PROSPECTS OF WARM CLIMATE TABLE GRAPE PRODUCTION IN NEPAL

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ABSTRACT

Common grape vine (Vitis vinifera) is assumed to have originated in moderate temperate climates, however, it is also now well established in subtropical and tropical climates around the world. The mechanisms of adaptation to warm climates are diverse and include both morphological and physiological attributes. Despite constraints to normal growth and consistent yield, expansion of table grape production in warm climate is increasing through optimal vine management and the use of growth regulators, with Israel, South Africa, Brazil, India and Australia leading in this area. Grape cultivation in Nepal is believed to have started within the Rana regime (>70 years ago) but there is effectively no current commercial production. Prospective areas for commercial grape production are in western terai, and although production constraints require further investigation, it is likely that diseases associated with the monsoon would be the major problems in terai and mid-hills. Shifting the harvesting time to before monsoon (June-July)is considered a plausible strategy for successful viticulture in comparatively warmer and drier subtropical climates of western Nepal. Implementation of this strategy will require research to achieve earlier and uniform budburst leading to synchronised flowering and harvesting in vineyard.

Key words: *budburst, defoliation, dormancy, hydrogen cyanamide and subtropical viticulture*

Introduction

The grape is the most widely cultivated fruit crop in the world. Its' domestication has long been claimed from the wild population of V. vinifera ssp. sylvestris (Levadoux, 1956).The hot and dry summers followed by moderately cool winters characterised as "Mediterranean" type of climate is the traditional grape growing environment, withthe majority (~70%) of commonly grown cultivars (cvs.) originating from the western Mediterranean region (Arroyo-Garcia et al., 2006). Over time, however, various cultivars have been developed, with specialisation to 'table grapes' for fresh consumption and 'wine grapes' for fermentation. Grape cultivars grown for fresh consumption (table grapes) have extended into warm climates, and extending the seasonal availability of grapes (Fig. 1).

Tonniety and Carbonneau (2004) classified five types of warm climate viticulture: tropical dry, tropical wet, tropical alternatively dry/wet, subtropical alternatively dry/wet and subtropical dominantly wet. Shikhamany (2006) used three classifications for production in India: subtropical, hot tropical and mild tropical grape growing agro-climatic zones. Countries with the largest warm climate table grape industries include India, South Africa, Brazil, Peru, Venezuela, Colombia, Guatemala, Thailand, Mexico, Australia, and Egypt (Souza Leao, 2014).India is the 9thlargest grape producing country (FAO, 2013)with tropical production accounting for more than 90% of its total production(Chadha, 2006).

