

Research Article

Growth status, curd yield and crop duration of late season cauliflower varieties

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ABSTRACT

Cauliflower is an important winter season vegetable crop having year-round demand in Nepal. Due to longer crop duration in late winter season, there was a production of poor-quality curds and lower yield faced by the farmers in Terai region of Nepal. An experiment was conducted to identify the short duration late season varieties at Rampur, Chitwan Nepal during November 2016 to March, 2017. These varieties were Freedom, Titan, Ravella, Amazing, Artica, Bishop, Casper, Indam 9803 and NS 106 (introduced from USA, Europe and India), and Snow Mystique and Snowball 16 (introduced from Japan). The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. The highest plant height (71.9 cm) and canopy diameter (74.5 cm) at last harvest of cauliflower was mostly produced by Titan followed by NS 106, Snow Mystique, Bishop and Indam 9803. Similarly, significantly shorter period for final curd initiation of 65 days after transplanting was observed in Freedom and shorter period for final curd maturation of 77 days after transplanting was also recorded in Freedom than other varieties. Significantly, higher curd yield of 54.8 t/ha was produced by Bishop than other varieties. In conclusion, Bishop was the best hybrid variety while other suitable varieties were NS 106, Titan, Artica and Snow Mystique for better growth and higher curd yield in Chitwan condition. Similarly, Freedom was identified as short duration varieties which can minimize the negative effects in late winter season due to higher temperature.

Keywords: Cauliflower, curd initiation, curd maturity, growth, late season

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INTRODUCTION

Cauliflower (*Brassica oleracea* var. *botrytis* L.) is one of the popular winter season vegetable crops in Nepal. It is also named as the king of the Cole crops. Cauliflower has the highest share (14.6%) of total vegetable production (534,141 mt.) followed by cabbage (484,036 mt). It is also important vegetable crop in terms of area which covers 35,974 ha (13%) of the total vegetable cultivated area (MoAD, 2018). Curd is the edible part and consumed as cooking vegetables, curry, raw as salad, pickle and widely used in preparing fried snacks, burger and sandwich in the restaurants (Ashraf et al., 2017). Cauliflower is rich source of vitamins and

minerals like phosphorus, potash, calcium, sodium and iron which can protect from cancers, heart diseases and also help to maintain the cholesterol level and immune system of the body if consume regularly (Keck, 2004).

Cauliflower is highly sensitive to climatic factors that play role on formation and growth of the curds. Initiation of curds in cauliflower also depends on the genetic characteristics of the varieties (Saini, 1996). Early varieties of the cauliflower require higher temperature i.e. 20-25°C for curd formation while late varieties require 10-16°C (Bose and Som, 1993 and Chatterjee, 2013). The temperature above 25°C adversely affects the formation of curd and that results formation of poor qualities or defective curds (Swiader et al., 1992).

Most of the commercial varieties of cauliflower in Nepal are hybrids and introduced from various countries. According to Krishi Diary, (2017), normally available early cauliflower varieties are Pusa Deepali, Silver Cup 60, NS 60, Snow Crown, White Top, Milk Way, White Flash and Sweta. Similarly, commonly available mid-season cauliflower varieties are NS 90, Snow Queen, Snow King, Kathmandu Local and Jyapu cauli while late season varieties are Kibo Giant, Madhuri, Snowball 16, Snow Mystique and NS 106. In earlier time, Kathmandu Local variety was a predominant open pollinated variety for normal season in Nepal, however, other exotic varieties like Snowball 16 and Kibo Giant were introduced and these varieties were successful in late mid-season and late season (Jaiswal and Subedi, 996). In late season, the most of the varieties cultivated by the farmers do not match the available climatic condition on that area. Long duration for curd maturity is major problems faced by the farmers in late winter season (Bose and Som, 1993). Thus, unavailability of appropriate cauliflower varieties for better quality and higher yield is the main problem faced by the commercial vegetable growers in Nepal especially during late winter season (HRD, 2013). Because of increasing temperature, the insect activities also increase. Identification and evaluation of short duration cauliflower varieties during late winter season can mitigate the negative effects of higher temperature and its impacts on incidence of insect as well as production of poor-quality curds. The objective of this study was to identify the short duration varieties of cauliflower during late winter season planting in Chitwan condition of Nepal.

