Summer 2018

The Identification of Interspecific Hybrids between Jaeger 70 X Vignoles Grapes Using SSR Markers

Carl William Knuckles IV
Missouri State University, Knuckles1985@live.missouristate.edu

THE IDENTIFICATION OF INTERSPECIFIC HYBRIDS BETWEEN JAEGER 70 X VIGNOLES GRAPES USING SSR MARKERS

A Master's Thesis

Presented to

The Graduate College of

Missouri State University

In Partial Fulfillment

Of the Requirements for the Degree

Master of Science, Plant Science

By

Carl William Knuckles IV

August 2018

THE IDENTIFICATION OF INTERSPECIFIC HYBRIDS BETWEEN JAEGER 70 X VIGNOLES GRAPES USING SSR MARKERS

Environmental Plant Science and Natural Resources

Missouri State University, August 2018

Master of Science

Carl William Knuckles IV

ABSTRACT

Jaeger 70 cultivar is an interspecific hybrid of *Vitis linececumii* x *Vitis rupestris*, with an interesting past. It was created by Hermann Jaeger of Neosho, MO, who is most notable for saving the French wine industry by developing phylloxera resistant rootstocks in the mid-1800s. Traditionally the Jaeger 70 variety has been grafted to French wine grape cultivars to impart disease resistance and cold hardiness while retaining desirable wine characteristics. One interesting characteristic of Jaeger 70 is that it is a female-only plant, allowing for many interesting areas of study. *Vitis* interspecific hybrid Vignoles, is a cold hardy cultivar of largely unknown parentage which produces high quality sweet fruity wines. Vignoles, however, produces compact clusters that are susceptible to bunch rot. In comparison, Jaeger 70 produces a moderately compact berry cluster which is highly resistant to bunch rot. The purpose of this study was to screen 508 progenies for hybrid confirmation of an F_1 interspecific hybridization of Jaeger 70 x Vignoles using SSR (Simple Sequence Repeat) markers enabling rapid creation of a mapping population. This study successfully identified 12 SSR markers for the testing of Jaeger 70, Vignoles and their offspring for hybrid confirmation. Out of the 508 possible Jaeger 70 x Vignoles progeny, 346 plants (68.1%) were determined to be true hybrids. Hybrid confirmation using SSR saves time, money, labor and materials due to not needing to maintain plants until maturity (3 to 5 years). Developing a mapping population is an important first step in a breeding program.

KEYWORDS: Jaeger 70, Vignoles, molecular breeding, ssr, microsatellite, Hermann Jaeger, hybrids, vitis, Munson

This abstract is approved as to form and content

_____

Chin-Feng Hwang, PhD
Chairperson, Advisory Committee
Missouri State University

THE IDENTIFICATION OF INTERSPECIFIC HYBRIDS BETWEEN JAEGER 70 X VIGNOLES GRAPES USING SSR MARKERS

By

Carl William Knuckles IV

A Master's Thesis
Submitted to the Graduate College
Of Missouri State University
In Partial Fulfillment of the Requirements
For the Degree of Master of Science, Plant Science

August 2018

Approved:

_____
Chin-Feng Hwang, PhD

_____
William McClain, PhD

_____
Li-Ling Chen, MS

_____
Julie Masterson, PhD: Dean, Graduate College

ACKNOWLEDGEMENTS

I would like to thank the following people for their support during my graduate studies. My committee members Chin-Feng Hwang, Li-Ling Chen, and Will McClain. Also, fellow lab members Surya Sapkota, Jacob Schneider, Rayanna Bailey, Sadie Land, and Karlene Negus. Finally, my parents Bill Knuckles, and Anita Knuckles, and my siblings Carter Knuckles, Ben Knuckles, and Samantha Oryshyn.

I dedicate this thesis to my grandmothers: Eloise Knuckles and Mary Ursery.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

According to the earliest archeological evidence, signs of humans domesticating grapes and grapevines date back 6000 to 8000 years (Myles et al., 2011). Since then, the grapevine and its fruit have come to symbolize many different things. The genus name for the grape is *Vitis*, which is derived from the Latin word *vita* meaning "for life" (Whitaker, 1993). This name was earned through the grape's use for nourishment, medicine, and recreation. The Greek philosopher Socrates enjoyed recreational use in the form of wine at "symposiums", a Greek-based word meaning a drinking party where ideas were discussed (Estreicher, 2006; Stevenson, 2010).

Grape products come in many forms, such as table grapes, raisins, juice, jams, jellies, and wine (Tordsen, 2015). In terms of production, grapes are ranked as one of the top five fruits in the world with an average of 81.7 million tons produced in 2014 (FAO-OIV FOCUS 2016, 2016; "FAOSTAT," 2017a). Out of the 81.7 million tons of grapes, 32.1 million went into wine production, which made up the largest utilization of the harvest ("FAOSTAT," 2017a, "FAOSTAT," 2017b). Table grapes (fresh grapes) consume the next highest use of grapes, with a global production of 29.8 million tons in 2014 (FAO-OIV FOCUS 2016, 2016). Raisins comprised the smallest amount of worldwide production in 2014 equaling 1.5 million tons (FAO-OIV FOCUS 2016, 2016).

Wine has been a popular and revered substance throughout history; it is mentioned in many religious texts including the Bible and Qur'an (Estreicher, 2006; Mullins et al., 1992). There were also several mythological deities who were patrons of wine, including Osiris, and Dionysus, (Mullins et al., 1992; This et al., 2006). Making

wine from grapes can be an accidental process due to the yeast found on the grapes skin. When this yeast comes into contact with the grape juice, and the right environmental conditions, fermentation begins. This miraculous process transforms the sugar in the juice to alcohol and carbon dioxide. This, along with the grape berries' other components, make up what we know as wine (Estreicher, 2006).

Wines popularity has grown to this day; in 2016, over one million acres of grape (table and wine) vineyards existed in the United States (USDA, 2017). On these, an average of 7.57 tons per acre of wine grapes were produced. This created 4.6 million tons of wine, with a value of $906 per ton (USDA, 2017). Wine grape production in the United States is important, as it contributes about $4.2 billion to the economy (USDA, 2017).

Humans began to practice selection for desirable traits in plants around 13000 to 10300 years ago (Kingsbury, 2009). Yield increased, pest resistance and ease of harvest were some of the first traits selected for breeding (Brown et al., 2014). Since then, many new tools and technologies have come about giving the modern plant breeder huge advantages. Advances in biotechnology, since 1953, have allowed breeders to screen a plant using genetic markers thus creating a unique fingerprint for individual plants and making it easier to find desirable traits (Neidle, 2008). These advancements can help modern plant breeders face the challenges of environmental stress and meet the needs of the ever growing world population (Alix, 2009; Brown et al., 2014).

Plant Breeding

Plant breeding is the act of improving horticultural and agricultural crops by selecting for desired traits and crossing according to genetic principals ("Plant Breeding," 2017). The earliest signs of plant improvement by humans was from 13000 to 10300 years ago, this was determined by archeological finds such as; sickle blades, mortars and pestles, and storage capabilities (Kingsbury, 2009). The domestication of wild plant varieties took place at relatively the same time, in several locations around the world (Alan B. Bennett, 2010). Around the period of 10300 to 7500 years ago, another great advancement in plant breeding was occurring, newly discovered wild varieties were then knowingly or unknowingly selected by seed selection, for specific traits allowing for the eventual domestication of the crop (Alan B. Bennett, 2010; Kingsbury, 2009). After these initial advancements in plant breeding, improvements to crops progressed at a much slower rate until the Age of Enlightenment (17^{th} and 18^{th} centuries) (Alan B. Bennett, 2010; Kingsbury, 2009).

During the Age of Enlightenment humans started to systematically experiment with pollenization techniques, allowing for better understanding of hybridization and the discovery of hybrid vigor (Alan B. Bennett, 2010). It wasn't until Gregor Mendel's work in the mid-1800s, that the idea of non-environmentally influenced trait inheritance could be predicted using statistics (Alan B. Bennett, 2010; Kingsbury, 2009). This led to Mendel's Laws of Inheritance, which formed the guidelines followed by future breeders (Alan B. Bennett, 2010; Kingsbury, 2009). Mendel's work was largely forgotten until the early 1900s, when it was rediscovered by multiple scientists experimenting with plant and animal breeding. It was several decades before his work was widely accepted

(Kingsbury, 2009). These advancements in thinking, practice, and technology formed the basis of what is known as traditional breeding, or classical breeding (Scaboo et al., 2010).

Molecular Breeding

Plant breeding continued to evolve with the discovery of the structure of DNA in 1953 (Neidle, 2008). This eventually paved the way for development of new techniques such as molecular breeding ("Plant Breeding," 2017). Molecular breeding is traditional breeding with the aid of DNA markers for the selection process. Utilizing newer methods breeders can use genetics to select for plants with desired traits while still in their seedling stage. When compared to using traditional breeding techniques alone, DNA markers greatly reduce the time needed to evaluate traits (Van Nocker and Gardiner, 2014). Utilizing molecular markers alongside of traditional breeding methods, breeders have been able to increase genetic diversity, while keeping desirable traits to meet the ever increasing performance demands being placed on plants (Kingsbury, 2009).

Molecular markers can reveal variations based on specific DNA sequences which vary by a few nucleotides between individual trees (Jones et al., 1997). This ability is why they are heavily utilized in the research of staple crops such as corn and soybean, and are more recently being applied in research of specialty crops like walnuts and grapevine (Di Gaspero et al., 2011). In grapevine research, molecular markers have been used to assess genetic relationships between species, cultivars, and varieties (Bautista et al., 2008). They have been utilized in grape research since the 1970's, and from this time to current day, several marker types have been developed; restriction fragment length polymorphism (RFLP), random amplified polymorphic DNA (RAPD), amplified

fragment length polymorphism (AFLP), single nucleotide polymorphism (SNP), and simple sequence repeat (SSR) (Adam-Blondon et al., 2011).

The traits of the SSR marker match well with the goal of hybrid confirmation of Jaeger 70 x Vignoles possible F1 progeny which is why they were chosen for this study. These markers are also known as microsatellites, which are repeats of 1 to 10 nucleotides long and can be highly polymorphic (Vieira et al., 2016). The ability to show polymorphism or differences in a specific DNA sequence is why SSR markers are used in hybrid confirmation (National Institutes of Health, 2018; Vieira et al., 2016). SSR markers are highly abundant in plant genomes and can be amplified by PCR. Transferability in, and between species and progeny, and ability to show codominance and high polymorphism in grapes is important to this studies goals(Adam-Blondon et al., 2011; Aradhya et al., 2003; Morgante et al., 2002). Based on previous research, SSR markers have proven a reliable means of hybrid identification in grapes (Adam-Blondon et al., 2011; Adhikari et al., 2014; Aradhya et al., 2003; Morgante et al., 2002).

Hermann Jaeger

One of the most famous American grape breeders is Hermann Jaeger. Jaeger, a swiss born immigrant, received viticulture training in Germany and France before settling on a farm in Newton county, Missouri in 1865 (Christensen et al., 1999). He and several of his contemporaries, are credited with saving the French wine industry from phylloxera, which at the time was decimating the industry (Christensen et al., 1999). In the late 1870s and 1880s, Jaeger sent phylloxera resistant rootstocks to France, allowing the for the European *Vitis vinifera* to be saved from destruction (Christensen et al., 1999). For his

efforts, Jaeger was awarded the cross of the Legion of Honor by the French Government in 1889 (Christensen et al., 1999; McLeRoy and Renfro, 2004).

Once settled in Missouri, Jaeger noticed the non-native grape cuttings he had brought with him were not hardy, falling victim to many pest, such as downy mildew, powdery mildew, and phylloxera (Christensen et al., 1999). Jaeger took notice that the native grapes were unaffected by these pests, and began collecting samples (Christensen et al., 1999). Over the span of twenty years Jaeger had observed more than ten thousand wild plants, determining that less than half a dozen were suitable for breeding (Munson, 1900). Jaeger's breeding program developed over one hundred different cultivars, based off a maternal Jaeger 43(Christensen et al., 1999; Munson, 1900). Two of his wild grape varieties stood out, Neosho and Jaeger 43, both were Post-Oak (*Vitis linececumii*) varieties and were the foundation of Jaeger's breeding program (Munson, 1900).

Jaeger 70

The Jaeger 70 cultivar was developed by Jaeger in the 1880s. It was a cross between his best wild varieties of Jaeger 43, and a male *Vitis rupestris,* which created a vigorous, hardy, and healthy female only plant (Munson, 1909). Both of Jaeger 70's parents were found in the early 1880s, growing wild in southwest Missouri, where they were found to be thriving even when exposed to many different pests (Di Gaspero et al., 2012; Munson, 1909). Hermann Jaeger bestowed upon this grape cultivar the name Munson after one of his contemporaries, Thomas Volney Munson, also a celebrated American grape breeder (Munson, 1909). Jaeger 70 became one of the most used varieties when creating what is known as the French-American hybrids (Di Gaspero et

al., 2012; Stafne, 2012). In the 1880's, Jaeger 70 was imported into France for use as a rootstock to combat the phylloxera epidemic plaguing the French wine industry (Stafne, 2012). During its utilization as a rootstock several notable French viticulturist, such as Seibel, Bertille Seyve, Joannes Seyve, Galibert, and Landot realized the value of Jaeger 70's disease resistance to phylloxera, downey mildew, and black rot, and began to hybridize it with non-resistant *Vitis vinifera* cultivars (Di Gaspero et al., 2012; Reisch, 2013; Stafne, 2012).

The maternal plant of Jaeger 70, Jaeger 43 (*Vitis linececumii*) was ideal for breeding due to it possessing a female only flower with recurved stamen incapable of self-pollenization, rendering the stamen effectively sterile (Munson, 1909). This removed the need of having to remove flower stamen, which is time consuming and could lead to self-pollenization, as the case would be in hermaphroditic flowers (Munson, 1909). Beside possessing an only female flower and insect resistance, the variety is extremely resistant to drought, but can show tolerance to mildew and rots (Munson, 1909). The vine is vigorous, but hard to propagate from cuttings, usually flowering from May 12th to May 20th and produces a very large moderately compact cluster of medium sized black berries ripening very late (Munson, 1909). These berries have thin tough skin with small seeds, and tender flesh (Munson, 1909). At one point Jaeger 43 was thought to have been lost, but it has been recently found in its original state in Japan (Hively, 2012).

The paternal plant of Jaeger 70 is a male *Vitis rupestris*, which is very vigorous and can easily pollenate many other *Vitis* species (Jaeger, 1881; Munson, 1909). Cuttings and seeds taken from *V. rupestris* are easy to propagate (Munson, 1909). *V. rupestris* germinates and matures very early, only growing to about four to eight feet tall (Munson,

1909). The plant thrives in moist sandy, and alluvial soil types allowing for it to handle climate change easily, except when it encounters a drought (Munson, 1909). In addition, *V. rupestris* is resistant to black rot and other pests, and tolerates anthracnose (Munson, 1909).

Jaeger 70, a female only vine, contains some of the best traits of its parents, being extremely drought tolerant, cold hardy to below -27°F without showing injury, and resistant to mildews, rots and insects (Munson, 1909). The plant is vigorous and healthy, flowing from May 10th to May 15th (Munson, 1909). Jaeger 70 is capable of bearing an immense crop if it is well pollinated, the clusters produced will be medium in size, with black colored medium sized berries (Munson, 1909). The berries ripen in the middle season when compared to other varieties and are capable of producing a fine red wine (Munson, 1909).

Vignoles

The Vignoles grape cultivar, also known as Ravat 51, originates from France, bred by J. F. Ravat. It produces a fruity wine (Brooks et al., 1997; Smiley, 2016). This cultivar has a complex, and at this time unknown parentage, but was thought to have been created in the 1930s (Bautista et al., 2008; Brooks et al., 1997; Smiley, 2016). Vignoles was introduced into the United States in 1949 under the names P17857 and 181481 ("Foundation Plant Services," 2018). In 1970 the Finger Lakes Wine Growers Association gave this cultivar the name Vignoles (Galet, 1979).

Vignoles, produces a white berry with a pink and green tint (Brooks et al., 1997; Smiley, 2016). The vine's hermaphroditic flowers produce tight cluster of small sized

berries (“Foundation Plant Services,” 2018; Smiley, 2016). The berry possesses a thick skin with the potential to crack, and juicy flesh that can be high in sugars and acidity (Brooks et al., 1997; Smiley, 2016). The vine itself is moderately vigorous, cold hardy, and productive (Brooks et al., 1997; Smiley, 2016). Vignoles is cold tolerant -10°F to -15°F (Smiley, 2016). This cultivar is susceptible to many pest: botrytis bunch rot, anthracnose, and downy mildew, crown gall, powdery mildew, eutypa dieback, phomopsis and black rot. (Hed et al., 2009; Smiley, 2016). Vignoles does possess an interesting tolerance to 2,4-D and dicamba (Smiley, 2016).

Study Overview

The purpose of this study was to screen 508 F_1 progenies of a Jaeger 70 x Vignoles cross for possible interspecific hybrids using SSR (Simple Sequence Repeat) markers. The purpose of crossing Jaeger 70 with Vignoles is to create a mapping population with end goal is to create a superior hybrid by combining the disease resistance and cold hardiness of the Jaeger 70 with the superior wine quality from Vignoles. Plant crosses made within the *Vitis* genus can result in true hybrids, but outcrossing may occur, leading to the need for hybrid confirmation (Adhikari et al., 2014). Hybrid confirmation in this way can result in the saving of time, money, labor and materials of maintaining plants until they are mature (3 to 5 years). Developing this mapping population is an important first step in a breeding program.

