Research Article

GROWTH, YIELD AND POST HARVEST QUALITY OF LATE SEASON VARIETIES OF CAULIFLOWER AT RAMPUR, CHITWAN

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ABSTRACT

An experiment was done to evaluate eleven late season cauliflower varieties at Rampur, Chitwan, Nepal during November 2017 to March, 2018. All the tested varieties were introduced from USA, Europe, and India viz. Amazing, Artica, Freedom, Ravella, Titan, Bishop, Casper, Indam 9803, and NS 106 while two varieties; Snowmystique and Snowball 16 were from Nepal. The experiment was set by using Randomized Complete Block Design (RCBD) with an arrangement of each treatment replicated for four times. The main objective of this study was to identify the short duration late season varieties of cauliflower to be adapted to high temperature condition during late winter. Parameters considered to evaluate the varieties included- plant height, leaf length, canopy diameter, curd height, curd diameter, yield, along with postharvest parameters, such as Total soluble solid (TSS), Titrable acidity (TA), pH, and Vitamin C content. Similarly, 50% curd initiation and curd maturity of the cauliflower was also measured to find the crop growth period. The highest plant height, leaf length and canopy diameter was mostly produced by Titan, Snow mystique, and NS 106 while the lowest plant height, leaf length and canopy diameter was produced by Snowball 16 and Amazing. Similarly, significantly shorter period for 50% curd initiation of 68 days was observed in NS 106 and shorter period for 50% curd maturation of 78 days was recorded in Freedom compared to the rest of the treatments. Significantly largest curd height and diameter was measured for NS 106. Similarly, significantly higher curd yield of 52.3 t/ha was produced by Bishop, but it was statistically similar ($p>0.05$) to NS 106 (51.1 t/ha). Likewise, significantly higher TSS of 5.4 ºBrix and Vitamin C content of 55 mg/100 g was produced by Snowball 16 and Bishop, respectively. Thus, the probable varieties that could be considered best for late winter could be Bishop, NS 106, Snowmystique, Artica, Freedom, Titan, and Amazing that may comparatively better adapt to the high temperature condition.

Key words: Cauliflower, curd maturity, late season, post-harvest,

INTRODUCTION

Cauliflower (*Brassica oleracea* L. var. botrytis) 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, which is 491,834 t. followed by cabbage i.e. 448,980 t. It is also the most important vegetable crop in terms of area which covers 13% of the total vegetable cultivated area of 3298,816 ha (MoAD, 2012). Curd is the edible part and consumed as cooking vegetables, curry, raw as salad, pickle and widely used in preparing chaaumin, pakauda, burger, sandwich in the restaurants (Ashraf et al., 2017). Cauliflower is also a rich source of vitamins and minerals (phosphorus, potash, calcium, sodium and iron) which can help reduce risks of cancers, heart diseases, helps in maintaining the cholesterol level as well as strengthens immune system of the body if consumed regularly (Keck, 2004).

Cauliflower is highly sensitive to climatic factors (Nath et. al., 1987) that mainly influence growth and development of curds. Production of cauliflower would be beneficial during winter season than late winter due to optimum temperature below 24^{0}C in winter season (Rahman et al., 2007). In late winter, fuzzy, riceyness and loosed curds of the cauliflower are observed due to higher temperature above 20^{0}C in late winter season (Fujime, 1983; Swiader et al., 1992). Appropriate temperature for curd formation in winter season is 14ºC-20ºC (Swiader et. al., 1992; Baloch, 1994). Initiation of curds in cauliflower depends upon the genetic characteristics of the varieties (Saini, 1996). Early varieties of the cauliflower require high temperature i.e. 20ºC-25^{0}C for curd formation while late varieties require 10ºC-16^{0}C (Bose & Som, 1993; Chatterjee, 1993). The formation of curds is inhibited above 25ºC and the poor quality with several defective curds is also observed beyond the optimum range of temperature (Swiader et al., 1992).