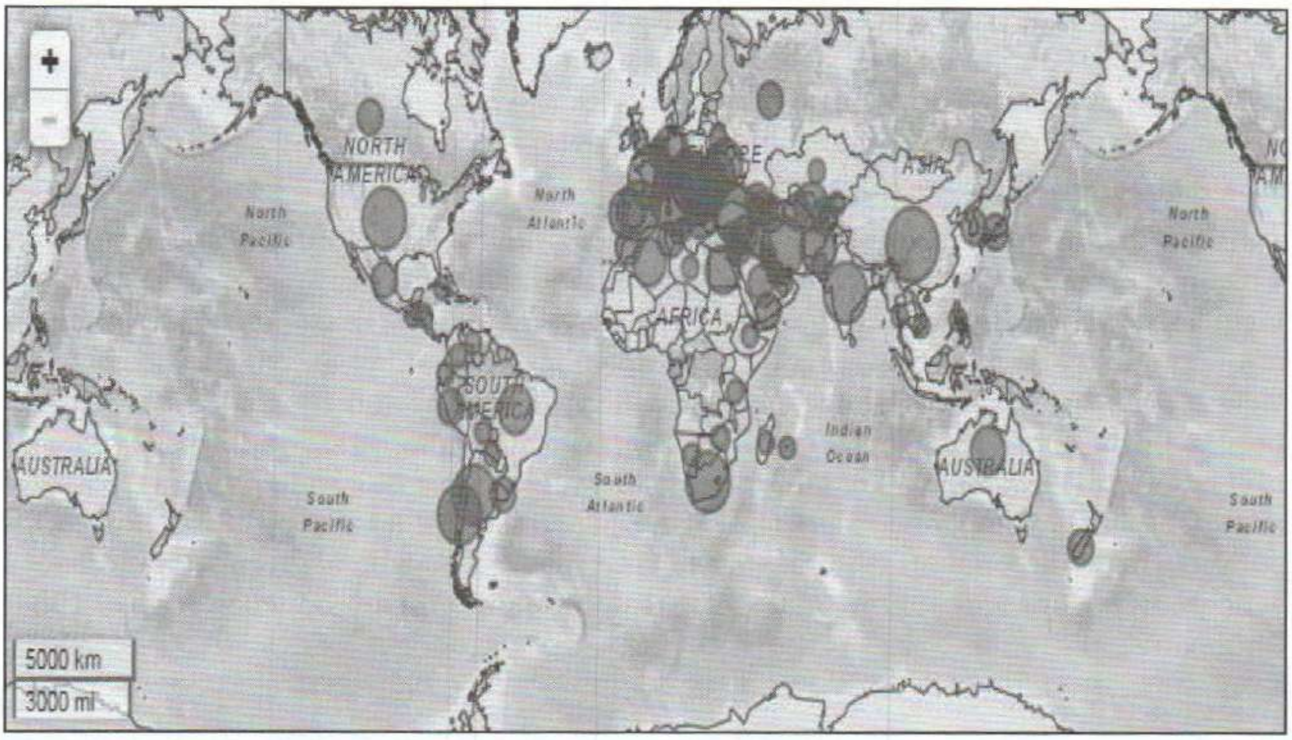

Figure 1. Major grape growing regions (Size of balloon indicates the quantity of grape produced in 2013; Source: FAO, 2013)

Grapevine growth is accelerated in warmer climates, and thus the phenological stages are compressed. Annual growth starts after sprouting of winter dormant buds, but in a mild tropical climate the vine grows continuously without a definite bud rest period, and the vines begin sprouting following pruning (Midmore, 2015). In traditional Mediterranean climates, bud burst starts in spring and is followed by a period of 8 to 12 weeks to flowering (Mullins et al., 1992), whereas in subtropical climates (e.g. Queensland, Australia),the same period lasts only for 6 to 7 weeks. A difference of 4oC in average monthly temperature reduced the period to anthesis from more than twelve weeks in a cool climate to less than eight weeks in a hot climate (Watt et al., 2008).There is thus the possibility of two or more crops in a year in warm climates, but challenges lie in growth synchronization i.e. uniform budburst (Lavee, 2000) and inconsistent yielding across the year (Dahal et al., 2014). The problem of poor and uneven budburst developing in subtropical regions due to insufficient chilling are considerable more severe than in the tropics and temperate regions.

This article is intended to explore the prospects of subtropical viticulture in Nepal, but for such a discussion, a brief understanding of grapevine physiology and a comparison of suggested practices with traditional climate viticulture are also made. In doing this, the lead author (currently engaged in a PhD program) summarises his experiences of table grape production in Australia.

Production Techniques in Warm Climates

Shifts of production from traditional climates towards the tropics have been accompanied by innovative management techniques. In tropical region, temperature does not limit the growth of the vine, hence, combination of pruning and harvesting practices alter the vine growth cycle. In hot and drytropical regions, double pruning with double harvest is possible, as buds are apt to sprout at any time of year. In wet tropical regions, where double prune to manage the vigorous vegetative growth, single harvest with double pruning is the general practiceand second harvest is not practical as coincides with rainy season (Souza Leao, 2014). In subtropical regions, similar to that in temperate, a single pruning during dormant stage and a single harvest are the accepted practice. Hence, the timing of management operations are quite different in different climates.

Vine reproductive cycle and physiology

The reproductive cycle of grapevine both in subtropical and temperate climates consists of a biennial process (two seasons) from inflorescence initiation to berry maturity. Season one includes flower induction, initiation and early differentiation.In season two,differentiation at budburst, followed by flowering to berry ripening (Carmona et al., 2008).The potential yield of a vine is largely determined approximately 15 months and 18 months before berry harvest in subtropical and temperate climates, respectively (Fig. 2). The subtropical climate is characterized by long dry hot summers and relatively short cool winter. In such climate, the suboptimal chilling due to brief dormancy condition will lead to poor bud burst with subsequent yield penalties. Vine management practices that break dormancyand cause synchrony in subsequent growth are vital to subtropical grape production (Lavee, 1984; Shulman et al., 1983).

