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Research Article

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Preponed Budburst in Grapevine 'Cabernet Sauvignon' Enables Berry Harvest before Monsoon in Lower Hills of Nepal

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Abstract

Berry harvesting coinciding with the monsoon is the major problem of grapevine (*Vitis vinifera* L.) cultivation in Nepal. Nepalese viticulture is benefitted by advancing budburst and hydrogen cyanamide (HC) has the potential to break the bud dormancy in grapevine leading to early harvesting. To prepone the budburst and thus the harvesting, field experiment was conducted in a commercial vineyard, Dhading, aiming to identify the appropriate dose of HC for the advancement of natural budburst in cv. Cabernet Sauvignon. Six HC application treatments; (i) Control, ii) 2% HC iii) 3.5% HC, iv) 5% HC, v) 6.5% HC and vi) 8% HC) were replicated four times considering vine as replication in randomized complete block design. Grapevine growth were recorded using a modified Eichhorn and Lorenz (E-L) growth stage notation, and other quantitative and qualitative attributes were measured at flowering and harvesting. HC preponed the budburst (about 3 weeks) compared to control. Number of days to 50% budburst was earlier (31 days) in 3.5% HC treated vines than in control. Budburst and flowering were maximum (70±2.72% and 63.33±4.08%, respectively) in 2% HC treated vines and the lowest (20.83±14.17% and 19.17±13.63%, respectively) was in 8% HC treated vines in 84 days after HC application. TSS was varied but the average bunch weight did not differ with HC treatments in the same day of harvest. Higher HC concentration (≥6.5%) adversely affected the budburst and thus in flowering and yield. The HC was effective to prepone the natural budburst calendar, shoot growth and flowering, enabling harvesting before monsoon. The HC 2% application in winter buds was found appropriate for the cv. Cabernet Sauvignon to prepone budburst and harvesting before monsoon. The HC dose and application timing might be differ in cultivars and growing condition, thus, cultivar and location specific researches are recommended.

Keywords : Budburst, Concentrations, Hydrogen Cyanamide, Dormex, Viticulture

Introduction:

Traditionally grapevine (*Vitis vinifera* L., 2n=2x=38) are grown in Mediterranean climates while in tropical and sub-tropical climates, poor and uneven budburst due to insufficient winter chilling pose significant challenges. Overtime, grape cultivars have been developed and successfully grown in tropics and sub-tropics through vigorous vine management and the use of plant growth regulators (Dahal et al., 2017). In low and inadequate winter chilling regions, combinations of winter pruning and application of hydrogen cyanamide (HC) ie H_2CN_2 treatment is very important to regulate budburst (Lombard et al., 2006). The harvesting season of grapes coincides with the monsoon, which is a major challenge for grape production in Nepal as the environment is ideal for fungal diseases such as anthracnose, powdery mildew, downy mildew, and insect infestation (Shrestha, 1998). The intense rainfall during monsoon also deteriorates the quality of berry produced and amplify the diseases on vine. Thus, prepone the budburst leading early harvesting may be a viable strategy for successful grape cultivation in Nepal (Dahal et al., 2017; Poudel et al., 2024).

Hydrogen cyanimide is the most effective chemical used to advance and synchronize budburst in deciduous fruit trees (Wang et al., 2021; Gaaliche et al., 2017). Applications of HC to grapevine buds promotes the breakage of endo-dormancy i.e. prepone the budburst leading to early harvesting. The effect of HC, on the other hand, varies depending on a number of factors, including concentration, time and mode of application, weather condition, and growing condition (Dokoozlian, 1999). At cellular level, HC transient respiratory disturbances, plant hormone signaling and oxidative stress that leads to breaking endo-dormancy (Perez et al., 2008; Sudawan et al., 2016; Liang et al., 2019). The HC also improves yield with higher sugar concentration in berries as a result of the earlier onset of leaf development (Wang et al., 2021). To harvest the berry before the monsoon in Nepal, dormancy must be broken earlier, and uniform budburst is another important criterion. Thus, this study aimed to prepone natural budburst, resulting in bunch harvesting before monsoon in the road and river corridor of low hill areas, which would be the potential area for viticulture in Nepal. The objective was to assess the effect of HC concentrations on grapevine phenology, yield attributes and berry quality attributes in cv. Cabernet Sauvignon.