Most of the commercial varieties of cauliflower are imported hybrids. Open pollinated varieties of cauliflower for late season from November to March are not available in Nepal and the farmers have been using inappropriate varieties which have resulted low yield and poor quality (HRD, 2006). Poor curd development and unfavorable postharvest quality is seen during late winter season mainly due to increase in temperature (Bose &Som, 1993). Activities of insects also become higher in late winter season, and cabbage butterfly acts as a major pest (Joshi, 1994). The late season varieties of cauliflower from November to March have long duration for curd maturity, low yield and poor post-harvest quality due to increase in temperature. The shortcoming of our local varieties is long duration i.e. 120-140 days for its maturity (HRD, 2013). So, the farmers are facing problems of having unattractive curd, poor taste, and low yield during late winter season. Identification of short duration genotypes of cauliflower

with higher yield 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. Thus, a field research on late season varieties of cauliflower was done with the objective to identify best performing short duration varieties suitable for Chitwan and its territories to be adapted to high temperature condition during late winter.

MATERIAL AND METHODS

An experiment on varietal trial was done at farm of Agriculture and Forestry University (AFU), Rampur Chitwan during November 2017 to March 2018. There were a total of eleven late season varieties of cauliflower and the experiment was done by using RCBD with the arrangement of each treatment replicated four times. The area of individual plot was 7.5 m^2 (3 m × 2.5 m) with 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. Details of late season varieties of cauliflower grown at Rampur Chitwan during November 2017 to March 2018

Varieties	seeds imported from	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
Snowmystique	Takii seed, Japan (Available in Nepal)	Hybrid
Snowball 16	Vegetable seed production centre, Dolpa	Open pollinated

The seedlings were transplanted four weeks after seed sowing and regular water application was done as per need of the crop. On the basis of recommended dose of 30 t FYM and 200:120:80 kg NPK, 22.5 kg FYM, 195 g DAP, 152 g urea, 100 g MoP and 10 g Borax per plot was provided as a basal dose and 98 g urea was supplied 40 days after transplanting as a split dose. Important growth and yield parameters such as plant height, leaf length, canopy diameter, curd height, curd diameter and curd yield were measured from those randomly selected five plants in each plot at harvest time. Similarly, the required days for 50% number of curds initiation and maturity were recorded from the whole populations, except border plants. Finally, the sample curds were collected from all eleven treatments including four replications and the curds were homogenized in a blender to extract juice for testing the chemical constituents. TSS, Vitamin C, TA and P^H were measured by using refractrometer, volumetric method, p^H meter and titration against 0.1 N NaOH, respectively, at laboratory of AFU, Rampur. Statistical tool Genstat 15th edition was used for general analysis of variance; grand mean and standard error of mean. Means were compared using Duncan's Multiple Range Test (DMRT) at 0.05 and 0.01 level of significance (Gomez and Gomez, 1984).

Agro-meteorological features of the experiment area

Average data on different weather parameters such as maximum temperature, minimum temperature, rainfall and relative humidity (RH) during cauliflower growing period from November 2017 to March 2018 was collected from National Maize Research Program (NMRP), Rampur Chitwan. The maximum temperature of 33ºC was recorded in March 2018 while the minimum temperature of 9ºC was observed in January 2018. Similarly, the maximum and minimum relative humidity of 96% and 71% was recorded during January and March, respectively. There was negligible rainfall for whole experiment period at Rampur (Figure 1).

