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Effect of Different Doses and Sources of Nitrogen on Postharvest Quality of Cauliflower

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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ABSTRACT

In Nepal, there is lacking of proper nitrogen management regarding postharvest quality of cauliflower in the Terai region of Nepal. In order to address these problems, a field experiment was conducted in a split-plot design to determine the appropriate dose of nitrogen and combined effect of urea and poultry manure for better postharvest quality of cauliflower in Rampur, Chitwan. The study was carried out in nine treatment combinations from two different factors, with four replications in a late season variety, Bishop from November 2017 to March 2018. The plots consisted of three treatments of 260, 200, and 140 kg N/ha, while the sub-plots were 100 % N from urea; 50% N from urea and 50% N from poultry manure; and 100% N from poultry manure. Significantly higher vitamin C content of 52.4 mg/100 g was found in 140 kg N/ha than other treatments. Similarly, higher TSS content of 6.3°Brix was found in 260 kg N/ha. More compact and acceptable curds were produced in 260 kg N/ha. Similarly, higher vitamin C content of 52.0 mg/100 g and higher TSS content of 6.0°Brix was produced by 50% N from urea plus 50% N from poultry manure. Significantly more tastier and compact curds were produced by 100% N from poultry manure along with 50% N from urea and 50% N from poultry manure. Higher physiological weight (30.3%) was found in 260 kg N/ha while lower physiological weight loss (24.4%) was found in 50% N from urea and 50% N from poultry manure. From this study, it was concluded that 200 kg nitrogen combination with poultry manure instead of inorganic fertilizer can improve the postharvest quality of cauliflower in Terai region of Nepal.

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Keywords: Organoleptic; physiological loss; poultry manure; taste; vitamin C.

1. INTRODUCTION

Cauliflower can be grown effectively from inner Terai to the high hills of Nepal [1]. The climate change has threatened sustainable agricultural production, which results in low productivity and poor postharvest quality of vegetable crops. The coping strategies for adverse effects of climate change on productivity are still limited in Nepal. There are many adverse symptoms of cauliflower such as stunted growth, small and pale green leaves, delayed curd formation and finally decreased yield and poor postharvest quality due to deficiency of nitrogen [2]. There are also deleterious effects on soil pH and physical properties of the soil due to excess application of nitrogen. The haphazard use of chemical fertilizers also impairs soil physical condition, and reduces organic matter content with micronutrient deficiencies and intensification of insects' activities [3,4]. Therefore, application of nitrogen in proper dose is a major factor for higher yield and better postharvest quality of cauliflower.

The negative effects of both low and excess nitrogen application can be mitigated by applying both organic and inorganic sources of nitrogenous fertilizers. Organic manure helps to increase the soil fertility over a long period because of long residual effect in cultivated crops [5]. Poultry manure is an excellent material which can reduce fertilizer cost in vegetable production [6] and that is locally available. Application of poultry manure also helps to increase water holding capacity of the soil [7].

Organic manure alone may not fulfill the nutrient requirement of high yielding crop varieties due to slow nutrients release and low nutrient contents. Integrated nutrient management of organic and inorganic sources is necessary to improve soil fertility and productivity of soil [8]. Application of organic manures with inorganic fertilizers may result in better yields and postharvest quality of crops than the use of inorganic fertilizers alone [9,10]. So, the interest has been initiated to minimize the use of chemical fertilizers with combined use of poultry manure for suitable integrated nutrient management. Therefore, a field study was conducted to identify the appropriate doses and sources of nitrogen combinations to attain the highest possible postharvest quality cauliflower in Rampur, Chitwan.

2. MATERIALS AND METHODS

An experiment for the effect of different doses and sources of nitrogen on postharvest quality of cauliflower was conducted at Horticulture Farm of Agriculture and Forestry University, Rampur, Nepal which is situated at 27º37’ North latitude and 84º25’ East longitude with elevation of 256 meter above sea level that falls in inner Terai region of Nepal. This experiment was carried out during November 2017 to March 2018 to assess the cauliflower postharvest quality. .