Materials and Methods:

The experiment was conducted from Jan 2021 to Jul 2021 in the established commercial vineyard located at Thakre Rural Municipality-10, Dhading which lies between 27.7471 latitude, 85.1065 longitude and at an altitude of 855 m above mean sea level. The 6 year-old grapevine cv. Cabernet Sauvignon grafted on 5C rootstock used as experimental vines. Six treatments were allotted in randomized complete block design (RCBD) with four replications considering vine as replication. Treatments were concentrations of HC applied 15 days after pruning; T_1: control (water spray), T_2: 2% HC, T_3: 3.5% HC, T_4: 5% HC, T_5: 6.5% HC and T_6: 8% HC. Spur pruning was done in vines leaving 3 basal buds in one year old shoot on Jan 17. The working concentration of HC (Dormex® a.i. 50% SL) applied in spur with the help of brush on Feb 1 2021.

Vines were tagged using different colored ribbons. Ten different colored threads were tagged for ten different spurs of each vine. Each bud of spur was marked from basal to distal as 1st, 2nd and 3rd bud position with marker pen. Thus, thirty buds were selected at most from each experimental vine. Phenological observations were taken with the reference of modified Eichhorn and Lorenz (E-L) grapevine growth stages (Coombe & Dry, 2004). The first observation was made on 16th Feb 2021 ie after 15 days of HC application (DAHC) and other observations were made on every 4±2 days interval until all the treatments were at full flowering stages 26 Mar 2021 (Figure 1).

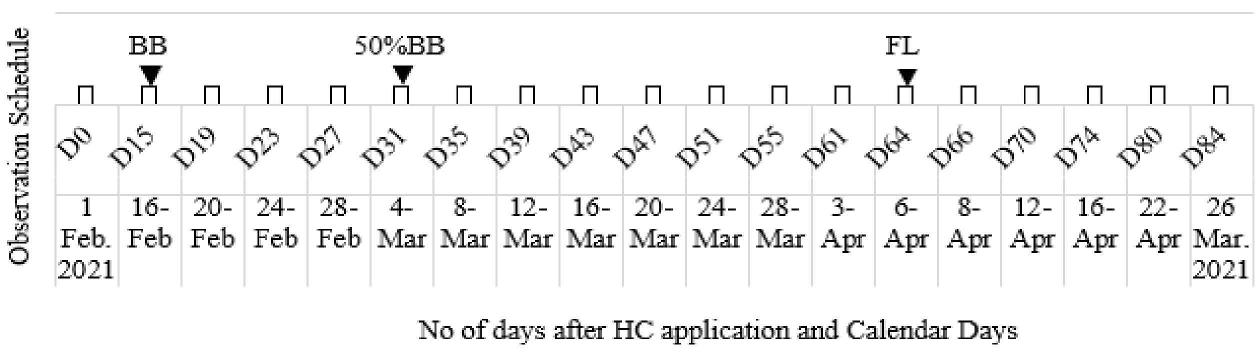

Figure 1. Data recording schedule for budburst, 50% budburst, growth stages, fruitfulness and flowering after HC application on 1 Feb 2021. BB: Budburst; FL: Flowering.

Budburst percentage was calculated by dividing number of burst nodes by total nodes and then multiplying with 100.

$$\text{Budburst (\%)} = \frac{\text{(Number of burst nodes)}}{\text{(Total nodes)}} \times 100$$

Observed fruitfulness (%) was calculated by dividing number of nodes with inflorescence (one and more than one) by total nodes or burst nodes.

$$\text{Observed fruitfulness (\%)} = \frac{\text{Number of nodes with inflorescence} \geq 1}{\text{Total nodes or Burst nodes}} \times 100$$

Harvesting was on the same day irrespective to treatments, hence, the berry quality attributes and bunch weight were considered to assess the minimum standard just before monsoon i.e. Jun 2021. Bunch weight was measured in gram (g) with the help of digital weighing balance and total soluble solid (TSS) was recorded using digital refractometer. Data collection, entry and analysis were done by using MSExcel and GenStat® (GTL 18.1, VSNi, UK) software.

Results:

Number of days required after HC application to first budburst and 50% budburst significantly varied in HC treated buds as compared to untreated buds (Figure 2). The earliest budburst (30 DAHC) was found in 3.5% HC treated buds while the delayed budburst (51 DAHC) was in control.

