# MAP-BASED CLONING OF THE *NIP* GENE IN MODEL LEGUME *Medicago truncatula*

Viktoriya Morris, B.Sc.

Thesis Prepared for the Degree of

MASTER OF SCIENCE

UNIVERSITY OF NORTH TEXAS

May 2007

APPROVED:

Rebecca Dickstein, Major Professor
Robert. C. Benjamin, Committee Member
Kent Chapman, Committee Member
Arthur. J. Goven, Chair of the Department of Biological Sciences
Sandra L. Terrell, Dean of the Robert B. Toulouse School of Graduate Studies

Morris, Viktoriya. Map-based cloning of the *NIP* gene in model legume *Medicago truncatula*. Master of Science (Molecular Biology), May 2007, 108 pp., 4 tables, 12 figures, bibliography, 29 titles.

Large amounts of industrial fertilizers are used to maximize crop yields. Unfortunately, they are not completely consumed by plants; consequently, this leads to soil pollution and negative effects on aquatic systems. An alternative to industrial fertilizers can be found in legume plants that provide a nitrogen source that is not harmful for the environment. Legume plants, through their symbiosis with soil bacteria called rhizobia, are able to reduce atmospheric nitrogen into ammonia, a biological nitrogen source. Establishment of the symbiosis requires communication on the molecular level between the two symbionts, which leads to changes on the cellular level and ultimately results in nitrogen-fixing nodule development. Inside the nodules hypoxic environment, the bacterial enzyme nitrogenase reduces atmospheric nitrogen to ammonia. *Medicago truncatula* is the model legume plant that is used to study symbiosis with mycorrhiza and with the bacteria *Sinorhizobium meliloti*. The focus of this work is the *M. truncatula* nodulation mutant *nip* (numerous infections and polyphenolics). The *NIP* gene plays a role in the formation and differentiation of nodules, and development of lateral roots. Studying this mutant will contribute knowledge to understanding the plant response to infection and how the invasion by rhizobia is regulated. Previous genetic mapping placed *NIP* at the top of linkage group 1 of the *M. truncatula* genome. A *NIP* mapping population was established with the purpose of performing fine mapping in the region containing *NIP.* DNA from two *M. truncatula* ecotypes A17 and A20 can be distinguished through polymorphisms.

Positional mapping of the *NIP* gene is based on the A17/A20 genetic map of *M. truncatula.* The *NIP* mapping population of 2277 plants was scored for their nodulation phenotype and genotyped with flanking molecular genetic markers 146o17 and 23c16d, which are located ~1.5 cM apart and on either side of *NIP*. This resulted in the identification of 170 recombinant plants, These plants' DNAs were tested further with different available genetic markers located in the region of interest, to narrow the genetic interval that contains the *NIP* gene. Segregation data from genotyping analysis of recombinant plants placed *NIP* in the region between 4L4 and 807 genetic markers.

ACKNOWLEDGEMENTS

First, I would like to thank my major professor Dr. Rebecca Dickstein. She is a great advisor. Her expertise, wonderful critique, patience, and her encouragement helped me to achieve my goal. Dr. Robert Benjamin, I thank you for your expertise, and help with the equipment. I thank members of the Dr. Dickstein lab, for your support and help. Special thanks to Dr. Laurent Coque, Dr. Catalina Pislariu, Brandon McKethan, Yi-Ching Lee, and former lab member Sumanjari Das for helping me learn the basics from making solutions to running PCR reactions. Thanks to all former and present undergraduate students: Timothy Flewelen, Bill Casady, Erich Spoor, Lily Kuo, and graduate students Rituraj Pal and Matthew Meckfessel for DNA extractions. Without your help my experiment would not have had such a great progress. Special thanks to my husband Mark Allen Morris for his endless support, infinite patience, and encouragement. You help me make my dream come true. Thanks to my family from Ukraine. That includes my Mother, Father, Sister my Grandmother Maria, and my uncle's family for giving me a reason to push myself and to work so hard.

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

Page

LIST OF ABBREVIATIONS

| | |
|---|---|
| BME | β-mercaptoethanol |
| bp | base pair |
| ºC | degree centigrade |
| CCaMK | Ca++/calmodulin-dependent protein kinase |
| cm | centimeter |
| CTAB | hexadecyl trimethylammonium bromide |
| dNTP | dideoxyribonucleotide |
| $ddH_2O$ | reverse osmosis and deionized water |
| $DIH_2O$ | deionized water |
| DNA | deoxyribonucleic acid |
| EDTA | ethylenediamine tetraacetic acid |
| EtOH | ethanol |
| g | gram |
| h | hour |
| KCl | potassium chloride |
| min | minutes |
| mix (F+R) | mixture of a forward and a reverse primer |
| $MgSO_4$ | magnesium sulfate |
| mL | milliliter |
| mM | millimolar |

# CHAPTER 1

## INTRODUCTION

### Legumes and Their Importance

In the third world regions poor nutrition and hunger are major issues. Soils there have low amount of nutrients, in addition, bad management of soil resources and inefficient use of fertilizers lead to very low yields of food crops. Use of mineral fertilizers is very expensive. For example, prices for fertilizers in some developing regions on average are two to six times more expensive when compared to prices in Europe, Asia and North America. Genetically modified crops containing higher amounts of nutritionally important compounds like vitamins, and amino acids can help with malnutrition. However, nitrogen depleted soils are the main problem for growing genetically engineered crops (Sanchez, 2002).

Use of nitrogen-fixing legume plants, the Leguminosae, can help to solve issues of poor nutrition, hunger, and can increase depleted soils with nitrogen. Legumes are second after cereal crops in their importance for human use. A large number of legume plants are used as important grain cultivars, some are valuable as feed for animals, and are cultivated on vast pasture areas. High quality protein content of legume seeds makes soybeans, beans, peas, and chickpeas major food staples. Soybeans and peanuts are valuable sources of vegetable oil worldwide. Many plants from the *Leguminosae* family develop tubercules. Plants such as alfalfa, clover and lupin are widely cultivated as food for animals (www.ildis.org).

Legume plants also utilized for nontraditional purposes. Obtaining tannins, gums and medicines are good examples. Species like *Derris* and *Lonchocarpus* are used to obtain rotenone, an insecticide used as a poison for fish and also as a molluscicide. Legume trees are used for timber and for collection of resins; other legume plants (genera *Indigofera* and *Copaifera*) are used as dye sources (www.ildis.org).

Many legume plants can utilize N2 from air and are able to reduce it into nitrogenous compounds that are useful for the plant. This is because plants in the Leguminosae can form a symbiotic relationship with soil bacteria called rhizobia. During the symbiosis the bacteria can reduce atmospheric nitrogen for the plants, which enables legume plants to live in low nitrogen conditions. Legume plants form root nodules, which are the place where nitrogen fixing bacteria reduce nitrogen. Plants provide the bacteria with a hypoxic environment, which is a necessary condition for optimal functioning of the bacterial enzyme nitrogenase. Also, plants supply bacteria with fixed carbon that is generated by plants through process of photosynthesis (www.ildis.org).

The ability of the legume plants to enter into a symbiotic nitrogen fixation relationship with bacteria reduces fertilizer use. The inclusion of legume plants in crop rotation systems can increase nitrogen levels in soils formerly depleted of nitrogen. The use of aerial plant parts as fertilizer further contributes to increasing soil nitrogen content. Nitrogen obtained through symbiosis contributes to increased amounts of protein in the foliage, and seeds of the legume plants when compared to protein content of the plants that are not able to get additional nitrogen through symbiosis. Higher

protein content makes legume plants valuable crops for agriculture (www.en.wikipedia.org).

Legume species present great value for humans. Nitrogen-fixing plants are well adapted for growth in low nitrogen environments. Their unique ability to form a symbiosis offers great scientific value. A deep understanding of symbiosis and the mechanisms that control it may enable future generations to apply knowledge and transform non-nitrogen-fixing plants like cereal crops with the ability to utilize an alternative environmentally friendly source of nitrogen.

## Benefits of Symbiotic Nitrogen Fixation

Fixing atmospheric nitrogen inside nodules by the means of symbiosis provides legume plants with the ability to live in the environments that are depleted in nitrogen. It allows plants to thrive without nitrogen fertilizers. Soils become enriched in nitrogen through fixation in nodules and the decomposition of foliage when the aerial parts of legumes are used as green fertilizers. Every year soils are being enriched by fifty million tons of nitrogen that is fixed by bacteria, and this source of nitrogen is not harmful for the environment (Udvardi and Scheible, 2005).

## Nodule Development

Nodules develop on the roots of the legume plants. Photographs of nodulated roots and a nodule are presented in Figure 1.

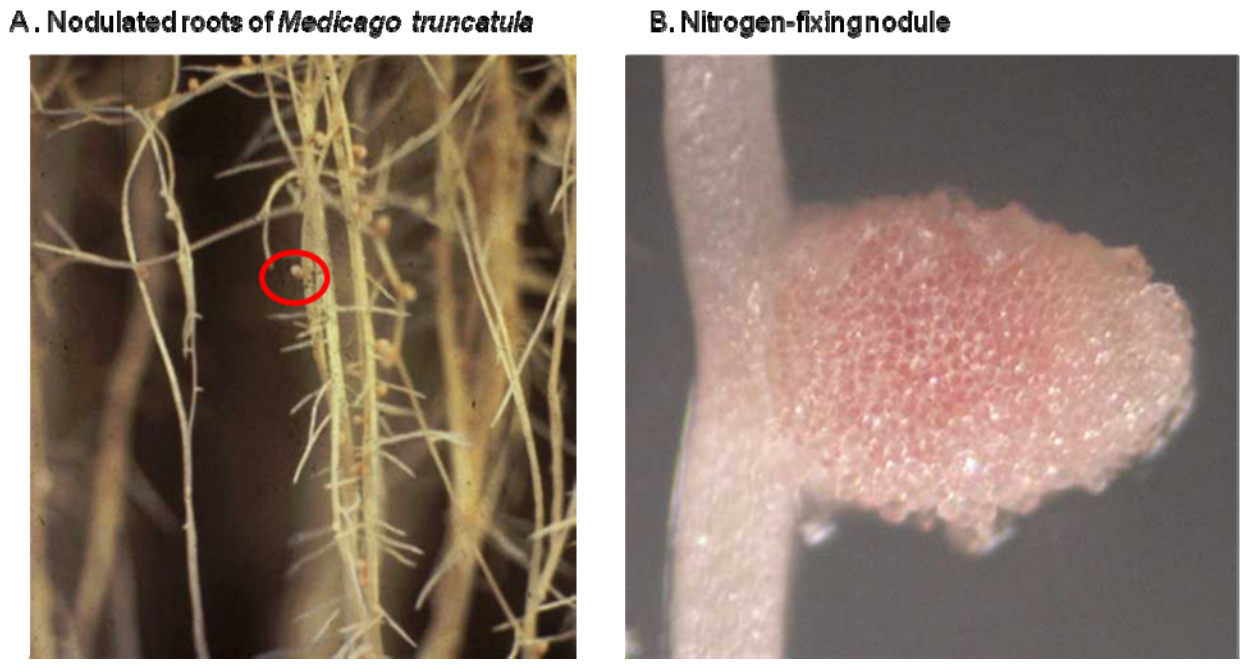



Figure 1. A. Nodulated roots of *M. truncatula*; B. Nitrogen fixing legume nodule

Nitrogen fixation takes place inside nodules where atmospheric nitrogen is reduced to ammonia by the bacterial enzyme nitrogenase.

$N_2 + 8H + 8e + 16Mg\text{-}ATP \rightarrow 2NH_3 + H_2 + 16Mg\text{-}ADP + 16Pi$ (Mylona et al., 1995)

Ammonia is used to make amino acids, which in turn are used to make other nitrogen-containing compounds (Hirsch, 1992). Conversion of nitrogen to ammonia is an oxygen-sensitive process and can be done only by some prokaryotic organisms (Mylona et al., 1995).

Legume plants will enter into the symbiosis with bacteria only if they grow in the nitrogen deficient conditions and if the correct type of bacteria are present (Hirsch, 1992). The process of nodule development can be divided into three steps: pre-

infection, nodule initiation and differentiation (Hirsch, 1992). During pre-infection the plant releases flavonoids into the rhizosphere. Flavonoids act as attractant for specific bacteria species, and they stimulate bacteria *nod* genes (nodulation genes) that are responsible for Nod factors synthesis (Mylona et al., 1995). Nod factors are lipochitooligosaccharides, a type of glycolipid, that generally have a 3-5 β-1, 4-linked N-acetylglucosamines with a fatty acid on the nonreducing sugar residue backbone (Mylona et al., 1995). Nod factors are important for initiating the symbiotic response in legume plant. The symbiotic response includes the recognition of bacteria by root-hair cells, curling of root hairs, initiation and propagation of infection threads, and the formation of root nodules (Cullimore and Denarie, 2003).

Nod factor binds on the roots to the receptor called Nod factor perception protein (NFP). *Nod Factor Perception (NFP*) is a putative Nod factor receptor gene. It was determined that NFP is a lysine motif (LysM)-receptor-like kinase (RLK) (Arrighi et al., 2006). In *L. japonicus* two transmembrane LysM-RLKs, *NFR1* and *NFR5*, were cloned. It is postulated that when activated as a heteroduplex complex NRF1/NRF5 they trigger calcium influx and cause swelling of root hair tips. The activated NFR1/NFR5 heteroduplex is necessary for activation of a putative receptor complex NORK/DMI2. NORK/DMI2 is responsible for plant symbiotic responses (Arrighi et al., 2006). In *M. truncatula* the LysM-RLKs LYK3 and LYK4 play a postulated role in recognition of Nod factors. It was shown that *LYK3* and *LYK4* genes are necessary for Nod factor induced infection of root hair cells by rhizobia (Cullimore and Denarie, 2003).

*LYK3* is predicted to be a putative Nod factor receptor, and it shows 72% sequence identity with *NFR5 L. japonicus* and 86% sequence identity with *SYM10* a

postulated Nod factor receptor from a pea (Arrighi et al., 2006). From studying mutants it was determined that *NFP* plays important role in Nod factor perception during early steps of the symbiotic interaction. *NFP* was placed upstream of the genes *DMI1, DMI2, DMI3, NSP1,* and *NSP2* that control symbiotic responses and nodulation (Arrighi et al., 2006).

From LYK3 and LYK4 the signal is transduced to another receptor like kinase DM12 and a putative cation channel DMI1 that regulates calcium spiking in the perinuclear region of root hair cells (Smit et al., 2005). The receptor like kinase DMI2 and the putative cation channel DMI1 are predicted to be upstream of both Ca++ spiking and DMI3 in the nodulation signaling pathway (Gleason et al., 2006). The initial detectable response to the Nod factor is the rise in cytosolic calcium in root hair epidermal cells that leads to the depolarization of the plasma membrane (Brewin, 2004). Cytosolic calcium spiking that is associated with the nucleus of epidermal root cells affects DMI3, a calcium/calmodulin-dependent protein kinase (Kalo et al., 2005). The DMI3 kinase is located in the nucleus of epidermal cells, and it is believed to interact with transcription factors that control the host plant gene expression (Smit et al., 2005). Nodulation signaling pathway genes *NSP1* and *NSP2* are located downstream of *DMI3*, and they are important for their role in the nodulation pathway (Smit et al., 2005). NSP1 and NSP2 are putative transcription factors belonging to the GRAS family. They are located in the nucleus of the plant root cells. NSP1 and NSP2 connect Nod factor to changes in expression of the plant genes that are necessary for nodule development. They are believed to be activated through phosphorylation by DMI3, which encodes the protein kinase Ca++/calmodulin-dependent protein kinase (CCaMK) (Gleason et al.,

2006). When in the active state, NSP1 and NSP2 promote transcription of the early nodulation genes (Udvardi and Scheible, 2005). Activation of NSP2 leads to production of a plant hormone cytokinin, which is important for nodule development. Increased amounts of cytokinin can induce nodule formation. Consequently, it was shown that inhibition of a *M. truncatula* receptor for cytokinin decreased nodulation (Oldroyd, 2007). Activation of *L. japonicus* cytokinin receptor histidine kinase1 (LHK1), is both necessary and sufficient for nodule organogenesis. LHK1 mutants abolished nodule primordium formation (Murray et al., 2007).

After the plant and bacteria recognize each other, bacteria attach to the root hair tip where the cell wall is thin. Specific recognition between the lectins, which are located on the surface of the plant root cells, and adhesins, which are located on the bacterial surface, aids in the attachment of the specific kind of the bacteria to the root cells. The signal produced by the bacteria increases as the numbers of bacteria increase (Brewin, 2004). After 6-18h from the initial contact with the bacteria, the plant root hair shape changes. Rhizobium *nod* genes are necessary for hair deformation (Hirsch, 1992). Under the action of the Nod factor, root hairs deform, yet the only shape that will lead to the future nodule development is a shepherd's crook. Shepherd's crook is when the root hair forms a 360 degree curl (Hirsch, 1992) and living rhizobia are required for its formation. It is thought that where rhizobia attach to the root surface they secrete Nod factor that causes change in local cell wall biosynthesis, and prolonged presence of the Nod factor results in change in the direction of the root tip growth towards bacteria (Brewin, 2004). As the root hair curls, bacteria become trapped inside the curl and bacteria multiply inside of the hair curl pocket. Inside of the curl a local hydrolysis of the

plant cell wall happens, plasma membrane invaginates, and new plant cell wall is deposited around it (Mylona et al.,1995; Brewin, 2004).