MATERIALS AND METHODS

An experiment was conducted in Horticulture farm of Agriculture and Forestry University, Rampur Chitwan during November 2016 to March 2017 to identify short duration late season cauliflowers varieties. This experiment site was situated at 27°37' North latitude and 84°25' East longitude with elevation of 256 meter above sea level which falls in inner Terai region of Nepal.

Agro-meteorological features of the experimental area

Average data on different weather parameters such as maximum temperature, minimum temperature, rainfall and relative humidity (RH) during cauliflower growing period from November 2016 to March 2017 was collected from National Maize Research Program, Rampur Chitwan. The maximum temperature of 29°C was recorded in November 2016 and March 2017 while the minimum temperature of 10°C was noticed in January 2017. Similarly, maximum and minimum relative humidity of 95% and 77% was recorded in January 2017 and November 2016 respectively. Light rainfall was recorded during January to March 2017

in Rampur, Chitwan during the cauliflower growing period.

Experiment design and treatments

There were altogether eleven late season varieties of cauliflower and the trial was adjusted in RCBD with four replications. The area of individual plot was 7.5 m² (3 m x 2.5 m) having 25 plants. Row to row distance was 60 cm and plant to plant distance was 50 cm. The varieties used in this experiment are listed in Table 1.

Table 1. List of late season cauliflower varieties in Rampur, Chitwan during November 2016 to March 2017

Varieties	Source	Variety type
Freedom	Park seed, USA	Hybrid
Titan	Osborne seed, USA	Hybrid
Ravella	Osborne seed, USA	Hybrid
Amazing	Territorial seed company, USA	Open pollinated
Artica	Stokes seeds, New York, USA	Hybrid
Bishop	Rijk Zwaan, Netherlands	Hybrid
Casper	Rijk Zwaan, Netherlands	Hybrid
Indam 9803	Indo-American hybrid seed, India	Hybrid
NS 106	Namdhari seeds Pvt. Ltd., India	Hybrid
Snow Mystique	Takii seed, Japan (Available in Nepal)	Hybrid
Snowball 16	Vegetable seed production center, Dolpa	Open pollinated

Soil properties of the experimental field

The soil samples from each block with 20 cm depth was taken before the transplanting for chemical analysis. The air dried and sieved samples were carried out to test the organic matter, total nitrogen, phosphorus, potassium, soil pH and type of soil texture at Agriculture Technological Centre (ATC), Lalitpur. The experiment field was slightly acidic with 5.6 soil pH, high organic matter content and sandy loam soil. The soil sample was also found medium nitrogen (0.19%), low phosphorus (42.0 kg/ha) and medium potash (118 kg/ha) at experimental field in Rampur, Chitwan (Table 2).

Table 2. Physical and chemical characteristics of soil at experiment field in Rampur, Chitwan during November 2016 to March 2017

Details	Mean	Ratings
pH	5.6	Acidic
Total nitrogen (%)	0.19	Medium
Phosphorous (kg/ha)	42	Low
Potash (kg/ha)	118	Medium
Organic matter (%)	4.2	High
Soil type		Sandy loam

Based on the recommended dose of 30 ton farmyard manure and 200:120:80 kg NPK, 22.5 kg FYM, 195 g DAP, 152 g urea and 100 g MoP per plot was provided as a basal dose and 98 g urea was supplied 40 days after transplanting as a split dose. The seedlings were transplanted four weeks after seed sowing and regular water application was done as per need by the crops. Important growth parameters such as plant height and canopy diameter were measured from those randomly selected five plants of each plot at different growth stages of cauliflower plants. Similarly, the days required for curd initiation (first curd initiation and

final curd initiation) and curd maturity (first curd maturity and final curd maturity) were recorded from the whole populations except border plants of each plot.

Data were recorded and entered into MS-Excel 2016. The analysis of variance (ANOVA) was identified by using GenStat 18th edition. Data analysis was done using Duncan's Multiple Range Test (DMRT) using GenStat. The significant differences between varieties were determined using the least significant difference (LSD) test at 1% or 5% level of significance (Gomez and Gomez 1984; Shrestha, 2019).

RESULTS AND DISCUSSION

Plant height

Plant height of the late season varieties of cauliflower at different growth stages were differed significantly at $p < 0.01$ (Table 3). At 25 days after transplanting (DAT), significantly higher plant height of 33.8 cm was recorded in Freedom while significantly lower plant height of 28.3 cm was produced by Amazing than other varieties. At 40 DAS, significantly higher plant height of 53.2 cm was recorded in Titan while significantly lower plant height of 45.1 cm was produced by Amazing than other varieties. At 55 DAS, significantly higher plant height of 62.5 cm was produced by Titan than other varieties, however, Titan was statistically similar to Freedom, Bishop, Indam 9803, NS 106 and Snow Mystique.