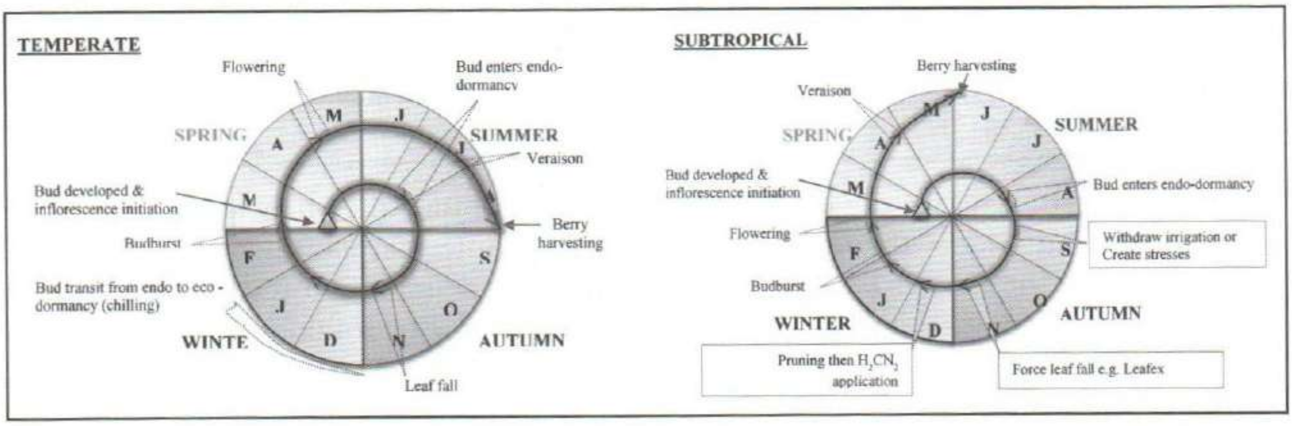

Figure 2. Reproductive growth cycle and key management of temperate and subtropical viticulture in the northern hemisphere (Modified from Considine, 2014)

Regulation of Budburst in Subtropical Viticulture

The key regulators of bud dormancy are temperature, especially accumulated chilling time, and photoperiod (Carmona et al, 2008; Fennell and Hoover, 1991). The application of a bud breaking chemical(e.g. hydrogen cyanamide)as well as time of pruning,temporary stresses (e.g. drought, nutrient deficiency/excess etc.), and forced defoliation of leaves (e.g. sodium chlorate) are important practices to increase and synchronise budburst in subtropical climate (Halaly et al., 2008; Keller, 2010; Lavee and May, 1997).

Use of Bud Breaking Agent

The responses of grapevine tobud breaking agents is unique. Hydrogen cyanimide (HC) which was developed for breaking dormancy in grapevines (Lavee et al., 1984; Shulman et al., 1983) is most efficient whereas other standard dormancy breaking agents like Dinitro-ortho-cresol (DNOC) andthioureahave only a weak or no effect on grapevine bud opening (Nir and Lavee, 1993). Dormex® (a.i. HC) is used to for the purposes of releasing buds from dormancy as well as to enhance a more uniform and rapid bud opening (Halaly et al., 2008). HC is appears to stimulate respiratory and oxidative stress through the perturbation in the activity of cytochrome pathwayin the mitochondria that leads to break of bud dormancy (Nir and Lavee, 1993; Vergara et al., 2012), however, the mechanism of action and interaction between respiration, cell cycle regulation and oxidative signalling has not been completely elucidated.

Timing of Hydrogen Cyanamide Application

HC application is effective and relatively cheap, and its effectiveness depends on stage and depth of dormancy, concentration, temperature at time of application and method of application.Most buds are more responsive to the pruning stimulus just before bud opening in the spring, but optimal pruning time or the earliest pruning date which will induce a uniform bud opening is important to achieve maximal precocity. Early application of HC may advance fruit maturity by 2-3 weeksbut yield may be decreased because of increased floral abscission and reduced cluster number(McColl, 1986; Shulman et al., 1985) and smaller cluster weight (Or et al., 1999). HC applied8-10 weeks before natural budburst advanced fruit maturity by 14-18 days, however HC application 4-6 weeks before natural budburst had little or no effect on time of berrymaturity(George et al., 1988). Early pruning is followed a month later by a Dormex® (a.i. HC) treatment produced a considerable higher yield than if sprayed at pruning time (Lavee and May, 1997).A recent studyin Western Australia showed that timely application of HC advances the budburst ~20 days as compared to control in Crimson Seedless cuttings where late application had a negligible or negative effect on bud burst response (Velappan et al., 2014).