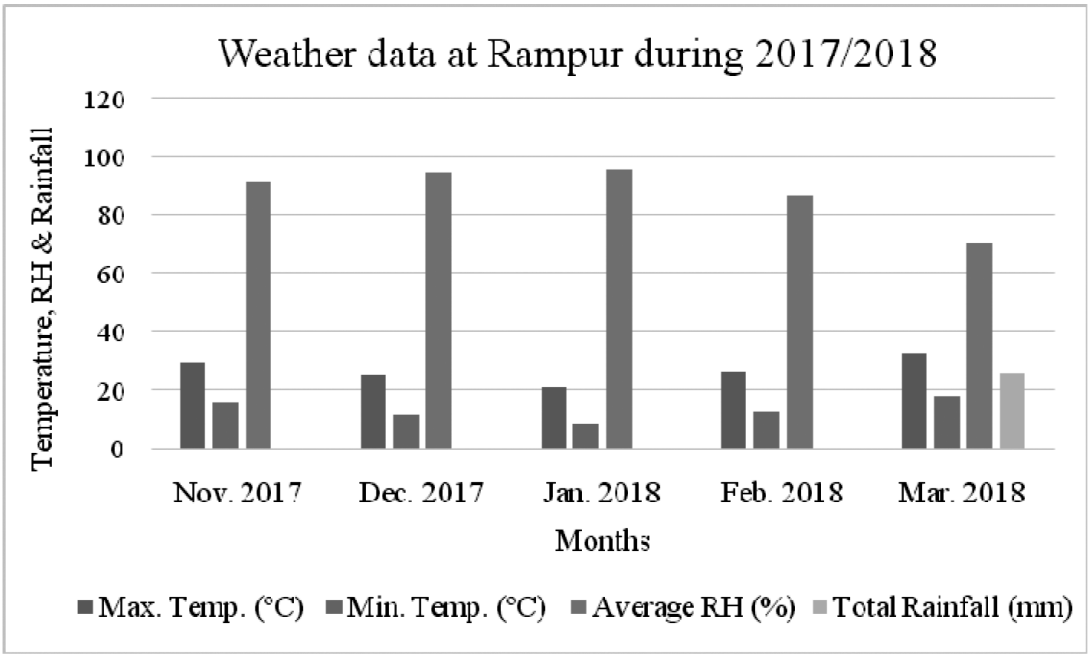

Figure 1. Prevailing weather condition throughout the experimental period at Rampur, Chitwan during November 2017 to March 2018

Soil properties of the experiment field

Composite soil samples from each block with 20 cm depth were taken for chemical analysis. It was taken before crop transplant and the samples were air dried and sieved through 2 mm mesh. Chemical analysis of soil sample was 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 5.4 soil p^H and sandy loam soil. The soil sample was also found medium nitrogen (0.15%), low phosphorus (47.6 kg/ha) & high potash (216.6 kg/ha) at experiment field, Rampur (Table 2).

Table 2. Physical and chemical characteristics of soil at experiment field, Rampur, Chitwan during November 2017 to March 2018

Details	Mean	Ratings
P^H	5.4	Acidic
Total nitrogen (%)	0.15	Medium
Phosphorous (kg ha^{-1})	47.6	Low
Potash (kg ha^{-1})	216.6	High
Organic matter (%)	3.9	Medium
Soil type		Sandy loam

RESULTS AND DISCUSSION

Plant growth parameters

Plant height, leaf length and canopy diameter of the late season varieties of cauliflower at harvest time were differed significantly at $p<0.01$ (Table 3). Significantly higher plant height of 63.8 cm than other varieties was recorded in Titan which was statistically similar to that of Snowmystique and Bishop. Similarly, considerably longer leaf length of 58.4 cm than other treatments was observed in Snowmystique which was statistically similar to Titan. Finally, significantly bigger canopy diameter of 68.6 cm was found in NS 106 and Titan than other varieties. The highest plant growth during final harvest was measured mainly in Titan, Bishop, Snowmystique, and NS 106 which were influenced by the environmental factors along with management practices at research field. The variation of plant growth within the varieties was due to the genetic characteristics of the cultivars which were introduced from different countries. The highest plant growth was obtained in hybrid varieties in comparison to open pollinated varieties- Snowball 16 and Amazing (Table 3).

