also reported by Sharma *et al*., (2006).

CONCLUSION

The growth and yield of cauliflower along with curd initiation and curd maturity was differed significantly among the late season varieties of cauliflower. Bishop produced the higher yield and matured the curd in short duration than other F1 hybrid varieties. Similarly, Amazing produced the higher yield and matured in early time than other open pollinated variety *i.e.* Snowball 16. From this experiment, it was concluded that Bishop was the best hybrid variety for higher yield and early maturation while Amazing was the better open pollinated for higher yield and early maturity than Snowball 16 in Mid hill region of Nepal.

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