Doses of Hydrogen Cyanamide

The effective concentration of HC varies with application date (days before natural budburst), bud physiological stage and genotypes but a general recommended doses of HC for table grape varieties is 2% v/v a.i. with non-ionic surfactant by using coarse droplet spray with nozzle pressure <40 psi. The effectiveness of HC 2% is considered at near lethal dosages (Fuchigami and Nee, 1987) for temperate woody perennials, but Siller-Cepeda et al. (1994) did not observe any negative impact on grapevine growth and yield when treated with up to 8% a.i. of HC at pruning, 5, 10 or 15 days after pruning. Dokoozlian (1998) suggested that the doses of HC could be increased or reduced depending on the ratio between the exposure of chilling temperature (<7 0C) and chill-negating temperatures (hours >200C).

Table Grapes in Nepal

Background

Worldwide, table grape consumption is increasing, as part of a trend towards 'convenience' fruit (small fruit that can be consumed without cutting). For Nepal, potential 'quantity' markets exist in northern India and Tibet, accessible by land transport and premium 'quality' markets exist in the Middle East countries, accessible by airfreight. Table grapes enjoy modest popularity with consumers in Nepal. The Nepalese table grapes demand is largely met by supply from India. Nepal imported 10,845 tonnes of table grapes during 2012, increasing from 1,439 tonnes in 2009 (http://faostat3.fao.org/browse/T/TP/E). Nepal has never exported grape.

Grape cultivation in Nepal is believed to have been started within the Rana regime (>70 years ago). Small vineyards on government's research stations/farms were established in temperate and warm temperate climates from 1968 AD (2025 BS) (Aatreya et al., 2015). However, viticulture has not been prioritized and there is effectively no commercial table grape production in Nepal. Monsoon associated diseases are believed to be the major limitations to production in the terai and mid-hills. Technology development and variety evaluation project was initiated in eastern terai part (wet subtropical) of Nepal during late 1980's (Shrestha, 1996). Varieties were heavily infected by diseases and research activities were shifted during the early 1990's from the eastern terai to the western terai i.e. Regional Agriculture Research Station (RARS), Banke, an area of comparatively drier subtropical climate (Shrestha, 1998).

Currently two vineyards located at temperate region (Marpha farm, Mustang; lat. 28°44'N, alt. 2677 masl), and warm temperate region (Centre horticulture farm, Kathmandu; lat. 27°4'N, alt. 1289 masl) under ministry of agriculture have been serving as resource centres for propagules; and one vineyard located at Khajura, Banke (lat. 28°06'N, alt. 149 masl) under Nepal agriculture research council developed as research centre for warm climate grape research. Cultivars like Thompson Seedless and Perlette gave earliest production of the nine cultivars tested in western terai (Joshi, 1998), but these cultivars were also heavily impacted by anthracnose diseases during the rainy season (Shrestha, 1996). Centre horticulture farm, Kathmandu identified Stuben, Muskut Berry, Kyoho and Black Olympia as promising cultivars but the quality of first two varieties were not preferred, while latter two varieties suffered various disease issues (Sakuma, 1995). The suggested production technology to for insect-pest reduction was bagging of bunches along with regular spraying of pesticides during rainy season, but these practices are labor intensive and costly. Current activity is limited to propagation and evaluation of varieties of a narrow variety base. Resource centres have been producing and distributing ~2000 cuttings of varieties (Perlette, Beauty Seedless, Himrod, Steuben etc.) every year for home garden and small scale orchard use. However, with minimum vineyard maintenance especially during the insurgency period much of the germplasm is now unproductive (RARS, 2012). Estimated area under grape cultivation is ~20 ha (including vines in home garden) with estimated total fresh production of 76 tonnes per annum in Nepal (Aatreyaet al., 2015).

Another constraint to the development of this industry is the high initial investment to establish a vineyard. Thus the industry requires an investor and co-operative or contract farming model, rather than involvement of low economic status small scale Nepalese farmer.

Prospects of Subtropical Climate Viticulture in Nepal

Nepal has a diversity of agro-climatic zones in which viticulture could be practiced. Remote high hill areas, e.g. Mustang, are not suitable for commercial table grape production given inaccessibility to large markets. Considering the production capacity, mechanization and proximity to market, subtropical climate of western terai is potential to expand commercial viticulture. In this area, winters are cold and foggy, and summers are hot and dry (minimum and maximum temperature 4.7oC and 43.3oC during winter and summer months respectively whereas relative humidity remains 45% to 95% at RARS, Khajura, Banke). In general, monsoon rains arrives on the third week of June and continues until September, with an average annual rainfall of around 920 mm. Occasional light rains can also be experienced during winter and May. The average minimum daily temperature starts to rise i.e. >10oC which is higher than the commonly accepted base temperatures (8.7oC; Oliveira, 1998)for grapevine budburst. There is potential for grape harvest to be finalised before start of the rainy season, with bud burst during the third and fourth weeks of February.