2.1 Weather Parameters of the Experimental Area

Monthly average, maximum and minimum atmospheric temperature, relative humidity and total rainfall during cauliflower growing period from November 2017 to March 2018 was collected from National Maize Research Program Rampur, Chitwan. 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 in January 2018 and March 2018 respectively. There was negligible rainfall for whole experimental period in Rampur. So, water was applied to the plants by sprinkler irrigation method at young stage and by flooding irrigation method during curd initiation and growth of the curd for two times.

2.2 Experiment Design and Treatments

A field experiment was laid out in split-plot design with four replications. There were three different doses of nitrogenous fertilizer and three different sources of nitrogen combinations of urea and poultry manure. There were a total of nine treatment combinations from different doses and sources of nitrogen. The area of individual plot was 7.5 m^2 (3 m × 2.5 m) with 25 plants. Row to row distance was maintained at 60 cm and plant to plant distance was 50 cm. Three treatments of the main plots (doses of nitrogen) were 260, 200, and 140 kg N/ha; while three treatments of the sub-plots (sources of nitrogen) were 100 % N from urea; 50% N from urea and 50% N from poultry manure, and 100% N from poultry manure. The details of these two different factors and their treatment combinations are presented as following in Tables 1 and 2 respectively.

2.3 Soil Properties of the Experimental Field

Soil samples from each plot were taken for chemical analysis before transplanting of seedlings. The air dried and filtered soil was taken in to the lab at Agriculture Technological Centre, Lalitpur to measure the total nitrogen, phosphorus, potassium, organic matter, soil pH and soil texture. The experimental field was acidic with 5.4 soil pH; medium nitrogen (0.15% N), high potassium content (293.6 kg/ha K), medium phosphorus content (61.6 kg/ha P), high organic matter content (3.8% OM) and sandy loam.

2.4 Field Preparation and Data Analysis

The total allocated amount of NPK and poultry manure based on the recommended dose was incorporated in the soil during field preparation as a basal dose and also as a split dose based to the nitrogenous fertilizers. The seedlings were transplanted in the main field when they were ready for transplanting about four weeks after the seeding date. The water application was continued until the establishment of seedlings in the main field. Vitamin C, total soluble solids (TSS), Titrable acidity (TA) after harvesting of curds were measured from randomly selected five plants of each plot. Similarly, physiological weight loss (%), organoleptic taste and sensory evaluation of cauliflower curds were measured from those randomly selected plants. The organoleptic and sensory evaluation was identified by numerical scoring test. This testing is done by a trained panelist (ten persons were used) who follow the sensory characteristics and marking is done on a score sheet on various parameters such as taste, compactness and acceptability.

Data were recorded and entered into MS-Excel 2016. The analysis of variance (ANOVA) was performed and means were compared using Duncan's Multiple Range Test (*DMRT)* at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1 Chemical Parameters of Cauliflower

3.1.1 Chemical parameters as affected by different doses and sources of nitrogen

Vitamin C and total soluble solid (TSS) content of cauliflower were differed significantly among the different doses of nitrogen but there was no significant differences on titrable acidity (TA) among them (Table 3). Significantly higher vitamin C content of 52.4 mg/100 g was recorded in 140 kg N/ha than 260 kg N/ha while 140 kg N/ha was statistically at par with 200 kg N/ha. This results shows that higher application dose of nitrogen resulted into lower vitamin C content in cauliflower. Similar findings were reported by Acikgoz et al. [11] and Ajibola et al. [12].

Significantly higher TSS content of 6.3^{0}Brix was found in 260 kg N/ha and 200 kg N/ha respectively, than 140 kg N/ha, as 260 kg N/ha was statistically similar to 200 kg N/ha. These results shows that higher nitrogen dose causesdoses cause higher TSS content in cauliflower. Higher concentration of glucosinolate resulted in higher TSS, as glucoses are the precursors for biosynthesis of amino acids [13].