A plant cell wall presents an obstacle for the bacteria to enter inside the plant. Modifications at the cellular level need to take place in order for the rhizobia to get inside a host plant, but it is not known how these occur. Nod factor produced by the bacteria causes cell cycle activation. Cell cycle activation in the outer cortex is accompanied by the relocation of the nucleus from the periphery to the center of the cell. Cells of the outer cortex do not progress further than the G2 phase of the cell cycle. These cells form aligned transcellular cytoplasmic strands that are known as the preinfection threads. Over time the infection threads will develop in the place of the preinfection threads (Brewin, 2004). Bacteria enter the plant through the infection threads (Mylona et al., 1995). Infection threads are the tubelike structures that have invading bacteria embedded into the plant extracellular matrix and they are bounded by the plant cell wall material (Brewin, 2004). A matrix that surrounds bacteria inside the infection thread is made from the compounds produced by a plant and bacteria (Mylona et al., 1995). Infection thread formation is thought to involve a reconstruction of plant cell walls as they grow and move across several layers of the cortical cells (Brewin, 2004). A number of changes occur at the cellular level not only in the outer cortex, but also in the inner cortex as the rhizobia enter the plant. Nodule organogenesis is initiated by dedifferentiation of root cortical cells that is followed by cell proliferation, establishing a cluster of meristematic cells that give rise to the nodule primordium (Tirichine et al., 2007). The nodule primordium is the place where plant cells initially become invaded by rhizobia. After activation of the cell cycle, cells of the endodermis and pericycle give rise

to the nodule vasculature, and the outer side of the non infected cortex of the mature nodule (Brewin, 2004). Bacterial invasion of primordia occurs through infection threads progression through root hairs into the root cortex (Gage, 2004).

When the infection thread reaches the nodule primordium, bacteria are released into the cytoplasm of nodule primordium cells. By a process similar to endocytosis, the rhizobia become surrounded by the plasma membrane (Brewin, 2004), forming a symbiosome. The symbiosome includes the symbiosome membrane, the symbiosome space, and bacteroid. Many symbiosomes can be found in each nodule cell (Catalano et al., 2006). The symbiosome membrane is initially derived from a plasma membrane, and during maturation it becomes biochemically different from the plant plasma membrane. The symbiosome membrane becomes enriched with additional proteins and lipids, differentiating it from a plasma membrane (Catalano et al., 2006). The symbiosome membrane forms a permeable barrier between a plant cell and rhizobia. Through the symbiosome membrane, an exchange of different signals and metabolites, e.g., ammonium, carbon sources, takes place. Once inside the symbiosome, the internalized bacteria are called bacteroids. The symbiosome membrane also protects the bacteroids from plant defense response (Mylona et al., 1995). Bacteroids grow, divide and elongate inside of the host cell until they mostly fill the host cell.

Differentiation of nodule primordia into mature nodules that are able to fix nitrogen occurs after rhizobia are initially released from infection threads into the infected cells. Secondary signals of unknown origin are believed to cause morphological cell changes and tissue differentiation. Two kinds of nodules are known: determinate nodules and indeterminate nodules. They are distinguished based on their growth

patterns (Mylona et al., 1995). In determinate nodules, the meristem stops dividing during the early stage of nodule development; therefore, all cells in the central tissue stay at the same developmental stage (Mylona et al., 1995). In contrast, in indeterminate nodules, different regions can be clearly identified. An indeterminate nodule can be divided into following regions: the invasion region is where infection threads can be observed, and initial symbiosis takes place in the prefixing zone II. Here the continual release of rhizobia from infection thread takes place and bacteroids divide and elongate. Zone III is divided into nitrogen-fixation zone and inefficient zone where nitrogenase activity is low. An interzone can be found between zones II and III and bacteroids that have reached their full elongated size are located here (Vasse et al., 1990). The senescent zone IV is the last zone (Hirsch, 1992). The locations of the four nodule zones are depicted in the Figure 2.

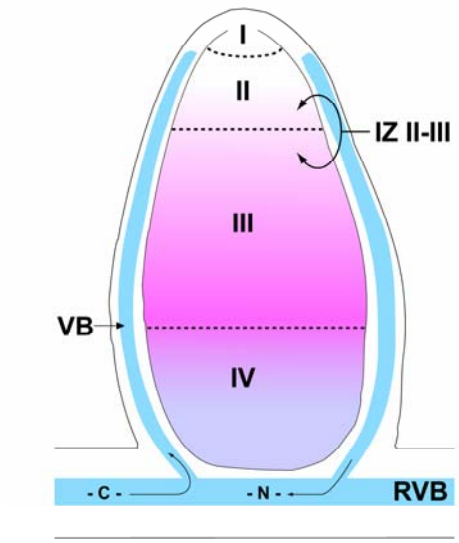



Figure 2. Schematic representation of a nodule.
I, II, III, and IV show location of the four major zones inside a nodule
IZ II-III shows position of the interzone region
VB indicates location of a vascular bundle
RVB indicates position of a root vascular bundle

(Adapted from Coque, 2006. PhD dissertation University of North Texas, Denton, Texas)

## *Medicago truncatula* as a Model Legume

*Medicago truncatula* is of particular interest for use in molecular genetics. It is an annual diploid 2n=16 plant that is largely cultivated as a foraging crop (Young et al., 2005). *M. truncatula* is self fertile, is easily transformed, and has a short reproductive cycle. Its genome is small, consisting of 500 Mb of DNA. Different ecotypes are available which allows for genetic studies. As a member of the *Galegoid* phylum *M. truncatula* is phylogenetically related to many agriculturally valuable legume crops, like pea, chickpea, faba bean, alfalfa and clover. This relatedness opens a possibility for useful findings from Medicago to be applied to related legumes that are useful for humanity. *M. truncatula* enters into the symbiotic relationship with well studied species of bacteria *Sinorhizobium meliloti*, whose genome is sequenced (Galibert et al., 2001). *M. truncatula* plants are also used to study symbiosis with mycorrhiza. Many different tools are presently available for genetic studies. These include cDNA libraries, a BAC library and numerous mutant lines (Thoquet et al., 2002). Also, microarray and DNA chips, as well as detailed physical and genetic maps are available for scientists to conduct their work (Young et al., 2005).

## *nip* Mutant

In our laboratory we study *M. truncatula*, and we are interested in gaining more knowledge about genes that are involved in the nodulation process. The goal is to identify genes that are important for nodulation. Several genes that are important for signal transduction pathways for nodule formation have been cloned (Mitra et al., 2004). We study mutants with defective nodulation phenotypes. Two mutants that we work

with are *nip* (numerous infections and polyphenolics) (Veereshlingam et al., 2004), and *sli* (sluggish mutation invasion) (Haynes et al., 2004), both of which have defects in the infection and invasion processes of nodule development. Studying these mutants will help to understand how plants respond to infection and how the invasion by the rhizobia is regulated. A primary goal of current research is to map and clone the *NIP* gene that is responsible for mutant phenotype, and later to map and clone *SLI* gene.

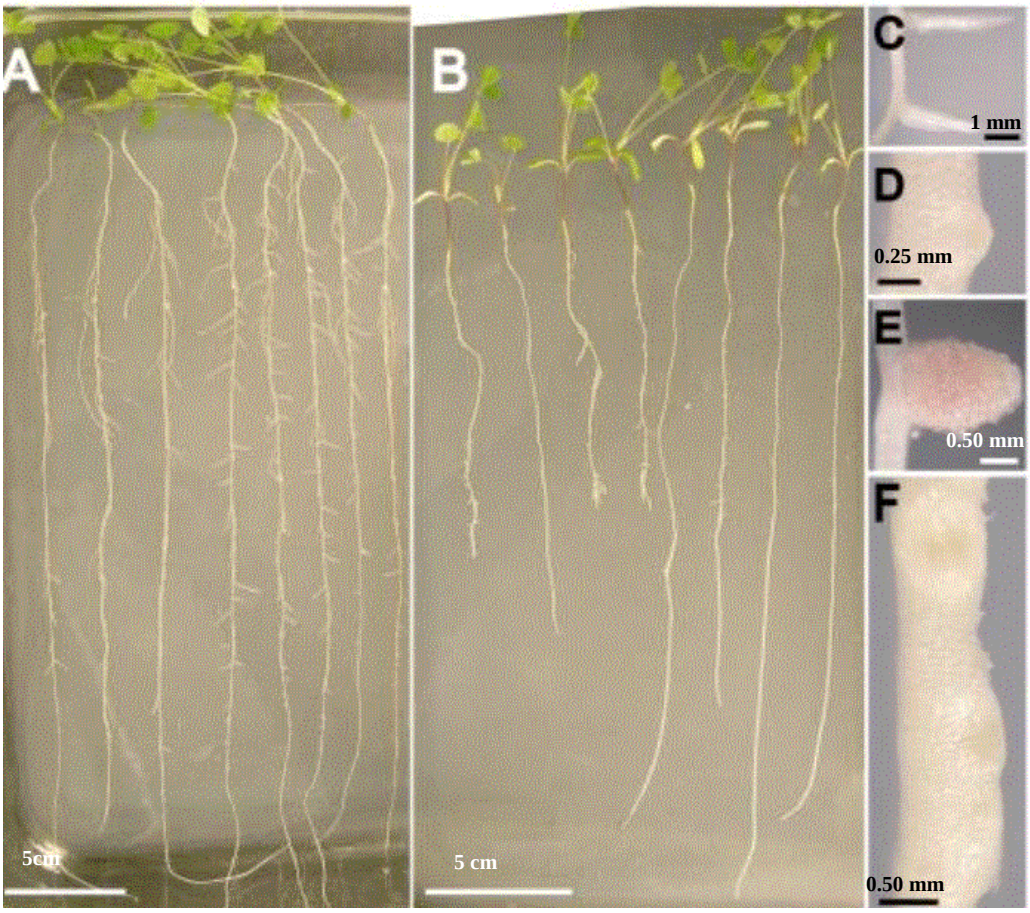
This project focuses on working with *nip* mutant plants. *nip* mutant plants are phenotypically different from wild type plants, and thus can be easily identified. Wild type plants are healthy and robust. They have a well developed root system. Wild-type plants have long primary roots, along with many developed lateral roots. Big pink nodules can be clearly seen on the wild-type plant roots. Pink nodules are indication of presence of leghemoglobin and an effective symbiosis with rhizobia.

*nip* mutant plants show nitrogen starvation symptoms when grown in media without nitrogen and in the presence of *S. meliloti*. When examining *nip* mutant plants, it can be seen that plants overall are weaker and smaller in size. They show signs of nitrogen deficiency. The root system of these plants is less developed. Generally, the main root is shorter when compared to wild-type plants, and *nip* plants have abnormal lateral roots. *nip* mutant plants have small nodule bumps— small white and brown nodules that fail to develop completely. *nip* nodules are stopped at an early developmental stage, and they show defective development of infection threads inside nodules. Abnormal infection threads can be explained as rhizobia not getting inside the plant host cells efficiently. Also, *nip* nodules have a brown pigment, and show accumulation of polyphenolics compounds, which is an indication of a plant defense

response (Veereshlingam et al., 2004). *NIP* is important for regulation in development of roots and nodules, since when it is defective, the mutant shows abnormal nodule development, abnormal progression of infection threads, and abnormal development of lateral roots. Accumulation of phenolic compounds also suggests that it might be involved in the defense response (Veereshlingam et al., 2004). Phenotypic differences between wild-type plants and *nip* plants are presented in Figure 3.

Figure 3 Phenotype of wild-type plants (A17) vs. phenotype of *nip* plants at 15 dpi.

A, Wild-type plants; B, *nip* plants; C, Wild-type primary root with emergent lateral roots;
D, *nip* lateral root;
E, Wild-type nodule; F, *nip* nodules/bumps.




(Veereshlingam et al., 2004)

## Positional Mapping of the *NIP* Gene

*nip* mutant plants, also called C90, with abnormal nodulation phenotype were isolated from a *M. truncatula* population that had been mutagenized with ethyl methane sulfonate (Penmetsa and Cook, 2000). The *nip* mutation was shown to be recessive and behaved as a single gene. The gene responsible for mutant phenotype was named *NIP*. Mutant *nip* is in the A17 background (*nip/nip*). To create a genetic mapping population, *nip* was crossed to wild-type *M. truncatula* of the ecotype A20. This ecotype pair, A17 and A20, is the basis for a genetic map of *M. truncatula* and many genetic markers are readily available for this cross. Positional mapping of the *NIP* gene is based on linkage analysis and the A17/A20 genetic map. The first generation of plants from this cross (F1) was obtained and found to be wild-type. These had a *NIP/nip* genotype. The F1s were selfed to create the F2 generation. In the F2 generation, segregation for the phenotype occurs and *NIP:nip* phenotype plants were observed to occur in a ratio of approximately 3:1 , which is consistent with a recessive gene behavior (Veereshlingam et al., 2004). In figure 4, the cross of heterozygous individuals from F1 to obtain F2, it can be seen that 25% of the F2 progeny should have mutant phenotype. Plants with *nip/nip* genotype will have *nip* phenotype, and plants with genotype *NIP/NIP* and *NIP/nip* will have wild-type phenotype (Griffiths et al., 1999).

Figure 4 Cross between F1 progeny to obtain F2 generation

| ♀/♂ | ***NIP*** | ***nip*** |
|---|---|---|
| ***NIP*** | ***NIP/NIP*** | ***NIP/nip*** |
| ***nip*** | ***NIP/nip*** | ***nip/nip*** |

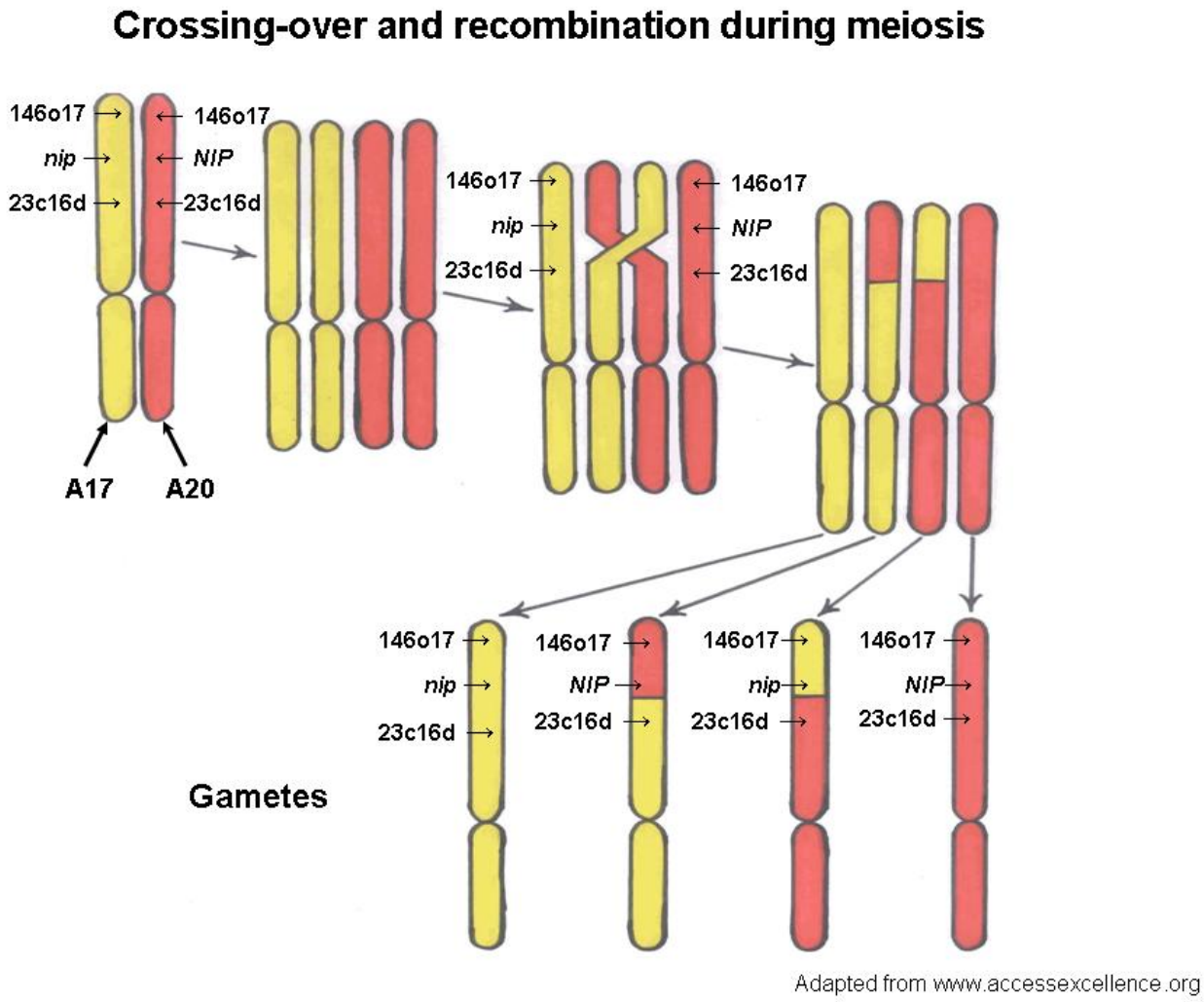
The progeny from these plants made the F2 *NIP* mapping population. Initially, the F2 progeny are evaluated by nodulation phenotype. The leaf material was collected for genomic DNA extraction, and when plants became mature their seeds were collected. The genomic DNA is extracted from plants that make up the F2 *NIP* mapping population. Then extracted DNA is used for the genotyping of the plants. Through the genotyping studies, plants of interest were identified for future propagation. Plants of interest showed a recombination event in the genetic interval that contains *NIP* or *nip*.