Table 3. Plant height of cauliflower at different growth stages in Rampur, Chitwan during November 2016 to March 2017

Treatments	Plant height (cm)			
	25 DAT	40 DAT	55 DAT	80 DAT
Freedom	33.8 ^a	51.9 ^{abc}	62.1 ^a	70.1 ^a
Titan	32.6 ^{ab}	53.2 ^a	62.5 ^a	71.9 ^a
Ravella	29.9 ^{bcd}	49.2 ^{bcd}	60.7 ^a	70.5 ^a
Amazing	28.3 ^d	45.1 ^e	53.5 ^{bc}	63.4 ^b
Artica	31.4 ^{abc}	48.5 ^{cd}	56.7 ^b	63.5 ^b
Bishop	32.1 ^{abc}	52.2 ^{ab}	63.5 ^a	70.6 ^a
Casper	30.9 ^{abcd}	45.2 ^e	51.9 ^c	57.2 ^c
Indam 9803	32.5 ^{ab}	51.6 ^{abc}	60.9 ^a	66.7 ^{ab}
NS 106	29.3 ^{cd}	50.1 ^{abcd}	61.5 ^a	70.0 ^a
Snow Mystique	32.3 ^{abc}	50.9 ^{abcd}	61.0 ^a	69.0 ^a
Snowball 16	29.9 ^{bcd}	47.9 ^{de}	57.0 ^b	55.3 ^c
F-test	**	**	**	**
LSD _{0.05}	2.76	3.06	3.49	4.84
CV, %	6.1	4.3	4.1	5.1

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% ($P < 0.01$) and NS: not significantly different at 5% ($P > 0.05$). LSD= Least significant difference, CV= Coefficient of variance & DAT=Days after transplanting

At last harvest in 80 DAT, significantly higher plant height of 71.9 cm was produced by Titan than other varieties, however, Titan was statistically similar to Freedom, Ravella, Bishop, NS 106 and Snow Mystique.

Canopy diameter of cauliflower

Canopy diameter of the late season varieties of cauliflower at 40 days after transplanting (DAT), 55 DAT and final harvest was differed significantly at $p < 0.05$ but there was no significant differences at 25 DAT (Table 4). At 40 DAT, significantly higher canopy diameter of 65 cm was recorded by NS 106 than other varieties, as NS 106 was statistically

similar to Titan, Indam 9803 and Snow Mystique. At 55 DAT, significantly higher canopy diameter of 68.1 cm was produced by NS 106 than other varieties, however, NS 106 was statistically similar to Snow Mystique. At last harvest in 80 DAT, significantly higher canopy diameter of 74.5 cm was produced by NS 106 than other varieties, however, NS 106 was statistically similar to Titan. Significantly smaller canopy diameter of 57.1 cm was produced by Snowball 16 than other varieties at last harvest. In this experiment, the maximum canopy diameter of cauliflower was produced by NS 106, Snow Mystique, Bishop and Titan than other varieties. Similarly, Titan, Bishop, NS 106, Indam 9803 and Snow Mystique were recognized as tall varieties than others. This variations in morphological growth of cauliflower within the varieties were due to the genetic characteristics of the cultivars, which were taken from different countries. The growth and its characteristic of the varieties were polygenic in nature, as it was also influenced by the environmental factors and management practices. Similar findings were mentioned by Meena et al. (2014) on their research. In this experiment, the vegetative growth of cauliflower such as plant height and canopy diameter were differed significantly among the varieties from beginning of the transplanting to final harvest, as similar findings were obtained by (Yadav et al., 2013; Pun et al., 2003 and Poudel, 2017).