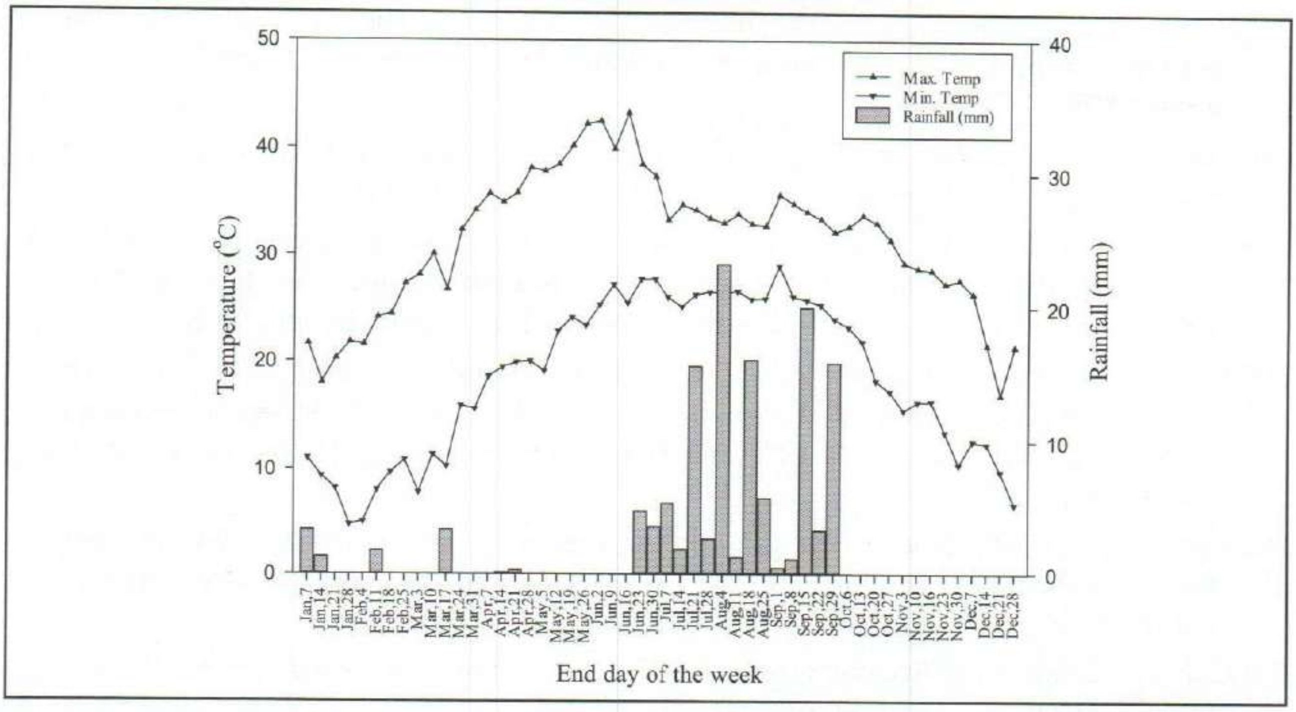

Figure 3. Weekly average temperatures and rainfall of 2011, RARS, Banke, Nepal

We contend that both a domestic and export market can be developed for table grapes. However, as a perennial crop, a dedicated viticulturist and technical staff are required to support the development of Nepalese viticulture. High table grape productivity (av. of 30 t/ha; Shikhamany, 2006) has been achieved in north-western India (lat. 280-320 N) which has similar agro-climate to south-western part of Nepal, and there is opportunity to acquire these skills and technologies for viticulture in Nepal.

Recommendations

Rainfall during the harvest period is a major constraint to production. The western terai is recommended for its drier climate however the window for production is short, and successful production would require vine growth management practices to ensure harvest well before the monsoon. We recommend establishment of trail vineyards in Banke and Bardiya districts of western terai, involving the early varieties Perlette, Flame Seedless, Beauty Seedless and Emerald Seedless, with comparative trials of vineyard management practices such as the use of hydrogen cyanimide for artificial induction of bud dormancy release (~4-6 weeks), use of defoliants and controlled irrigation to control vigor and excess growth, use of a telephone trellis training system and use of machinery for effective spray of hormones and pesticides for the development of a table grape industry. We suggest future research aims at early and uniform budburst to shift the harvesting time well before monsoon and vine protection strategies during heavy rainfall period.

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