MATERIALS AND METHODS

Study Design

For this study, two separate crosses between the female only maternal plant, Jaeger 70, and the paternal plant, Vignoles were made at Post Familie Vineyards in Altus, Arkansas. The F_1 progeny (n=508) were tested for hybrid status by extracting DNA obtained from seedling leaf tissue. The DNA was amplified with SSR primers by PCR (Polymerase Chain Reaction). The PCR product was checked using agarose gel electrophoresis. Capillary electrophoresis was used to determine exact allele sizes, allowing for the comparison of the parents against the progeny and confirmation of hybrid status.

Plant Materials

Two separate cross pollinations were made between Jaeger 70 (maternal) and Vignoles (paternal), in May 2014, and May 2015 respectively, both using pollination protocol detailed by Adhikari et al. (2014). The May 2014 cross pollination event was done using a Jaeger 70 as a maternal plant with pollen from Vignoles 1, both were provided by Post Familie Vineyard. The May 2015 cross pollination event was done using a Jaeger 70 maternal plant provided by Post Familie Vineyard, and pollen from Vignoles 2 was obtained from the Missouri State Fruit Experiment Station. During harvest, seeds were extracted from the fruit, and floated in water to test for germination viability (Mann, 2016). Seeds that floated were thrown out (Mann, 2016). The viable seeds that remained were cold stratified for three months at 4°C in a media of sterilized sand (Mann, 2016). The seeds were planted and germinated in a greenhouse at Karl's

Hall on the Missouri State University Campus over the course of three years. In the early spring of 2015 all seeds of the May 2014 cross pollination event were planted and allowed to germinate in the greenhouse at Karl's Hall on the Missouri State University Campus. The seedlings were then moved to Missouri State Fruit Experiment Station in Mountain Grove, MO in May 2015, and kept in a shade house until transplant into the field in the fall of 2015. This process was repeated over the next two years (2016, 2017) with seeds from the May 2015 cross pollination event. The May 2014 cross pollination event produced 115 progeny, and the May 2015 cross pollination event produced 389 (2016 - 248 plants, 2017 - 145 plants) progeny for a total of 508 F_1 possible interspecific hybrids. During the study some of the possible progeny died and were discontinued from further use in the study. Due to the plant death and limited resources the field population was relabeled two separate times October 2016, and September 2017.

DNA Extraction

At the seedling stage, a 50 mg sample of plant leaf tissue was obtained from each of the progeny. A 50 mg sample was also obtained from each parent. DNA was extracted from each sample and isolated with a Synergy™ 2.0 Plant DNA Extraction Kit (OPS Diagnostics LLC, Lebanon, NJ) following a modified manufacturer provided protocol. The modified protocol is as follows:

- 50 mg of leaf tissue combined with 500 µL of Plant Homogenization Buffer was combined in a 2 ml Synergy homogenization tube
- Homogenization tube was placed into the bead beater and ran for 6 minutes or until adequately processes, which is when the tube lacked foam inside.
- The homogenized sample was then centrifuged at 15,000 x g for 7 minutes to grind resin and remove contaminates
- The clear supernatant was then transferred into a 1.5 ml Eppendorf tube

- 3 µL of RNase A Solution was added to the supernatant to produce RNA-free DNA, this was then Vortexed and placed in a heating block at 37°C for 15 minutes
- The total volume of the supernatant and RNase A Solution was then measured, 70% of the volume of 100% isopropanol was then added, vortexed, and placed in a freezer at -20°C for 15 minutes
- The solution was transferred into a spin column, which was inserted into a collection tube, and centrifuged at 8000 x g for 1 minute to bind DNA to the column
- The spin column was then washed with 250 µl of ice cold 70% ethanol and centrifuged at 8000 x g for 1 minute, this step was repeated
- The washed spin column was placed into a clean Eppendorf tube and eluted with 100 µl of sterile DI water
- A second elution was repeated with varying amounts of sterile DI water depending on leaf tissue quality

The isolated DNA was then tested to determine concentration with a NanoDrop spectrophotometer (Thermo Fisher Scientific, Waltham, MA). Once DNA concentrations had been determined the samples were diluted to 15 ng/µL, and preserved at -20°C for future use.

Development of SSR Markers for Jaeger 70 x Vignoles

Thirty-seven different SSR markers, and eight EST-SSR markers were selected from genomic databases and previously published papers as possible markers to screen the identity of the F_1 population against the parents (Adhikari et al., 2014; Bautista et al., 2008; Ganesch, n.d.; NCBI, 2016). Markers were initially screened on six of the possible F_1 interspecific hybrids and one of each parent as outlined by (This et al., 2004).

Forty-five total markers showed bands, twelve were able to be amplified successful by PCR, and show polymorphism. These twelve markers were used to screen the parents, Jaeger 70, Vignoles 1 and Vignoles 2 by capillary electrophoresis, and their peak patterns were analyzed and recorded (Fig. 1-6). The 508 possible Jaeger 70 x

Vignoles progeny were screened using a combination of up to twelve SSR marker. All possible Jaeger 70 x Vignoles seedlings and parents were screened with nine of the twelve SSR markers, VMC2B3, CTG5780, VVIV69, VMC5A1, VRIP93, CTG5955, AF8125, VMC4D9.2, andPSCTG196_2. These nine markers showed a robust pattern, sufficient for the screening process.

PCR Amplification and DNA Fragment Analysis

SSR marker alleles were amplified by PCR based on a modified protocol described by Adhikari et al., (2014) using a 8.4 µL volume per reaction. The PCR reaction volume was comprised of:

- 0.8 µL of H_2O
- 0.8 µL at 15ng / µL of DNA template
- 0.8 µL of 0.1 µM of forward primer
- 0.8 µL of 2 µM of reverse primer
- 0.8 µL at 2 µM of M13 WellRed Primer
- 0.2 µL at 25 mM of $MgCl_2$
- 4.2 µL of AmpliTaq GoldR 360 Master Mix buffer (Thermo Fisher Scientific, Waltham, MA)

Touchdown PCR protocol utilized to amplify the DNA consisted of:

- 1 cycle:
    - Initial denaturation stage: 95°C for 10 minutes
- 10 cycles of touchdown:
    - Denaturation stage: 94°C for 30 seconds
    - Annealing stage: 62°C for 30 seconds, consecutively decreasing 1°C each cycle
    - Extension Stage: 72°C for 1 minute, consecutively decreasing 1°C each cycle
- 24 cycles:
    - Denaturation stage: 94°C for 30 seconds
    - Annealing stage: 62°C for 30 seconds
    - Extension Stage: 72°C for 1 minute
- Final extension stage: 72°C for 7 minutes.

Three µL of PCR product were loaded into a 1.5% agarose gel for visual confirmation under UV light to check for a successful reaction, and to determine quantities to be used in capillary electrophoresis (Bio-Rad, Hercules, CA).

Capillary electrophoresis was preformed using a GenomeLab GeXP Genetic Analysis System (Beckman Coulter, Brea, CA). A standard DNA ladder 400bp (base pairs) in size was used as a control. This was also combined with a Sample Loading Solution and predetermined quantity of the PCR product for analysis. Multiplexing was used to analyze nine to eleven PCR products concurrently. The Fragment Analysis Module within the GenomeLab GeXP Genetic Analysis System software was utilized to determine allele sizes. Once allele sizes were found in the hybrids and parents, they could be comparatively assessed allowing for verification of hybrid status. The possible progeny were broken into 4 categories, Dead (plants that had died before May 2017 and further testing was no longer continued), Not True (plants do not match allele sizes in paternal plants), Vignoles 1, and Vignoles 2 (plants that are true hybrids containing matching maternal and paternal allele size were further analyzed to determine which was the paternal plant). A confirmation of a positive F_1 interspecific hybrid of Jaeger 70 x Vignoles, required the individual to show a mixed heritage in all SSR markers.

RESULTS

It was revealed during screening that two different genotypes of Vignoles were used as parental plants. Previously only one genotype of Vignoles was thought to be the parental plant. A pattern emerged relating to progeny from the May 2015 cross pollination event. The May 2015 cross pollination used the maternal plant Jaeger 70 of Post Familie Vineyard in Altus, AR and pollen from the paternal plants came from Vignoles of Missouri State University Fruit Experiment Station in Mountain Grove, MO (Table 1). Further testing of paternal plants Vignoles at Missouri State University Fruit Experiment Station showed two different genotypes of Vignoles were used. These were then labeled Vignoles 1, and Vignoles 2. Vignoles 1 from Missouri State University Fruit Experiment Station and the Vignoles used to pollenate the cross in May 2014 from Post Familie Vineyard match all marker allele sizes 100%, whereas Vignoles 2 only showed up in the May 2015 cross. Vignoles 1, and Vignoles 2 match allele sizes 100% in markers VMC2B3, UDV-021, VMC1C10 and AF8125, in markers CTG5780, and VRIP93 allele sizes match 50%, while markers VMC4D9.2, CTG5955, VMC5A1, VVIV69, VMC4D2 and PSCTG196_2 are 100% polymorphic (Table 2).

Therefore, these nine SSR markers were selected due to their amplification by PCR, being codominant and polymorphic. Markers selected were: VMC4D9.2, VMC2B3, AF8125, CTG5780, CTG5955, VMC5A1, VVIV69, VRIP93, and PSCTG196_2 (Table 3-4). Additionally, ninety-one additional samples were screened using three additional SSR markers VMC4D2, VMC1C10, and UDV-021 (Table 5).

Out of the 508 possible Jaeger 70 x Vignoles progeny, 346 plants (68.1%) were determined to be true hybrids (Table 4). From the 346 true hybrids, 330 (65.0%) were from the paternal plant Vignoles 1, and 16 (3.1%) were from the paternal plant Vignoles 2. Through hybrid confirmation 135 non-hybrids (26.6%) were found and were discontinued from further use along with 27 plants (5.3%) that had died before May 2017. Between May 2017 and September 2017, an additional 73 plants in the field had died reducing the number of true hybrids to 273, with 263 coming from the Vignoles 1 parent, and 10 from the Vignoles 2 parent.

DISCUSSION

A grapevine breeders' ability to create new cultivars is often limited by the time it takes for vines to mature and produce fruit (3 to 5 years). This delays the selection of desirable plant characteristics. This period can be reduced through creation of a mapping population via marker-assisted hybrid confirmation. This mapping population can then be used for construction of a linkage map when more markers are incorporated. A linkage map combined with phenotypic data (desirable and/or undesirable traits) can yield Quantitative Trait Loci (QTL), meaning traits can be associated with certain markers allowing marker assisted selection (MAS) to be applied early in the plant's lifecycle.

Using SSR markers and capillary electrophoresis has allowed for quick and efficient true hybrid confirmation of Jaeger 70 x Vignoles progeny. These methods have been applied previously to similar studies in other species, having proved reliable in hybrid confirmation (Adhikari et al., 2014). This study produced 346 true hybrids of Jaeger 70 x Vignoles out of a possible 508 progenies, or 68.1%. These results are similar to previous studies from which this studies methods are derived (Adhikari et al., 2014). There were 135 (26.6%) non-hybrid progeny that shared alleles with the female only Jaeger 70 (maternal), this indicates possible errors relating to pollination during the cross-pollination event. Rogue pollen may have fertilized the Jaeger 70 maternal plant through many means such as; wind, insects, animals and/or contaminated equipment.

Issues arose in this study due to the design, where two crosses were made with pollen from two different locations. This allowed for two different genotypes of Vignoles to be selected as the pollen source, therefore two different paternal Vignoles. More

extensive testing of the possible pollen donor, Vignoles, would have been ideal prior to cross-pollination. As the two different genotypes of Vignoles match 100% of alleles in VMC2B3, UDV-021, VMC1C10 and AF8125 markers, and 50% in CTG5780 and VRIP93, it went undetected in preliminary testing. The two genotypes of Vignoles at the Missouri State University Fruit Experiment Station at Mountain Grove, Missouri may have been caused by a mislabeled plant, or mutations. Multiple studies have shown clonal mutations are possibly related to transposable elements in somatic cells (Carrier et al., 2012; Moncada et al., 2006).

CONCLUSION

This study successfully identified 12 SSR markers for the testing of Jaeger 70, Vignoles and their offspring for hybrid confirmation. Using these markers allowed rapid identification and production of 273 live Jaeger 70 x Vignoles F_1 progenies for use as a mapping population. Possible further testing of "Vignoles 2" may be needed to determine if the plants are mislabeled or a mutation occurred. Along with other markers, the creation of this Jaeger 70 x Vignoles F_1 mapping population will allow for linkage map construction and future studies on traits of interest for discovery of QTLs.

REFERENCES

Adam-Blondon, A.-F., Martínez-Zapater, J.M., Kole, C. (Eds.), 2011, Genetics, genomics and breeding of grapes, Genetics, genomics and breeding of crop plants. Science Publishers ; Marketed and distributed by CRC Press, Enfield, NH : Boca Raton, FL.

Adhikari, P., Chen, L.-L., Chen, X., Sapkota, S.D., Hwang, C.-F., 2014, Interspecific hybrid identification of Vitis aestivalis-derived 'Norton'-based populations using microsatellite markers. Scientia Horticulturae 179, 363–366. https://doi.org/10.1016/j.scienta.2014.09.048.

Alan B. Bennett, 2010, A Plant Breeder's History of the World. Science 391.

Alix, K., 2009, Principles and practices of plant genomics. Volume 2: Molecular breeding. Annals of Botany 104, viii–viii. https://doi.org/10.1093/aob/mcp165.

Aradhya, M.K., Dangl, G.S., Prins, B.H., Boursiquot, J.-M., Walker, M.A., Meredith, C.P., Simon, C.J., 2003, Genetic structure and differentiation in cultivated grape, Vitis vinifera L. Genetical Research 81, 179–192. https://doi.org/10.1017/S0016672303006177.

Bautista, J., Dangl, G.S., Yang, J., Reisch, B., Stover, E., 2008, Use of Genetic Markers to Assess Pedigrees of Grape Cultivars and Breeding Program Selections. Am. J. Enol. Vitic. 59, 248.

Brooks, R.M., Olmo, H.P., Brooks, R.M., 1997, Brooks and Olmo Register of Fruit & Nut Varieties. ASHS press.

Brown, J., Caligari, P.D.S., Campos, H.A., 2014, Plant breeding. Hoboken, NJ : John Wiley & Sons Ltd, 2014.

Carrier, G., Le Cunff, L., Dereeper, A., Legrand, D., Sabot, F., Bouchez, O., Audeguin, L., Boursiquot, J.-M., This, P., 2012, Transposable Elements Are a Major Cause of Somatic Polymorphism in Vitis vinifera L. PLoS ONE 7, e32973. https://doi.org/10.1371/journal.pone.0032973.

Christensen, L.O., Foley, W.E., Kremer, G., 1999, Dictionary of Missouri Biography. University of Missouri Press.

Di Gaspero, G., Canaguier, A., Jusseaume, J., Tassin, J., Lemainque, A., Thareau, V., Adam-Blondon, A.-F., Testolin, R., 2011, Molecular linkage maps: strategies, resources and achievements. Genetics, Genomics and Breeding of Crop Plants. 2011, 111-136.

Di Gaspero, G., Copetti, D., Coleman, C., Castellarin, S.D., Eibach, R., Kozma, P., Lacombe, T., Gambetta, G., Zvyagin, A., Cindrić, P., 2012, Selective sweep at the Rpv3 locus during grapevine breeding for downy mildew resistance. Theoretical and applied genetics 124, 277–286.

Estreicher, S.K., 2006, Wine : From Neolithic Times to the 21st Century. Algora Publishing, New York.

FAO-OIV FOCUS 2016, 2016, Table and dried grapes. Food and Agriculture Organization of the United Nations, International Organisation of Vine and Wine, S.l.

FAOSTAT [WWW Document], 2017a, URL http://www.fao.org/faostat/en/#data/QD/visualize (accessed 1.27.18).

FAOSTAT [WWW Document], 2017b, URL http://www.fao.org/faostat/en/#data/QC/visualize (accessed 1.27.18).

Foundation Plant Services [WWW Document], 2018, URL http://fps.ucdavis.edu/fgrdetails.cfm?varietyid=2808 (accessed 2.12.18).

Galet, P., 1979, A Practical Ampelography : Grapevine Identification. Comstock Pub. Associates., Ithaca, N.Y.

Ganesch, J.K.-I. (JKI), Federal Research Centre for Cultivated Plants, Institute for Grapevine Breeding, Geilweilerhof ,Siebeldingen, Erika Maul, Reinhard Töpfer, Alina, n.d. VIVC [WWW Document]. URL http://www.vivc.de/ (accessed 11.6.17).

Hed, B., Ngugi, H.K., Travis, J.W., 2009, Relationship Between Cluster Compactness and Bunch Rot in Vignoles Grapes. Plant Disease 93, 1195–1201. https://doi.org/10.1094/PDIS-93-11-1195.

Hively, K., 2012, Grapes back on Jaeger farm [WWW Document]. Neosho Daily News. URL http://www.neoshodailynews.com/article/20120531/NEWS/305319797 (accessed 2.12.18).

Jaeger, H., 1881, Correspondence : Jaeger (Hermann) and Engelmann (George), 1881-1883.