Vitamin C, TSS and TA content of cauliflower were differed significantly among the different sources of nitrogen (Table 3). Significantly

Table 1. Treatments on different doses and sources of nitrogen in Rampur, Chitwan during November 2017 to March 2018

Treatments	Symbol
Doses of nitrogenous fertilizer (Main plot)	
1. 260 kg of N/ha	N_1
2. 200 kg of N/ha	N_2
3. 140 kg of N/ha	N_3
Sources of nitrogen through urea and poultry manure (Sub-plot)	
1. 100% N from urea	C_1
2. 50% N from urea and 50% N from poultry manure	C_2
3. 100% N from poultry manure	C_3

Table 2. Treatment combinations from the interaction of different doses and sources of nitrogen in Rampur, Chitwan during November 2017 to March 2018

Name	Name of the treatment combinations	Symbol
T_1	100% N from urea and 260 kg N/ha	N_1C_1
T_2	50% N from urea and 50% N from poultry manure and 260 kg N/ha	N_1C_2
T_3	100% N from poultry manure and 260 kg N/ha	N_1C_3
T_4	100% N from urea and 200 kg N/ha	N_2C_1
T_5	50% N from urea and 50% N from poultry manure and 200 kg N/ha	N_2C_2
T_6	100% N from poultry manure and 200 kg N/ha	N_2C_3
T_7	100% N from urea and 140 kg N/ha	N_3C_1
T_8	50% N from urea and 50% N from poultry manure and 140 kg N/ha	N_3C_2
T_9	100% N from poultry manure and 140 kg N/ha	N_3C_3

Table 3. Effect of different doses and sources of nitrogen on vitamin C, TSS and TA of cauliflower in Rampur, Chitwan during November 2017 to March 2018

Treatments	Chemical parameters		
	Vitamin C (mg/100 g)	TSS (^{0}Brix)	TA (%)
Doses of nitrogen (Main plot)			
260 kg N/ha	46.5^b	6.3^a	0.21
200 kg N/ha	50.0^{ab}	6.1^a	0.22
140 kg N/ha	52.4^a	5.6^b	0.22
$LSD_{0.05}$	2.04**	0.37**	ns
CV, %	6.5	8.8	8.4
Sources of nitrogen (Sub-plot)			
100% N- urea	47.7^b	5.3^b	0.21^b
50% N- urea and 50% N- PM	55.2^a	6.0^a	0.21^b
100% N- PM	54.4^a	5.9^a	0.24^a
$LSD_{0.05}$	4.17*	0.65*	0.02**
Grand Mean	52.4	5.7	0.22

*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 and TA =Titrable acidity*

higher vitamin C content of 55.2 mg/100 g was recorded in 50% nitrogen from urea plus 50% nitrogen from poultry manure than 100% nitrogen from urea, whereas combination of 50% nitrogen from urea plus 50% nitrogen was statistically at par with 100% nitrogen from poultry manure. Significantly maximum vitamin C content was found by the combination of inorganic and organic sources of nitrogen, a similar finding was reported by Timsina, [8].

Similarly, higher TSS content of 6.0^{0}Brix was found in 50% nitrogen from urea plus 50% nitrogen from poultry manure which was statistically similar to 100% nitrogen from poultry manure, respectively. Chemical fertilizers along with organic fertilizers positively influenced the TSS content in cauliflower curds, as similar findings were reported by Laxmi et al. [14] and Mallareddy, [15].

Significantly higher TA content of 0.24% was recorded in 100% N from poultry manure than other treatments. Due to application of organic fertilizer in higher dose also increased the Titrable acidity in cauliflower, a similar finding was reported by Billis et al. [16].

3.1.2 Interaction effect of different doses and sources of nitrogen on chemical parameters

Vitamin C and TA content of cauliflower was differed significantly among the interaction effect of different doses and sources of nitrogen but there was no significant differences on TSS among the treatments (Table 4 and Fig. 1). Significantly higher vitamin C of 58.0 mg/100 g was recorded in 200 kg N/ha with 100% N from poultry manure which was statistically similar to 260 kg N/ha with 100% N from poultry manure and 140 kg N/ha with 100% N from poultry manure.