The A17 and A20 DNA are polymorphic; therefore, A17 DNA can be distinguished from A20 DNA due to the DNA difference of the different loci.

Having A17, A20 homozygote DNA and A17/A20 heterozygote DNA allowed us to utilize genetic studies to construct a genetic map. Genetic map relies on linkage analysis. Genes that are located closer to each other tend to segregate together. Genes that are further apart are at higher risk to be subjected to the crossing over event during

meiosis (Griffiths et al., 1999). Recombination also occurs during propagation from F1 to F2 between the A17 and A20 genotypes. Because the grandparents of the F2 generation were originally *nip/nip* in the A17 ecotype background and *NIP/NIP* in the A20 ecotype background, A17 DNA can be expected to co-segregate with *nip* and A20 DNA with *NIP.* The A17/A20 heterozygote plants were selfed to form F3's providing additional possible recombination events. Figure 5 is the schematic representation of the crossing-over and recombination during meiosis.

Figure 5 Crossing-over and recombination during meiosis

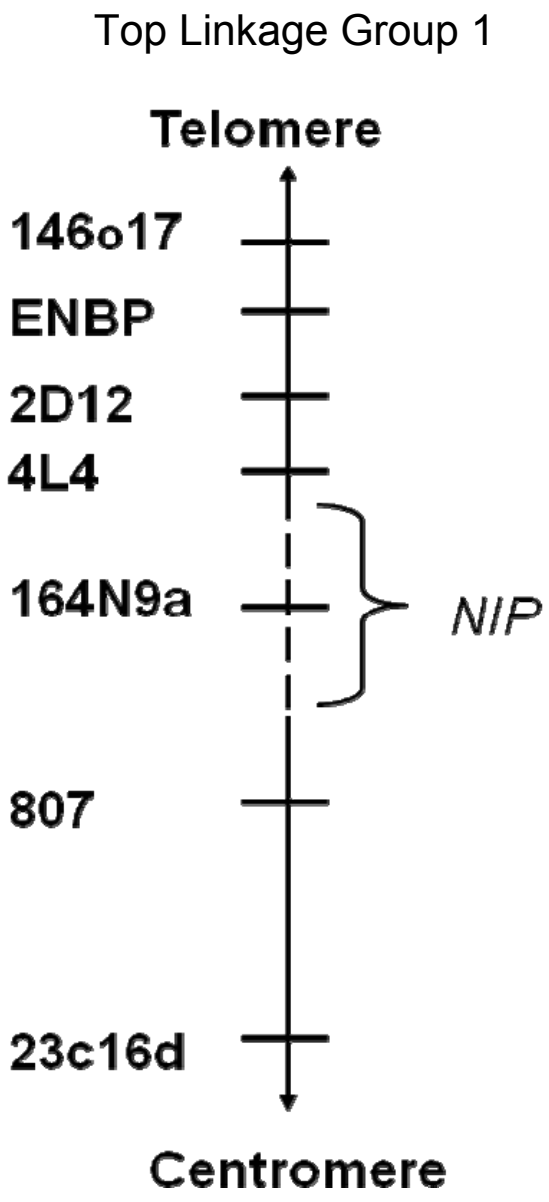


The current goal is to screen for recombinant plants by determining a genotype of each F2 plant at two loci located approximately 1.5 cM apart at the top of the chromosome 1. The loci 146o17 and 23c16d were amplified by PCR. The two loci chosen flank the *NIP* gene and are polymorphic in A17 and A20. Markers 146o17 and 23c16 can be used in a duplex PCR reaction because they have a significant difference in product sizes. Marker 146o17 is telomeric, while 23c16d is located on the centromeric side of the region where the *NIP* gene is located. Duplex PCR with these two markers gives us an opportunity to identify recombinant plants more quickly.

By analyzing the genotyping data, it is possible to isolate events of informative recombination within the mutant population. Each locus can be identified as either an A17 homozygote, an A20 homozygote or, a heterozygote. Recombinant plants are isolated, and their DNA material is further tested with other genetic markers.

At present, we have seven genetic markers (146o17, ENBP, 002D12, 4L4, 164n9, 807, and 23c16d) across the narrow genetic interval containing *NIP*. The position of the markers is presented in the Figure 6. These markers were developed from available BAC sequences and show polymorphisms in the different A17 and A20 ecotypes. When working with the genetic markers, studies will pinpoint the location of crossing over and the location of the *NIP*. Future genetic markers are being developed as the physical interval containing *NIP* is delimited.

Figure 6 Schematic representation of the top part of Linkage Group 1



## Objective and Means

### Objective

My contribution to the research conducted in Dr. Dickstein laboratory was to identify genetically important plants, and to genotype them with currently available genetic markers. The primary objective of this work was identification of recombinant plants in the *NIP* mapping population. These are then genotyped at multiple loci with various genetic markers. Information gathered from recombinant plant analysis will allow us to localize *NIP* with respect to the known polymorphic markers on the *M. truncatula* genetic map.

### Means

During transfer of plants from hydroponic chamber into soil an individual number was assigned to each plant. A total of 1766 F2 plants compose the primary *NIP* mapping population. Second generation plants 1-953 were genotyped by Heath Wessler. I genotyped all plants with assigned individual numbers 954 to 1766, using leaf material for DNA extraction and further genetic studies.

Each plant was evaluated for the nodulation phenotype, which allowed observation whether genetic markers segregate together with *NIP* gene. Leaf material was collected from each plant for DNA extraction. Genomic DNA was extracted using the CTAB method (http://iprotocol.mit.edu/protocol/120.htm/), from F2 generation plants.

The next step was to determine each plant's genotype. Knowing the genotype at several marker loci was a main criterion for the identification of recombinant plants. Plants from F2 mapping population were genotyped with two flanking markers 146o17, and 23c16d, and with the ENBP marker. Therefore, recombinant plants were identified.

To make sure that no mistakes occurred, and that signal received from the PCR reaction was not false, the DNA from leaves of the plants that tested once for recombination were re-extracted. Re-extracted DNA was tested again with the markers to confirm that particular plant is truly recombinant. Plants that tested a second time for recombination were selected for “recombinants pool”. This means that DNA material was placed and kept in a special box for F2 generation recombinant plants only, DNA was placed on DNA microtiter plate for recombinant DNA only (20x dilution) – ready to be used in PCR reaction with any genetic markers of interest. Also, tubes with leaf material were isolated, and placed into the box containing leaf material that originates from recombinant plants. This box is retained in case more DNA is needed for tests in the future.

Another part of the objective was to assist with keeping track of several F3 generation plants, which have been generated from heterozygous plants in the main mapping population with the purpose to identify more recombinant plants. DNA was extracted from F3 plants generation, and transferred to 96 well microtiter DNA plates. Plants from F3 generation were also evaluated for their nodulation phenotypes. The F3 generation of plants was genotyped, and screened only with two flanking markers 146o17, and 23c16d, for the purpose of quick identification of recombinant plants. Recombinant plants were identified, tested a second time for verification of the recombination event, and then placed into the F3 “recombinant pool”.

Microtiter DNA plates with F3 and F2 recombinant DNA were tested with available genetic markers: 146o17, ENBP, 2d12, 4L4, 164n9, 807 and 23c16d. Analyzing all the data from genotyping with genetic markers helped to determine in what

place recombination took place; it also helped to evaluate position of the *NIP* gene that is surrounded by A17 DNA with respect to recombination. This analysis helped to delimit the region where it is believed *NIP* gene is located.

# CHAPTER 2

# IDENTIFICATION OF RECOMBINANT PLANTS

## Introduction

The *nip* (numerous infections and polyphenolics) mutant (Veereshlingam et al., 2004), was identified from the EMS generated *Medicago* truncatula mutants (Penmetsa and Cook, 2000). The goal of the work described here was to genotype the *NIP* mapping population F2 generation, and to identify recombinant plants. To accomplish the goal plants were phenotyped with respect to nodulation. DNA was extracted and regions of interest were amplified by PCR. PCR products were analyzed on 8% polyacrylamide gels, and DNA was stained with SYBR Green stain.

### *NIP* Mapping Population F2 Generation and Screening for Recombinant Plants

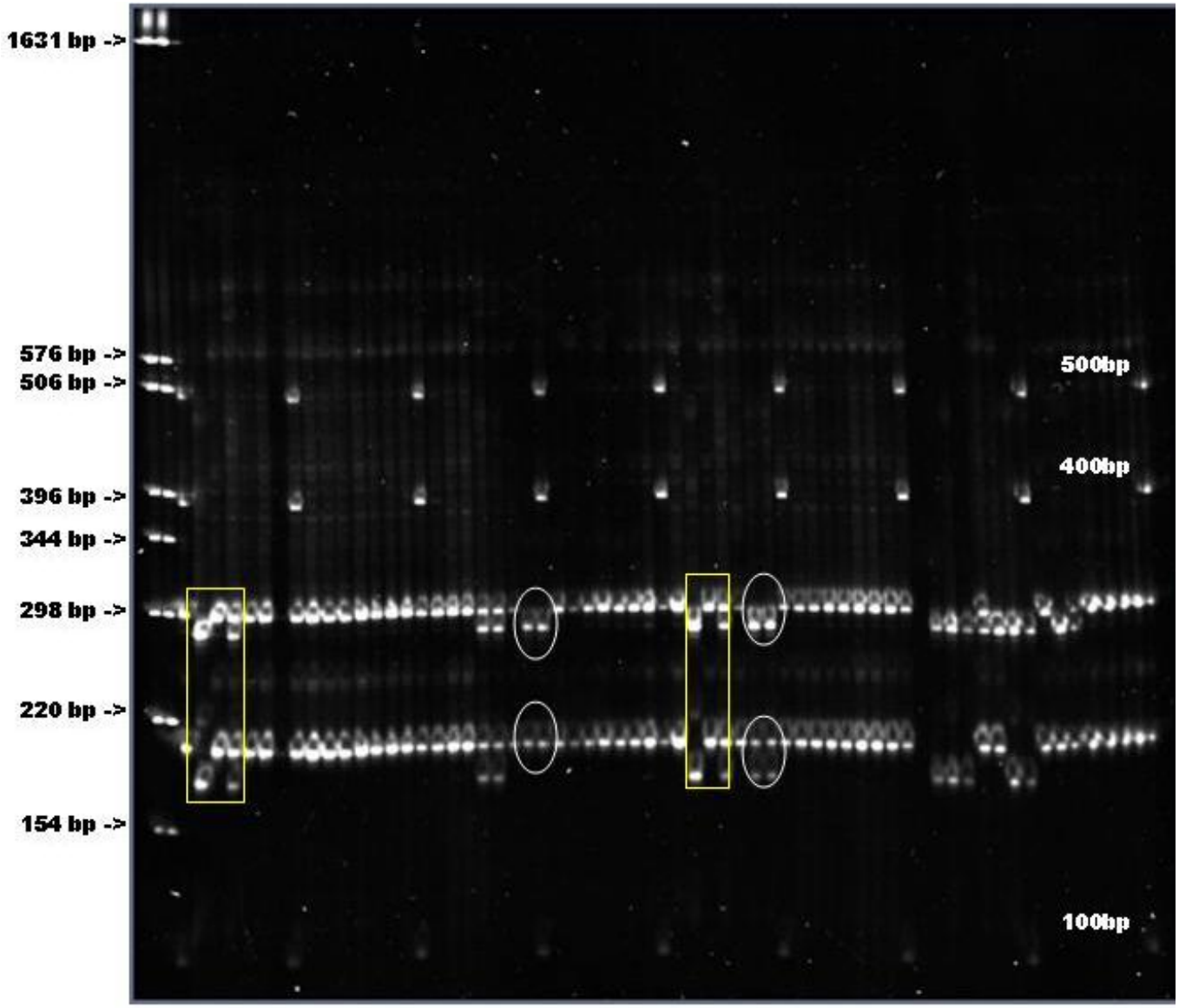
*nip* mutant plants were created in the A17 ecotype of *Medicago* truncatula. Mutant plants were crossed into different ecotype of *Medicago* truncatula, the A20 ecotype, that has wild-type alleles of the *NIP* gene. The progeny obtained from these plants made the F2 *nip* mapping population. The *NIP* mapping population F2 generation includes a total of 1766 plants. All plants composing the *NIP* mapping population were assigned individual identification numbers starting from 1 and ending at 1766. Plants from 1 to 953 were genotyped by Heath Wessler. I genotyped plants from 954 to 1766, a total of 812 plants. Of 812 plants, 126 plants were initially too small and later died, therefore we could not collect leaf material for the DNA extraction and genotyping.

Total of 686 plants from the *NIP* mapping population F2 generation have been genotyped at two flanking markers 23c16d and 146o17. Figure7 a typical 8% polyacrylamide gel stained with SYBR green with the duplex PCR reaction for the

genetic markers 23c16d and 146o17. A significant difference in the PCR product sizes, and similar PCR conditions for the amplification of these two genetic markers allowed duplex PCR reactions. Duplex PCR reactions provided faster genotyping at two the 23c16d and 146o17 loci that flank the region of the *NIP* location, and allowed for easy scoring of the recombinant plants on the same gel.

Figure 7 Genotyping with 23c16d and 146o17 genetic markers

The amplicon derived from the genetic marker 23c16d forms top row located in the 298 bp region, and 146o17 amplicon forms the bottom row in the region slightly below 220 bp. The control DNAs for A17, A20 and H (heterozygote) are highlighted in the boxes. The A17 DNA yields a single lower band, the A20 DNA yields a higher band with respect to A17 band, and the H DNA gives two bands. Recombinant DNA samples are highlighted in the circles.

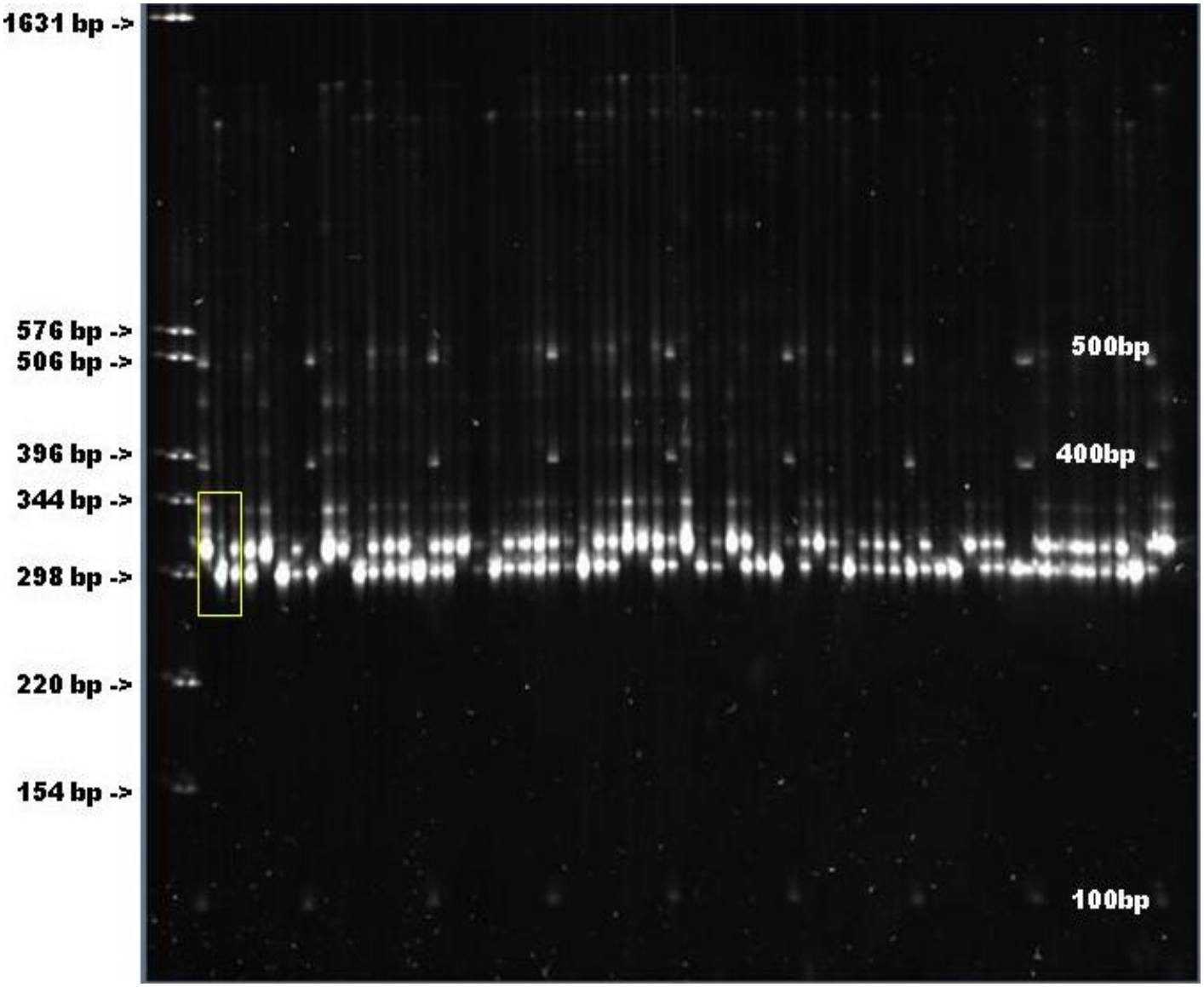


## Genotyping with ENBP Genetic Marker

The F2 *NIP* mapping population was genotyped with the 23c16d and 146o17 genetic markers, but also plants from F2 generation were genotyped with the ENBP marker that is located near 146o17 genetic marker. ENBP is one of the first genetic markers that we had and it is located in the region between two flanking markers. Genotyping with ENBP allowed us to isolate plants with recombination in the area between ENBP and 23c16d markers. Plants that had recombination in the area between 146o17 and ENBP markers were not of interest for further testing. *NIP* is between ENBP and 23c16d. Most of the identified recombinant plants showed that in plants with wild-type nodulation phenotype heterozygous DNA was segregating with 23c16d marker and in some cases with ENBP marker too. Plants that had *nip* mutant nodulation phenotype showed that A17 DNA was segregating with 23c16d marker. From segregation data, we concluded that the *NIP* gene is located in the area between the ENBP and 23c16d markers. Figure 8 presents a picture of the 8% polyacrylamide gel with the PCR products for the ENBP genetic marker.