Jones, N., Ougham, H., Thomas, H., 1997, Markers and mapping: We are all geneticists now. New Phytologist 137, 165–177.

Kingsbury, N., 2009, Hybrid : The History and Science of Plant Breeding. University of Chicago Press, Chicago.

Mann, M.E., 2016, Utilization Of Microsatellite Markers For A Comparative Assessment Of Norton And Cynthiana, And The Linkage Map Construction Of A "Chambourcin" X "Cabernet Sauvignon" Population. MSU Graduate Theses. 2385.

McLeRoy, S.S., Renfro, R.E., 2004, Grape man of Texas : the life of T.V. Munson. Eakin Press, Austin, Tex.

Moncada, X., Pelsy, F., Merdinoglu, D., Hinrichsen, P., 2006, Genetic diversity and geographical dispersal in grapevine clones revealed by microsatellite markers. Genome 49, 1459–1472. https://doi.org/10.1139/g06-102.

Morgante, M., Hanafey, M., Powell, W., 2002, Microsatellites are preferentially associated with nonrepetitive DNA in plant genomes. Nature Genetics 30, 194–200. https://doi.org/10.1038/ng822.

Mullins, M.G., Bouquet, A., Williams, L.E., 1992, Biology of the grapevine., Biology of horticultural crops. Cambridge ; New York : Cambridge University Press, 1992.

Munson, T.V., 1909, Foundations of American grape culture. [electronic resource], Core historical literature of agriculture: Crop protection and improvement. New York : Orange Judd Company, [©1909].

Munson, T.V., 1900, Investigation and Improvement of American Grapes at the Munson Experiment Grounds Near Denison, Texas, from 1876 to 1900. Von Boeckmann, Schutze & Company.

Myles, S., Boyko, A.R., Owens, C.L., Brown, P.J., Grassi, F., Aradhya, M.K., Prins, B., Reynolds, A., Chia, J.-M., Ware, D., Bustamante, C.D., Buckler, E.S., 2011, Genetic structure and domestication history of the grape. PNAS 108, 3530–3535. https://doi.org/10.1073/pnas.1009363108.

National Institutes of Health, 2018, National Human Genome Research Institute (NHGRI) [WWW Document]. National Human Genome Research Institute (NHGRI). URL https://www.genome.gov/glossary/ (accessed 6.7.18).

NCBI, 2016, Database resources of the National Center for Biotechnology Information. Nucleic Acids Research 44, D7–D19. https://doi.org/10.1093/nar/gkv1290.

Neidle, S., 2008, Principles of Nucleic Acid Structure. [electronic resource], 1st ed. Amsterdam : Elsevier ; Boston : Academic Press, 2008.

Plant Breeding, 2017, . Funk & Wagnalls New World Encyclopedia 1p. 1.

Reisch, B., 2013, French-American and Other Interspecific Varieties [WWW Document]. Interspecific Hybrids. URL http://www.hort.cornell.edu/reisch/grapegenetics/bulletin/wine/winetext4.html (accessed 2.11.18).

Scaboo, A.M., Chen, P., Sleper, D.A., Clark, K.M., Bilyeu, K., Ratnaparkhe, M., Kole, C., 2010, Classical Breeding and Genetics of Soybean. Genetics, Genomics and Breeding of Soybean 19.

Smiley, L., 2016, A Review of Cold Climate Grape Cultivars [WWW Document]. HORT3040.pdf. URL https://store.extension.iastate.edu/Product/A-Review-of-Cold-Climate-Grape-Cultivars-pdf.

Stafne, E., 2012, Interspecific Hybrid (French-American) Wine Grapes [WWW Document]. URL http://articles.extension.org/pages/58074/interspecific-hybrid-french-american-wine-grapes (accessed 2.11.18).

Stevenson, A., 2010, symposium. Oxford Dictionary of English.

This, P., Jung, A., Boccacci, P., Borrego, J., Botta, R., Costantini, L., Crespan, M., Dangl, G.S., Eisenheld, C., Ferreira-Monteiro, F., 2004, Development of a standard set of microsatellite reference alleles for identification of grape cultivars. Theoretical and Applied Genetics 109, 1448–1458.

This, P., Lacombe, T., Thomas, M.R., 2006, Historical origins and genetic diversity of wine grapes. Trends in Genetics 22, 511–519. https://doi.org/10.1016/j.tig.2006.07.008.

Tordsen, C., 2015, Grapes | Agricultural Marketing Resource Center [WWW Document]. URL https://www.agmrc.org/commodities-products/fruits/grapes/ (accessed 12.2.17).

USDA, 2017, Noncitrus Fruits and Nuts [WWW Document]. URL http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1113 (accessed 11.3.17).

Van Nocker, S., Gardiner, S.E., 2014, Breeding better cultivars, faster: applications of new technologies for the rapid deployment of superior horticultural tree crops. Horticulture Research 1, 14022.

Vieira, M.L.C., Santini, L., Diniz, A.L., Munhoz, C. de F., 2016, Microsatellite markers: what they mean and why they are so useful. Genetics and Molecular Biology 39, 312–328. https://doi.org/10.1590/1678-4685-GMB-2016-0027.

Whitaker, W., 1993, William Whitaker's Words [WWW Document]. University of Notre Dame Archives. URL http://archives.nd.edu/cgi-bin/wordz.pl?english=life (accessed 11.3.17).

Table 1. Summary of cross pollination events of Jaeger 70 x Vignoles with pollen source and progeny produced at Post Familie Vineyard

Cross Pollination Event	Vineyard Location	Pollen Source	Progeny Produced
May 2014	Altus, AR	Post Familie Vineyard	115
May 2015	Altus, AR	Missouri State University Fruit Experiment Station	393

Table 2. Primers used in testing F_1 Jaeger 70 x Vignoles Population, and parent associated allele sizes expressed as base pairs (bp)

Primers	Jaeger 70 (bp)	Vignoles 1 (bp)	Vignoles 2 (bp)
VMC4D9.2	241, 255	238, 261	256, 259
VCM2B3	182, 199	184, 195	184, 195
AF8125	150, 152	150, 167	150, 167
CTG5780	280, 282	266, 284	266, 282
CTG5955	286, 302	295, 316	289, 302
VMC5A1	180, 192	187, 199	177, 192
VVIV69	297, 300	292, 305	300, 310
VRIP93	226, 243	208, 217	208, 215
PSCTG196_2	303, 318	301, 308	311, 329
VMC4D2	110, 116	114, 116	127, 129
VMC1C10	162, 171	171, 181	171, 181
UDV-021	148, 150	161, 164	161, 164

Table 3. Parent plants (Jaeger 70, Vignoles 1, and Vignoles 2) and 508 possible progeny screened using VMC2B3, CTG5780, VVIV69, VMC5A1, and VRIP93 SSR markers with associated allele sizes. No data is represented by "-".

Plant	VMC2B3	CTG5780	VVIV69	VMC5A1	VRIP93
Jaeger 70	182, 199	280, 282	297, 300	180, 192	226, 243
Vignoles 1	184, 195	266, 284	292, 305	187, 199	208, 217
Vignoles 2	184, 195	266, 282	300, 310	177, 192	208, 215
JxV 001	195, 199	266, 280	292, 300	180, 187	217, 243
JxV 002	195, 199	266, 280	300, 305	180	217, 226
JxV 003	195, 199	266, 280	292, 297	180, 187	208, 226
JxV 004	195, 199	280	292, 300	180, 199	208, 226
JxV 005	184, 199	282, 284	292, 300	180, 187	208, 243
JxV 006	182, 184	282, 286	292, 300	180, 183	226
JxV 007	182, 195	280, 284	300, 305	180, 199	217, 243
JxV 008	184, 199	282, 284	297, 305	180, 187	217, 226
JxV 009	182, 184	266, 282	297, 305	180, 199	217, 226
JxV 010	182, 184	282, 284	297, 292	180, 199	208, 243
JxV 011	182, 195	266, 282	300, 305	192, 199	208, 243
JxV 012	195, 199	266, 280	292, 297	187, 192	217, 243
JxV 013	195, 199	280, 284	292, 297	180, 187	208, 226
JxV 014	195, 199	266, 282	297, 305	187, 192	217, 243
JxV 015	182, 195	282, 284	292, 297	187, 192	217, 226
JxV 016	184, 199	266, 282	300, 305	180, 199	217, 243
JxV 017	195, 199	266, 280	292, 300	192, 199	217, 243
JxV 018	182, 184	266, 282	300, 305	187, 192	217, 226
JxV 019	184, 199	266, 282	292, 297	187, 192	217, 243
JxV 020	195, 199	266, 280	292, 300	192, 199	217, 226
JxV 021	195, 199	280, 284	297, 305	-	217, 243
JxV 022	182, 195	266, 280	297, 305	180, 199	217, 226
JxV 023	182, 205	182, 205	297	190, 192	226, 243
JxV 024	182, 195	282, 284	292, 300	187, 192	217, 226
JxV 025	195, 199	266, 280	292, 297	180, 187	217, 226
JxV 026	195, 199	266, 280	292, 297	192, 199	208, 226
JxV 027	195, 199	266, 280	300, 305	180, 187	217, 226
JxV 028	195, 199	266, 282	297, 305	180, 199	217, 243
JxV 029	182	266, 282	297, 305	180, 199	208, 243
JxV 030	-	280, 284	300, 305	180, 187	208, 226
JxV 031	182, 195	266, 282	300, 305	187, 192	208, 226

Table 3. continued

Plant	VMC2B3	CTG5780	VVIV69	VMC5A1	VRIP93
JxV 032	182, 195	-	280, 300	192, 199	-
JxV 033	184, 199	280, 284	292, 297	180, 190	208, 243
JxV 034	182, 184	-	297	180, 187	-
JxV 035	195, 199	-	300, 305	180, 187	-
JxV 036	195, 199	-	292, 297	192, 199	-
JxV 037	184, 199	266, 282	297, 305	180, 199	208, 243
JxV 038	182, 184	266, 282	300, 305	192, 199	208, 243
JxV 039	182, 195	-	300, 305	187, 192	-
JxV 040	195, 199	-	292, 300	180, 187	-
JxV 041	195, 199	-	292, 297	192, 199	-
JxV 042	182, 205	-	292, 300	180, 190	-
JxV 043	-	-	-	-	-
JxV 044	184, 199	266, 280	300, 305	180, 187	208, 226
JxV 045	195, 199	-	300, 305	187, 192	-
JxV 046	184, 199	-	300, 305	180, 187	-
JxV 047	182, 195	-	297	180, 199	-
JxV 048	182, 195	-	300, 305	192, 199	-
JxV 049	182, 203	-	280, 297	192	-
JxV 050	182, 195	-	292, 297	187, 192	-
JxV 051	195, 199	-	300, 305	192, 199	-
JxV 052	182, 184	-	300, 305	180, 187	-
JxV 053	182, 195	-	292, 300	180, 187	-
JxV 054	195, 199	-	300, 305		-
JxV 055	195, 199	-	300, 305	180, 187	-
JxV 056	182, 195	-	292, 297	187, 192	-
JxV 057	184, 199	-	292, 300	187, 192	-
JxV 058	182, 184	-	300, 305	180, 187	-
JxV 059	182, 195	-	292, 297	180, 187	-
JxV 060	184, 199	-	292, 297	180, 199	-
JxV 061	184, 199	-	292, 297	180, 199	-
JxV 062	184, 199	-	297, 305	192, 199	-
JxV 063	182, 195	-	292, 297	187, 192	208, 226
JxV 064	184, 199	-	292, 297	187, 192	217, 243
JxV 065	199, 205	-	292	180, 183	208, 226
JxV 066	184, 199	-	-	180, 199	208, 243

Table 3. continued

Plant	VMC2B3	CTG5780	VVIV69	VMC5A1	VRIP93
JxV 067	182, 184	-	292, 310	177, 192	226
JxV 068	184, 199	-	292, 297	187, 192	217, 243
JxV 069	199, 205	-	297	180, 183	208, 226
JxV 070	195, 199	-	292, 300	192, 199	217, 226
JxV 071	182, 195	-	292, 300	180, 187	217, 243
JxV 072	195, 199	-	292, 297	187, 192	208, 243
JxV 073	182, 184	-	297, 305	192, 199	208, 243
JxV 074	-	-	-	-	-
JxV 075	182, 184	-	292, 300	180, 183	208, 226
JxV 076	182, 184	-	297	190, 192	208, 226
JxV 077	182, 184	-	292, 300	180, 199	208, 243
JxV 078	195, 199	-	292, 297	180, 199	217, 226
JxV 079	182, 184	-	300, 305	195, 202	217, 243
JxV 080	182, 184	-	300, 305	180, 199	208, 243
JxV 081	195, 199	-	292, 300	192, 199	217, 226
JxV 082	182, 184	226, 280	292, 300	180, 199	208, 243
JxV 083	182, 195	-	300, 305	180, 187	217, 226
JxV 084	182, 195	266, 282	292, 297	180, 199	208, 243
JxV 085	195, 199	-	292, 300	180, 187	208, 243
JxV 086	182, 184	-	292, 300	180, 187	226
JxV 087	182, 195	-	292, 297	187, 192	-
JxV 088	195, 199	-	300, 305	180, 187	217, 243
JxV 089	182, 184	-	297, 305	187, 192	217, 226
JxV 090	184, 199	266, 280	300, 305	180, 199	208, 243
JxV 091	182, 184	-	292, 300	187, 192	217, 226
JxV 092	182, 195	-	297, 305	180, 187	208, 243
JxV 093	195, 199	-	297, 305	187, 192	217, 226
JxV 094	195, 199	266, 282	297, 305	180, 199	208, 243
JxV 095	195, 199	266, 282	297, 305	180, 199	208, 243
JxV 096	195, 199	282, 284	292, 297	192, 199	217, 243
JxV 097	195, 199	266, 280	292, 297	187, 192	217, 226
JxV 098	182, 184	-	-	180, 199	208, 243
JxV 099	182, 206	280, 282	300	180, 187	208, 243
JxV 100	182, 195	266, 280	300, 305	192, 199	217
JxV 101	182, 195	266, 282	292, 297	192, 199	217, 243

Table 3. continued

Plant	VMC2B3	CTG5780	VVIV69	VMC5A1	VRIP93
JxV 102	184, 199	282, 284	297, 305	180, 199	217, 243
JxV 103	184, 199	266, 282	292, 300	187, 192	208, 243
JxV 104	184, 199	266, 282	292, 300	187, 192	208, 243
JxV 105	184, 199	282, 284	292, 297	192, 199	217, 243
JxV 106	184, 199	266, 280	292, 297	180, 187	208, 243
JxV 107	182, 184	266, 280	292, 297	180, 192	208, 226
JxV 108	182, 195	282, 284	292, 297	180, 199	208, 226
JxV 109	182, 184	282, 284	292, 300	187, 192	217, 226
JxV 110	184, 199	280, 284	292, 297	187, 192	208, 243
JxV 111	195, 199	266, 280	292, 297	180, 199	217, 226
JxV 112	182, 195	266, 280	300, 305	180, 187	208, 217
JxV 113	195, 199	280, 284	300, 305	192, 199	208, 226
JxV 114	-	266, 282	292, 297	187, 192	208, 226
JxV 115	182, 184	266, 280	292, 297	187, 192	208, 243
JxV 116	195, 199	282, 284	297, 305	192, 199	208, 243
JxV 117	184, 199	266, 282	292, 300	180, 187	217, 226
JxV 118	184, 199	280, 284	297, 300	180, 187	226
JxV 119	195, 199	266, 280	292, 300	180, 187	217, 226
JxV 120	182, 205	266, 280	286, 300	180, 190	226, 243
JxV 121	184, 199	266, 282	300	180, 192	226
JxV 122	182, 184	266, 282	292, 297	180, 199	208, 243
JxV 123	182, 195	266, 282	300, 305	180, 199	217, 243
JxV 124	199, 205	266, 282	292, 300	180, 190	208, 243
JxV 125	182, 205	280, 286	297, 300	180, 190	208, 226
JxV 126	182, 184	266, 282	292, 300	-	-
JxV 127	195, 199	266, 280	297, 305	180, 187	217, 226
JxV 128	182, 184	282, 284	292, 297	183, 192	226
JxV 129	182, 184	266, 280	297, 305	187, 192	208, 243
JxV 130	195, 199	266, 280	297, 305	187, 192	208, 226
JxV 131	195, 199	266, 280	292, 297	187, 192	208, 226
JxV 132	199, 204	266, 280	292, 297	180, 190	208, 226
JxV 133	195, 199	266, 280	300	180, 187	217, 243
JxV 134	199, 204	280, 284	295, 297	187, 192	226, 243
JxV 135	195, 199	266, 280	297, 305	187, 192	217, 226
JxV 136	184, 199	280, 284	292, 300	180, 199	208, 243