Significantly higher TA content was found in 260 kg N/ha with 100% N from poultry manure which was statistically similar to 200 kg N/ha with 100% N from poultry manure and 140 kg N/ha with 100% N from poultry manure.

3.2 Organoleptic Taste and Sensory Evaluation of Cauliflower Curds

3.2.1 Organoleptic taste and sensory evaluation as affected by different doses and sources of nitrogen

Compactness and acceptability of cauliflower curd was differed significantly among the doses of nitrogen but there was no significant differences on taste among the treatments (Table 5). Significantly highly compact curds of 6.6 score were recorded in 260 kg N/ha and 200 kg N/ha respectively, than 140 kg N/ha, while 260 kg N/ha was statistically similar to 200 kg N/ha. Similarly, higher acceptability curds of 6.4 score was found in 260 kg N/ha than 140 kg N/ha, while 260 kg N/ha was statistically similar to 200 kg N/ha. In this study, comparatively more compact and acceptable curds was producedand acceptability of curds were found at increased in nitrogen level. When nitrogen is deficit in plants, it inhibits the synthesis of glucose - 6 phosphate dehydrogenase. As result, it gives browning of curds and produces less attractive and loose curds due to poor application of nitrogen. Similar findings were reported by Gupta and Samnotra [17].

Table 4. Interaction effect of different doses and sources of nitrogen on vitamin C, TSS and TA of cauliflower in Rampur, Chitwan during November 2017 to March 2018

Treatments	Chemical parameters		
	Vitamin C (mg/100 g)	TSS (°Brix)	TA (%)
260 kg N/ha and 100% N- urea	43.9^{cd}	5.0	0.20^{cd}
260 kg N/ha and 50% N- U+50% N- PM	46.1^{cd}	5.0	0.21^{bcd}
260 kg N/ha and 100% N- PM	57.6^{a}	5.1	0.26^{a}
200 kg N/ha and 100% N- urea	50.4^{bcd}	5.0	0.22^{bc}
200 kg N/ha and 50% N- U+50% N- PM	47.0^{bcd}	5.0	0.23^{abc}
200 kg N/ha and 100% N- PM	58.0^{a}	5.1	0.25^{ab}
140 kg N/ha and 100% N- urea	50.2^{bcd}	6.0	0.22^{bc}
140 kg N/ha and 50% N- U+50% N- PM	46.3^{cd}	5.5	0.19^{d}
140 kg N/ha and 100% N- PM	54.5^{ab}	6.2	0.25^{ab}
Grand Mean	50.4	5.3	0.22
$LSD_{0.05}$	6.40*	ns	0.04**
CV, %	8.4	2.2	9.3

*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, CV = Coefficient of variance, TSS =Total soluble solid and TA =Titrable acidity*

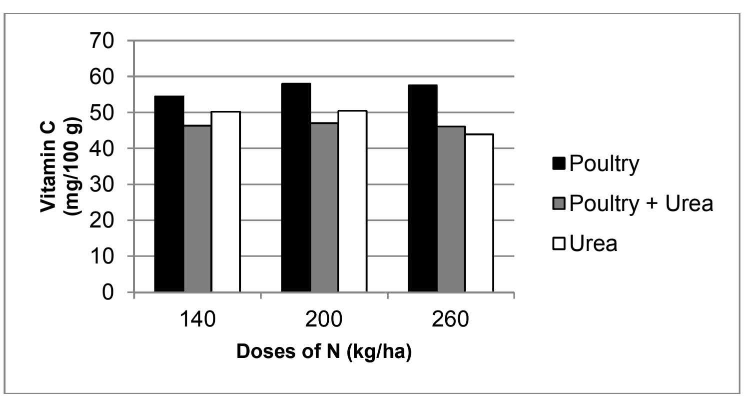

Fig. 1. Interaction effect of different doses and sources of nitrogen on vitamin C

Taste, compactness and acceptability of cauliflower curds were differed significantly among the different sources of nitrogen (Table 5). Significantly better tasty curds of 6.2 score was observed in 100% N from poultry manure which was statistically similar to 50% N from urea and 50% N from poultry manure. Significantly highly compact curds of 6.0 score was recorded in 50% N from urea and 50% N from poultry manure which was statistically at par 100% N from poultry manure. Similarly, higher acceptability curds of 5.8 score was found in 50% N from urea and 50% N from poultry manure which was statistically similar with 100% N from poultry manure. The highest consumer acceptability and tasty curds were produced at higher dose of organic manure in substitution of inorganic fertilizers. Similar findings were also reported by Sapkota, [18].