Figure 8 Genotyping with ENBP genetic marker

The genetic marker ENBP yields amplicons of approximately 300 bp sizes. The control DNA A17, A20 and H are highlighted in the box. The A17 DNA forms a higher band with respect to the A20 DNA that forms a lower band, and the H DNA forms two bands.



Data for phenotyping and genotyping with 23c16d, 146o17 and ENBP genetic markers of the plants from the *NIP* mapping population from F2 generation are presented in Table 1 in the appendix. From genotyping data from 686 plants from F2 generation it was possible to identify 67 recombinant plants, generated from 17 parental lines.

*NIP* Mapping Population F3 Generation and Screening for Recombinant Plants

Genotyping of the plants from *NIP* mapping population F2 generation did not yield a lot of recombinant plants. Identified recombinant plants had either A20 DNA at one locus and H DNA at another locus, or A17 DNA for one locus and H DNA for second locus. In order to determine the location of the A17 DNA it was necessary to further propagate progeny of the recombinant plants to obtain segregation data. Also, to obtain more recombinant plants the heterozygous plants were propagated because of the higher probability of recombination event to occur. Therefore, heterozygous plants and recombinant plants were propagated to create *NIP* mapping population from F3 generation. Each plant in the *NIP* mapping population F3 generation was assigned an individual identification number, starting at 3000 to avoid confusion with F2 generation plants. I have genotyped plants in the F3 generation starting from individual plant number 3000 and ending at individual plant number 4836. This makes total number of F3 generation plants 1836, and out of this total number 245 plants died before any leaf material could be collected for DNA extraction and genotyping. Therefore, the number of plants that was actually genotyped is 1591. Plants from F3 generation have been genotyped with two flanking markers 23c16d and 146o17 for fast identification of recombinant plants. From 1591 plants, 103 recombinant plants were identified, and

these plants originated from 36 different parental lines. Results on genotyping and phenotyping plants from the F3 generation are presented in the Table 2 in the appendix.

# CHAPTER 3

# ISOLATION OF RECOMBINANT PLANTS AND TESTING THEIR DNA WITH DIFFERENT GENETIC MARKERS

## Introduction

As described in the previous chapter, plants from F2 and F3 generations from *NIP* mapping population were genotyped with two flanking markers 23c16d and 146o17. The main goal of the genotyping was to identify recombinant plants. From the second generation of plants 67, recombinant plants were identified, and they originate from 17 parental lines. Currently, from the F3 generation of plants, 103 recombinant plants were identified and these plants originate from 36 different parental lines. More work is being done by other members of the Dr. Dickstein lab to obtain more recombinant plants, test them with various genetic markers, and to develop new genetic markers to the region of interest.

All identified recombinant plants from F2 and F3 generations were isolated, and their DNA was genotyped at multiple loci with available genetic markers ENBP, 2D12, 164n9, 4L4 and 807. Main purpose of this work was to determine the region where recombination took place and what markers co-segregate with A17 DNA or A20 DNA relative to location of the *NIP* gene.

Figure 9 Genotyping with 2D12 genetic marker

The genetic marker 2D12 forms bands in the range between 300 bp and 225 bp sizes. The control DNA A17, A20 and H are highlighted in the box. The A17 DNA forms two bands that are positioned lower with the respect to two bands formed by A 20 DNA. A20 DNA forms to bands that are positioned higher with respect bands formed by A17 DNA. Heterozygote (H) DNA forms four bands.

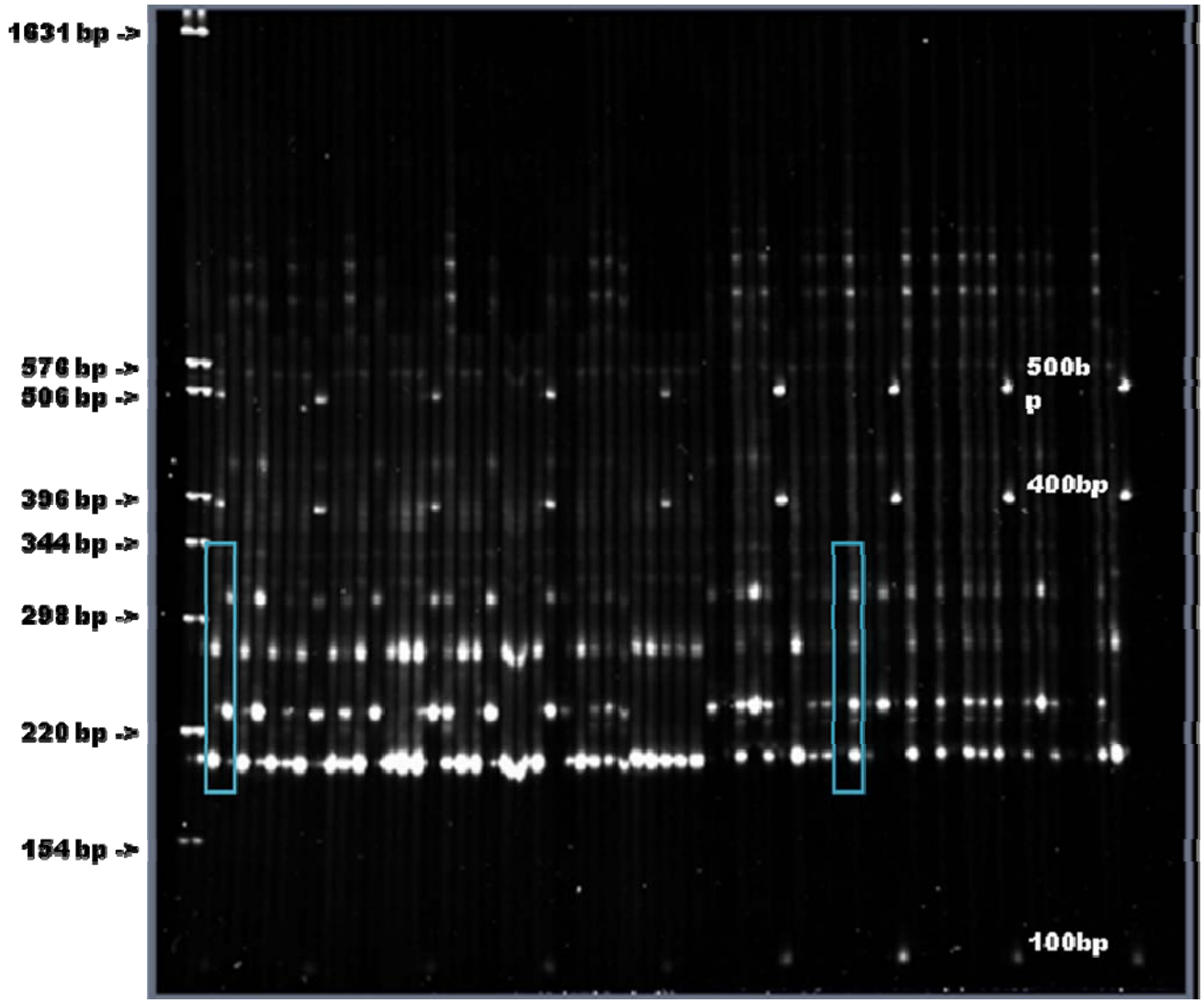


Figure 10 Genotyping with 164n9 genetic marker

The genetic marker 164n9 forms bands of 220 bp sizes. The control DNA A17, A20 and H are highlighted in the boxes. The A17 DNA forms a higher band with respect to the A20 DNA that forms a lower band, and the H DNA forms two bands.

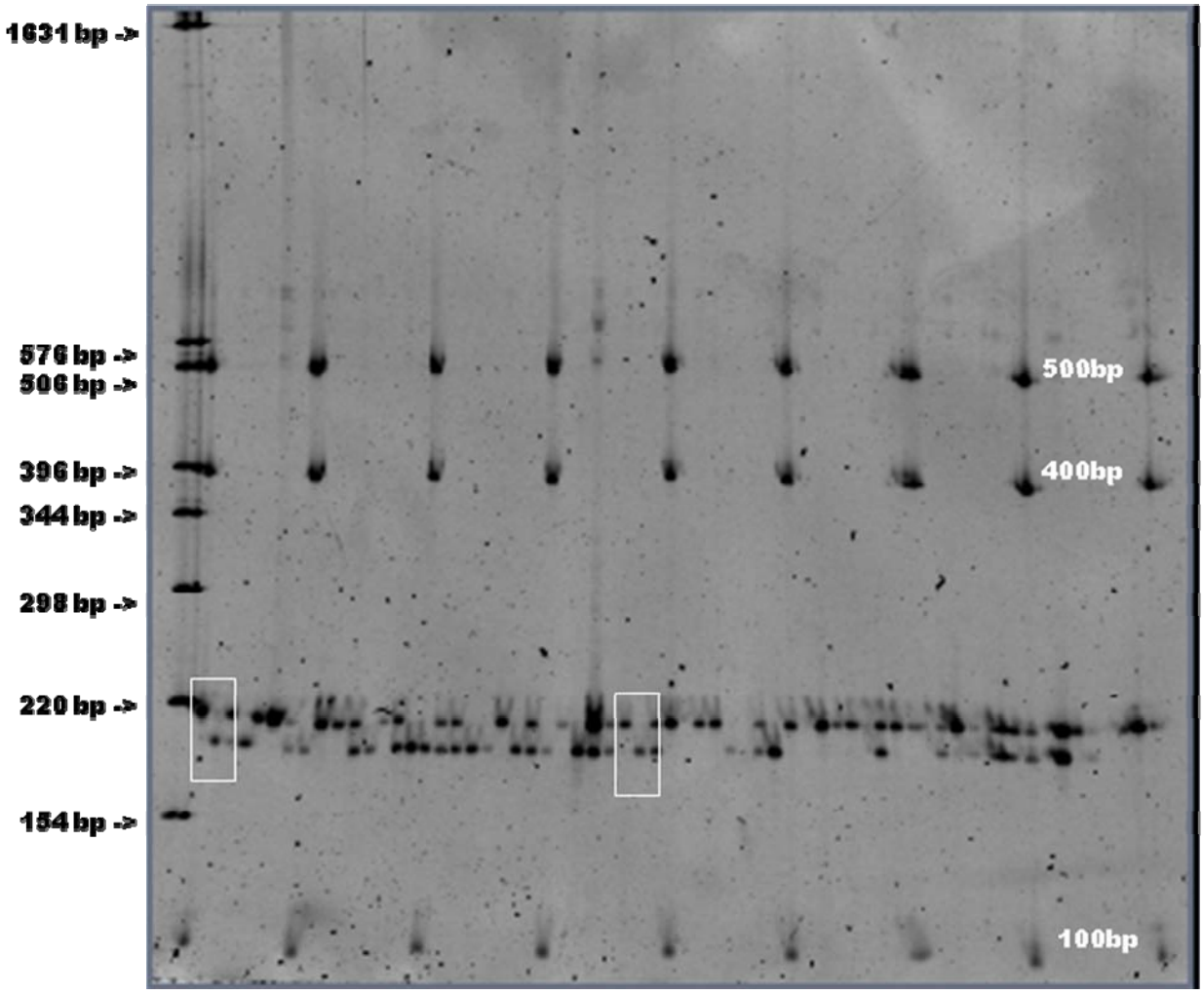


Figure 11 Genotyping with 4L4 genetic marker

The genetic marker 4L4 forms bands of 640bp and 720bp sizes. The control DNA A17, A20 and H are highlighted in the boxes. The A17 DNA yields a lower band with respect to the A20 DNA that yields a higher band, and the H DNA yields two bands.

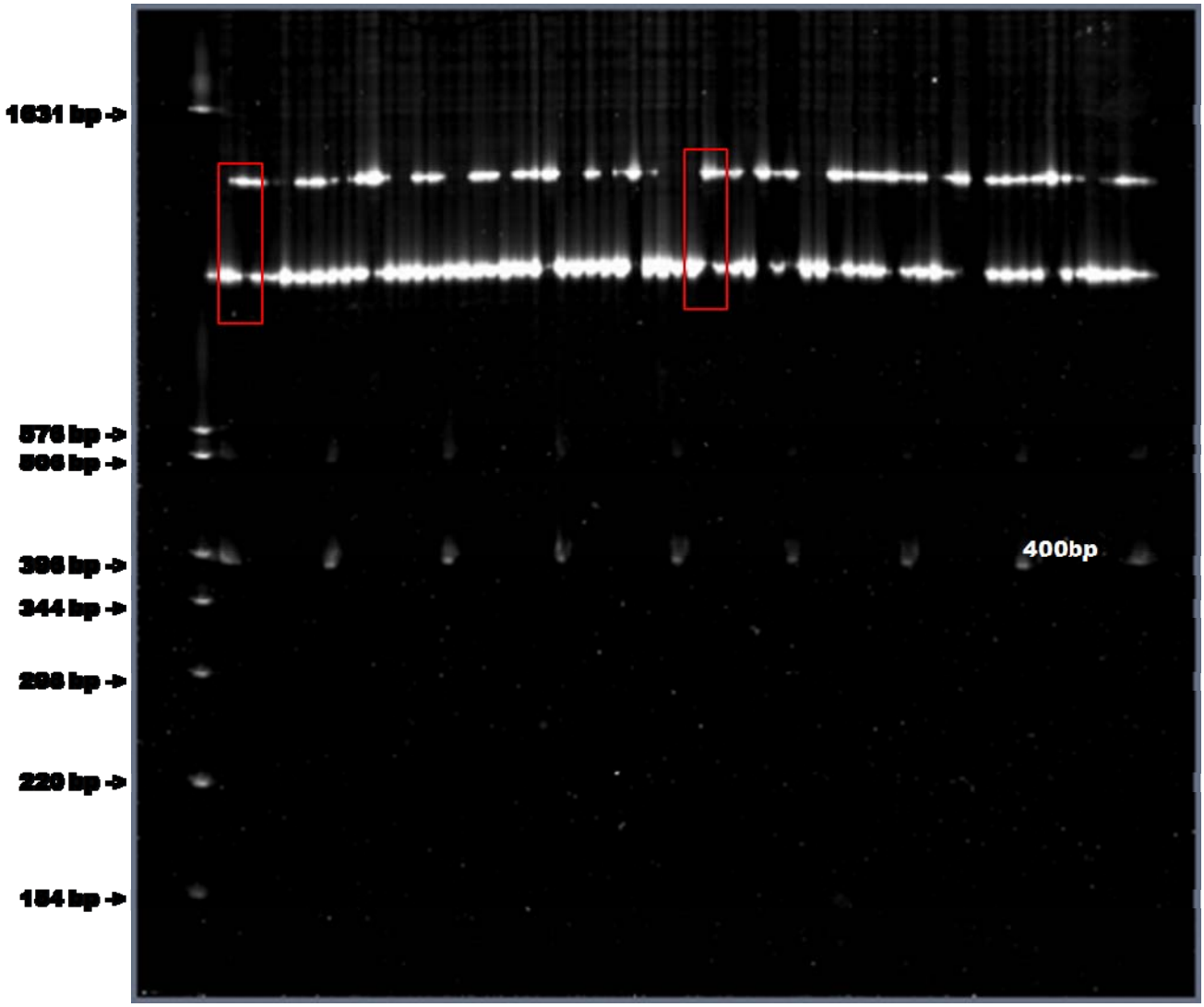
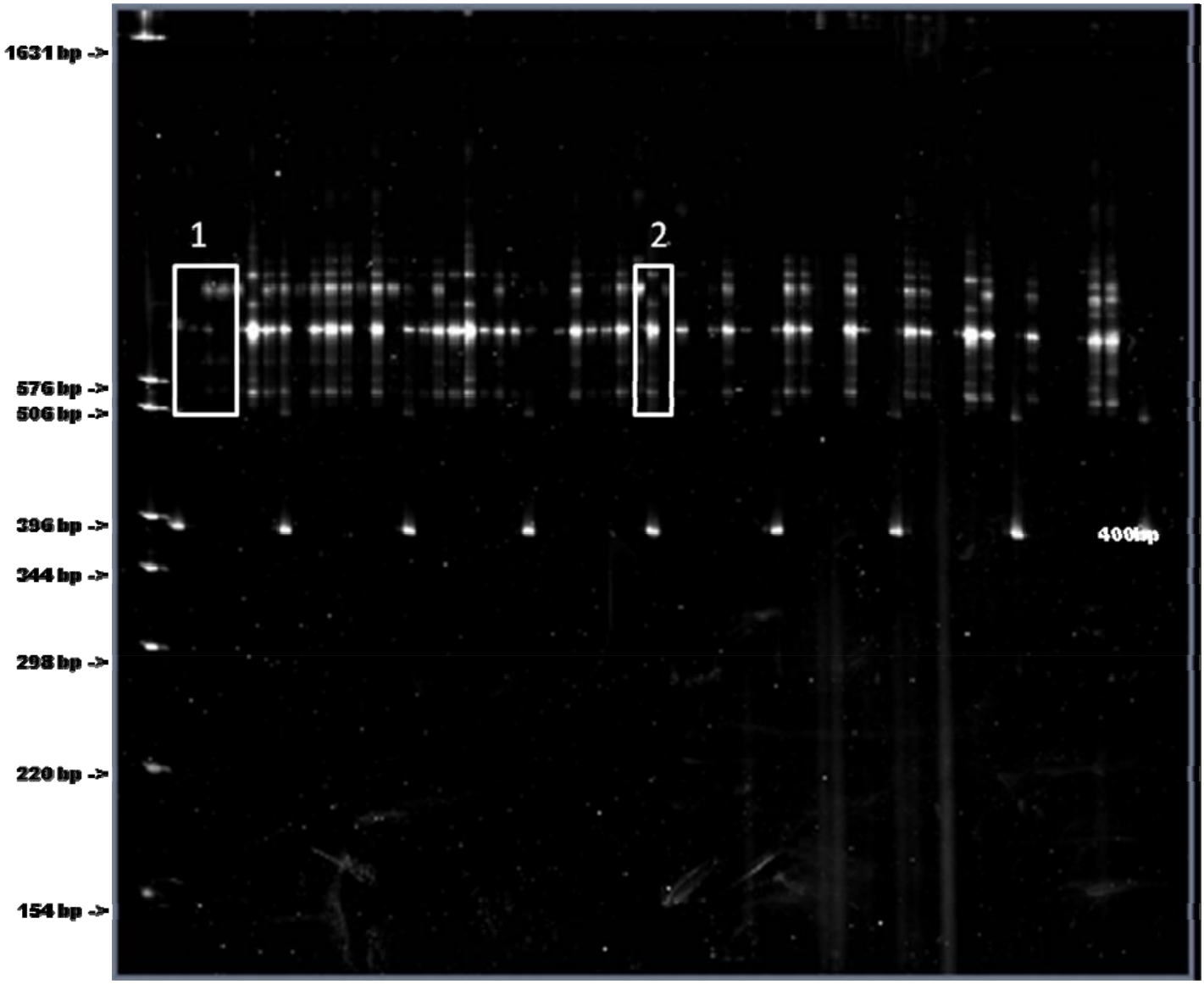