Table 4. Canopy diameter of cauliflower at different growth stages in Rampur, Chitwan during November 2016 to March 2017

Treatments	Canopy diameter (cm)			
	25 DAT	40 DAT	55 DAT	80 DAT
Freedom	42.4 ^{ab}	62.0 ^{ab}	65.2 ^{ab}	73.3 ^{ab}
Titan	42.3 ^{ab}	64.0 ^a	65.5 ^{ab}	74.1 ^a
Ravella	37.5 ^c	57.2 ^b	63.0 ^{bc}	70.3 ^{bcd}
Amazing	38.0 ^{bc}	57.3 ^b	60.7 ^c	68.4 ^d
Artica	40.8 ^{abc}	59.9 ^{ab}	62.8 ^{bc}	69.2 ^d
Bishop	39.2 ^{abc}	60.9 ^{ab}	65.5 ^{ab}	72.7 ^{abc}
Casper	40.0 ^{abc}	59.9 ^{ab}	62.6 ^{bc}	69.5 ^{cd}
Indam 9803	43.1 ^a	63.7 ^a	65.4 ^{ab}	71.6 ^{abcd}
NS 106	38.3 ^{bc}	65.0 ^a	68.1 ^a	74.5 ^a
Snow Mystique	40.6 ^{abc}	64.0 ^a	67.0 ^a	70.0 ^{cd}
Snowball 16	39.5 ^{abc}	59.9 ^{ab}	60.7 ^c	57.1 ^e
F-test	NS	*	**	**
LSD _{0.05}		4.94	3.19	2.94
CV, %	7.0	5.6	3.4	2.9

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% ($P < 0.01$) and NS: not significantly different at 5% ($P > 0.05$). LSD=Least significant difference, CV=Coefficient of variance & DAT=Days after transplanting

Curd initiation and curd maturity of cauliflower

First curd initiation, final curd initiation, first curd maturity and final curd maturity of the late season varieties of cauliflower was differed significantly at $p < 0.01$ (Table 5). Significantly shorter period for first curd initiation of 61 days after transplanting (DAT) was recorded in Freedom than other varieties. Similarly, shorter period for final curd initiation of 65 DAT was recorded in Freedom than other varieties, however, Freedom was statistically similar to Bishop. Significantly shorter period for first curd maturity of 72 DAT was recorded in Freedom and NS 106 than other varieties. Similarly, shorter period for final curd maturation of 77 DAT was recorded in Freedom than other varieties. Snowball 16 recorded significantly the longest period for curd initiation and curd maturity than other varieties. The research

finding by Pandey (2003) supported this research finding. Curd initiation and curd maturity of cauliflower were differed significantly due to genetic characteristics of cultivars, as similar findings acquired by (Saini, 1996; Booiij, 1990 and Wurr et al., 1996). The late season varieties introduced from USA and India performed similar curd maturity period at Rampur as mentioned in individual varietal catalogue.

Table 5. Curd initiation and curd maturity of cauliflower in Rampur, Chitwan during November 2016 to March 2017

Treatments	Curd initiation (DAT)		Curd maturity (DAT)	
	First curd initiation	Final curd initiation	First curd maturity	Final curd maturity
Freedom	61 ^e	65 ^e	72 ^f	77 ^e
Titan	66 ^b	71 ^b	78 ^b	82 ^b
Ravella	63 ^{cde}	68 ^c	74 ^{de}	79 ^{cd}
Amazing	65 ^{bc}	70 ^b	75 ^{cde}	78 ^{de}
Artica	63 ^{cde}	69 ^c	76 ^c	80 ^c
Bishop	62 ^{de}	66 ^e	73 ^{ef}	78 ^{de}
Casper	64 ^{bc}	71 ^b	75 ^{cd}	78 ^{cde}
Indam 9803	62 ^{de}	67 ^{cd}	73 ^{ef}	78 ^{de}
NS 106	63 ^{cde}	66 ^{de}	72 ^f	78 ^{de}
Snow Mystique	64 ^{cd}	72 ^b	79 ^b	82 ^b
Snowball 16	86.5 ^a	92 ^a	93 ^a	99 ^a
F-test	**	**	**	**
LSD _{0.05}	2.02	1.60	1.78	1.45
CV, %	2.1	1.6	1.6	1.2

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% ($P < 0.01$) and NS: not significantly different at 5% ($P > 0.05$). SEM = Standard error of mean, LSD = Least significant difference, CV = Coefficient of variance and DAT = Days after transplanting

Curd yield of cauliflower

Curd yield of the late season cauliflower varieties was differed significantly at $p < 0.01$ (Figure 1). Significantly higher curd yield of 54.8 t/ha was found in Bishop while the lowest curd yield of 25 t/ha was found in Snowball 16 than other varieties. In this experiment, it was found that open pollinated varieties Snowball 16 and Amazing produced the lower curd yield than other hybrid varieties. The yield of cauliflower is polygenic in nature, as it is influenced by the environmental factors and various management practices. Similar findings were obtained by the researcher (Meena et al., 2010 and Sharma et al., 2006).