3.3 Physiological Weight Loss

3.3.1 Physiological weight as affected by different doses and sources of nitrogen

Physiological weight loss of cauliflower was differed significantly among the different doses of nitrogen (Table 6). Significantly lower physiological weight of 25.4% was recorded in

Table 5. Effect of different doses and sources of nitrogen on taste, compactness and acceptability of curds in Rampur, Chitwan during November 2017 to March 2018

Treatments	Organoleptic taste and sensory evaluation (1-9)		
	Taste	Compactness	Acceptability
Doses of nitrogen (Main plot)			
260 kg N/ha	5.2	6.6^{a}	6.4^{a}
200 kg N/ha	4.9	6.2^{a}	6.2^{a}
140 kg N/ha	5.1	5.7^{b}	5.3^{b}
$LSD_{0.05}$	ns	0.32^{**}	0.42^{**}
CV, %	6.8	5.6	7.6
Sources of nitrogen (Sub-plot)			
100% N- urea	4.2^{b}	6.5^{b}	5.1^{b}
50% N- urea and 50% N- PM	5.7^{ab}	6.0^{a}	5.8^{a}
100% N- PM	6.2^{a}	5.9^{a}	5.6^{a}
$LSD_{0.05}$	0.25^{**}	0.32^{*}	0.14^{*}
Grand mean	5.4	6.1	5.5

*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 [9 score was a superior value on rating]*

Table 6. Physiological weight loss of cauliflower as affected by different doses and sources nitrogen in Rampur, Chitwan during November 2017 to March 2018

Treatments	PLW (%)
Doses of nitrogen (Main plot)	
260 kg N/ha	30.3^{a}
200 kg N/ha	28.2^{ab}
140 kg N/ha	25.4^{bc}
LSD 0.05	4.82*
CV, %	12.2
Sources of nitrogen (Sub-plot)	
100% N – urea	30.5^{a}
50% N – urea and 50% N – PM	24.4^{b}
100% N - PM	27.2^{ab}
$LSD_{0.05}$	4.21*
Grand mean	27.4

*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, CV = Coefficient of variance, PM = Poultry manure, and PLW = Physiological loss in weight*

140 kg N/ha than other treatments. Physiological weight after harvesting of cauliflower curds were increased at increased in nitrogen level. Similarly, significantly lower physiological weight loss of 24.4% was recorded in 50% N from urea and 50% N from poultry manure which was statistically similar to 100% N from poultry manure. The least physiological weight loss in weight after harvesting of cauliflower curd was observed at increment of organic manure in substitution rate of inorganic fertilizers. Similar findings was also reported by Naik, [19] and Bhattarai & Budhathoki, [20].