Table 3. continued

Plant	VMC2B3	CTG5780	VVIV69	VMC5A1	VRIP93
JxV 137	182, 184	266, 282	300, 305	180, 187	208, 243
JxV 138	184, 199	266, 280	297, 305	187, 192	208, 226
JxV 139	182, 204	280, 284	300	180, 182	208, 226
JxV 140	184, 199	266, 280	292, 300	187, 192	217, 243
JxV 141	184, 199	266, 282	292, 297	187, 192	217, 243
JxV 142	195, 199	266, 280	300, 305	180, 187	208, 243
JxV 143	182, 184	266, 280	292, 300	192, 199	217, 226
JxV 144	182, 184	266, 282	300, 305	180, 187	217, 226
JxV 145	199, 205	280	297	190, 192	208, 243
JxV 146	182, 195	266, 280	292, 300	192, 199	208, 226
JxV 147	199, 204	280, 284	292, 300	180, 183	226
JxV 148	195, 199	280, 284	292, 300	187, 192	-
JxV 149	184, 199	266, 282	292, 300	192, 199	217, 243
JxV 150	182, 184	266, 280	292, 297	180, 199	208, 243
JxV 151	182, 195	266, 282	297, 305	192, 199	217, 226
JxV 152	182, 184	280, 284	297	180, 187	208, 243
JxV 153	182, 184	280, 282	286, 297	180, 183	208, 243
JxV 154	182	266, 280	288, 300	180, 187	226, 243
JxV 155	199, 204	282, 284	292, 300	180, 182	208, 226
JxV 156	182, 184	266, 280	292, 300	180, 187	208, 243
JxV 157	195, 199	266, 282	300, 305	180, 187	217, 243
JxV 158	182, 195	266, 280	297, 305	180, 187	208, 226
JxV 159	184, 199	282, 284	292, 297	180, 187	208, 226
JxV 160	182, 195	280, 284	292, 300	187, 192	217, 226
JxV 161	195, 199	266, 282	300, 305	180, 187	208, 243
JxV 162	184, 199	266, 282	292, 300	180, 187	208, 226
JxV 163	184, 199	280, 284	300	192	208, 226
JxV 164	182, 195	266, 280	292, 297	192, 199	217, 226
JxV 165	182, 184	280, 284	292, 300	180, 187	208, 226
JxV 166	184, 199	282, 284	292, 300	180, 187	208, 243
JxV 167	182, 184	280, 286	300	180, 192	208, 243
JxV 168	182, 195	266, 280	297, 305	180, 199	208, 243
JxV 169	182, 184	280, 284	292, 300	187, 192	208, 226
JxV 170	-	-	-	-	-

Table 3. continued

Plant	VMC2B3	CTG5780	VVIV69	VMC5A1	VRIP93
JxV 171	182, 184	266, 280	292, 300	180, 187	217, 243
JxV 172	182, 204	280, 284	292, 297	180, 192	226, 243
JxV 173	184, 199	280, 284	292, 297	187, 192	208, 226
JxV 174	184, 199	266, 280	292, 300	187, 192	217, 226
JxV 175	182, 184	266, 280	292, 297	187, 192	217, 243
JxV 176	-	-	-	-	-
JxV 177	182, 184	280, 284	292, 300	180, 187	226, 243
JxV 178	182, 205	282, 284	292, 300	180, 190	208, 226
JxV 179	184, 199	280, 284	300	180, 187	226, 243
JxV 180	182, 204	266, 284	292, 300	187, 192	226
JxV 181	182, 184	266, 282	297, 305	187, 192	217, 243
JxV 182	182, 195	282, 284	297, 305	187, 192	217, 243
JxV 183	182, 195	282, 284	297, 305	180, 199	208, 243
JxV 184	184, 199	280, 282	300	180, 187	226
JxV 185	182, 195	266, 282	292, 300	180, 187	217, 243
JxV 186	184, 199	280, 286	300	180, 187	208, 226
JxV 187	195, 199	282, 284	292, 297	187, 192	208, 226
JxV 188	182, 184	280, 284	292, 297	184, 192	226
JxV 189	184, 199	280, 284	297, 305	180, 199	208, 243
JxV 190	182, 184	280, 284	292, 300	-	226
JxV 191	182, 184	266, 280	292, 297	187, 192	208, 226
JxV 192	182, 204	266, 280	292, 297	187, 192	-
JxV 193	-	-	-	-	-
JxV 194	184, 199	180, 184	292, 297	180, 190	266, 243
JxV 195	184, 199	282, 284	297, 305	180, 199	217, 226
JxV 196	182, 195	266, 282	297, 305	180, 187	217, 243
JxV 197	-	-	-	-	-
JxV 198	195, 199	266, 280	292, 300	180, 199	217, 243
JxV 199	182, 184	266, 280	292, 300	180, 192	208, 243
JxV 200	184, 199	266, 280	300	180, 192	226, 243
JxV 201	199	266, 280	292, 297	180, 187	208, 226
JxV 202	195, 199	282, 284	292, 297	180, 187	208, 226
JxV 203	182	282, 284	292, 297	182	226
JxV 204	182, 184	266, 280	292, 297	180, 187	217, 226
JxV 205	182, 204	266, 280	292, 297	180, 187	208, 243

Table 3. continued

Plant	VMC2B3	CTG5780	VVIV69	VMC5A1	VRIP93
JxV 206	182, 195	282, 284	300, 305	187, 192	-
JxV 207	182, 195	266, 282	297, 305	180, 187	208, 243
JxV 208	182, 184	266, 284	292, 297	187, 192	208, 226
JxV 209	184, 199	266, 280	292, 297	180, 187	226, 243
JxV 210	184, 199	266, 282	297, 305	187, 192	208, 226
JxV 211	182, 195	282, 284	292, 297	180, 187	208, 226
JxV 212	184, 199	266, 282	292, 297	187, 192	208, 226
JxV 213	184, 199	280, 284	292, 297	180, 187	217, 243
JxV 214	184, 199	266, 284	292, 300	180, 199	208, 243
JxV 215	182, 184	266, 286	292, 300	183, 192	226, 243
JxV 216	182, 205	280, 284	292, 297	183	226, 243
JxV 217	-	-	-	-	-
JxV 218	182, 195	266, 282	292, 297	192, 199	208, 226
JxV 219	182, 184	280	297	180, 190	208, 243
JxV 220	195, 199	282, 284	292, 300	180, 199	208, 243
JxV 221	184, 199	280	297	190, 192	226, 243
JxV 222	182, 184	280	300	-	226
JxV 223	-	-	-	-	-
JxV 224	184, 199	266, 280	297, 305	187, 192	217, 226
JxV 225		280	297	187, 192	232, 243
JxV 226	195, 199	266, 282	297, 305	180, 199	208, 243
JxV 227	182, 195	266, 282	297, 305	192, 199	208, 243
JxV 228	195, 199	266, 280	292, 297	187, 192	208, 226
JxV 229	182	280, 282	300	192	226
JxV 230	184, 199	266, 282	292, 300	192, 199	208, 226
JxV 231	182, 199	266, 282	300, 305	180, 187	217, 243
JxV 232	182, 184	280, 284	292, 300	187, 192	217, 226
JxV 233	182, 184	266, 282	292, 297	187, 192	208, 226
JxV 234	199, 205	280	300	182, 192	226, 243
JxV 235	182, 205	280, 284	292, 300	182	226
JxV 236	182, 205	280, 286	292, 297	182, 192	208, 243
JxV 237	182, 195	266, 282	292, 297	187, 192	208, 226
JxV 238	184, 199	280	297	180, 182	226, 243
JxV 239	182, 184	266, 280	300, 305	180, 187	217, 226
JxV 240	182, 184	266, 280	300, 305	192, 199	208, 243

Table 3. continued

Plant	VMC2B3	CTG5780	VVIV69	VMC5A1	VRIP93
JxV 241	184, 199	280, 286	297	190, 192	226
JxV 242	195, 199	266, 282	297, 305	192, 199	208, 243
JxV 243	199, 205	282, 286	292, 297	182, 192	226
JxV 244	184, 199	282, 286	292, 300	182	226
JxV 245	182, 184	266, 280	292, 300	180, 187	208, 226
JxV 246	182, 184	266, 282	292, 300	180, 187	208, 226
JxV 247	184, 199	280, 284	292, 297	180, 199	217, 243
JxV 248	182	266, 280	300	180, 192	226, 247
JxV 249	182, 205	282, 284	292, 300	190, 192	208, 243
JxV 250	182, 205	282, 284	292, 297	182, 192	226, 243
JxV 251	199, 203	266, 280	297	184, 192	217, 243
JxV 252	184, 199	266, 282	297, 305	192, 199	217, 243
JxV 253	-	-	-	-	-
JxV 254	182	280	297	180, 192	217, 226
JxV 255	195, 199	280, 284	292, 300	192, 199	217, 243
JxV 256	182, 184	280, 284	297, 305	192, 199	208, 243
JxV 257	182, 195	266, 280	292, 297	192, 199	243, 217
JxV 258	184, 199	280, 286	300	180, 190	226, 243
JxV 259	182	-	-	177, 180	226, 243
JxV 260	182, 205	280, 284	297	180, 183	208, 243
JxV 261	182, 205	-	-	180, 184	208, 226
JxV 262	199, 205	282, 286	292, 297	180, 182	208, 243
JxV 263	195, 199	266, 280	292, 300	180, 187	208, 243
JxV 264	182, 184	280, 286	297	180, 183	208, 226
JxV 265	182, 195	266, 282	292, 300	180, 199	217, 226
JxV 266	184, 199	282, 284	300, 305	180, 187	208, 226
JxV 267	182, 184	266, 282	-	180	217, 243
JxV 268	182, 184	266, 282	292, 297	180, 199	208, 243
JxV 269	182, 195	266, 280	292, 300	180, 187	208, 243
JxV 270	182, 184	266, 280	292, 297	180, 187	208, 243
JxV 271	195, 199	266, 282	297, 305	180, 187	208, 226
JxV 272	195, 199	266, 280	292, 297	187, 192	217, 226
JxV 273	182, 205	278, 282	297	180, 182	226, 243
JxV 274	182, 202	282	297, 310	180, 182	226
JxV 275	-	-	-	-	-

Table 3. continued

Plant	VMC2B3	CTG5780	VVIV69	VMC5A1	VRIP93
JxV 276	182, 195	266, 282	297, 305	180, 199	217, 226
JxV 277	-	-	-	-	-
JxV 278	195, 199	266, 280	300, 305	180, 199	217, 226
JxV 279	182, 195	266, 280	292, 297	180, 199	217, 243
JxV 280	182, 195	266, 282	292, 297	180, 187	208, 243
JxV 281	182, 195	282, 284	-	180, 199	208, 243
JxV 282	184, 199	266, 280	300, 305	180, 199	217, 226
JxV 283	-	-	-	-	-
JxV 284	184, 199	266, 282	292, 297	180, 199	208, 226
JxV 285	182, 184	280, 282	297, 310	180	215, 226
JxV 286	182	280	300	180	208, 243
JxV 287	182, 205	280, 284	292, 300	180	226, 243
JxV 288	195, 199	266, 282	292, 297	180, 199	217, 243
JxV 289	-	-	-	-	-
JxV 290	195, 199	266, 282	300, 305	180	208, 226
JxV 291	182, 184	282, 284	292, 300	180, 199	217, 226
JxV 292	-	-	-	-	-
JxV 293	182	282	300	180, 187	226
JxV 294	182, 184	280, 286	297	180, 199	208, 243
JxV 295	182, 195	266, 282	292, 297	180, 187	217, 243
JxV 296	182, 195	266, 282	297, 305	180, 187	217, 243
JxV 297	184, 199	266, 280	292, 300	180, 199	208, 243
JxV 298	-	-	-	-	-
JxV 299	-	-	-	-	-
JxV 300	195, 199	280, 284	292, 297	180, 187	208, 226
JxV 301	182, 184	266, 280	292, 297	180, 199	208, 243
JxV 302	195, 199	266, 280	292, 297	180, 199	208, 243
JxV 303	199, 205	280, 284	300	183, 192	208
JxV 304	195, 199	266, 280	292, 297	180, 199	217, 226
JxV 305	-	-	-	-	-
JxV 306	-	-	-	-	-
JxV 307	182, 195	282, 284	292, 297	192, 199	217, 243
JxV 308	182, 184	280, 282	297	180, 190	226, 243
JxV 309	182, 195	-	-	180, 199	208, 243
JxV 310	-	-	-	-	-

Table 3. continued

Plant	VMC2B3	CTG5780	VVIV69	VMC5A1	VRIP93
JxV 311	182, 184	280, 284	292, 300	190, 192	226, 243
JxV 312	184, 199	266, 280	292, 300	180, 199	208, 243
JxV 313	-	-	-	-	-
JxV 314	182, 184	266, 282	292, 300	192, 199	208, 226
JxV 315	-	-	-	-	-
JxV 316	182, 184	266, 282	300, 305	192, 199	208, 226
JxV 317	182, 195	266, 282	292, 297	180, 187	217, 243
JxV 318	-	-	-	-	-
JxV 319	-	280, 284	-	180, 199	217, 226
JxV 320	-	-	-	-	-
JxV 321	-	-	-	-	-
JxV 322	184, 199	282	292, 297	182, 192	208, 243
JxV 323	184, 199	266, 280	300, 305	180, 187	217, 226
JxV 324	199, 203	280	288, 297	180, 190	217, 243
JxV 325	182, 205	280, 284	292, 297	180, 190	208, 226
JxV 326	199, 205	280, 286	292, 297	182, 192	208, 243
JxV 327	184, 199	280, 284	300	182, 180	208, 243
JxV 328	182, 195	266, 282	297, 305	180, 187	217, 243
JxV 329	195, 199	280, 282	300, 310	177, 180	226
JxV 330	182, 195	266, 280	297, 305	180, 187	208, 226
JxV 331	184, 199	280, 286	292, 300	182, 192	226, 243
JxV 332	-	-	-	-	-
JxV 333	195, 199	266, 280	300, 305	187, 192	217, 243
JxV 334	199, 205	282, 284	292, 300	190, 192	208, 226
JxV 335	195, 199	266, 284	292, 300	187, 192	217, 226
JxV 336	182, 184	280, 284	300, 305	187, 192	208, 243
JxV 337	182, 195	266, 280	292, 300	180, 199	208, 243
JxV 338	182, 195	266, 282	292, 297	180, 199	208, 243
JxV 339	182, 195	266, 282	297, 305	187, 192	217, 243
JxV 340	182, 184	-	292, 300	187, 192	208, 243
JxV 341	184, 199	266, 282	300, 305	192, 199	208, 243
JxV 342	184, 199	280, 282	300	177, 180	208, 226
JxV 343	199, 205	282, 284	292, 297	180, 190	226, 243
JxV 344	182, 195	284, 282	292, 297	180, 199	217, 226
JxV 345	182, 195	282, 284	292, 297	192, 199	208, 243

Table 3. continued

Plant	VMC2B3	CTG5780	VVIV69	VMC5A1	VRIP93
JxV 346	182, 195	266, 280	300, 305	180, 187	217, 243
JxV 347	182, 184	280	300	187, 192	226
JxV 348	184	280, 286	292, 297	182, 192	226, 243
JxV 349	195, 199	266, 282	300, 305	180, 199	208, 243
JxV 350	-	-	-	-	208, 226
JxV 351	182, 184	280, 284	300, 305	180, 199	217, 243
JxV 352	182, 184	280, 284	292, 300	192, 199	217, 243
JxV 353	182, 184	266, 280	292, 300	187, 192	208, 243
JxV 354	182, 195	282, 284	292, 300	180, 187	208, 243
JxV 355	184, 199	282, 284	300, 305	192, 199	208, 226
JxV 356	195, 199	266, 282	300, 305	180, 199	217, 243
JxV 357	184, 199	266, 282	300, 305	180	-
JxV 358	-	-	-	-	-
JxV 359	182, 184	280, 284	292, 300	180, 192	208, 243
JxV 360	182, 195	266, 280	292, 300	180, 199	217, 226
JxV 361	199, 203	282	300	187, 192	226
JxV 362	195, 199	282, 284	297, 305	180, 199	217, 226
JxV 363	184, 199	266, 282	297, 305	192, 199	208, 226
JxV 364	184, 199	282, 284	300, 305	180, 187	208, 243
JxV 365	184, 199	280, 286	292, 297	180	208, 243
JxV 366	182	280, 286	297	180, 192	226, 243
JxV 367	184, 199	266, 282	292, 297	180, 182	226
JxV 368	184, 199	266, 280	297, 305	180, 182	217, 243
JxV 369	184, 199	266, 280	292, 297	180, 187	217, 226
JxV 370	199, 206	266, 280	-	-	208, 243
JxV 371	195, 199	266,284	292, 300	180, 199	208, 226
JxV 372	184, 199	266, 282	297, 305	180, 199	217, 243
JxV 373	195, 199	266, 282	297, 305	180, 187	217, 243
JxV 374	182, 195	266, 280	292, 297	180, 199	217, 243
JxV 375	182, 184	266, 280	297, 300	180, 199	208, 226
JxV 376	195, 195	266, 280	300, 305	180, 199	217, 226
JxV 377	184, 199	280, 284	292, 300	180	226, 243
JxV 378	-	-	-	-	-
JxV 379	182	266, 280	288, 300	-	226
JxV 380	184, 199	280, 284	297, 305	180, 187	208, 243