Figure 12 Genotyping with 807 genetic marker

The genetic marker 807 forms bands of 640bp and 720bp sizes. The control DNA A17, A20 and H are highlighted in the box 1, and A17, A20DNA only are highlighted in the box 2. The A17 DNA forms a higher band with respect to the A20 DNA that forms a lower band, and the H DNA forms two bands.



Results for genotyping with various available genetic markers of identified recombinant plants from F2 and F3 generations are presented in Table 3 in the appendix.

Key for the Table 3 is the same as for the Table 2

Note that not all plants presented in the table 3 were tested with all 7 genetic markers. From the available data in Table 3 that presents all identified recombinant plants it was decided to choose only 2-3 recombinant plants from each line to represent each recombination event and have recombination in the region of interest. These plants will be a subject for further testing with newly developed markers. Currently work is being done by other members of Dr. Dickstein's lab to obtain new markers in the region of interest. Table 4 presents a data that includes only few plants that were chosen to be representatives of a particular plant parental line.

Key for the Table 4 is the same as for the Table 2.

# CHAPTER 4

# DISCUSSION

Earlier genetic mapping has placed *nip* on linkage group 1 of *M. truncatula* and fine mapping of the *nip* locus is the central focus of this work. Genomics project of *M truncatula* that is currently in progress has generated genetic map between A17 and A20 cultivars (Choi et al., 2004). Previous studies showed that *nip* did not complement *latd,* and it is believed that *nip* is allelic to *latd.* Genetic markers NCAS, DK140 and R15J11L placed *latd* on the top of linkage group1 (Bright et al., 2005). Molecular markers located on the top of the chromosome one were used to see if *nip* was linked to them. Markers 003C01 and DK140L were used by Veereshlingham, and results showed that *nip* homozygous plants co-segregated with both markers. It placed *nip* on the upper arm of the chromosome 1.

With the purpose to map-based clone *NIP* the mapping population was established. To create a mapping population, and for purposes of genetic characterization male sterile C90 plants were crossed into the backround of the different ecotype the wild-type genotype A20 (Penmetsa and Cook, 2000; Kuppusamy et al., 2004). F1 from the cross between *nip* and A20 showed a wild type phenotype for nodulation, consistent with the recessive nature of the mutant. This F2 segregating population was scored for its nodulation phenotype and collected as the mapping population. In F2 generation from 686 plants that were phenotyped 177 plants had *nip* phenotype and 509 plants had wild type nodulation phenotype, which makes up a ratio of 1:2.9 nip:wild-type. Frequency of phenotypes positive for nodulation and phenotypes negative for nodulation in the F2 generation was consistent with segregation as a single

recessive allele. From F2 generation 686 plants were genotyped with three markers 146017, ENBP and 23c16d. From genotyping 67 recombinant plants were identified.

Twenty two of the sixty seven recombination events were in the *nip* homozygous background, thus permitting location of the recombinants relative to *nip* and the markers based on F2 data. The remaining 45 recombinants occurred in phenotypically wild-type plants. Mapping these recombinants relative to *nip* would be accomplished by phenotyping and genotyping of F3 progeny, placing *nip* between 23c16d and 146o17 markers. From F2 generation the A17/A20 heterozygote plants were selfed to form F3 plants providing additional possible recombination events. From F3 generation of *NIP* mapping population 1591 individuals were evaluated for nodulation phenotype and genotyped with two flanking genetic markers 146o17 and 23c16d. From genotyping plant from F3 generation 103 recombinant plants were identified. 38 of the 103 recombination events were in plants with *nip* nodulation phenotype. Other 63 recombinants occurred in phenotypically wild-type plants. Progeny from these plants will be needed in order to map these recombinants relative to *nip*. The other two recombinant plant had no identified phenotype because plants were small and had no nodules and it was hard to distinguish if it was wild-type or nip nodulation phenotype.

Recombinant plants were isolated and their DNA was placed on the DNA microtiter plate are summarized in the Table 3. Some of these plants were tested with ENBP, 2D12, 4L4 164n9, 807 genetic markers. Based on the segregation data it was decided not to test all of the plants presented in the Table 3 with all available markers. Plants with recombination between 146o17 and ENBP (plant line #133) were not of interest to us because both markers are telomeric to *NIP*. For some lines it was decided

to choose only a couple plants that were representatives of the particular line, and test them with markers. From the genotyping results we obtained three plant lines that have recombination between 4L4 and 164n9 markers. Plants originating from lines #133#3 and line #390 had wild-type nodulation phenotype. And plants originating from the line #368 had *nip* nodulation phenotype. Other 12 lines showed recombination event between markers 164n9 and 807. Plants originating from lines #278, #368, #683 had *nip* nodulation phenotype. Plants originating from lines # 133#1, #511, #660, #531, #155, #698, #850, and #683 had wild-type nodulation phenotype. These data points that *nip* is located in the interval between 4L4 and 807 genetic markers. Several plants from these lines were chosen for further testing with available genetic markers. For plants with wild-type phenotype we need to obtain progeny to know if they are homozygous or heterozygous. Plants that were chosen for further testing are listed in Table 4.

In summary, this work has resulted in genotyping 2277 plants, and the identification of 170 plants in the *NIP* mapping population with recombination events between 146o17 and 23c16d genetic markers. These are listed in Table 3. The recombinants have helped us narrow the genetic interval that contains the *NIP* gene to that between markers 4L4 and 807. Further efforts towards for fine mapping of the *NIP* gene are being pursued by other members of the lab.

# CHAPTER 5

# MATERIAL AND METHODS

DNA extraction protocol from plant tissues:

DNA extraction protocol was adapted from Aldrich and Cullis, 1993. The initial preparation step for DNA extraction was to warm up extraction buffer in 65ºC water bath. Extraction buffer is composed of 2X CTAB and 0.2% β-mercaptoethanol (BME).

100ml stock 2XCTAB:

of 2%(v/v) CTAB:2G

100mM Tris: 10ml of 1M Tris, pH8.0

20mM EDTA: 4ml of 0.5M EDTA, pH 8.0

1.4M NaCl: 8.2g

2% PVP: 2g

In order to determine the necessary volume of 2XCTAB, we multiplied number of samples by 0.7. Obtained number indicated what volume of 2X CTAB (ml) to use. Then the BME was added in proportion of 20µl per 10ml of CTAB solution.

One large leaf or small trifoliate was grinded in 1.5ml Eppendorf tube in the presence of liquid nitrogen. Frozen leaf was grinded to a powder with a pestle. Then, 700µl of the warm extraction buffer was added to the tube with leaf powder, and content was grinded more until the uniform green solution was made. Tube was placed in to the 65ºC water bath for incubation for minimum 30min, but no longer than 2 h.

After incubation, 570µl of the solution of Chloroform:Isoamylalcol (24:1 v/v) was added. Then, samples were shake fast for 1min. For extraction of genomic DNA the use of the

vortex is not recommended, because it can break large DNA. Next, samples were centrifuged for 5min at 13000rpm. After centrifugation three layers formed. The top clear layer, which contains DNA, was transferred to the clean Eppendorf tube. DNA was precipitated with 2/3 volume of 100% isopropanol for at least 5min. Then, samples were centrifuged for 10min at 13000rpm. Supernatant was removed, and the pellet was washed twice with 400µl of 70% EtOH. After each wash samples were centrifuged for 3min at 13000rpm. Finally, 70% EtOH was removed from the tube, and the pellet was left to air dry until it was clear. DNA was re-suspended in 20µl of the TE buffer pH8 (10mM TrisHCl, pH 8.0 and 1mMEDTA, pH 8.0). DNA was stored in -80ºC.

DNA Dilution

20X diluted DNA were used for PCR reactions. DNA dilution was done in the 96 well microtiter DNA plates (GeneMate). Sterile double distilled water was added to each well in the amount of 76µl, and then 4µl of DNA was added into each well. Microtiter DNA plates were sealed with adhesive sealing film for PCR (GeneMate, Kaysville,UT), and strip of parafilm around the edges of the DNA microtiter plates, and they were kept at -20ºC.

Polymerase Chain Reaction

PCR markers that had polymorphisms for A17 and A20 DNA were chosen for genotyping. Each PCR reaction was a 22µl reaction per well. Each PCR reaction included 2µl of 10X Thermopol buffer (1X ThermoPol Reaction Buffer: 10mM KCl, 10 mM $(NH_4)_2SO_4$, 20mM Tris-HCl, 2mM $MgSO_4$, 0.1% Triton X-100, pH 8.8 @ 25ºC) (NE Biolabs), 2 µl of 2.5mM dNTP, 0.8µl of 5mM each forward and reverse primer (for some primers amounts had to be adjusted), 0.15µl of Taq DNA polymerase (NE Biolabs),

sterile distilled water to reach volume of 20µl, and then 2µl of 1:20 diluted DNA was added last. PCR conditions were as follows: 94ºC for 4min or 94ºC for 7min if amplified pieces were more than 500bp, cycling was accomplished at 94ºC for 30sec, 52-57ºC (depending on primer sets) for 25sec, elongation at 72ºC for 30-50sec. (depending on the size of the product), this was run for 30-35 cycles, and then kept at 4ºC. PCR products were run on the polyacrylamide gels.

Primers and Conditions Used for PCR Reaction

Primers were designed based on the sequence information available at NCBI (http://www.ncbi.nlm.nih.gov).

h2_23c16d-F (Tm55.9C)

5'-TTTCCCAATAGATCCACATGC-3'

h2_23c16d-R (Tm 57.3C)

5'-CACTCATGGTCTCAAGCCAA-3'

146o17-01F (Tm 58.4C)

5'-GTCCGTGGATTGATTAACAGTC-3'

146o17-01R (Tm 56.5C)

5'-TTGGAATGTGTTCTGCATCAAG-3'

Duplex PCR reaction master mix for 1 reaction: 2.25ul 10X ThermoPol buffer, 1.8ul 2.5mM dNTPs, 0.9ul of 146o17 primer mix(F+R) 5mM, 0.7ul of 23c16d primer mix (F+R) 5mM, 0.15 Taq, 14.3ul dd $H_2O$

Duplex PCR protocol (30 cycles): 94C-4min, 94C-30sec,-54.5C-30sec, 72C-30sec, 72C-7min, 4C-hold

ENBP1F (Tm 64.4C)

5’-CACTTCCCACTGTCCTAGTCCTAC-3’

ENBP1R (Tm 62.7C)

5’-GACTCGTCATCACCAGTTTCATCC-3’

Master mix for 1reaction: 2.2ul 10X ThermoPol buffer,1.8ul 2.5mM dNTPs, primer mix ENBP (F+R) 5mM 3ul, Taq 0.15ul, 12.9ul dd$H_2O$

PCR protocol: 94C-3min, 94C-30sec, 52-30sec, 72-40sec, 34cycles, 72-5min, 4hold

2D12-F

5’-GGCGTGGACAATATTTGAGTG-3’

2D12-R

5’-CGTACGTACCCTTGTCCTCC-3’

Master mix for 1reaction: 2.25ul 10X ThermoPol buffer, 1.8ul 2.5mM dNTPs, 0.9ul of 2D12 primer mix(F+R) 5mM, 0.15 Taq, 14.9ul dd $H_2O$

PCR protocol (32 cycles): 94C-5min, 94C-30sec, 53.9C-30sec,72C-30sec, 72C-10min and 4C-hold

h2_164n9a-F (Tm59.4C)

5’-CCACTTCCCACAACCTCTGT-3’

h2_164n9a-R (Tm 57.3C)

5’-CACCCTTTCTGGGTTGAGAA-3

Master mix for 1reaction: 2ul 10X ThermoPol buffer, 2ul 2.5mM dNTPs, 0.9ul of 164n9 primer mix (F+R) 5mM, 0.15 Taq, 14.9ul dd $H_2O$

PCR protocol: 94C-7min, 94C-30sec, 52C-25sec, 72C-40sec, 35cycles, 72C10min, 4C hold.

4L4-S-1F (Tm55.3C)

5’-CCC GAG AAC GAA CAA AAG AA-3’

4L4-S-1R (Tm 57.3C)

5’-TAA GGT ACC GTT TGG CCT GA-3’

PCR protocol (4L4) (30cycles): 94C-7min, 94C-30sec, 51C-25sec, 72C-50sec, 72C-10min, 4C-hold

Master mix for 1PCR reaction: 2ul of 10X ThermoPol Buffer, 2ul of 2.5mM dNTPs, 1ul of primer mix (F+R) 5mM, 0.15ul Taq, 14.9ul dd$H_2O$

807-20F (Tm 59.7C)

5’-AAC TTG TGT GTT CCT TTC CAA CTA G-3’

807-20R (Tm 62.4C)

5’-CCG GCC CCG AGT ATG ATA ATT TC-3’

807-21R (Tm 69.5C)

5’-AGG GCT GAC CCC TGA TGT CAA GAG ACT TAA AG-3’

Master mix for 1reaction: 2ul of 10X ThermoPol Buffer, 2ul of 2.5mM dNTPs, 2ul of primer mix (F+R) 5mM, 0.15ul Taq, 13.9ul dd$H_2O$

PCR protocol: 94C-7min, 94C-30sec, 57C-25sec, 72C-40sec, 72-7min, 4C hold

Polymerase Chain Reaction

PCR markers that amplified polymorphic regions in A17 and A20 DNA were chosen for genotyping. Each PCR reaction was a 22ul reaction per 1 well. PCR reaction included 2ul of 10X Thermopol buffer (1X ThermoPol Reaction Buffer: 10mM KCl, 10mM $(NH_4)_2SO_4$, 20mM Tris-HCL, 2mM $MgSO_4$, 0.1% Triton X-100, pH 8.8 @ 25ºC) (NE Biolabs), 2ul of 2.5mM dNTPs, 0.8ul of 5mM each forward and reverse primer (for

some primers amounts had to be adjusted), 0.15ul of Taq DNA polymerase (NE Biolabs), sterile distilled water to reach volume of 20ul, and then 2ul of 1:20 diluted DNA was added last. PCR conditions were as follows: 94ºC for 4minutes or 94ºC for 7min if amplified pieces were more than 500bp, cycling was accomplished at 94ºC for 30 seconds, 52-57ºC (depending on primer sets) for 25 sec, elongation at 72ºC for 30-50 sec (depending on the size of the product), this was run for 30-35 cycles, then 72ºC for 7min and kept at 4ºC. PCR products were electrophoresed on the polyacrylamide gels.