4. CONCLUSION

The chemical constituents such as vitamin C, TSS and TA of cauliflower along with physiological weight loss, organoleptic taste and sensory evaluation significantly differed among different doses and sources of nitrogen. TSS content increased and a higher number of compact curds were produced at increasing nitrogen rates; while vitamin C content decreased. Physiological weight was also maximum at increased nitrogen rates. By increasing rates of organic manure application, more tasty and attractive curds were produced. Similarly, minimum physiological weight along with higher vitamin C, TSS and TA content was also found by increasing the rates of organic manure instead of inorganic fertilizer. From this study, it was concluded that 200 kg of nitrogen application along with poultry manure can improve the postharvest quality of cauliflower in Terai region of Nepal.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Pandey YR Pokhrel TR. Varietal evaluation of late season cauliflower. In Proceedings of the 3rd National Horticultural Research Workshop, Horticulture Research Division. 2000;46-49.
2. Shanmugavelu KG. Production technology of vegetable crops. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, India. 1989;630.
3. Joshi N, Singh MP. Response of cauliflower to bio-fertilizers. In: Proceedings of the forth national workshop on horticulture. NARC, Khumaltar, Lalitpur, Nepal; 2004.
4. Shomasundaran E, Nankaran N, Chandragiri KK Thiyogarajan TM. Biogas slurry and panchagavya promising organic to reconstruction our agro ecosystem. Agro-bios India. 2004;2:13-14.
5. Sharma A, Mittra B. Effect of different rates of application of organic and nitrogen fertilizers in a rice-based cropping system. The Journal of Agricultural Science. 1991; 117(3):313-318.
6. Hochmuth G, Hochmuth R, Mylavaapau R. Using composted poultry manure (litter) in mulched vegetable production. Nutrient Management of Vegetable Row Crops Handbook. 2009;191-199.
7. Ramesh P, Singh M Rao SA. Organic farming: It's relevance to the Indian context. Current Science. 2005;88(4):561-568.
8. Timsina J. Can organic sources of nutrients increase crop yields to meet global food demand? Agronomy. 2018; 8(10):214.
9. Illias M, Vimala P. Application of chicken manure on lowland cabbage (*Brassica oleraceae var. capitata* L.) grown on peat soil under rain shelter. Journal of Tropical Agriculture and Food Science. 2005;33(1): 25-32.
10. Rami SN Mallareddy K. Effect of different organic manures and inorganic fertilizers on growth, yield and quality of carrot (*Dacus carota* L.). Karnataka Journal Agriculture Science. 2007;20(3):686-688.
11. Acikgoz FE, Adiloglu A, Daglioglu F, Adiloglu S, Celikyurt G, Karakas O. The effect of increasing doses of nitrogen application for some nutrient elements, vitamin C and protein contents of komatsuna (*Brassica rapa* var. *perviridis*) plant. Bulgarian Journal of Agricultural Science. 2014;20(2):321-324.
12. Ajibola VO, Babatunde OA, Suleiman S. The effect of storage method on the vitamin C content in some tropical fruit juices. Trends Applied Science Research. 2009;4(2):79-84.
13. Fitzgerald LM, Szmant AM. Biosynthesis of ‘essential amino' acids by scleractinian

corals. Biochemical Journal. 1997;322(1): 213-221.
14. Lakshmi CSR, Rao PC, Sreelatha T, Madahvi M, Padmaja G, Rao PV et al. Manurial value of different vermicomposts and conventional composts. Global Advanced Research Journal of Agricultural Science. 2013;2(2):59-64.
15. Mallareddy K, Rani SN. Effect of different organic manures and inorganic fertilizers on growth, yield and quality of carrot (*Daucus carota* L.), Department of Horticulture. Karnataka Journal of Agricultural Sciences. 2007;20(3):686-688.
16. Bilalis D, Krokida M, Roussis I, Papastylianou P, Travlos I, Cheimona N, et al. Effects of organic and inorganic fertilization on yield and quality of processing tomato (*Lycopersicon esculentum* Mill.). Folia Horticulturae. 2018;30(2):321-332.
17. Gupta AK Samnotra RK. Effect of bio-fertilizers and nitrogen on growth, quality and yield of cabbage cv Golden Acre. Environment and Ecology. MKK publication, India. 2004;22(3):551-553.
18. Sapkota D. Response of late cauliflower (*Brassica oleracea* var. *botrytis* L.) cultivars to different sources of nitrogen. (Mater Thesis, Institute of Agriculture and Animal Science, Chitwan, Nepal); 2013.
19. Naik MR Sreedhar D. Growth and yield response of radish cv. Pusa Himani to integrated nutrient management practices. International Journal of Agriculture, Environment and Bioresearch. 2018; (3):3.
20. Bhattarai DR, Budhathoki K. Effect of organic manures on post-harvest physiology and consumer's acceptability of cauliflower. Nepal Journal of Science and Technology. 2005;6:11-14.

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