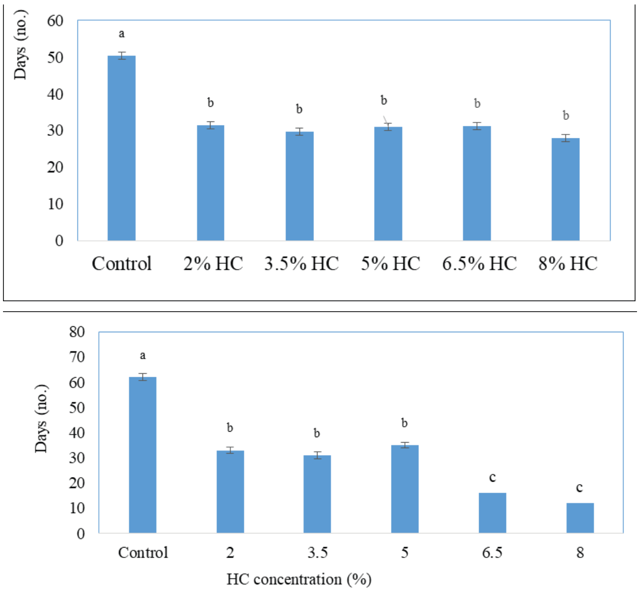

Figure 2. Effect of HC concentrations on (A) number of days (mean ± se) to first budburst; (B) number of days (mean ± se) to 50% budburst; se; standard error of sample means (n=4).

Nearly 3 weeks (19-21 days) earlier budburst was observed in HC treated, however, the earliness in budburst was irrespective to the HC concentrations. Similarly, number of days required to 50% budburst was almost double in control buds (62 days) as compared to 2-5% HC treated buds (31-35 days). Here, some of the vines treated with 6.5-8% HC did not reach to 50% budburst as most of the buds damaged with higher HC concentrations.

Grapevine growth stages

Grapevine growth stage (modified E-L) varied significantly with concentrations of HC applied since D19 (Figure 3). The average growth stage was the highest in 2% HC (20.82±1.19) followed by 3.5% HC (18.71±1.31), 5% HC (18.29±1.26), Control (12.68±1.01), 6.5% HC (10.66±1.24) and the lowest in 8% HC (6.82±1.06) after 84 DAHC. Growth stages were differed gradually since D19 days towards the end of growth stage monitored ie D84. The growth stages of shoots in HC treated vines over observation period were largely followed two patterns; 2-5% HC and ≥ 6.5% HC concentrations.

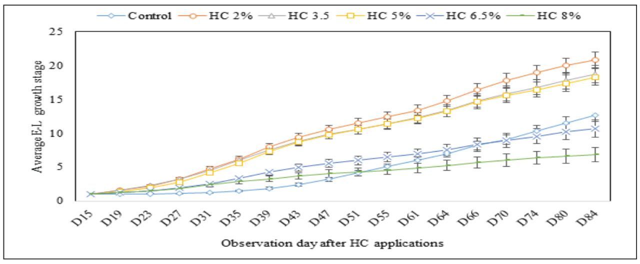

Figure 3. Effect of HC concentrations on annual growth stage of grapevine (μ±se). μ: mean growth stage of grapevine and se: standard error of sample means (n=4). D=Days after HC application on which the observation was recorded. D15 (16th Feb.), D19 (20th Feb.), D23 (24th Feb.), D27 (28th Feb.), D31 (4th Mar.), D35 (8th Mar.), D39 (12th Mar.), D43 (16th Mar.), D47 (20th Mar.), D51 (24th Mar.), D55 (28th Mar.), D61 (3rd Apr.), D64 (6th Apr.), D66 (8th Apr.), D70 (12th Apr.), D74 (16th Apr.), D80 (22th Apr.), and D84 (26th Apr.).

Budburst percentage

As indicated in Figure 4, significant difference on mean budburst (%) was observed between HC treated vines and control on D23, while significant difference on mean budburst (%) among HC concentrations was found only after D31. Control had the lowest mean budburst (%) till 47th day and then it exceeded 6.5% HC and 8% HC on D51 onwards. On D55, the highest mean budburst (69.17%) was observed in 2% HC, which was statistically at par with 5% HC (65%), 3.5% HC (62.5%) and Control (45%), and the lowest was observed on 8% HC (21.67%). Most of the vines treated with HC (2-5%) had more than 50% budburst at D31 while the HC untreated vines (control) had 50% budburst at D55. This shows HC treated vines had earlier and better budburst than control while ≥ 6.5% HC treated vines had earlier but lower budburst even than control.