Table 3. Plant height, leaf length and canopy diameter of late season varieties of cauliflower at Rampur, Chitwan during November 2017 to March 2018

Varieties	Plant height (cm)	Leaf length (cm)	Canopy diameter (cm)
Freedom	60.6^{abc}	55.6^{ab}	64.0^{ab}
Titan	63.8^{a}	58.1^{a}	68.6^{a}
Ravella	60.6^{abcd}	55.1^{ab}	63.0^{abc}
Amazing	53.5^{e}	51.5^{bc}	62.7^{bc}
Artica	56.8^{bcde}	50.8^{c}	65.0^{ab}
Bishop	62.1^{a}	55.6^{ab}	67.0^{ab}
Casper	55.8^{ce}	50.6^{c}	63.0^{abc}
Indam 9803	60.9^{ab}	55.8^{ab}	66.6^{ab}
NS 106	61.4^{ab}	55.6^{ab}	68.6^{a}
Snowmystique	63.7^{a}	58.4^{a}	67.3^{ab}
Snowball-16	54.3^{e}	49.3^{c}	58.1^{c}
Grand mean	59.45	54.27	69.94
SEM	2.22	1.98	2.42
F-test	**	**	**
$LSD_{0.05}$	4.54	4.05	4.96
CV, %	5.3	5.2	5.3

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 and CV = Coefficient of variance

Curd initiation and curd maturity of cauliflower

Curd initiation and curd maturity of the cauliflower after transplanting differed (p<0.01) markedly (Table 4). Significantly shorter period for 50% curd initiation of 68 days was recorded in NS 106 than other varieties. Likewise, shorter period for 50% curd maturation of 78 days than other treatments was observed in Freedom. The period for curd initiation and its final maturity was differed due to the environmental factors and also genetic characteristics of the cultivars, as similar finding was reported by Saini, (1996). The varieties introduced from USA and India had the similar maturity period as mentioned in varietal catalogue (Table 4).

Table 4. Curd initiation and curd maturity periods of late season varieties of cauliflower at Rampur, Chitwan during November 2017 to March 2018

Varieties	Curd initiation (days)	Curd maturity(days)
Freedom	68^{e}	78^{e}
Titan	78^{b}	84^{b}
Ravella	72^{d}	80^{c}
Amazing	74^{c}	80^{c}
Artica	78^{b}	84^{b}
Bishop	70^{d}	79^{cd}
Casper	78^{b}	84^{b}
Indam 9803	71^{d}	80^{c}
NS 106	68^{e}	79de
Snowmystique	77^{b}	84^{b}
Snowball-16	85^{a}	99^{a}
Grand mean	74.95	83.13
SEM	0.74	0.39
F-test	**	**
$LSD_{0.05}$	1.52	0.80
CV, %	1.4	0.7

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 and CV = Coefficient of variance

Yield parameters of cauliflower

Curd height, curd diameter and curd yield of the late season varieties of cauliflower at final harvest differed ($p<0.01$) significantly (Table 5). Significantly higher curd height of 14 cm was recorded in NS 106. Similarly, significantly larger curd diameter of 21.6 cm was observed in NS 106. Likewise, significantly higher curd yield of 52.3 t/ha was recorded in Bishop, but it was statistically similar ($p>0.05$) to NS 106. The highest yield attributes and curd yield of cauliflower was produced by Bishop and NS106 while the lowest curd yield was produced by Snowball 16 followed by Amazing. Both Snowball 16 and Amazing are open pollinated varieties which produced lower yield than other hybrid varieties (Table 5). The productivity of cauliflower is highly influenced by the genetic characteristics of the cultivar, planting time, growing temperature and applied nutrients. Yield parameters and economic yield of the late season varieties of cauliflower were significantly differed due to specified genetic characteristics of cultivars at similar environmental condition for all varieties. Sharma et al. (2018) reported that yield parameters of the cauliflower were given emphasis for higher yields during the selection of varieties. The yield of the crops and its constituents are polygenic in nature, as it is also influenced by the environmental factors and management practices, as similar findings was reported by Sharma et al., (2018).