Table 3. continued

Plant	VMC2B3	CTG5780	VVIV69	VMC5A1	VRIP93
JxV 381	184, 199	278, 286	297	180	208, 226
JxV 382	182, 195	266, 280	297, 305	180, 187	217, 226
JxV 383	184, 199	282, 284	292, 297	-	217, 243
JxV 384	182, 206	266, 282	300	-	208, 226
JxV 385	182, 184	266, 280	300, 305	-	208, 226
JxV 386	182, 184	266, 280	292, 300	-	217, 226
JxV 387	182, 184	280, 284	292 ,297	-	208, 226
JxV 388	184, 199	266, 282	297, 305	-	208, 226
JxV 389	182, 184	266, 282	292, 297	-	208, 226
JxV 390	182, 184	266, 280	297, 305	180, 187	208, 226
JxV 391	180, 181	266, 282	288, 297	180, 192	217, 226
JxV 392	182, 204	280, 284	292, 300	180, 187	226
JxV 393	182, 184	266, 280	292, 297	180, 187	208, 226
JxV 394	182, 184	282, 284	288, 300	180, 192	208, 226
JxV 395	182, 184	280, 282	292, 297	180, 199	208, 226
JxV 396	182, 184	266, 280	292, 300	180, 187	208, 243
JxV 397	182, 195	266, 280	300, 305	180, 199	208, 243
JxV 398	180, 181	280, 286	295, 297	180, 192	208, 226
JxV 399	-	-	-	-	-
JxV 400	199, 205	280, 282	297, 300	180	226
JxV 401	184, 199	266, 282	292, 297	180, 187	217, 226
JxV 402	184, 199	266, 280	286, 292	180, 199	208, 243
JxV 403	182, 195	266, 282	300, 305	180, 187	208, 226
JxV 404	199, 202	282, 284	300, 310	180, 187	226, 243
JxV 405	182, 195	266, 280	297, 305	180, 187	208, 226
JxV 406	182, 184	266, 280	292, 297	180, 187	208, 226
JxV 407	195, 199	266, 280	297, 305	180, 187	208, 226
JxV 408	182, 195	266, 280	292, 300	180, 187	208, 226
JxV 409	182, 199	280, 284	300, 310	180, 187	226
JxV 410	199, 204	280, 284	295, 297	180, 183	226, 243
JxV 411	182, 204	266, 280	292, 297	180, 183	224, 226
JxV 412	182, 195	280, 284	300, 305	180, 187	208, 243
JxV 413	184, 199	266, 280	300, 305	180, 187	217, 243
JxV 414	-	-	-	-	-
JxV 415	182, 206	280, 282	295, 297	180	226, 232

Table 3. continued

Plant	VMC2B3	CTG5780	VVIV69	VMC5A1	VRIP93
JxV 416	184, 199	266, 280	297, 305	180, 187	217, 243
JxV 417	195, 199	266, 280	292, 297	180, 199	217, 243
JxV 418	184, 199	266, 280	292, 297	180, 199	217, 243
JxV 419	-	-	-	-	-
JxV 420	195, 199	282, 285	292, 300	180	217, 243
JxV 421	182, 184	266, 280	297, 305	180, 187	208, 243
JxV 422	184, 199	266, 285	297, 305	180, 187	208, 226
JxV 423	182, 205	280, 286	292, 300	180, 182	208, 226
JxV 424	195, 199	280, 284	297, 305	187, 192	217, 226
JxV 425	184, 199	282, 286	292, 300	180, 182	208, 243
JxV 426	182, 184	266, 280	292, 297	192, 199	208, 226
JxV 427	184, 199	282, 284	292, 300	180, 182	208, 243
JxV 428	184, 199	280, 282	300	187, 192	226
JxV 429	184, 199	266, 282	292, 297	180, 199	217, 243
JxV 430	182, 195	280, 284	292, 297	180, 187	208, 226
JxV 431	199, 205	280, 282	300	180, 182	226
JxV 432	184, 199	266, 282	292, 297	192, 199	217, 243
JxV 433	184, 199	266, 282	297, 305	187, 192	208, 243
JxV 434	182, 199	280, 282	300, 310	180, 187	208, 243
JxV 435	199, 205	280, 284	292, 300	182, 192	226
JxV 436	182, 195	266, 280	300, 305	180, 199	217, 243
JxV 437	182, 205	282, 286	292, 297	180, 190	208, 226
JxV 438	182, 195	266, 282	300, 305	180, 199	217, 226
JxV 439	182, 199	282, 284	297, 300	180, 182	217, 243
JxV 440	182, 199	266, 282	297, 305	187, 192	217, 226
JxV 441	182, 195	266, 281	292, 297	180, 199	208, 226
JxV 442	182, 205	280, 286	292, 300	180, 190	226, 243
JxV 443	187, 199	282, 284	292, 300	180, 182	205, 226
JxV 444	184, 199	266, 280	292, 300	180, 187	217, 226
JxV 445	195, 199	266, 280	292, 297	192, 199	217, 243
JxV 446	182, 195	266, 282	292, 300	187, 192	217, 243
JxV 447	195, 199	266, 282	292, 300	187, 192	217, 243
JxV 448	195, 199	266, 282	292, 300	180, 187	208, 226
JxV 449	182, 195	280, 284	292, 297	187, 192	217, 243
JxV 450	-	-	-	-	-

Table 3. continued

Plant	VMC2B3	CTG5780	VVIV69	VMC5A1	VRIP93
JxV 451	184, 199	282, 284	300, 305	180, 187	208, 243
JxV 452	182, 195	266, 280	300, 305	180, 199	208, 243
JxV 453	195, 199	266, 282	300, 305	180, 199	208, 243
JxV 454	195, 199	282, 284	297, 305	180, 187	217, 243
JxV 455	182, 184	266, 282	300, 305	192, 199	217, 226
JxV 456	184, 199	280, 284	297, 305	192, 199	208, 226
JxV 457	195, 199	266, 280	292, 297	192, 199	208, 243
JxV 458	199, 202	280, 282	300	187, 192	226, 243
JxV 459	182, 205	282, 284	292, 297	182, 192	226, 243
JxV 460	182	280, 282	297	180, 190	217, 226
JxV 461	184, 199	280, 284	292, 297	180, 190	208, 226
JxV 462	184, 199	282, 286	300	190, 192	208, 226
JxV 463	199, 202	280, 282	289, 297	180, 192	226, 243
JxV 464	184, 199	280, 284	292, 300	182, 192	226, 243
JxV 465	182, 195	282, 284	292, 300	180, 199	208, 226
JxV 466	199	266, 280	297	180, 192	208, 226
JxV 467	182, 195	266, 282	297, 305	180, 187	208, 226
JxV 468	182, 184	266, 282	292, 297	180, 199	208, 243
JxV 469	182, 184	282, 286	292, 297	190, 192	208, 226
JxV 470	195, 199	266, 280	300, 305	180, 187	217, 226
JxV 471	199, 206	280, 282	300	187, 192	226, 231
JxV 472	182, 184	282, 286	292, 300	180, 182	208, 226
JxV 473	182, 184	280, 286	300	180, 190	208, 226
JxV 474	182	280, 286	297	180, 190	217, 243
JxV 475	199, 205	282, 284	292, 300	182, 192	226
JxV 476	182, 184	280, 284	300, 305	180, 187	208, 243
JxV 477	182, 199	266, 280	297	180, 192	208, 226
JxV 478	195, 199	266, 280	292, 297	180, 187	208, 226
JxV 479	184, 199	280, 284	297	180, 187	208, 226
JxV 480	195, 199	266, 282	292, 300	192, 199	208, 243
JxV 481	182, 184	266, 280	297, 305	187, 192	208, 226
JxV 482	195, 199	266, 280	292, 297	192, 199	217, 243
JxV 483	187, 199	282, 284	292, 300	182	208, 226
JxV 484	182, 195	266, 289	292, 297	187, 192	217, 243
JxV 485	195, 199	266, 282	289, 297	180, 187	217, 243

Table 3. continued

Plant	VMC2B3	CTG5780	VVIV69	VMC5A1	VRIP93
JxV 486	182, 184	266, 280	300	-	208, 243
JxV 487	199, 205	282, 284	292, 297	180, 182	226
JxV 488	182, 184	282, 284	292, 297	187, 192	217, 243
JxV 489	182, 184	280, 286	292, 297	180, 192	226
JxV 490	182, 184	266, 282	297, 305	187, 192	217, 226
JxV 491	182, 195	282, 284	297, 300	180, 183	217, 243
JxV 492	182, 195	266, 280	300, 305	180, 199	208, 226
JxV 493	195, 199	280, 284	292, 297	187, 192	217, 226
JxV 494	182, 205	282, 286	292, 300	180, 183	226
JxV 495	182, 184	266, 282	292, 297	180, 199	217, 226
JxV 496	182, 202	280, 282	297, 300	180, 192	217, 243
JxV 497	184, 199	282, 286	300	190, 192	208, 226
JxV 498	195, 199	282, 284	297, 305	180, 187	217, 243
JxV 499	182, 195	266, 280	292, 297	180, 199	208, 226
JxV 500	184, 199	266, 280	292, 300	180, 199	208, 226
JxV 501	195, 199	266, 282	292, 297	180, 187	208, 226
JxV 502	182, 184	280, 286	297	190, 192	217, 243
JxV 503	182, 202	280, 286	297, 300	190, 192	217, 243
JxV 504	182, 184	266, 280	297, 305	180, 199	217, 243
JxV 505	182, 195	266, 282	297, 305	180, 187	217, 243
JxV 506	182, 184	280, 286	297	180, 190	217, 243
JxV 507	184, 199	280, 284	297	180, 190	226, 243
JxV 508	182, 195	280, 284	292, 297	187, 192	217, 243

Table 4. Parent plants (Jaeger 70, Vignoles 1, and Vignoles 2) and 508 possible progeny screened using CTG5955, AF8125, VMC4D9.2, and PSCTG196_2 SSR markers with associated allele sizes. No data is represented by "-", True hybrids of Jaeger 70 x Vignoles father parents are represented as "Vignoles 1" and "Vignoles 2", non-true hybrids as "Not True", and dead plants as "Dead".

Plant	CTG5955	AF8125	VMC4D9.2	PSCTG196_2	Hybrid Status
Jaeger 70	286, 302	150, 152	241, 255	303, 318	
Vignoles 1	295, 316	150, 167	238, 261	301, 308	
Vignoles 2	289, 302	150, 167	256, 259	311, 329	
JxV 001	286	150, 167	241, 261	301, 318	Vignoles 1
JxV 002	286, 316	150	238, 255	301, 303	Vignoles 1
JxV 003	302, 316	150	238, 255	308, 318	Vignoles 1
JxV 004	302, 316	150	238, 241	303, 308	Vignoles 1
JxV 005	295, 302	150	255, 261	301, 303	Vignoles 1
JxV 006	286, 295	152, 152	233, 255	318, 323	Not True
JxV 007	286, 316	150, 152	238, 255	301, 318	Vignoles 1
JxV 008	295, 302	150	241, 261	301, 318	Vignoles 1
JxV 009	286, 295	152, 167	255, 261	301, 303	Vignoles 1
JxV 010	286, 295	150, 152	238, 241	308, 318	Vignoles 1
JxV 011	286, 316	150, 152	241, 261	301, 318	Vignoles 1
JxV 012	302, 316	150, 152	238, 255	308, 318	Vignoles 1
JxV 013	302, 316	150	241, 261	301, 318	Vignoles 1
JxV 014	302	150, 167	255, 261	301, 303	Vignoles 1
JxV 015	302, 316	150	238, 255	301, 318	Vignoles 1
JxV 016	295, 302	150, 167	255, 261	308, 318	Vignoles 1
JxV 017	302, 316	150	238, 255	303, 308	Vignoles 1
JxV 018	286, 295	152, 167	241, 261	303, 308	Vignoles 1
JxV 019	302, 316	150	241	303, 308	Vignoles 1
JxV 020	295, 302	150	238, 241	308, 318	Vignoles 1
JxV 021	295, 302	-	238, 255	301, 318	Vignoles 1
JxV 022	286, 316	150, 152	238, 255	301, 303	Vignoles 1
JxV 023	286, 289	152, 160	241, 261	303, 324	Not True
JxV 024	286, 316	150	238, 241	301, 303	Vignoles 1
JxV 025	302	150, 167	255, 261	301, 318	Vignoles 1
JxV 026	302, 316	150	255, 261	301, 303	Vignoles 1
JxV 027	302, 316	150	238, 241	301, 318	Vignoles 1

Table 4. continued

Plant	CTG5955	AF8125	VMC4D9.2	PSCTG196_2	Hybrid Status
JxV 028	302, 316	-	238, 241	303, 308	Vignoles 1
JxV 029	295, 302	-	241, 261	308, 318	Vignoles 1
JxV 030	286, 295	152, 167	238, 241	301, 303	Vignoles 1
JxV 031	302, 316	150	241, 261	308, 318	Vignoles 1
JxV 032	286, 316	-	-	303, 308	Not True
JxV 033	295, 302	152, 157	241, 255	303, 323	Not True
JxV 034	286, 295	152, 167	-	303, 308	Vignoles 1
JxV 035	302, 316	150	-	308, 318	Vignoles 1
JxV 036	302, 316	150	-	308, 318	Vignoles 1
JxV 037	295, 302	150	238, 241	301, 318	Vignoles 1
JxV 038	295, 302	150, 167	255, 261	301, 318	Vignoles 1
JxV 039	286	150, 152	-	301, 303	Vignoles 1
JxV 040	286	150	-	303, 308	Vignoles 1
JxV 041	286	150, 152	-	301, 318	Vignoles 1
JxV 042	286, 295	152, 167	-	303, 324	Not True
JxV 043	-	-	-	-	Dead
JxV 044	286, 316	150, 152	238, 241	303, 308	Vignoles 1
JxV 045	286, 295	150, 167	-	301, 303	Vignoles 1
JxV 046	295, 302	150, 167	-	301, 303	Vignoles 1
JxV 047	286, 316	150, 152	-	303, 308	Vignoles 1
JxV 048	286, 316	152, 167	-	308, 318	Vignoles 1
JxV 049	277, 286	150, 152	-	277, 303	Not True
JxV 050	295, 302	150, 167	-	303, 308	Vignoles 1
JxV 051	302, 316	150	-	308, 318	Vignoles 1
JxV 052	286, 295	152, 167	-	303, 308	Vignoles 1
JxV 053	286, 316	152, 167	-	303, 308	Vignoles 1
JxV 054	302, 316	150	-	303, 308	Vignoles 1
JxV 055	286	150, 167	-	301, 303	Vignoles 1
JxV 056	286, 316	150, 152	-	301, 303	Vignoles 1
JxV 057	295, 302	150	-	301, 303	Vignoles 1
JxV 058	286, 295	152, 167	-	308, 318	Vignoles 1
JxV 059	286, 316	152, 167	-	301, 318	Vignoles 1
JxV 060	286	152, 167	-	301, 318	Vignoles 1
JxV 061	295, 302	150, 167	-	301, 308	Vignoles 1

Table 4. continued

Plant	CTG5955	AF8125	VMC4D9.2	PSCTG196_2	Hybrid Status
JxV 062	295, 302	150, 167	-	301, 318	Vignoles 1
JxV 063	286, 316	150, 152	255, 261	301, 303	Vignoles 1
JxV 064	286, 316	150	241	301, 318	Vignoles 1
JxV 065	289, 302	150	241, 261	303, 324	Not True
JxV 066	295, 302	150, 167	238, 255	301, 318	Vignoles 1
JxV 067	286, 302	150, 167	241, 256	318	Vignoles 2
JxV 068	302, 316	-	238, 255	308, 318	Vignoles 1
JxV 069	289, 302	150, 160	241, 261	301, 318	Not True
JxV 070	302, 316	150, 152	241, 261	301, 303	Vignoles 1
JxV 071	286, 295	150, 152	238, 255	301, 303	Vignoles 1
JxV 072	302, 316	150	241, 261	301, 303	Vignoles 1
JxV 073	295, 302	150	238, 241	301, 318	Vignoles 1
JxV 074	-	-	-	-	Dead
JxV 075	286, 295	152, 158	241, 261	318, 324	Not True
JxV 076	286, 289	152, 158	255, 261	303, 324	Not True
JxV 077	295, 302	152, 167	241, 261	301, 318	Vignoles 1
JxV 078	286, 316	150, 152	255, 261	301, 303	Vignoles 1
JxV 079	286, 295	147	255, 261	303, 308	Not True
JxV 080	286, 295	152, 167	238, 255	301, 318	Vignoles 1
JxV 081	302, 316	152, 167	241	301	Vignoles 1
JxV 082	286, 295	150, 152	255, 261	301, 303	Vignoles 1
JxV 083	286, 316	133	241, 261	301, 303	Not True
JxV 084	286, 316	150, 152	255, 261	301, 303	Vignoles 1
JxV 085	302, 316	150	238, 255	303, 308	Vignoles 1
JxV 086	286, 295	150, 157	255, 261	318, 323	Not True
JxV 087	286, 316	150, 152	238, 255	-	Vignoles 1
JxV 088	295, 302	150, 167	238, 341	301, 318	Vignoles 1
JxV 089	295, 302	150	238, 241	303, 308	Vignoles 1
JxV 090	295, 302	152, 167	241, 255	301, 318	Vignoles 1
JxV 091	302, 316	150	238	301, 318	Vignoles 1
JxV 092	286, 316	150	238, 241	308, 318	Vignoles 1
JxV 093	302, 316	-	241, 255	308, 318	Vignoles 1
JxV 094	302, 316	150	238, 255	301, 303	Vignoles 1
JxV 095	295, 302	150, 167	238, 255	301, 303	Vignoles 1