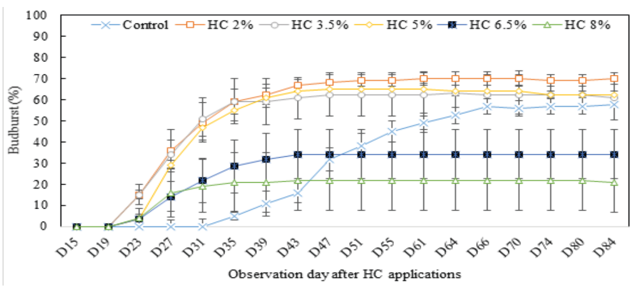

Figure 4. Effect of HC concentrations on budburst (μ±se%). μ: mean stage of grapevine and se: standard error of sample means (n=4). The dotted horizontal line is the reference for 50% budburst. D= Days after HC application on which the observation was recorded. D15 (16th Feb.), D19 (20th Feb.), D23 (24th Feb.), D27 (28th Feb.), D31 (4th Mar.), D35 (8th Mar.), D39 (12th Mar.),

D43 (16th Mar.), D47 (20th Mar.), D51 (24th Mar.), D55 (28th Mar.), D61 (3rd Apr.), D64 (6th Apr.), D66 (8th Apr.), D70 (12th Apr.), D74 (16th Apr.), D80 (22th Apr.), and D84 (26th Apr.).

Observed fruitfulness

The flowering (cap fall i.e. calyptra) accelerated in all HC treated vines from D51 while there was no flowering in control until D64 (Figure 5). Mean flowering (%) from total observed nodes found ≥50% in 2%, 3.5% and 5% HC treated vines, while control vines never reached 50% nodes in flowering. This shows the flowering was preponed by HC application compared to control i.e. natural flowering time. Highest flowering (%) in observed buds (63.33±4.08%) was in 2% HC treated vines which was statistically at par with 3.5% HC and 5% HC throughout the observation period. The lowest flowering (19.17±13.63%) was found in 8% HC which was at par with 6% HC. In control, flowering was delayed but continued to increase throughout the period. While comparing the flowering (%) with total observed buds and bursted buds, the higher HC concentrations (≥6%) potentially damaged the buds to burst rather bursted buds to flowering.

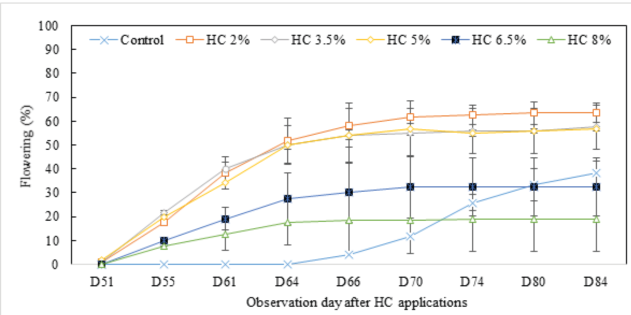

Figure 5. Effect of HC concentrations on flowering (μ±se%) from total buds. μ: mean flowering in observed buds and se: standard error of sample means (n=4). The dotted horizontal line is the reference for 50% flowering. D51 (24th Mar.), D55 (28th Mar.), D61 (3rd Apr.), D64 (6th Apr.), D66 (8th Apr.), D70 (12th Apr.), D74 (16th Apr.), D80 (22th Apr.), and D84 (26th Apr.).

Bunch and Berry Attributes

The average bunch weight among treatments did not differ significantly (Table 1). The TSS (°B) was higher in 8% HC treated vines while the lowest was in control for the same day of harvested berries (Table 1). In HC treated vines, approximately 20°B TSS on 14th Jun harvested berries revealed that berries were ready to harvest before monsoon.