Preparation of the 8% polyacrylamide gel

Two glass plates, bigger plate with dimensions 8” by 9” and smaller 8” by 8” plates, were cleaned with alconox powder detergent. They were dried with a paper towel and cleaned on both sides with 70% EtOH. Plastic spacer strips were cleaned with 70% EtOH also. Plastic spacer strips (3 long & thin, and 1 short & wide).

Kimwipe folded 3 times were used under the hood to apply 5% DichlorodimethylSilane (ALDRICH, Dichlorodimethylsilane,99%) in Heptane (Kodak) solution on the surface of the plates that would be in contact with the gel.

On the leveled bench area 4 large stoppers were placed for support of the glass plates. Large glass plate was placed facing up with the side that was covered with the 5% Dichlorodimethyl Silane in Heptane solution. Short (1.3cm by 20.5cm) plastic spacer strip was placed on the bottom edge of the plate, and two longer (1.3cm by 25cm) spacer strips were placed on the sides of the plate. Then the smaller glass plate was placed on top of the larger glass plate and the spacer strips. It is important that the area covered with 5% Dichlorodimethyl Silane in Heptane solution faces inside to where it would be in contact with the gel. Glass plates and spacers were adjusted so that all

edges were evenly aligned. Four large paperclips were used per each side of the gel chamber to fix plates together.

Gel preparation:

For 8% polyacrylamide gel, 50ml total volume uses the following ingredients:

10ml of 5% TBE buffer (pH 8.13-8.23) (Tris-Borate-EDTA 10X : 1000ml water, Tris base 108g, Boric acid 55g, 0.5 M EDTA pH 8.0 40ml)

8ml of Long Ranger Gel solution (CambrexBioscience, Rockland, ME, USA)

Distilled water to the volume of 50ml

The Aspirator Pump Model 7049-00 Cole-Parmer Instruments Company was used to filter the above solution through Filter Paper (Fisherbrand, Qualitative P5, porosity-medium, flow rate-slow, diameter 5.5cm).

After filtering, 0.06g of Ammonium persulfate electrophoresis grade (FisherScientific) was added, and then the solution was mixed and degassed. 12 µl of SIGMA TEMED (N,N,N',N'-Tetramethylenediamine) 99% was added to the degassed mixture. A 60ml syringe was filled with the gel solution. It is important that air bubbles are present inside the syringe. The gel solution was poured slowly in between the glass plates. The gel solution needs to be poured in the continuous manner to avoid introducing air bubbles into the gel. Short (2.5cm by 17.5cm) plastic spacer was placed on the top part of the gel in between glass plates, and the 3 large paper clips were clipped on the top part of the gel chamber. It takes 15min for the gel solution to assume gel consistency. Yet, it is better to use the gel after 12 hours which provides for a better polymerization.

Running polyacrylamide gel:

After gel polymerization took place all paperclips were removed, and the short plastic spacer on the bottom of the gel and short wide plastic spacer on the top part of the gel were removed also. Gel was washed under the tap water, and a brush was used to remove excess polyacrylamide from the glass plates. Glass plates were dried with a paper towels.

A vertical electrophoresis unit was set up. The bottom chamber of the electrophoresis unit was filled with 250ml of 1X TBE buffer first. Glass plates were placed inside the electrophoresis unit. Spacer blocks (LifeTechnologies) and the side plastic spacers of the gel chamber need to be lined up. The spacer blocks need to be tightly adjacent to the short glass plate to prevent leaking of the buffer. Large paperclips were used to attach glass plates to the electrophoresis unit, and thus create a top chamber. 250-300ml of 1X TBE buffer was added to the top electrophoresis chamber. Syringe was utilized to remove air bubbles between two glass plates in both electrophoresis chambers. An aluminum plate 8” by 4” to dissipate heat was attached behind the glass plates with two large paper clips.

Gel was warmed up prior to loading PCR samples on the gel. Vertical electrophoresis unit was connected to the power supply (BioRad Model 3000Xi Computer Controlled Electrophoresis Power Supply) and run the empty gel was running for 12min at 250-300V.

Next, the power supply was turned off, and a rubber tube was used to remove buffer from the top electrophoresis chamber. With a paper towel the area between glass

plates was dried from the buffer. The space between two plates was filled with a Ficoll solution, and a layer of the Ficoll was place on the top edge of the short glass plate.

20% Ficoll loading solution is prepared as follows:

20g of Ficoll 400 powder was mixed with deionized water, and brought to a final volume of 100ml. The solution was kept on a hot plate (50ºC), while stirring with a magnetic stir bar, for several hours until Ficoll went into the solution. Water needs to be added on the consistent basis to maintain a total volume of 100ml. Next, 1.2ml of a 50mg/ml stock of Blue Dextran was added. Then, a 5g of BioRad AG501-X8 deionizing resin was added to the solution, and it was stirred for additional 60-90minutes

The solution was decanted off the deionizing resin and filered through a 0.45 micron filter into a sterile vessel. The solution was stored at 4.0ºC (www.Gelcompany.com ).

Eight channel multichannel pipettor 0.5-10ul was used to load 2ul of PCR sample into the 64 well membrane tray (The Gel Company #TAM64). It is recommended to use platinum low retention tips (Gene Mate 10ul, cat# P-3296-1) to load PCR samples.

PCR samples need to be mixed with the loading dye mix of Orange G and blue (Xylene Cyanol) prior to loading them on the gel. Loading dye (50ml) is composed of 2.5ml of 0.5M EDTA pH8, 7.5g Ficoll, 0.25g Xylene Cyanol or OrangeG (Sambrook et al.,1989). Blue Xylene Cyanol can be use alone. Unlaminated comb membrane (The Gel Company) was used to soak up the PCR samples from each well. The membrane comb was air dried, and then it was placed in between two glass plates on the surface of the gel. 1X TBE buffer was added into the top electrophoresis chamber to the level where buffer slightly covers top edge of the short glass plate. Then, the power unit was turned on to 500V for 2-3min, or until all samples traveled from membrane into the gel. After all

samples migrated inside the gel the power supply was turned off, and the membrane was removed. 1X TBE buffer was added to fill the top electrophoresis chamber. Pasteur pipette was used to flush out the Ficoll solution from the space in between the glass plates. Finally, the power supply was set to 350-400V, and the gel was run for 1h 30min to up to 2h depending on the size of the PCR product.

DNA STAINING:

DNA staining was done by using SYBR Green dye. 500ml of 1X TBE buffer was poured into the rectangular plastic container and 30µl of 10000X concentrated SYBR Green dye (Invitrogen) was added. Container was wrapped in the aluminum foil, because SYBR Green dye is light sensitive, and kept at -4ºC. Gel was kept in the staining solution for 30min, and then scanned using BioRad FX laser scanner. One gel staining solution was used to stain 4-5 gels.

# APPENDIX

Key for Table 1

| | |
|---|---|
| + | Plants with wild-type nodulation phenotype |
| ***nip*** | Plants with *nip* nodulation phenotype |
| ? | Plants with undetermined nodulation phenotype |
| **A17** | Plants with A17 genotype at a particular locus |
| **A20** | Plants with A20 genotype at a particular locus |
| **H** | Plants with both A20 and A17 genotypes at a particular locus |
| redo | Plants that tested positive for recombination event once, and no leaf material was found to retest them for recombination |
| confirmed | Recombinant plants that tested positive for recombination second time |

Note: plants that died before leaf material could be collected, and therefore before they could yield any genotyping data, are not shown in the table.

Table 1

| Phenotyping And Genotyping Data For The *Nip* Mapping Population (F2 Generation) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Parents | Plant # | Phenotype | Plate # | 146o17 | ENBP | 23c16 | Comments |
| C90 X A20 155# | #954 | + | 4 | A20 | A20 | A20 | |
| C90 X A20 51# | #955 | *nip* | 4 | H | H | H | |
| C90 X A20 74# | #958 | *nip* | 4 | A17 | A17 | A17 | |
| C90 X A20 51# | #959 | *nip* | 4 | A17 | A17 | A17 | |
| C90 X A20 51# | #960 | + | 4,12,38 | H | H | H | |
| C90 X A20 51# | #961 | + | 4 | A20 | A20 | A20 | |
| C90 X A20 51# | #962 | + | 4,23 | H | H | H | |
| C90 X A20 148# | #963 | + | 4 | A20 | A20 | A20 | |
| C90 X A20 133# | #964 | + | 6,31 | A20 | H | H | redo |
| C90 X A20 133# | #965 | + | 6,31 | A20 | H | H | redo |
| C90 X A20 133# | #966 | + | 6 | A20 | A20 | A20 | |
| C90 X A20 133# | #967 | + | 6,31 | A20 | H | H | confirmed |
| C90 X A20 133# | #968 | + | 6 | A20 | A20 | A20 | |
| C90 X A20 133# | #969 | + | 6 | A20 | A20 | A20 | |
| C90 X A20 133# | #970 | + | 6,31 | A20 | H | H | confirmed |
| C90 X A20 133# | #971 | + | 6,31 | A20 | H | H | |
| C90 X A20 133# | #972 | + | 4 | A20 | A20 | A20 | |
| C90 X A20 133# | #973 | + | 4,31 | A20 | H | H | confirmed |
| C90 X A20 133# | #974 | + | 4,31 | A20 | H | H | confirmed |
| C90 X A20 133# | #975 | + | 4,31 | A20 | H | H | redo |
| C90 X A20 133# | #976 | *?* | 4,31 | A20 | H | H | |
| C90 X A20 133# | #977 | *nip* | 4 | A17 | A17 | A17 | |
| C90 X A20 133# | #978 | + | 4 | A20 | A20 | A20 | |
| C90 X A20 133# | #979 | + | 4 | H | H | H | |
| C90 X A20 133# | #980 | *nip* | 4 | A17 | A17 | A17 | |
| C90 X A20 133# | #981 | *nip* | 4 | A17 | A17 | A17 | |
| C90 X A20 133# | #982 | + | 4 | H | H | H | |
| C90 X A20 133# | #984 | + | 4 | H | H | H | |
| C90 X A20 133# | #985 | + | 4 | H | H | H | |
| C90 X A20 133# 3. | #986 | + | 12 | A20 | A20 | A20 | |
| C90 X A20 133# 3. | #987 | *nip* | 4 | A17 | A17 | A17 | |
| C90 X A20 133# 3. | #989 | + | 4 | A20 | A20 | A20 | |
| C90 X A20 133# 3. | #990 | *nip* | 4 | A17 | A17 | A17 | |
| C90 X A20 133# 3. | #991 | *nip* | 4 | A17 | A17 | A17 | |
| C90 X A20 133# 3. | #992 | + | 4,16 | H | H | H | |
| C90 X A20 133# 3. | #993 | + | 4,16 | H | H | H | |
| C90 X A20 133# 3. | #994 | + | 4,16 | H | H | H | |
| C90 X A20 133# 3. | #996 | *nip* | 4 | A17 | A17 | A17 | |
| C90 X A20 281#5. | #997 | *nip* | 6 | A17 | A17 | A17 | |
| C90 X A20 281#5. | #998 | + | 6 | H | H | H | |
| C90 X A20 281#5. | #999 | *nip* | 9 | H | H | H | |
| C90 X A20 281#5. | #1000 | + | 9 | A20 | A20 | A20 | |
| C90 X A20 281#5. | #1001 | + | 9 | H | H | H | |
| C90 X A20 281#5. | #1002 | *nip* | 9 | A17 | A17 | A17 | |
| C90 X A20 281#5. | #1004 | *nip* | 9 | A17 | A17 | A17 | |
| C90 X A20 281#5. | #1005 | + | 9 | H | H | H | |
| C90 X A20 281#5. | #1006 | + | 31 | H | H | H | |
| C90 X A20 281#2. | #1007 | + | 9 | A20 | H | A20 | redo |
| C90 X A20 281#2. | #1008 | + | 4 | H | H | H | |
| C90 X A20 281#2. | #1009 | + | 4 | H | H | H | |
| C90 X A20 281#2. | #1010 | + | 4,16 | H | H | H | |
| C90 X A20 281#2. | #1011 | + | 4 | H | H | H | |
| C90 X A20 281#2. | #1012 | + | 4,16 | A20 | A20 | A20 | |
| C90 X A20 281#2. | #1013 | + | 4 | H | H | H | |

Table 1

| Phenotyping And Genotyping Data For The *Nip* Mapping Population (F2 Generation) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Parents | Plant # | Phenotype | Plate # | 146o17 | ENBP | 23c16 | Comments |
| C90 X A20 281#2. | #1014 | + | 4,16 | H | H | H | |
| C90 X A20 281#2. | #1016 | + | 4 | H | H | H | |
| C90 X A20 281#2. | #1017 | + | 4 | A20 | A20 | A20 | |
| C90 X A20 281#2. | #1018 | + | 4 | H | H | H | |
| C90 X A20 281#2. | #1019 | *nip* | 4 | A17 | A17 | A17 | |
| C90 X A20 281#2. | #1020 | + | 4,31 | H | H | H | |
| C90 X A20 281#2. | #1021 | + | 9,31 | A20 | A20 | A20 | |
| C90 X A20 281#2. | #1022 | + | 9 | H | H | H | |
| C90 X A20 281#2. | #1023 | *nip* | 9 | A17 | A17 | A17 | |
| C90 X A20 281# | #1024 | + | 9 | H | H | H | |
| C90 X A20 281# | #1025 | + | 9 | H | H | H | |
| C90 X A20 281# | #1026 | + | 12 | H | H | H | |
| C90 X A20 281# | #1027 | + | 9 | A20 | A20 | A20 | |
| C90 X A20 281# | #1028 | + | 9 | A20 | A20 | A20 | |
| C90 X A20 281# | #1029 | *?* | 9 | H | H | H | |
| C90 X A20 281# | #1030 | + | 9 | H | H | H | |
| C90 X A20 281# | #1031 | + | 9 | H | H | H | |
| C90 X A20 281# | #1032 | + | 9 | H | H | H | |
| C90 X A20 281# | #1033 | + | 9 | H | H | H | |
| C90 X A20 281# | #1034 | + | 9 | H | H | H | |
| C90 X A20 281# | #1035 | *nip* | 9 | A17 | A17 | A17 | |
| C90 X A20 281# | #1036 | + | 9 | A20 | A20 | A20 | |
| C90 X A20 278# | #1038 | *nip* | 9,16 | A17 | A17 | H | confirmed |
| C90 X A20 278# | #1039 | *nip* | 9,31 | A17 | A17 | A17 | |
| C90 X A20 278# | #1040 | *nip* | 9,16 | A17 | A17 | H | confirmed |
| C90 X A20 278# | #1041 | *nip* | 9,16 | A17 | A17 | H | confirmed |
| C90 X A20 278# | #1042 | *nip* | 4,16 | A17 | A17 | H | confirmed |
| C90 X A20 278# | #1043 | *nip* | 4,16 | A17 | A17 | H | confirmed |
| C90 X A20 278# | #1044 | *nip* | 12,4 | A17 | A17 | A17 | |
| C90 X A20 278# | #1045 | *nip* | 4,31 | A17 | A17 | H | confirmed |
| C90 X A20 278# | #1046 | *nip* | 4 | A17 | A17 | H | redo |
| C90 X A20 278# | #1047 | *nip* | 4,16,31 | A17 | A17 | H | confirmed |
| C90 X A20 278# | #1048 | *nip* | 4,31 | H | A17 | H | redo |
| C90 X A20 278# | #1049 | *nip* | 5,31 | A17 | A17 | H | redo |
| C90 X A20 278# | #1050 | *nip* | 5,31 | A17 | A17 | H | redo |
| C90 X A20 278# | #1051 | *nip* | 5 | A17 | A17 | H | redo |
| C90 X A20 278# | #1052 | *nip* | 5,31 | A17 | A17 | H | confirmed |
| C90 X A20 133#1. | #1053 | + | 12,5 | H | H | H | |
| C90 X A20 133#1. | #1054 | *nip* | 5 | A17 | A17 | A17 | |
| C90 X A20 133#1. | #1055 | *nip* | 5 | A20 | A20 | A20 | |
| C90 X A20 133#1. | #1056 | *?* | 5 | H | H | H | |
| C90 X A20 133#1. | #1057 | *nip* | 5 | H | H | H | |
| C90 X A20 133#1. | #1058 | *nip* | 5 | H | H | H | |
| C90 X A20 133#1. | #1059 | *nip* | 5 | H | H | H | |
| C90 X A20 133#1. | #1060 | *nip* | 5 | H | H | H | |
| C90 X A20 148#4. | #1061 | *nip* | 5 | H | H | H | |
| C90 X A20 148#4. | #1062 | *?* | 5 | A17 | A17 | A17 | |
| C90 X A20 148#4. | #1063 | + | 5 | H | H | H | |
| C90 X A20 148#4. | #1065 | + | 5 | A20 | A20 | A20 | |
| C90 X A20 148#4. | #1066 | + | 12,5 | H | H | H | |
| C90 X A20 148#4. | #1067 | + | 5 | H | H | H | |
| C90 X A20 148#4. | #1068 | + | 5 | A20 | A20 | A20 | |
| C90 X A20 100# | #1069 | *nip* | 5 | A17 | A17 | A17 | |
| C90 X A20 100# | #1070 | *nip* | 5 | A17 | A17 | A17 | |