Table 4. continued

Plant	CTG5955	AF8125	VMC4D9.2	PSCTG196_2	Hybrid Status
JxV 096	302, 316	150	238, 255	303, 308	Vignoles 1
JxV 097	302, 316	150	238, 255	303, 318	Vignoles 1
JxV 098	-	150, 167	238, 241	-	Vignoles 1
JxV 099	286, 295	150, 152	241, 255	318, 320	Not True
JxV 100	286, 295	-	238, 241	301, 303	Vignoles 1
JxV 101	286	150	238, 255	301, 303	Vignoles 1
JxV 102	-	150, 167	238, 241	308, 318	Vignoles 1
JxV 103	295, 302	150	241, 261	301, 303	Vignoles 1
JxV 104	295, 302	150	241, 261	301, 303	Vignoles 1
JxV 105	302, 316	150	238, 241	301, 303	Vignoles 1
JxV 106	302, 316	150	238, 255	301, 318	Vignoles 1
JxV 107	286, 295	152, 167	238, 241	301, 318	Vignoles 1
JxV 108	286, 316	150, 152	238, 255	303, 308	Vignoles 1
JxV 109	286, 295	152, 167	238, 255	301, 318	Vignoles 1
JxV 110	295, 302	150, 167	238, 255	301, 303	Vignoles 1
JxV 111	302, 316	150, 167	238, 255	301, 318	Vignoles 1
JxV 112	286, 316	150, 167	255, 261	303, 318	Not True
JxV 113	302, 316	150	241, 261	301, 318	Vignoles 1
JxV 114	302, 316	150	241, 261	301, 303	Vignoles 1
JxV 115	286, 295	150, 152	238, 255	308, 318	Vignoles 1
JxV 116	302, 316	150, 167	238, 255	301, 318	Vignoles 1
JxV 117	286, 295	150, 167	-	301, 318	Vignoles 1
JxV 118	295, 302	152, 157	241, 261	301, 318	Vignoles 1
JxV 119	302, 316	150, 152	238, 255	308, 318	Vignoles 1
JxV 120	286, 289	152, 160	241, 261	301, 303	Not True
JxV 121	302	150, 152	241, 259	303, 311	Vignoles 2
JxV 122	286, 295	152, 167	238, 255	308, 318	Vignoles 1
JxV 123	286, 316	150	238, 241	301, 303	Vignoles 1
JxV 124	289, 302	150, 160	238, 241	303, 322	Not True
JxV 125	289, 303	150, 160	238, 255	303, 322	Not True
JxV 126	286, 295	-	238, 241	301, 318	Vignoles 1
JxV 127	302, 316	150	255, 261	301, 303	Vignoles 1
JxV 128	286, 295	152, 157	241, 261	301, 318	Not True
JxV 129	302	-	241	301, 303	Vignoles 1

Table 4. continued

Plant	CTG5955	AF8125	VMC4D9.2	PSCTG196_2	Hybrid Status
JxV 130	-	150, 152	238, 255	301, 318	Vignoles 1
JxV 131	302, 316	150	241, 255	301, 318	Vignoles 1
JxV 132	289, 302	150, 160	238, 255	301, 318	Not True
JxV 133	302, 316	150, 167	238, 255	301, 318	Vignoles 1
JxV 134	289, 302	150, 160	238, 241	301, 318	Not True
JxV 135	302, 316	150, 152	238, 241	301, 318	Vignoles 1
JxV 136	295, 302	150, 167	238, 241	301, 318	Vignoles 1
JxV 137	286, 295	152, 167	238, 255	301, 318	Vignoles 1
JxV 138	295, 302	150, 167	238, 241	301, 308	Vignoles 1
JxV 139	289, 302	150, 160	255, 261	301, 318	Not True
JxV 140	295, 302	150, 167	238, 241	301, 318	Vignoles 1
JxV 141	295, 302	150	238, 255	301, 318	Vignoles 1
JxV 142	286, 295	-	238, 255	303, 308	Vignoles 1
JxV 143	286, 295	152, 167	238, 241	303, 308	Vignoles 1
JxV 144	286, 295	-	238, 255	301, 303	Vignoles 1
JxV 145	289, 302	150, 157	241, 259	301, 318	Not True
JxV 146	-	152, 167	238, 241	303, 308	Vignoles 1
JxV 147	289, 302	150, 160	255, 261	301, 318	Not True
JxV 148	295, 302	150	238, 241	301, 318	Vignoles 1
JxV 149	302	150	238, 241	301, 318	Vignoles 1
JxV 150	286, 295	-	238, 241	303, 308	Vignoles 1
JxV 151	286, 295	152, 167	238, 241	303, 308	Vignoles 1
JxV 152	286, 289	152, 160	241, 259	301, 303	Not True
JxV 153	286, 295	150, 157	255, 261	301, 318	Not True
JxV 154	286, 302	152	238, 241	301, 303	Vignoles 1
JxV 155	289, 302	150, 160	241, 261	318, 323	Not True
JxV 156	286, 295	150, 152	238, 241	301, 318	Vignoles 1
JxV 157	-	150, 167	238, 255	301, 318	Vignoles 1
JxV 158	286, 316	150, 152	238, 255	303, 308	Vignoles 1
JxV 159	295, 302	-	241, 261	301, 318	Vignoles 1
JxV 160	286, 316	-	238, 255	301, 303	Vignoles 1
JxV 161	302, 316	150	255	301, 303	Vignoles 1
JxV 162	295, 302	150, 167	238, 255	301, 303	Vignoles 1
JxV 163	289, 302	-	241	311, 318	Vignoles 2

Table 4. continued

Plant	CTG5955	AF8125	VMC4D9.2	PSCTG196_2	Hybrid Status
JxV 164	286, 316	150, 152	238, 241	308, 318	Vignoles 1
JxV 165	286, 295	150	241, 261	301, 303	Vignoles 1
JxV 166	295, 302	152, 167	238, 241	301, 308	Vignoles 1
JxV 167	286, 295	150, 160	255, 261	301, 318	Not True
JxV 168	286, 295	152, 167	238, 241	301, 318	Vignoles 1
JxV 169	302, 316	150, 152	241, 255	301, 303	Vignoles 1
JxV 170	-	-	-	-	Dead
JxV 171	286, 295	152, 167	238, 255	303, 308	Vignoles 1
JxV 172	286, 295	150, 160	238, 241	301, 323	Not True
JxV 173	295, 302	150	255, 261	301, 303	Vignoles 1
JxV 174	295, 302	150, 167	241, 255	303, 308	Vignoles 1
JxV 175	286, 295	150, 167	241, 261	308, 318	Vignoles 1
JxV 176	-	-	-	-	Dead
JxV 177	286, 295	152, 157	238, 261	301, 318	Not True
JxV 178	289, 302	150	255	301, 303	Not True
JxV 179	289, 302	150, 160	255, 261	301, 303	Not True
JxV 180	286, 289	152, 160	238, 241	301, 303	Not True
JxV 181	286, 295	150, 167	238, 241	303, 308	Vignoles 1
JxV 182	302, 316	150, 167	255, 261	301, 318	Vignoles 1
JxV 183	286, 295	150, 152	238, 255	301, 318	Vignoles 1
JxV 184	295, 302	150, 157	-	301, 318	Not True
JxV 185	286, 316	-	241	301, 303	Vignoles 1
JxV 186	295, 302	150, 160	241, 261	301, 318	Not True
JxV 187	302, 316	150	238, 241	308, 318	Vignoles 1
JxV 188	295, 302	150, 160	238, 241	301, 318	Not True
JxV 189	302	150, 167	238, 241	301, 303	Vignoles 1
JxV 190	302	-	238, 255	301, 303	Vignoles 1
JxV 191	286, 295	152, 167	241, 261	303, 308	Vignoles 1
JxV 192	286, 289	150, 160	238, 241	301, 303	Not True
JxV 193	-	-	-	-	Dead
JxV 194	295, 302	152, 157	241, 261	301, 303	Not True
JxV 195	295, 302	150, 167	255, 261	308, 318	Vignoles 1
JxV 196	286, 316	150, 152	255, 261	308, 318	Vignoles 1
JxV 197	-	-	-	-	Dead

Table 4. continued

Plant	CTG5955	AF8125	VMC4D9.2	PSCTG196_2	Hybrid Status
JxV 198	302, 316	150	238, 255	301, 318	Vignoles 1
JxV 199	286	150, 167	241, 255	303, 318	Vignoles 1
JxV 200	289, 302	150	241, 259	303, 311	Vignoles 2
JxV 201	302	150, 152	241, 261	301, 303	Vignoles 1
JxV 202	302, 316	150	238, 241	308, 318	Vignoles 1
JxV 203	286, 289	152, 157	-	301, 318	Not True
JxV 204	286, 295	150	-	308, 318	Vignoles 1
JxV 205	286, 295	150, 160	241, 255	301, 303	Not True
JxV 206	295, 302	150, 152	238, 255	308, 318	Vignoles 1
JxV 207	286, 316	150, 152	241, 261	303, 308	Vignoles 1
JxV 208	286, 302	150, 167	241, 255	308, 318	Vignoles 1
JxV 209	295, 302	150	255, 261	301, 303	Vignoles 1
JxV 210	295, 302	150	241, 261	303, 308	Vignoles 1
JxV 211	286, 316	150	-	308, 318	Vignoles 1
JxV 212	295, 302	-	-	301, 318	Vignoles 1
JxV 213	295, 302	150, 167	238, 255	303, 308	Vignoles 1
JxV 214	302, 316	150	238, 241	301, 303	Vignoles 1
JxV 215	286, 295	-	-	301, 318	Not True
JxV 216	286, 289	150, 160	-	301, 303	Not True
JxV 217	-	-	-	-	Dead
JxV 218	286, 316	150, 152	255, 261	-	Vignoles 1
JxV 219	286, 295	152, 157	-	-	Not True
JxV 220	302, 316	150	-	-	Vignoles 1
JxV 221	295, 302	150, 157	-	-	Not True
JxV 222	286, 295	-	-	-	Vignoles 1
JxV 223	-	-	-	-	Dead
JxV 224	295, 302	-	241, 261	-	Vignoles 1
JxV 225	295, 302	-	-	-	Not True
JxV 226	295, 302	150, 167	241, 261	301, 318	Vignoles 1
JxV 227	286, 316	150, 152	238, 255	-	Vignoles 1
JxV 228	-	150, 167	255, 261	-	Vignoles 1
JxV 229	-	150, 167	-	-	Vignoles 2
JxV 230	-	150, 167	-	-	Vignoles 1
JxV 231	-	-	238, 255	-	Vignoles 1

Table 4. continued

Plant	CTG5955	AF8125	VMC4D9.2	PSCTG196_2	Hybrid Status
JxV 232	-	-	-	-	Vignoles 1
JxV 233	-	150, 167	238, 255	-	Vignoles 1
JxV 234	-	150, 160	-	-	Not True
JxV 235	-	152, 157	-	-	Not True
JxV 236	286, 289	152, 160	238, 255	-	Not True
JxV 237	286, 295	152, 167	238, 241	301, 303	Vignoles 1
JxV 238	295, 302	-	-	-	Not True
JxV 239	286, 295	152, 167	238, 255	-	Vignoles 1
JxV 240	286, 295	152, 167	-	-	Vignoles 1
JxV 241	295, 302	152, 157	241, 261	318, 323	Not True
JxV 242	286, 316	152, 167	241, 261	301, 303	Vignoles 1
JxV 243	289, 302	150, 167	241, 261	301, 318	Not True
JxV 244	295, 302	152, 157	241, 261	318, 323	Not True
JxV 245	302, 316	150	241, 255	303, 308	Vignoles 1
JxV 246	286, 295	150, 167	238, 241	-	Vignoles 1
JxV 247	295, 302	150, 167	241, 261	-	Vignoles 1
JxV 248	286, 302	152	-	-	Vignoles 2
JxV 249	286, 289	152, 160	255, 261	-	Not True
JxV 250	286, 289	152, 160	-	-	Not True
JxV 251	276, 289	150, 152	255, 261	-	Not True
JxV 252	295, 302	150	-	-	Vignoles 1
JxV 253	-	-	-	-	Not True
JxV 254	276, 302	150, 152	-	-	Not True
JxV 255	303, 315	150	241	-	Vignoles 1
JxV 256	286, 295	150	-	-	Vignoles 1
JxV 257	286, 316	-	-	-	Vignoles 1
JxV 258	295, 302	150, 157	-	-	Not True
JxV 259	302	150	-	-	Vignoles 2
JxV 260	286, 289	152, 160	241, 261	301, 318	Not True
JxV 261	286, 295	150	241, 261	301	Not True
JxV 262	286, 289	152, 160	255, 361	301, 303	Not True
JxV 263	302, 316	150	241, 261	303, 308	Vignoles 1
JxV 264	286, 295	150, 157	241, 261	303	Not True
JxV 265	286, 316	150, 152	238, 241	303, 308	Vignoles 1

Table 4. continued

Plant	CTG5955	AF8125	VMC4D9.2	PSCTG196_2	Hybrid Status
JxV 266	286, 295	152, 167	238, 241	301, 303	Vignoles 1
JxV 267	286, 295	152, 167	-	-	Vignoles 1
JxV 268	286, 295	150, 167	-	308, 318	Vignoles 1
JxV 269	286, 316	150, 152	238, 255	301, 303	Vignoles 1
JxV 270	286, 295	150, 167	255, 261	301, 303	Vignoles 1
JxV 271	286, 295	150, 167	241, 261	-	Vignoles 1
JxV 272	286, 295	152, 167	241, 261	301, 303	Vignoles 1
JxV 273	289, 302	150, 160	255, 261	303	Not True
JxV 274	286, 295	152, 167	252	-	Not True
JxV 275	-	-	-	-	Dead
JxV 276	286, 316	150, 152	-	303, 308	Vignoles 1
JxV 277	-	-	-	-	Dead
JxV 278	286, 316	150, 152	241, 261	-	Vignoles 1
JxV 279	286, 316	150, 152	241, 261	301, 303	Vignoles 1
JxV 280	286, 316	152, 167	238, 255	301, 303	Vignoles 1
JxV 281	286, 316	150, 152	-	301, 318	Vignoles 1
JxV 282	286, 295	150, 167	241, 261	301, 303	Vignoles 1
JxV 283	-	-	-	-	Dead
JxV 284	286, 295	150, 167	241, 261	301, 318	Vignoles 1
JxV 285	286, 302	152, 167	241, 259	-	Vignoles 2
JxV 286	286, 289	150, 152	241, 256	-	Vignoles 2
JxV 287	286, 295	150, 152	238, 240	301, 303	Not True
JxV 288	302, 316	150	238, 241	301, 303	Vignoles 1
JxV 289	-	-	-	-	Dead
JxV 290	302, 316	150	238, 241	303, 308	Vignoles 1
JxV 291	286, 295	150, 167	-	301, 303	Vignoles 1
JxV 292	-	-	-	-	Not True
JxV 293	302	150	241, 256	303	Vignoles 2
JxV 294	286, 295	152, 157	-	318, 324	Not True
JxV 295	286, 295	152, 167	241, 261	-	Vignoles 1
JxV 296	286, 316	150, 152	255, 261	303, 308	Vignoles 1
JxV 297	302, 316	152, 167	-	301, 318	Vignoles 1
JxV 298	-	-	-	-	Not True
JxV 299	-	-	-	-	Not True

Table 4. continued

Plant	CTG5955	AF8125	VMC4D9.2	PSCTG196_2	Hybrid Status
JxV 300	302, 316	150	238, 255	301, 303	Vignoles 1
JxV 301	286, 295	150, 167	-	301, 303	Vignoles 1
JxV 302	302, 316	150	241, 261	301, 303	Vignoles 1
JxV 303	289, 302	150, 160	241, 261	318, 323	Not True
JxV 304	302, 316	150	-	301, 318	Vignoles 1
JxV 305	-	-	-	-	Dead
JxV 306	-	-	-	-	Dead
JxV 307	286, 316	150, 152	241, 261	301, 318	Vignoles 1
JxV 308	286, 295	152, 160	241, 261	318, 323	Not True
JxV 309	286, 316	150, 152	-	301, 318	Vignoles 1
JxV 310	-	-	-	-	Dead
JxV 311	286, 295	150, 157	-	303, 323	Not True
JxV 312	295, 302	-	238, 255	301, 303	Vignoles 1
JxV 313	-	-	-	-	Dead
JxV 314	286, 295	150, 152	241, 261	301, 318	Vignoles 1
JxV 315	-	-	-	-	Dead
JxV 316	286, 316	150, 152	238, 255	301, 318	Vignoles 1
JxV 317	295, 302	150, 167	241, 261	301, 303	Vignoles 1
JxV 318	-	-	-	-	Dead
JxV 319	302, 316	150, 152	-	301, 318	Vignoles 1
JxV 320	-	-	-	-	Dead
JxV 321	-	-	-	-	Dead
JxV 322	295, 302	150, 167	241, 250	318, 329	Not True
JxV 323	302, 316	-	-	301, 303	Vignoles 1
JxV 324	276, 302	150, 152	255	303, 329	Not True
JxV 325	286, 289	152, 160	241, 261	303, 323	Not True
JxV 326	289, 302	150, 157	-	301, 303	Not True
JxV 327	286, 295	150, 160	241, 261	303, 323	Not True
JxV 328	286, 316	150, 152	238, 255	301, 303	Vignoles 1
JxV 329	295, 302	152, 167	255, 256	303, 329	Vignoles 2
JxV 330	295, 302	150, 167	-	303, 308	Vignoles 1
JxV 331	295, 302	152, 157	-	301, 318	Not True
JxV 332	-	-	-	-	Dead
JxV 333	302, 316	150	-	301, 318	Vignoles 1