Table 5. Curd height, curd diameter and curd yield of late season varieties of cauliflower at Rampur, Chitwan during November 2017 to March 2018

Varieties	Curd height (cm)	Curd diameter (cm)	Curd yield (t/ha)
Freedom	13.2^{abc}	20.0^{bc}	46.0^{bc}
Titan	12.8^{abcd}	17.9^{e}	45.1^{bcd}
Ravella	12.6^{bcd}	19.1^{cd}	42.5^{d}
Amazing	11.3^{e}	17.9^{e}	35.4^{e}
Artica	12.1^{cde}	18.3^{de}	46.1^{bc}
Bishop	13.4^{ab}	20.0^{bc}	52.3^{a}
Casper	12.0^{de}	18.8^{de}	45.4^{bcd}
Indam 9803	13.2^{abc}	20.0^{bc}	47.8^{b}
NS 106	14.0^{a}	21.6^{a}	51.1^{a}
Snowmystique	13.6^{ab}	20.3^{b}	44.6^{cd}
Snowball-16	13.0^{abcd}	19.9^{bc}	26.8^{f}
Grand mean	12.88	19.47	43.96
SEM	0.53	0.46	1.36
F-test	**	**	**
$LSD_{0.05}$	1.08	0.93	2.79
CV, %	5.8	3.3	4.4

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 and CV = Coefficient of variance

Chemical constituents of cauliflower

There was no significant differences ($p>0.05$) in TA and P^H values of cauliflower varieties whereas TSS and Vitamin C content differed ($p<0.05$) significantly (Table 6). Significantly higher TSS value of 5.4 ºBrix was recorded in Snowball 16. Similarly, significantly higher Vitamin C of 55 mg/100 g was found in Bishop. This variation of chemical constituents is due to genetic variation in late season varieties of the cauliflower which were introduced from different countries. Higher TSS value was obtained from open pollinated varieties than hybrid varieties. Lee & Kadar, (2000) reported that an increased in plant foliage might be reduced in light intensity and accumulation of ascorbic acid might be also lower which is not agreed in this trial.

Table 6. Chemical constituents of late season varieties of cauliflower at Rampur, Chitwan

Varieties	TSS (°Brix)	TA	P^H (%)	Vitamin C (mg/100 g)
Freedom	4.5^{cd}	0.18	6.81	41.9^{bc}
Titan	4.5^{cd}	0.14	6.85	47.7^{abc}
Ravella	4.8^{bc}	0.17	6.85	46.7^{abc}
Amazing	4.9^{bc}	0.16	6.85	53.6^{ab}
Artica	4.4^{cde}	0.19	6.80	43.3^{abc}
Bishop	5.0^{ab}	0.13	6.84	55.0^{a}
Casper	4.1^{de}	0.17	6.93	36.4^{c}
Indam 9803	4.0^{e}	0.19	6.85	44.8^{abc}
NS 106	4.9^{abc}	0.15	6.95	50.9^{ab}
Snowmystique	5.2^{ab}	0.17	6.83	50.2^{ab}
Snowball-16	5.4^{a}	0.16	6.92	48.2^{ab}
Grand mean	4.74	0.16	6.86	47.20
SEM	0.22	0.02	0.08	5.08
F-test	**	NS	NS	*
$LSD_{0.05}$	0.45			10.37
CV, %	6.6	19.2	1.8	15.2

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, TSS = Total soluble solid, TA = Titrable acidity and p^H = Power of hydrogen ion

CONCLUSION

The important plant growth parameters, yield factors, curd yield, postharvest quality, curd initiation and curd maturity of the major late season varieties of cauliflower differed significantly. The better performance in growth parameter was achieved by newly introduced varieties Bishop, NS 106, and Titan. 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. Bishop and NS 106 had higher yield and yield attributing factors than other late season varieties of cauliflower. Similarly, the highest TSS and Vitamin C content was produced by Snowball 16 and Bishop, respectively. Hence, the findings of this research depicts the fact that probable varieties along with Bishop and NS 106 could be Snowmystique, Titan, Artica, Freedom, and Amazing in terms of adaptation and better performance , but it is necessary to evaluate these varieties with detail assessment and nice specific variability across the locations before drawing any concrete conclusions.

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