Table 1

| Phenotyping And Genotyping Data For The *Nip* Mapping Population (F2 Generation) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Parents | Plant # | Phenotype | Plate # | 146o17 | ENBP | 23c16 | Comments |
| C90 X A20 100# | #1071 | *nip* | 5 | A17 | A17 | A17 | |
| C90 X A20 100# | #1072 | *nip* | 5 | A17 | A17 | A17 | |
| C90 X A20 100# | #1073 | *nip* | 5 | A17 | A17 | A17 | |
| C90 X A20 100# | #1074 | *nip* | 5 | A17 | A17 | A17 | |
| C90 X A20 100# | #1075 | *nip* | 5 | A17 | A17 | A17 | |
| C90 X A20 100# | #1076 | *nip* | 5 | A17 | A17 | A17 | |
| C90 X A20 100# | #1077 | *nip* | 5 | A17 | A17 | A17 | |
| C90 X A20 100# | #1078 | *nip* | 5 | A17 | A17 | A17 | |
| C90 X A20 100# | #1079 | *nip* | 5 | A17 | A17 | A17 | |
| C90 X A20 100# | #1080 | *nip* | 5 | A17 | A17 | A17 | |
| C90 X A20 133 #3 | 1081 | + | 2 | A20 | A20 | A20 | |
| C90 X A20 133 #3 | 1082 | + | 2 | H | H | H | |
| C90 X A20 133 #3 | 1083 | *nip* | 12,2,31 | A17 | A17 | A17 | |
| C90 X A20 133 #3 | 1084 | + | 2,16 | H | H | H | |
| C90 X A20 133 #3 | 1085 | + | 2 | A20 | A20 | A20 | |
| C90 X A20 133 #3 | 1087 | + | 2 | H | H | H | |
| C90 X A20 133 #3 | 1088 | + | 2 | A17 | A17 | A17 | |
| C90 X A20 133 #3 | 1089 | *nip* | 2 | A17 | A17 | A17 | |
| C90 X A20 133 #3 | 1090 | + | 2 | H | H | H | |
| C90 X A20 133 #3 | 1091 | + | 2,12,31 | H | H | A20 | confirmed |
| C90 X A20 133 #3 | 1092 | + | 2,31 | A20 | A20 | A20 | |
| C90 X A20 133 #3 | 1093 | + | 2 | H | H | H | |
| C90 X A20 133 #3 | 1094 | + | 2 | A17 | A17 | A17 | |
| C90 X A20 133 #3 | 1095 | + | 2,31 | H | H | H | |
| C90 X A20 133 #3 | 1096 | + | 2 | H | H | H | |
| C90 X A20 133 #3 | 1097 | *nip* | 2 | A17 | A17 | A17 | |
| C90 X A20 133 #3 | 1098 | + | 2 | H | H | H | |
| C90 X A20 133 #3 | 1100 | + | 2 | A17 | A17 | A17 | |
| C90 X A20 133 #3 | 1101 | + | 2 | H | H | H | |
| C90 X A20 133 #3 | 1102 | + | 2 | H | H | H | |
| C90 X A20 133 #3 | 1103 | + | 2 | H | H | H | |
| C90 X A20 133 #3 | 1104 | + | 2 | H | H | H | |
| C90 X A20 133 #3 | 1105 | + | 2 | A20 | A20 | A20 | |
| C90 X A20 133 #3 | 1106 | + | 2 | H | H | H | |
| C90 X A20 133 #3 | 1107 | + | 2 | H | H | H | |
| C90 X A20 133 #3 | 1108 | + | 2 | H | H | H | |
| C90 X A20 133 #3 | 1109 | + | 31 | A20 | A20 | A20 | |
| C90 X A20 133 #3 | 1110 | + | 2 | H | H | H | |
| C90 X A20 133 #3 | 1111 | + | 2 | H | H | H | |
| C90 X A20 133 #3 | 1112 | + | 2 | H | H | H | |
| C90 X A20 133 #3 | 1113 | + | 2 | H | H | H | |
| C90 X A20 133 #3 | 1114 | + | 2 | A20 | A20 | A20 | |
| C90 X A20 133 #3 | 1115 | + | 2,16 | A20 | A20 | A20 | |
| C90 X A20 133 #3 | 1116 | *nip* | 2,12 | A17 | A17 | A17 | |
| C90 X A20 133 #3 | 1117 | *nip* | 2,12 | A17 | A17 | A17 | |
| C90 X A20 133 #3 | 1118 | *nip* | 2,31 | A17 | A17 | A17 | |
| C90 X A20 133 #3 | 1119 | *nip* | 2 | A17 | A17 | A17 | |
| C90 X A20 133 #3 | 1120 | *nip* | 2 | A17 | A17 | A17 | |
| C90 X A20 133 #3 | 1121 | *nip* | 2 | A17 | A17 | A17 | |
| C90 X A20 133 #3 | 1122 | *nip* | 2 | A17 | A17 | A17 | |
| C90 X A20 133 #3 | 1123 | *nip* | 2,12 | A17 | A17 | A17 | |
| C90 X A20 133 #3 | 1124 | *nip* | 2 | A17 | A17 | A17 | |
| C90 X A20 133 #3 | 1125 | + | 2,30 | H | H | H | |
| C90 X A20 133 #3 | 1126 | + | 2,30 | A20 | A20 | A20 | |

Table 1

| Phenotyping And Genotyping Data For The *Nip* Mapping Population (F2 Generation) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Parents | Plant # | Phenotype | Plate # | 146o17 | ENBP | 23c16 | Comments |
| C90 X A20 133 #3 | 1127 | + | 12,30 | H | H | H | |
| C90 X A20 133 #3 | 1128 | + | 27 | A20 | A20 | A20 | |
| C90 X A20 133 #3 | 1129 | + | 27 | H | H | H | |
| C90 X A20 133 #3 | 1130 | + | 27 | H | H | H | |
| C90 X A20 133 #3 | 1131 | + | 27 | H | H | H | |
| C90 X A20 133 #3 | 1132 | + | 27 | H | H | H | |
| C90 X A20 133 #3 | 1133 | + | 27,30 | A20 | A20 | H | redo |
| C90 X A20 133 #3 | 1134 | + | 27 | H | H | H | |
| C90 X A20 133 #3 | 1135 | + | 27 | A20 | A20 | A20 | |
| C90 X A20 133 #3 | 1136 | + | 27 | A20 | A20 | A20 | |
| C90 X A20 133 #3 | 1137 | + | 27 | H | H | H | |
| C90 X A20 133 #3 | 1138 | + | 30,27 | H | H | H | |
| C90 X A20 133 #3 | 1139 | + | 2,30 | H | H | H | |
| C90 X A20 133 #3 | 1142 | + | 2 | H | H | H | |
| C90 X A20 133 #3 | 1144 | + | 2 | A20 | A20 | A20 | |
| C90 X A20 133 #3 | 1145 | + | 2,30 | H | H | H | |
| C90 X A20 133 #1 | 1147 | *nip* | 2,30 | A17 | A17 | A17 | |
| C90 X A20 133 #1 | 1149 | *nip* | 2,30 | A17 | A17 | A17 | |
| C90 X A20 133 #1 | 1150 | *nip* | 3 | A17 | A17 | A17 | |
| C90 X A20 133 #1 | 1151 | *nip* | 6,3,30 | A17 | A17 | A17 | |
| C90 X A20 133 #1 | 1152 | *nip* | 3 | A17 | A17 | A17 | |
| C90 X A20 133 #1 | 1153 | *nip* | 3 | A17 | A17 | A17 | |
| C90 X A20 133 #1 | 1154 | *nip* | 3 | A17 | A17 | A17 | |
| C90 X A20 133 #1 | 1155 | *nip* | 3 | A17 | A17 | A17 | |
| C90 X A20 133 #1 | 1156 | *nip* | 12,6,3 | A17 | A17 | A17 | |
| C90 X A20 133 #1 | 1157 | *nip* | 3 | A17 | A17 | A17 | |
| C90 X A20 133 #1 | 1158 | *nip* | 6,3 | A17 | A17 | A17 | |
| C90 X A20 133 #1 | 1159 | *nip* | 6,3 | A17 | A17 | A17 | |
| C90 X A20 133 #1 | 1161 | *nip* | 3 | A17 | A17 | A17 | |
| C90 X A20 133 #1 | 1163 | + | 6,3 | H | H | H | |
| C90 X A20 133 #1 | 1164 | + | 3 | A20 | A20 | A20 | |
| C90 X A20 133 #1 | 1166 | + | 3 | A20 | A20 | A20 | |
| C90 X A20 133 #1 | 1167 | + | 3 | A20 | A20 | A20 | |
| C90 X A20 133 #1 | 1168 | + | 6,3 | H | H | H | |
| C90 X A20 133 #1 | 1169 | + | 16,3 | H | H | H | |
| C90 X A20 133 #1 | 1170 | + | 3 | H | H | H | |
| C90 X A20 133 #1 | 1171 | + | 3 | H | H | H | |
| C90 X A20 133 #1 | 1172 | + | 3,31 | A20 | A20 | H | confirmed |
| C90 X A20 133 #1 | 1173 | + | 1 | A20 | A20 | A20 | |
| C90 X A20 133 #1 | 1174 | + | 1 | A20 | A20 | A20 | |
| C90 X A20 133 #1 | 1175 | + | 1 | H | H | H | |
| C90 X A20 133 #1 | 1176 | + | 12,3,1 | H | H | H | |
| C90 X A20 133 #1 | 1177 | + | 3,1 | H | H | H | |
| C90 X A20 133 #1 | 1178 | + | 1 | H | H | H | |
| C90 X A20 133 #1 | 1179 | + | 1 | H | H | H | |
| C90 X A20 133 #1 | 1180 | + | 12,3,1 | H | H | H | |
| C90 X A20 133 #1 | 1182 | + | 1 | A20 | A20 | A20 | |
| C90 X A20 133 #1 | 1185 | + | 1 | A20 | A20 | A20 | |
| C90 X A20 133 #1 | 1186 | + | 1 | H | H | H | |
| C90 X A20 133 #1 | 1187 | + | 1 | A20 | A20 | A20 | |
| C90 X A20 133 #1 | 1188 | + | 1 | H | H | H | |
| C90 X A20 133 #1 | 1189 | + | 1 | A20 | A20 | A20 | |
| C90 X A20 133 #1 | 1190 | + | 1 | H | H | H | |
| C90 X A20 133 #1 | 1191 | + | 12,3,1 | H | H | H | |

Table 1

| Phenotyping And Genotyping Data For The *Nip* Mapping Population (F2 Generation) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Parents | Plant # | Phenotype | Plate # | 146o17 | ENBP | 23c16 | Comments |
| C90 X A20 133 #1 | 1192 | + | 12,1 | A20 | A20 | A20 | |
| C90 X A20 133 #1 | 1193 | + | 1 | A20 | A20 | A20 | |
| C90 X A20 133 #1 | 1194 | + | 1 | A20 | A20 | A20 | |
| C90 X A20 133 #1 | 1195 | + | 20,1 | A17 | A17 | A17 | |
| C90 X A20 133 #1 | 1196 | + | 20,1 | H | H | H | |
| C90 X A20 133 #1 | 1197 | + | 20,1 | A20 | A20 | A20 | |
| C90 X A20 133 #1 | 1198 | + | 3,1 | H | H | H | |
| C90 X A20 133 #1 | 1199 | + | 3,1 | H | H | H | |
| C90 X A20 133 #1 | 1200 | + | 20,1 | A20 | A20 | A20 | |
| C90 X A20 133 #1 | 1201 | + | 20,1 | A20 | A20 | A20 | |
| C90 X A20 133 #1 | 1203 | + | 3,20,1 | H | H | H | |
| C90 X A20 133 #1 | 1204 | + | 3,1 | H | H | H | |
| C90 X A20 133 #1 | 1205 | + | 20,1 | A20 | A20 | A20 | |
| C90 X A20 133 #2 | 1206 | + | 20,1 | H | H | H | |
| C90 X A20 133 #2 | 1207 | + | 20,1 | H | H | H | |
| C90 X A20 133 #2 | 1208 | + | 20,1 | H | H | H | |
| C90 X A20 133 #2 | 1209 | + | 20,1 | H | H | H | |
| C90 X A20 133 #2 | 1210 | + | 20,1 | H | H | H | |
| C90 X A20 133 #2 | 1211 | + | 6,3 | A20 | A20 | A20 | |
| C90 X A20 133 #2 | 1212 | + | 3,1 | A20 | A20 | A20 | |
| C90 X A20 133 #2 | 1214 | + | 16,1 | A20 | A20 | A20 | |
| C90 X A20 133 #2 | 1215 | + | 20,1 | H | H | H | |
| C90 X A20 133 #2 | 1216 | + | 20,1 | H | H | H | |
| C90 X A20 133 #2 | 1217 | + | 20,1 | H | H | H | |
| C90 X A20 133 #2 | 1218 | + | 20,1 | H | H | H | |
| C90 X A20 133 #2 | 1219 | + | 20,1 | H | H | H | |
| C90 X A20 133 #2 | 1220 | + | 20,1 | A20 | A20 | A20 | |
| C90 X A20 133 #2 | 1221 | + | 20,1 | A20 | A20 | A20 | |
| C90 X A20 133 #2 | 1222 | + | 20,1 | H | H | H | |
| C90 X A20 133 #2 | 1223 | + | 20,1 | H | H | H | |
| C90 X A20 133 #2 | 1224 | + | 20,1 | A20 | A20 | A20 | |
| C90 X A20 133 #2 | 1225 | + | 20,1 | H | H | H | |
| C90 X A20 133 #2 | 1226 | + | 20,1 | A20 | A20 | A20 | |
| C90 X A20 133 #2 | 1227 | + | 20,1 | A20 | A20 | A20 | |
| C90 X A20 133 #2 | 1228 | + | 20,1 | H | H | H | |
| C90 X A20 133 #2 | 1229 | + | 20,1 | A20 | A20 | A20 | |
| C90 X A20 133 #2 | 1230 | + | 20,1 | A20 | A20 | A20 | |
| C90 X A20 133 #2 | 1231 | + | 20,1 | H | H | H | |
| C90 X A20 133 #2 | 1232 | + | 20,1 | A20 | A20 | A20 | |
| C90 X A20 133 #2 | 1233 | + | 20,1 | H | H | H | |
| C90 X A20 133 #2 | 1234 | + | 20,1 | H | H | H | |
| C90 X A20 133 #2 | 1236 | + | 20,1 | H | H | H | |
| C90 X A20 133 #2 | 1237 | *nip* | 20,1 | A17 | A17 | A17 | |
| C90 X A20 133 #2 | 1238 | *nip* | 20,1 | A17 | A17 | A17 | |
| C90 X A20 133 #2 | 1239 | *nip* | 20,1 | A17 | A17 | A17 | |
| C90 X A20 133 #2 | 1240 | *nip* | 20,1 | A17 | A17 | A17 | |
| C90 X A20 133 #2 | 1241 | *nip* | 1 | A17 | A17 | A17 | |
| C90 X A20 133 #2 | 1243 | *nip* | 1 | A17 | A17 | A17 | |
| C90 X A20 133 #2 | 1244 | *nip* | 20,1,31 | A17 | A17 | A17 | |
| C90 X A20 133 #2 | 1246 | *nip* | 12,1 | A17 | A17 | A17 | |
| C90 X A20 133 #4 | 1251 | *nip* | 20,1,31 | A20 | A17 | A17 | confirmed |
| C90 X A20 133 #4 | 1252 | *nip* | 20,1,27 | A20 | A17 | A17 | confirmed |
| C90 X A20 133 #4 | 1254 | *nip* | 16,1,27 | A20 | A17 | A17 | confirmed |
| C90 X A20 133 #4 | 1255 | *nip* | 20,1,27 | A20 | A17 | A17 | confirmed |