Table 4. continued

Plant	CTG5955	AF8125	VMC4D9.2	PSCTG196_2	Hybrid Status
JxV 334	289, 302	150, 160	-	303, 323	Not True
JxV 335	302, 316	150	241, 261	308, 318	Vignoles 1
JxV 336	286, 295	152, 167	238, 255	303, 308	Vignoles 1
JxV 337	286, 316	150, 152	238, 255	308, 318	Vignoles 1
JxV 338	286, 316	150	238, 255	301, 303	Vignoles 1
JxV 339	286, 316	150, 152	241, 261	301, 318	Vignoles 1
JxV 340	286, 295	152, 167	-	-	Vignoles 1
JxV 341	295, 302	150, 167	-	308, 318	Vignoles 1
JxV 342	302	150	255, 256	310, 318	Vignoles 2
JxV 343	289, 302	150, 160	241, 261	303, 323	Not True
JxV 344	286, 316	150, 152	-	301, 303	Vignoles 1
JxV 345	286, 316	-	-	303, 308	Vignoles 1
JxV 346	286, 316	150, 152	238, 255	301, 303	Vignoles 1
JxV 347	286, 295	152, 157	-	-	Not True
JxV 348	295, 302	150, 157	255, 261	318, 323	Not True
JxV 349	302, 316	150	-	308, 318	Vignoles 1
JxV 350	-	150, 152	-	301, 303	Vignoles 1
JxV 351	286, 295	150, 152	241, 261	301, 318	Vignoles 1
JxV 352	286, 295	150, 152	241	301, 303	Vignoles 1
JxV 353	286, 295	150	-	303, 308	Vignoles 1
JxV 354	286, 316	152, 167	-	301, 303	Vignoles 1
JxV 355	295, 302	150, 167	241	301, 318	Vignoles 1
JxV 356	302, 316	150	255, 261	301, 318	Vignoles 1
JxV 357	295, 302	150, 167	-	301, 303	Vignoles 1
JxV 358	-	-	-	-	Dead
JxV 359	286, 295	-	-	301, 318	Vignoles 1
JxV 360	286, 316	-	255, 261	301, 318	Vignoles 1
JxV 361	302	150	241, 261	318, 323	Not True
JxV 362	302, 316	150	-	308, 318	Vignoles 1
JxV 363	295, 316	150, 167	238, 255	301, 303	Vignoles 1
JxV 364	302, 316	150, 152	238, 241	301, 303	Vignoles 1
JxV 365	294, 302	150, 157	241, 255	301, 318	Not True
JxV 366	276, 286	150	241, 257	303, 329	Not True
JxV 367	286, 295	150, 160	241, 255	301, 303	Not True

Table 4. continued

Plant	CTG5955	AF8125	VMC4D9.2	PSCTG196_2	Hybrid Status
JxV 368	286, 295	152, 167	241, 261	301, 303	Vignoles 1
JxV 369	286, 302	152, 167	238, 255	301, 303	Vignoles 1
JxV 370	286, 302	150, 162	241, 259	-	Not True
JxV 371	302, 316	150, 152	238, 255	301, 303	Vignoles 1
JxV 372	286, 295	150, 167	255, 261	301, 303	Vignoles 1
JxV 373	302, 316	150, 152	238, 255	303, 308	Vignoles 1
JxV 374	286, 316	150, 152	241, 261	301, 318	Vignoles 1
JxV 375	286, 295		241, 261	301, 303	Vignoles 1
JxV 376	302, 316	150, 152	238, 241	303, 308	Vignoles 1
JxV 377	295, 302	150, 160	241, 261	-	Vignoles 1
JxV 378	-	-	-	-	Dead
JxV 379	276, 286	152	-	303	Not True
JxV 380	302, 316	150	-	301, 318	Vignoles 1
JxV 381	295, 302	150, 160	-	301, 303	Not True
JxV 382	286, 316	152, 167	241, 261	301, 303	Vignoles 1
JxV 383	295, 302	150, 167	-	301, 303	Vignoles 1
JxV 384	286	150, 152	255, 256	301	Not True
JxV 385	302, 316	150	238	301, 303	Vignoles 1
JxV 386	286, 295	150, 152	238, 261	301, 303	Vignoles 1
JxV 387	286, 295	152, 157	238, 241	301, 303	Not True
JxV 388	286, 295	150, 167	-	301, 303	Vignoles 1
JxV 389	286, 295	152, 167	-	301, 303	Vignoles 1
JxV 390	286	152, 167	-	308	Vignoles 1
JxV 391	286, 295	150, 152	238, 241	301, 303	Not True
JxV 392	286, 289	152, 157	238, 254	301, 303	Not True
JxV 393	286, 316	150, 152	254, 261	303, 308	Vignoles 1
JxV 394	286, 295	150, 152	238, 241	300, 301	Not True
JxV 395	286, 295	150, 152	241, 261	300, 301	Not True
JxV 396	286, 295	150, 152	238, 255	301, 303	Vignoles 1
JxV 397	286	152, 167	241, 261	303, 308	Vignoles 1
JxV 398	286, 302	150, 152	255, 259	301, 303	Not True
JxV 399	-	-	-	-	Dead
JxV 400	289, 302	150, 160	241, 255	301, 303	Not True
JxV 401	286, 295	150, 167	238, 261	301, 303	Vignoles 1

Table 4. continued

Plant	CTG5955	AF8125	VMC4D9.2	PSCTG196_2	Hybrid Status
JxV 402	286, 302	150, 157	241, 261	301, 303	Not True
JxV 403	286, 316	150	241, 255	301, 318	Vignoles 1
JxV 404	286, 302	150, 167	238, 261	301, 303	Not True
JxV 405	286, 302	150, 152	241, 261	301, 303	Vignoles 1
JxV 406	286, 302	150, 152	241, 261	301, 303	Vignoles 1
JxV 407	286, 316	150	241, 255	301, 303	Vignoles 1
JxV 408	286, 316	150, 152	238, 255	308, 318	Vignoles 1
JxV 409	286, 302	152, 167	238, 255	301, 318	Not True
JxV 410	289, 302	150, 160	238, 255		Not True
JxV 411	286, 302	150, 160	255, 261	301, 303	Not True
JxV 412	286, 316	150, 152	255, 261	301, 303	Vignoles 1
JxV 413	286	150	241, 261	301, 303	Vignoles 1
JxV 414	-	-	-	-	Dead
JxV 415	286, 302	152, 162	238, 241	301, 303	Not True
JxV 416	286, 295	152, 167	238, 255	301, 318	Vignoles 1
JxV 417	286, 316	150	238, 261	301, 303	Vignoles 1
JxV 418	286, 295	150, 167	238, 241	301, 303	Vignoles 1
JxV 419	-	-	-	-	Dead
JxV 420	286, 316	150, 152	238, 255	303, 308	Vignoles 1
JxV 421	295, 302	152, 167	238, 255	301, 303	Vignoles 1
JxV 422	286, 295	150, 167	238, 241	301, 303	Vignoles 1
JxV 423	286, 289	152, 157	255, 256	301, 318	Not True
JxV 424	295, 302	150, 167	238, 261	301	Vignoles 1
JxV 425	295, 302	150, 157	241, 261	303, 324	Not True
JxV 426	286, 295	152, 167	238, 255	-	Vignoles 1
JxV 427	295, 302	150, 157	-	301, 303	Not True
JxV 428	295, 302	150, 167	241, 259	303, 311	Vignoles 2
JxV 429	295, 302	152, 167	238, 255	303, 308	Vignoles 1
JxV 430	286, 295	152, 167	255, 261	301, 303	Vignoles 1
JxV 431	286, 295	152, 157	255, 261	301, 318	Not True
JxV 432	295, 302	150, 167	241, 261	308, 318	Vignoles 1
JxV 433	286, 295	150, 152	238, 255	308, 318	Vignoles 1
JxV 434	302	150	241, 256	303, 329	Vignoles 2
JxV 435	289, 302	150, 157	-	301, 303	Not True

Table 4. continued

Plant	CTG5955	AF8125	VMC4D9.2	PSCTG196_2	Hybrid Status
JxV 436	286, 316	150, 152	238, 241	303, 308	Not True
JxV 437	286, 289	152, 160	241, 261	301, 318	Not True
JxV 438	286, 316	150, 152	241, 261	-	Vignoles 1
JxV 439	286, 302	152, 167	241, 250	318, 329	Not True
JxV 440	286, 316	150, 152	241, 261	303, 308	Vignoles 1
JxV 441	286, 316	152, 167	238, 241	301, 303	Vignoles 1
JxV 442	286, 289	152, 160	238, 255	303, 323	Not True
JxV 443	289, 302	150, 167	241, 259	303, 308	Not True
JxV 444	295, 302	152, 167	238, 255	308, 318	Vignoles 1
JxV 445	302, 316	150	241, 261	301, 303	Vignoles 1
JxV 446	286, 316	150	255, 261	301, 318	Vignoles 1
JxV 447	286, 316	150	238, 255	301, 303	Vignoles 1
JxV 448	302, 316	150, 152	255, 261	301, 318	Vignoles 1
JxV 449	286, 316	152, 167	238, 241	308, 318	Vignoles 1
JxV 450	-	-	-	-	Dead
JxV 451	302, 316	150, 152	255, 261	301, 303	Vignoles 1
JxV 452	286, 316	152, 167	255, 261	301, 318	Vignoles 1
JxV 453	302, 316	150	241, 261	301, 318	Vignoles 1
JxV 454	302, 316	150, 152	255, 261	301, 318	Vignoles 1
JxV 455	302, 316	150, 167	238, 255	301, 318	Vignoles 1
JxV 456	295, 302	150, 167	238, 255	303, 308	Vignoles 1
JxV 457	302, 316	150	238, 255	308, 318	Vignoles 1
JxV 458	295, 302	152, 167	255	318, 323	Not True
JxV 459	286, 289	152, 160	255, 261	303, 324	Not True
JxV 460	276, 286	152	255	303, 318	Not True
JxV 461	295, 302	150, 157	238, 255	318, 323	Not True
JxV 462	295, 302	150, 160	255, 261	301, 303	Not True
JxV 463	276, 302	150, 152	241, 259	303	Not True
JxV 464	295, 302	150, 157	255, 261	301, 303	Not True
JxV 465	286, 316	150, 152	238, 241	301, 303	Vignoles 1
JxV 466	302	150, 152	241, 256	311, 318	Vignoles 2
JxV 467	286, 316	150	238, 241	301, 303	Vignoles 1
JxV 468	286, 295	152, 167	241, 261	308, 318	Vignoles 1
JxV 469	286, 295	152, 160	241, 261	303, 323	Not True

Table 4. continued

Plant	CTG5955	AF8125	VMC4D9.2	PSCTG196_2	Hybrid Status
JxV 470	302, 316	150	241, 261	301, 303	Vignoles 1
JxV 471	302	150	241, 259	303, 321	Not True
JxV 472	286, 289	152, 160	240, 255	303, 324	Not True
JxV 473	286, 295	150, 157	241, 261	303, 324	Not True
JxV 474	276, 286	150, 152	241, 255	303, 327	Not True
JxV 475	289, 302	152, 160	241, 261	318, 324	Not True
JxV 476	286, 295	152, 167	241, 261	301, 303	Vignoles 1
JxV 477	286, 302	150	241, 256	311, 318	Vignoles 2
JxV 478	295, 302	150, 167	-	301	Vignoles 1
JxV 479	295, 302	150	238, 241	301, 303	Vignoles 1
JxV 480	302, 316	150	255, 261	303, 308	Vignoles 1
JxV 481	286	150, 152	-	301	Vignoles 1
JxV 482	302, 316	150	241, 261	-	Vignoles 1
JxV 483	302, 289	150, 167	241, 255	303, 308	Not True
JxV 484	286, 316	150	255, 256	303, 318	Not True
JxV 485	286, 316	150, 152	238, 241	308, 318	Vignoles 1
JxV 486	286, 295	150, 152	241, 261	301, 303	Vignoles 1
JxV 487	289, 302	150, 160	255, 261	303, 324	Not True
JxV 488	286, 295	152, 167	241, 261	301, 318	Vignoles 1
JxV 489	286, 295	152, 157	255, 261	301, 303	Not True
JxV 490	286, 295	150, 167	238, 241	301, 303	Vignoles 1
JxV 491	286, 302	152, 167	241, 250	318	Not True
JxV 492	286, 316	152, 167	255, 261	301, 318	Vignoles 1
JxV 493	302, 316	150, 152	241, 261	303, 308	Vignoles 1
JxV 494	286, 295	152, 157	255, 261	301, 303	Not True
JxV 495	302, 316	150	238, 255	301, 303	Vignoles 1
JxV 496	276, 286	150, 152	255, 259	303, 318	Not True
JxV 497	295, 302	150, 157	241, 261	343	Not True
JxV 498	302, 316	150, 152	255, 261	301, 318	Vignoles 1
JxV 499	286, 316	152, 167	238, 241	301, 303	Vignoles 1
JxV 500	302	150, 167	238, 241	301, 318	Vignoles 1
JxV 501	302, 316	150	241, 261	308, 318	Vignoles 1
JxV 502	277, 286	150, 152	255, 259	303, 318	Not True
JxV 503	277, 286	150, 152	255, 256	318, 329	Not True
JxV 504	286, 295	152, 167	241, 261	301, 303	Vignoles 1

Table 4. continued

Plant	CTG5955	AF8125	VMC4D9.2	PSCTG196_2	Hybrid Status
JxV 505	286, 295	152, 167	255, 261	301, 318	Vignoles 1
JxV 506	277, 286	150, 152	255, 256	303, 329	Not True
JxV 507	289, 302	150, 160	241, 261	301, 323	Not True
JxV 508	286, 316	152, 167	238, 241	308, 318	Vignoles 1

Table 5. Parent plants (Jaeger 70, Vignoles 1, and Vignoles 2) and 91 possible progeny screened using VMC4D2, VMC1C10, and UDV-021 SSR markers with associated allele sizes. No data is represented by "-".

Plant	VMC4D2	VMC1C10	UDV-021
Jaeger 70	110, 116	162, 171	148, 150
Vignoles 1	114, 116	171, 181	161, 164
Vignoles 2	127, 129	171, 181	161, 164
JXV01	116	162, 181	161
JXV02	116	162, 171	148, 161
JXV03	116	162, 171	148, 161
JXV04	116	171	148, 161
JXV05	116	171	148
JXV06	110	162	148, 150
JXV07	110, 116	171	148, 161
JXV08	114, 116	171, 181	-
JXV09	110, 114	171, 181	148, 161
JXV10	110, 114	171	161
JXV12	116	171	148, 161
JXV13	116	162, 171	161
JXV14	116	162	161
JXV15	110, 116	171	148, 161
JXV16	114, 116	171, 181	148, 161
JXV17	116	162, 181	148, 161
JXV18	110, 114	171, 181	148, 161
JXV19	114, 116	162, 181	148, 161
JXV20	114, 116	161, 181	148, 161
JXV21	116	171, 181	148, 161
JXV22	110, 116	161, 171	148, 161
JXV23	110, 114	162, 171	148, 150
JXV24	110, 116	171	148, 161
JXV25	116	162, 171	148, 161
JXV26	116	171, 181	148, 161
JXV27	116	171, 181	148, 161
JXV28	116	162, 171	161
JXV29	114, 116	162, 171	148, 161
JXV30	110, 114	171, 181	148, 161
JXV31	-	-	-
JXV32	110, 116	162, 171	148, 164

Table 5. continued

Plant	VMC4D2	VMC1C10	UDV-021
JXV33	116	171	148, 164
JXV34	110, 114	162, 181	158
JXV35	116	171, 181	148, 161
JXV36	116	171	161
JXV39	114, 116	162, 171	148, 164
JXV40	114, 116	171	148, 161
JXV41	116	171	161
JXV42	110, 116	171	148, 164
JXV44	116, 123	171	161, 164
JXV45	110, 116	171, 181	148, 161
JXV46	110, 116	162, 171	148, 158
JXV47	116	171	148, 161
JXV48	110, 116	171	155, 161
JXV49	110	162	148
JXV50	110, 116	171	148, 161
JXV51	116	162, 181	155, 161
JXV52	110, 114	171	148, 161
JXV53	110, 116	171	148, 161
JXV54	116	162, 171, 181	148, 161
JXV55	116	162, 171	148, 161
JXV56	110, 116	162, 181	161, 161
JXV57	114, 116	171	148, 161
JXV58	110, 114	171	164
JXV59	110, 116	171, 181	158
JXV60	114, 116	162, 171	148, 158
JXV61	114, 116	171	148, 164
JXV62	114, 116	162, 181	148, 161
JXV63	110, 116	162, 171	150, 158
JXV64	102, 110	171	148, 165
JXV65	114, 116	162, 171	161, 165
JXV66	114, 116	171, 181	148, 161
JXV67	110, 114	171	150, 161
JXV68	114, 116	162, 181	148, 161
JXV69	114, 116	162, 171	148, 161
JXV70	116	162, 171	148, 161