Discussion:

The number of days required for 50% budburst was almost double for control compared to HC treated vines. Carreno et al. (1999) also found 8–18 days earlier budburst in HC treated vines over control. George et al. (1988); Zelleke & Kliewer (1989) and Arora & Gill (2011) had also reported the application of HC enable the buds to sprout earlier. Foott (1987) mentioned that 2.5% HC application to dormant 'Chardonnay' and 'Cabernet Sauvignon' cultivars resulted in earlier budbreak. HC treatment causes sudden starch breakdown and temporary sugar buildup in seedless grapevine tissues (Liang et al., 2019), resulting in earlier, uniform budburst and growth stage compared to the control as observed by Carreno et al. (1999) and Lavee et al. (1984).

The application of HC has shown positive effect on percentage of budburst and there were significant differences between HC treated vines and control with respect to the mean budburst (%). Wicks et al. (1984) found 1.8 times higher budburst with 2.5% HC in 'Thompson Seedless'. Similarly, earlier and maximum budburst was achieved with application of 5% HC when compared to untreated vines in 'Thompson seedless' (Butler & Rush, 1994). In a comprehensive study, Shulman et al. (1983) reported that 'Cabernet Sauvignon' grapevines grown in Davis, California had higher budburst than those grown further north in Oakville, California when treated with 1.25% solution of HC. Later experiments, higher budburst was found with 2% and 3% HC treatments in Oakville. Arora & Gill (2011) also reported the advanced

Table 1. Effect of HC concentrations on qualitative and quantitative characteristics of grape berries.

Treatment	TSS (°Brix)	Average bunch weight (g)
Control	15.39^{d}±0.84	58.86±6.88
2% HC	20.27^{b}±0.76	73.00±7.36
3.5% HC	19.00^{c}±0.73	56.78±4.05
5% HC	18.59^{c}±0.61	50.29±2.34
6.5% HC	19.07^{c}±0.38	57.91±2.96
8% HC	21.40^{a}±0.91	63.61±5.92
Grand mean	18.95	60.07
LSD (5% level)	1.01***	ns
CV%	3.5	17.2

Note: Mean with the same letter(s) within the column do not differ significantly at p=0.05 by Fisher Protected Test. Values are mean ± se (Standard error of mean); LSD = Least Significance Difference; CV = Coefficient of variance; NS= Not significant.

and better budburst in 'Perlette' and the flowering was 10-13 days earlier treated by Dormex® than in control vines. ElMasri et al. (2018), Muhtaseb & Ghnaim (2008) and George et al. (1988) demonstrated that HC application after pruning advanced the flowering and maturity as compared to untreated vines.

In the observed nodes, percent flowering was lower than the percent budburst for all treatments. It is likely there was damage or death of the buds after the budburst. In general, food and growth substances move upward from the storage organs of the vine to support the new shoot growth up to two to three weeks after budburst (Dahal et al., 2019). Higher concentration of HC could potentially be phytotoxic to the very young tissues, thus the buds apt to sprouts could potentially damage and thus reduced the percent budburst. The potential damages of HC to the floral primordia or the young shoot that were not fully matured have been reported by Or et al. (2015).

The HC treated vines reached maturity approximately one month earlier than untreated vines. HC treated vines also improved fruit quality with higher TSS (Williams, 1987; Muhtaseb & Ghnaim, 2008 and Arora and Gill, 2011). The bunch weight is largely governed by the source sink relationship and crop load; thus application of HC may not have direct effect on the bunch attributes. In this study, there was no significant differences in bunch weight though the mean bunch weight was higher in 2% HC treated vines. Arora & Gill (2011) and Carreno et al. (1999) also reported that HC did not effect on bunch weight. Since HC application showed the variation in budburst (%) and flowering (%) that directly impact on shoots and inflorescences in vine.

Conclusion:

Application of HC preponed the natural budburst timing of grapevine cv. Cabernet Sauvignon about three weeks in river corridor of lower-hill, Nepal. Earlier budburst coupled with better budburst and early flowering in comparison to control led to harvesting of berry before monsoon without compromising in berry quality. Considering overall performance, application of 2% HC sufficiently triggers the bud physiology of grapevine for early and uniform budburst at least in cv. Cabernet Sauvignon. This study open up the avenue that grape harvesting is possible before monsoon in Nepalese condition.

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Declaration of conflict of interest and ethical approval:

KC Dahal conceptualized the experiments and executed with P Sapkota, P. Poudel, N Ghimire, and R Sapkota. P Sapkota drafted the manuscript and all authors contributed on this manuscript. Authors declare no conflict of interest for the publication of this article.

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