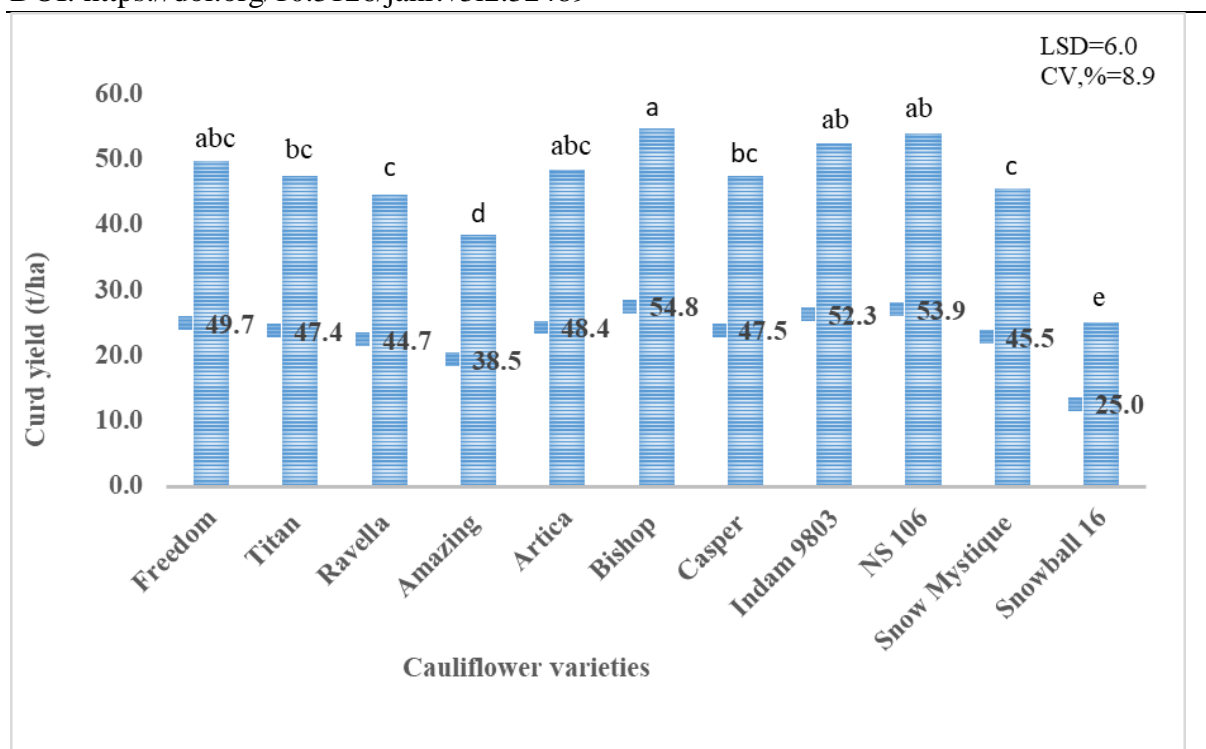


Figure 1. Curd yield of cauliflower at final harvest in Rampur, Chitwan during November 2016 to March 2017

CONCLUSION

Plant growth parameters such as plant height and canopy diameter at different growth stages, curd yield at final harvest along with curd initiation and curd maturity were differed significantly among the late season cauliflower varieties. The highest morphological growth was achieved in Titan, NS 106, Snow Mystique, Bishop and Indam 9803 than other varieties. Similarly, Freedom followed by Bishop and NS 106 were identified as short duration varieties which can minimize the negative effects of high temperature during late winter season. The highest curd yield was produced by Bishop while the lowest curd yield was produced by Snowball 16. From this research, it was concluded that Bishop was the best performing variety while other probable varieties were NS 106, Titan, Artica and Snow Mystique for better growth and higher curd yield.

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Authors’ contributions

H. N. Giri wrote the whole paper as well as collected all the information from fields and extracted information from literatures, M.D Sharma, R.B. Thapa, K.R. Pande and B.B. Khatri were involved to guide and monitor the research activities and also preparation of paper.

Conflict of interest

The authors declare no conflicts of interest regarding publication of this manuscript.

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