Table 5. continued

Plant	VMC4D2	VMC1C10	UDV-021
JXV71	110, 113	162, 171	148, 164
JXV72	116	162, 171	148, 164
JXV73	114, 116	171	148, 164
JXV75	110, 138	171	148, 150
JXV76	110, 114	162, 171	148, 150
JXV77	110, 116	171, 181	156, 158
JXV78	116	162, 171	148, 161
JXV79	96, 101	162, 181	148
JXV80	110, 116	171	148, 161
JXV81	116	162, 171	148, 164
JXV82	110, 114	171, 181	148, 161
JXV83	110, 116	171	148, 161
JXV85	116	162, 181	148, 164
JXV86	110, 114	171	148, 150
JXV87	110, 116	162, 181	148, 164
JXV88	116	171, 181	148, 164
JXV89	114, 116	162, 171	148, 164
JXV90	114, 116,	171	161, 164
JXV91	116	162, 181	148, 164
JXV92	110, 116	171, 181	148, 161
JXV93	116	162, 171	161, 164
JXV96	-	-	161
JXV97	-	-	161, 164
JXV98	116	162, 181	148, 161
JXV99	110, 114	162, 181	148, 164

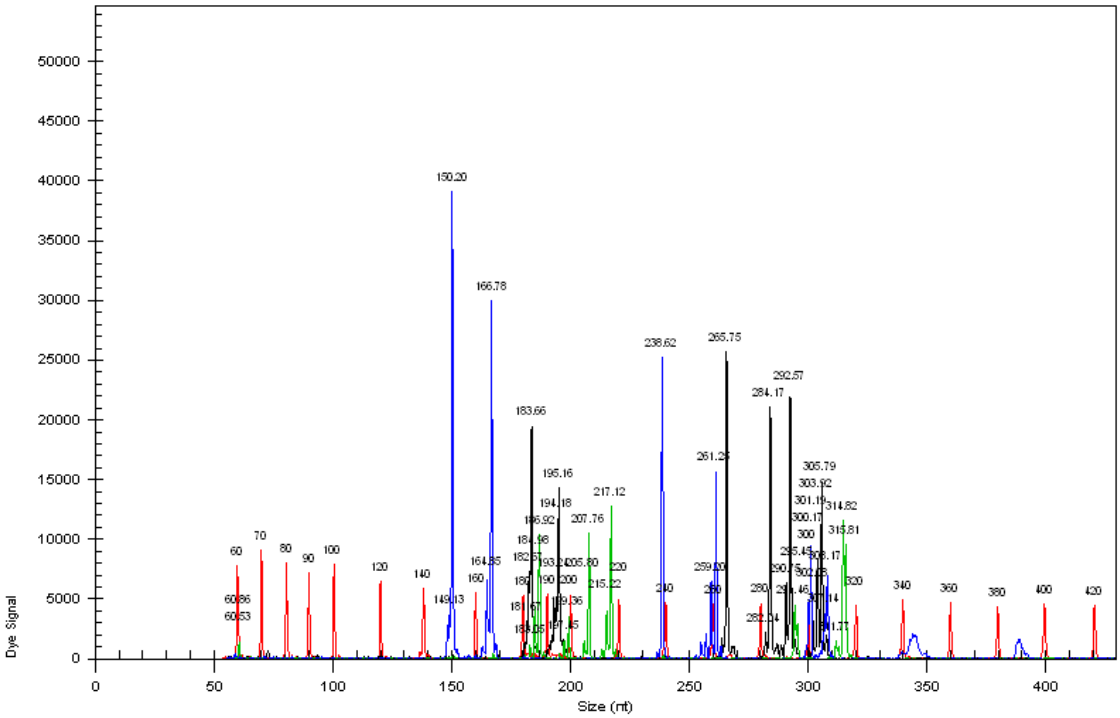

Fig. 1. (Vignoles 1) Vignoles SSR marker (VMC2B3, CTG5780, VVIV69, VMC5A1, VRIP93, CTG5955, AF8125, VMC4D9.2, and PSCTG196_2) capillary electrophoresis chromatogram

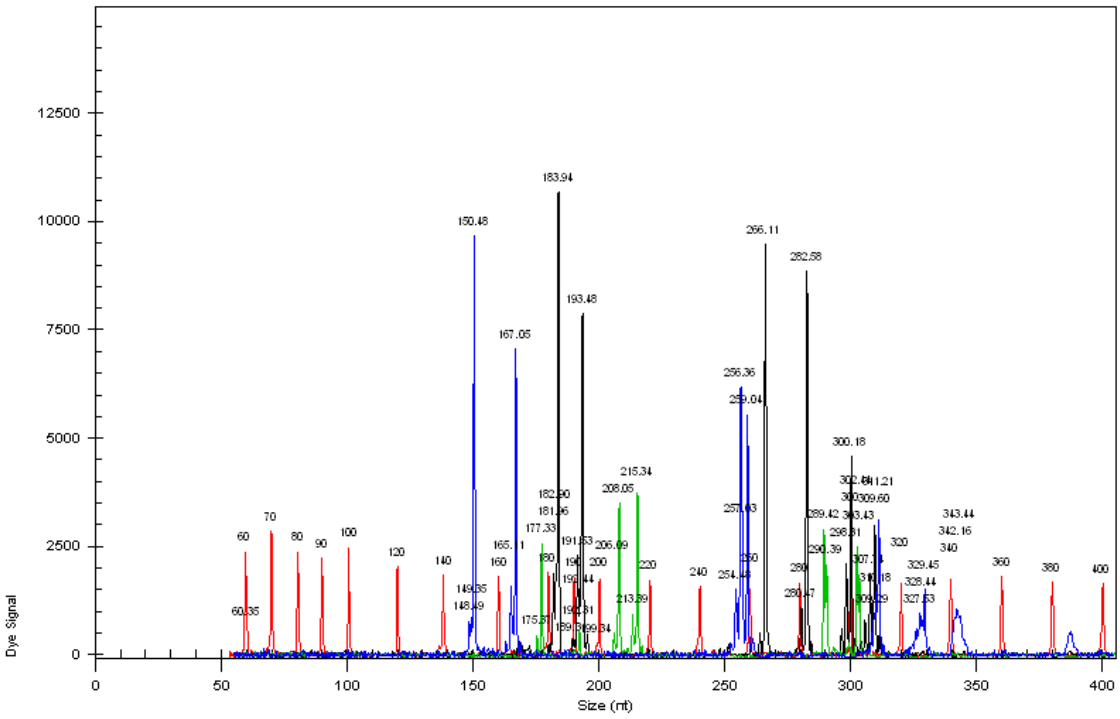

Fig. 2. (Vignoles 2) Vignoles SSR marker (VMC2B3, CTG5780, VVIV69, VMC5A1, VRIP93, CTG5955, AF8125, VMC4D9.2, and PSCTG196_2) capillary electrophoresis chromatogram

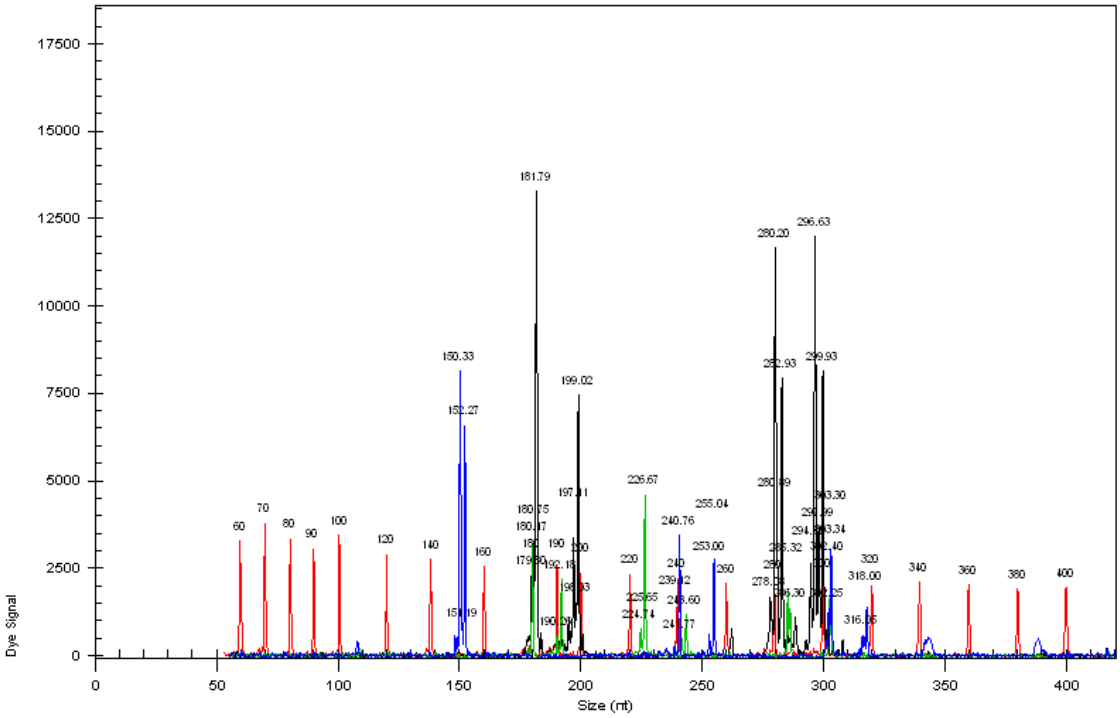

Fig. 3. Jaeger 70 SSR marker (VMC2B3, CTG5780, VVIV69, VMC5A1, VRIP93, CTG5955, AF8125, VMC4D9.2, and PSCTG196_2) capillary electrophoresis chromatogram

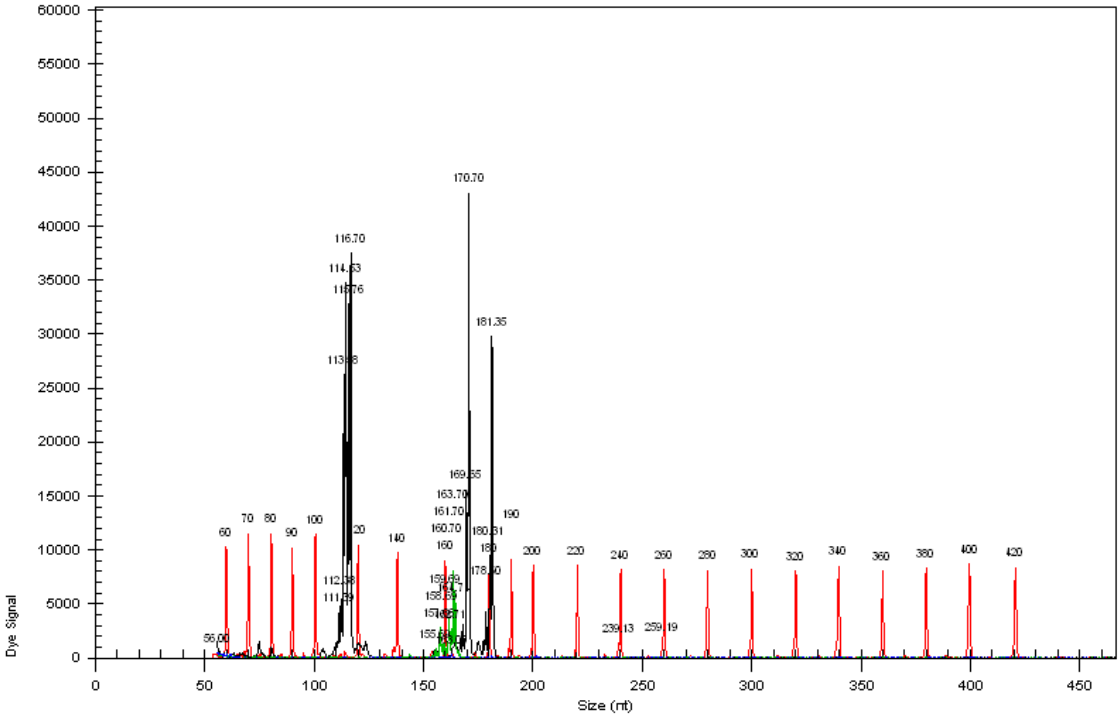

Fig. 4. (Vignoles 1) Vignoles SSR marker (VMC4D2, VMC1C10, and UDV-021) capillary electrophoresis chromatogram

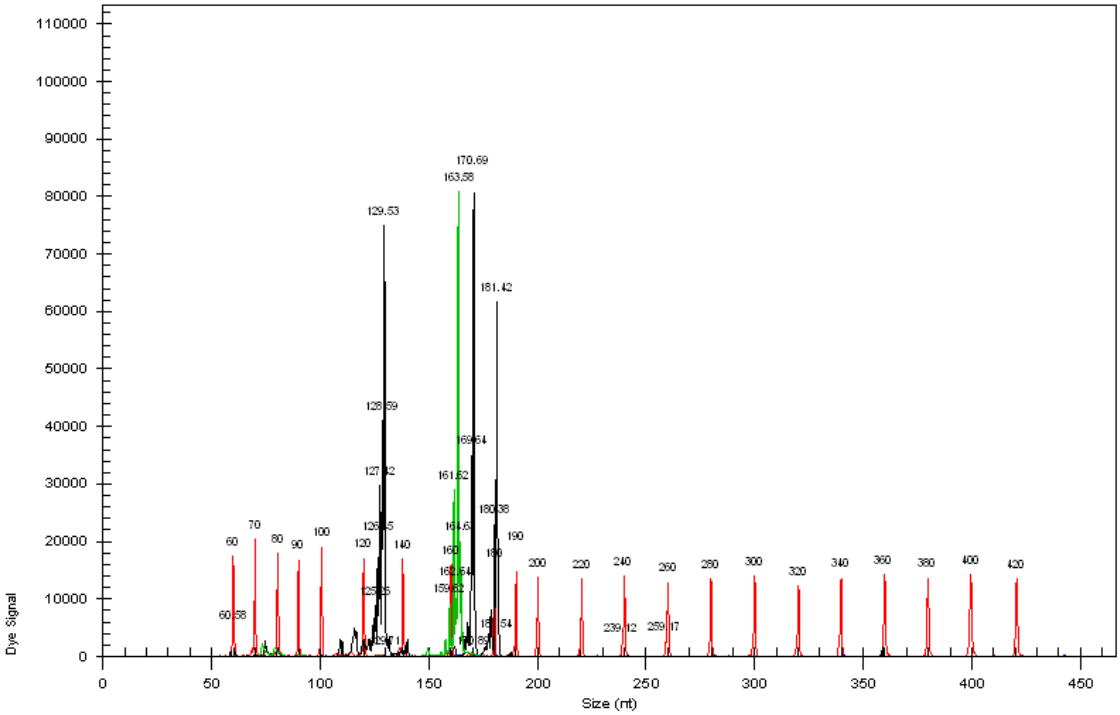

Fig. 5. (Vignoles 2) Vignoles SSR marker (VMC4D2, VMC1C10, and UDV-021) capillary electrophoresis chromatogram

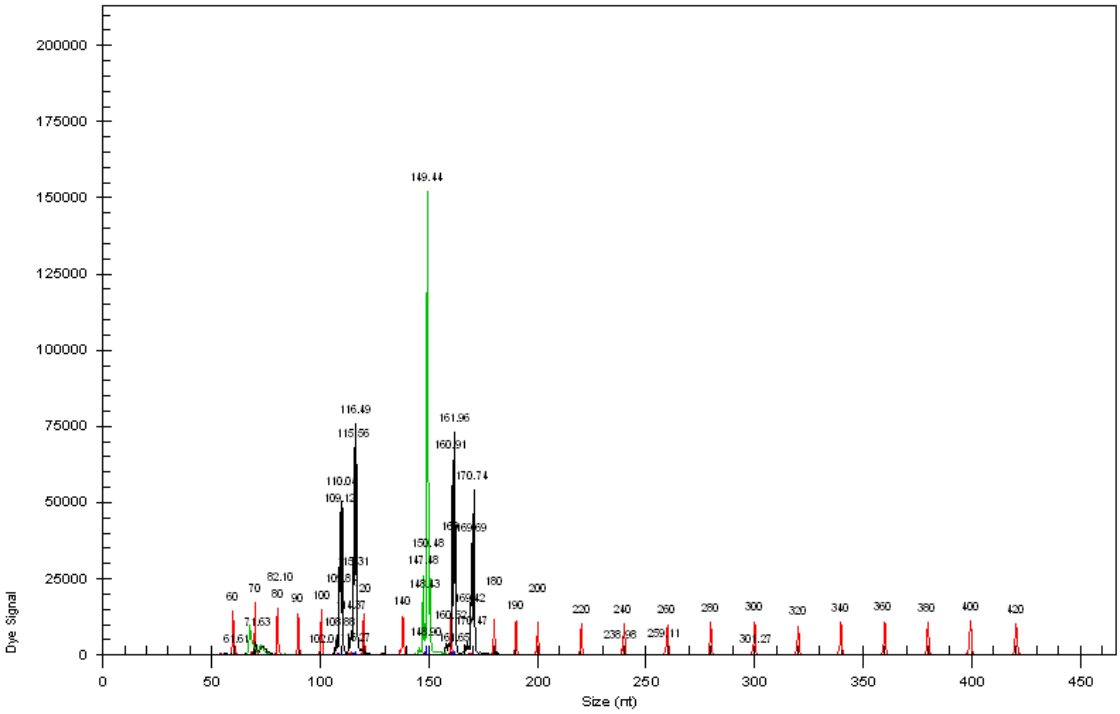

Fig. 6. Jaeger 70 SSR marker (VMC4D2, VMC1C10, and UDV-021) capillary electrophoresis chromatogram