Table 1

| Phenotyping And Genotyping Data For The *Nip* Mapping Population (F2 Generation) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Parents | Plant # | Phenotype | Plate # | 146o17 | ENBP | 23c16 | Comments |
| C90 X A20 133 #4 | 1256 | *nip* | 20,1,27,38 | A20 | A17 | A17 | confirmed |
| C90 X A20 133 #4 | 1258 | *nip* | 20,1,27 | A20 | A17 | A17 | confirmed |
| C90 X A20 133 #4 | 1259 | *nip* | 12,1 | A20 | A17 | A17 | confirmed |
| C90 X A20 133 #4 | 1261 | *nip* | 20,1,27 | A20 | A17 | A17 | confirmed |
| C90 X A20 133 #4 | 1262 | *nip* | 12,1 | A17 | A17 | A17 | |
| C90 X A20 133 #4 | 1264 | + | 20,1,27 | A20 | H | H | confirmed |
| C90 X A20 133 #4 | 1265 | + | 16,1 | A20 | A20 | A20 | |
| C90 X A20 133 #4 | 1266 | + | 16,1 | A20 | H | H | confirmed |
| C90 X A20 133 #4 | 1267 | + | 1,27 | A20 | H | H | confirmed |
| C90 X A20 133 #4 | 1268 | + | 20,1,27 | A20 | H | H | confirmed |
| C90 X A20 133 #4 | 1270 | + | 12,15,1,30 | A20 | H | H | confirmed |
| C90 X A20 133 #4 | 1271 | + | 12,16,1,30 | A20 | H | H | confirmed |
| C90 X A20 133 #4 | 1272 | + | 1,30 | A20 | H | H | confirmed |
| C90 X A20 133 #4 | 1273 | + | 16,1,30 | A20 | H | H | confirmed |
| C90 X A20 133 #4 | 1275 | + | 12,1,30 | A20 | H | H | confirmed |
| C90 X A20 133 #4 | 1276 | + | 1 | A20 | A20 | A20 | |
| C90 X A20 133 #4 | 1278 | + | 16,1,30 | A20 | H | H | confirmed |
| C90 X A20 133 #4 | 1279 | + | 2,16,30 | A20 | H | H | confirmed |
| C90 X A20 133 #4 | 1280 | + | 2,16,30 | A20 | A20 | H | confirmed |
| C90 X A20 133 #4 | 1281 | + | 2,16,30 | A20 | H | H | confirmed |
| C90 X A20 133 #4 | 1286 | + | 31 | A20 | H | H | |
| C90 X A20 133 #4 | 1287 | + | 31 | A20 | A20 | A20 | |
| C90 X A20 133 #4 | 1289 | + | 31 | A20 | A20 | A20 | |
| C90 X A20 133 #4 | 1292 | + | 12,31,27 | A20 | H | H | confirmed |
| C90 X A20 133 #4 | 1293 | + | 31 | A20 | H | H | |
| C90 X A20 133 #4 | 1294 | + | 31 | A20 | H | H | |
| C90 X A20 133 #4 | 1297 | + | 31 | A20 | H | H | redo |
| C90 X A20 133 #4 | 1298 | + | 31 | A20 | H | H | redo |
| C90 X A20 133 #4 | 1299 | + | 31 | A20 | A20 | A20 | |
| C90 X A20 #356 | 1300 | + | 2 | H | H | H | |
| C90 X A20 #356 | 1301 | + | 31 | H | H | H | |
| C90 X A20 #356 | 1302 | *nip* | 2 | A17 | A17 | A17 | |
| C90 X A20 #356 | 1303 | *nip* | 2 | A17 | A17 | A17 | |
| C90 X A20 #356 | 1304 | *nip* | 2 | A17 | A17 | A17 | |
| C90 X A20 #356 | 1305 | *nip* | 2 | A17 | A17 | A17 | |
| C90 X A20 #356 | 1306 | *nip* | 2 | A17 | A17 | A17 | |
| C90 X A20 #356 | 1307 | + | 31 | H | H | H | |
| C90 X A20 #356 | 1308 | + | 2,30 | H | H | H | |
| C90 X A20 #356 | 1309 | + | 2 | H | H | H | |
| C90 X A20 #356 | 1310 | + | 2 | H | H | H | |
| C90 X A20 #356 | 1311 | + | 2 | H | H | H | |
| C90 X A20 #356 | 1312 | + | 2 | H | H | H | |
| C90 X A20 #356 | 1313 | *nip* | 31 | A17 | A17 | A17 | |
| C90 X A20 #356 | 1314 | + | 31 | H | H | H | |
| C90 X A20 # 316 | 1315 | + | 2 | H | H | H | |
| C90 X A20 # 316 | 1316 | *nip* | 31 | A17 | A17 | A17 | |
| C90 X A20 # 316 | 1317 | + | 2 | H | H | H | |
| C90 X A20 # 316 | 1318 | + | 30 | A20 | A20 | A20 | |
| C90 X A20 # 316 | 1319 | + | 2 | H | H | H | |
| C90 X A20 # 316 | 1320 | + | 2 | H | H | H | |
| C90 X A20 # 316 | 1321 | + | 2 | H | H | H | |
| C90 X A20 # 316 | 1322 | + | 2,30 | H | H | H | |
| C90 X A20 # 351 | 1323 | *nip* | 2,30 | A17 | A17 | A17 | |
| C90 X A20 # 351 | 1324 | *nip* | 2 | A17 | A17 | A17 | |

Table 1

| Phenotyping And Genotyping Data For The *Nip* Mapping Population (F2 Generation) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Parents | Plant # | Phenotype | Plate # | 146o17 | ENBP | 23c16 | Comments |
| C90 X A20 # 351 | 1325 | + | 30 | H | H | H | |
| C90 X A20 # 351 | 1326 | + | 30 | H | H | H | |
| C90 X A20 # 351 | 1327 | + | 30 | H | H | H | |
| C90 X A20 # 351 | 1328 | + | 30 | H | | H | |
| C90 X A20 #326 | 1329 | + | 30 | H | H | H | |
| C90 X A20 #326 | 1330 | + | 30 | A20 | A20 | A20 | |
| C90 X A20 #326 | 1331 | + | 30 | H | H | H | |
| C90 X A20 #326 | 1332 | + | 30 | H | H | H | |
| C90 X A20 #326 | 1333 | + | 30 | H | H | H | |
| C90 X A20 #326 | 1334 | + | 30 | H | H | H | |
| C90 X A20 #326 | 1335 | + | 30 | H | H | H | |
| C90 X A20 #326 | 1336 | *nip* | 30 | A17 | A17 | A17 | |
| C90 X A20 #326 | 1337 | *nip* | 30 | A17 | A17 | A17 | |
| C90 X A20 #326 | 1338 | *nip* | 30 | A17 | A17 | A17 | |
| C90 X A20 #326 | 1339 | + | 30 | H | H | H | |
| C90 X A20 #326 | 1340 | + | 30 | A20 | A20 | A20 | |
| C90 X A20 #326 | 1342 | + | 31 | H | H | H | |
| C90 X A20 #326 | 1343 | + | 31 | H | H | H | |
| C90 X A20 #326 | 1344 | + | 31 | H | H | H | |
| C90 X A20 #326 | 1345 | + | 31 | H | H | H | |
| C90 X A20 #326 | 1346 | *nip* | 31 | A17 | A17 | A17 | |
| C90 X A20 #326 | 1347 | + | 2 | A20 | A20 | A20 | |
| C90 X A20 #326 | 1348 | *nip* | 2 | A17 | A17 | A17 | |
| C90 X A20 #326 | 1349 | *nip* | 31 | A17 | A17 | A17 | |
| C90 X A20 #326 | 1351 | *nip* | 31 | A17 | A17 | A17 | |
| C90 X A20 #326 | 1353 | + | 12,2 | A20 | A20 | A20 | |
| C90 X A20 #326 | 1354 | + | 31 | H | H | H | |
| C90 X A20 #326 | 1355 | + | 12,2 | H | H | H | |
| C90 X A20 #326 | 1356 | + | 2,12 | A20 | A20 | A20 | |
| C90 X A20 #326 | 1357 | + | 12,2,30 | H | H | H | |
| C90 X A20 #326 | 1358 | + | 12,2 | A20 | A20 | A20 | |
| C90 X A20 #326 | 1359 | + | 2 | H | H | H | |
| C90 X A20 #325 | 1360 | + | 2 | A20 | A20 | A20 | |
| C90 X A20 #325 | 1361 | + | 2 | A17 | A17 | A17 | |
| C90 X A20 #325 | 1362 | *nip* | 2,31 | A17 | A17 | A17 | |
| C90 X A20 #325 | 1363 | + | 2,31 | H | H | H | |
| C90 X A20 #325 | 1364 | + | 2,30,38 | A20 | A20 | A20 | |
| C90 X A20 #325 | 1365 | + | 2 | A20 | A20 | A20 | |
| C90 X A20 #325 | 1366 | + | 2 | H | H | H | |
| C90 X A20 #325 | 1367 | + | 2 | A20 | A20 | A20 | |
| C90 X A20 #325 | 1368 | *nip* | 3 | A17 | A17 | A17 | |
| C90 X A20 #325 | 1369 | + | 3 | A20 | A20 | A20 | |
| C90 X A20 #325 | 1370 | + | 3 | H | H | H | |
| C90 X A20 #325 | 1371 | + | 3,31 | A20 | A20 | A20 | |
| C90 X A20 #325 | 1372 | + | 3 | H | H | H | |
| C90 X A20 #325 | 1373 | + | 3 | A20 | A20 | A20 | |
| C90 X A20 #325 | 1374 | + | 3 | A20 | A20 | A20 | |
| C90 X A20 #325 | 1375 | *nip* | 6,3 | A17 | A17 | A17 | |
| C90 X A20 #325 | 1376 | + | 3 | A20 | A20 | A20 | |
| C90 X A20 #325 | 1377 | + | 3 | A17 | A17 | A17 | |
| C90 X A20 #325 | 1378 | + | 3,31 | A20 | A20 | A20 | |
| C90 X A20 #325 | 1379 | *nip* | 3 | A17 | A17 | A17 | |
| C90 X A20 #325 | 1380 | + | 3,31 | A20 | A20 | A20 | |
| C90 X A20 #353 | 1381 | + | 3 | H | H | H | |

Table 1

| Phenotyping And Genotyping Data For The *Nip* Mapping Population (F2 Generation) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Parents | Plant # | Phenotype | Plate # | 146o17 | ENBP | 23c16 | Comments |
| C90 X A20 #353 | 1382 | + | 6,3 | H | H | H | |
| C90 X A20 #353 | 1383 | + | 3 | H | H | H | |
| C90 X A20 #353 | 1384 | + | 3 | A20 | A20 | A20 | |
| C90 X A20 #353 | 1385 | + | 3 | A20 | A20 | A20 | |
| C90 X A20 #353 | 1386 | *nip* | 3 | A17 | A17 | A17 | |
| C90 X A20 #353 | 1387 | + | 3,31 | H | H | H | |
| C90 X A20 #353 | 1388 | + | 6,3 | H | H | H | |
| C90 X A20 #353 | 1389 | + | 6,3 | H | H | H | |
| C90 X A20 #353 | 1391 | *nip* | 3 | A17 | A17 | A17 | |
| C90 X A20 #353 | 1392 | + | 3 | H | H | H | |
| C90 X A20 #317 | 1393 | + | 31 | H | H | H | |
| C90 X A20 #317 | 1394 | + | 3,31 | A20 | A20 | A20 | |
| C90 X A20 #317 | 1395 | *nip* | 3 | A17 | A17 | A17 | |
| C90 X A20 #319 | 1402 | + | 3 | A20 | A20 | A20 | |
| C90 X A20 #319 | 1403 | *nip* | 3 | H | H | H | |
| C90 X A20 #319 | 1405 | + | 3 | H | H | H | |
| C90 X A20 #319 | 1406 | + | 3,30 | A20 | A20 | A20 | |
| C90 X A20 #319 | 1407 | + | 3 | H | H | H | |
| C90 X A20 #319 | 1408 | + | 3 | H | H | H | |
| C90 X A20 #319 | 1409 | + | 3 | H | H | H | |
| C90 X A20 #319 | 1410 | *nip* | 3 | A17 | A17 | A17 | |
| C90 X A20 #319 | 1411 | *nip* | 3 | A17 | A17 | A17 | |
| C90 X A20 #319 | 1412 | + | 3 | A20 | A20 | A20 | |
| C90 X A20 #319 | 1413 | + | 3 | H | H | H | |
| C90 X A20 #319 | 1414 | + | 3 | H | H | H | |
| C90 X A20 #319 | 1415 | *nip* | 3 | A17 | A17 | A17 | |
| C90 X A20 #319 | 1416 | + | 3 | H | H | H | |
| C90 X A20 #319 | 1418 | + | 3 | H | H | H | |
| C90 X A20 #319 | 1419 | + | 3,31 | H | H | H | |
| C90 X A20 #319 | 1420 | + | 31 | H | H | H | |
| C90 X A20 #319 | 1421 | + | 3 | H | H | H | |
| C90 X A20 #319 | 1422 | + | 3 | A20 | A20 | A20 | |
| C90 X A20 #319 | 1423 | + | 3 | H | H | H | |
| C90 X A20 #319 | 1424 | + | 3 | H | H | H | |
| C90 X A20 #319 | 1425 | + | 3,31 | H | H | H | |
| C90 X A20 #319 | 1426 | *nip* | 31 | A17 | A17 | A17 | |
| C90 X A20 #319 | 1427 | *nip* | 31 | A17 | A17 | A17 | |
| C90 X A20 #327 | 1428 | *nip* | 31 | A17 | A17 | A17 | |
| C90 X A20 #327 | 1429 | + | 3 | H | H | H | |
| C90 X A20 #327 | 1430 | *nip* | 31 | A17 | A17 | A17 | |
| C90 X A20 #327 | 1431 | + | 3,31 | H | H | H | |
| C90 X A20 #327 | 1432 | + | 3 | H | H | H | |
| C90 X A20 #327 | 1433 | + | 3 | A20 | A20 | A20 | |
| C90 X A20 #327 | 1434 | + | 3 | A20 | A20 | A20 | |
| C90 X A20 #327 | 1435 | + | 3 | A20 | A20 | A20 | |
| C90 X A20 #327 | 1436 | + | 3,30 | A20 | A20 | A20 | |
| C90 X A20 #327 | 1437 | + | 30 | A20 | A20 | A20 | |
| C90 X A20 #327 | 1438 | + | 30,38 | H | | H | |
| C90 X A20 #327 | 1439 | + | 30 | H | H | H | |
| C90 X A20 #327 | 1441 | + | 30 | ? | H | H | |
| C90 X A20 #327 | 1442 | + | 30 | A20 | A20 | A20 | |
| C90 X A20 #327 | 1443 | + | 30 | H | H | H | |
| C90 X A20 #327 | 1444 | + | 30 | A20 | A20 | A20 | |
| C90 X A20 #327 | 1445 | *?* | 30 | H | H | H | |

Table 1

| Phenotyping And Genotyping Data For The *Nip* Mapping Population (F2 Generation) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Parents | Plant # | Phenotype | Plate # | 146o17 | ENBP | 23c16 | Comments |
| C90 X A20 #327 | 1446 | + | 30,38 | A20 | A20 | A20 | |
| C90 X A20 #327 | 1447 | + | 30 | A20 | A20 | A20 | |
| C90 X A20 #327 | 1448 | + | 30 | A20 | A20 | A20 | |
| C90 X A20 #327 | 1452 | + | 20 | H | H | H | |
| C90 X A20 #327 | 1454 | *nip* | 12 | H | H | H | |
| C90 X A20 #511 | 1457 | + | 6 | A20 | A20 | A20 | |
| C90 X A20 #511 | 1458 | + | 6,20,27 | A20 | A20 | H | confirmed |
| C90 X A20 #511 | 1462 | + | 6 | H | H | H | |
| C90 X A20 #511 | 1464 | + | 6,20 | H | H | H | |
| C90 X A20 #511 | 1465 | + | 6,20,27 | A20 | A20 | H | confirmed |
| C90 X A20 #511 | 1466 | + | 6 | H | H | H | |
| C90 X A20 #511 | 1468 | + | 6 | A20 | A20 | A20 | |
| C90 X A20 #511 | 1470 | + | 6 | A20 | A20 | A20 | |
| C90 X A20 #511 | 1471 | + | 6 | H | H | H | |
| C90 X A20 #511 | 1472 | + | 6 | H | H | H | |
| C90 X A20 #362 | 1478 | + | 6,20,30 | H | H | H | |
| C90 X A20 #362 | 1479 | *nip* | 30 | A17 | A17 | A17 | |
| C90 X A20 #362 | 1481 | + | 6 | A20 | A20 | A20 | |
| C90 X A20 #362 | 1484 | + | 6 | H | A20 | A20 | redo |
| C90 X A20 #362 | 1485 | + | 6,27 | A20 | A20 | H | confirmed |
| C90 X A20 # 526 | 1486 | + | 6,12 | H | H | H | |
| C90 X A20 # 526 | 1488 | *nip* | 12 | A17 | A17 | A17 | |
| C90 X A20 # 526 | 1489 | + | 6,20,31 | H | H | H | |
| C90 X A20 # 526 | 1490 | + | 6 | A20 | A20 | A20 | |
| C90 X A20 # 526 | 1491 | + | 6,38 | H | ? | H | |
| C90 X A20 #530 | 1492 | + | 6,27 | A20 | A20 | H | confirmed |
| C90 X A20 #530 | 1493 | + | 6 | H | H | H | |
| C90 X A20 #530 | 1497 | + | 12 | H | H | H | |
| C90 X A20 #530 | 1498 | + | 6 | A20 | A20 | A20 | |
| C90 X A20 #530 | 1499 | *nip* | 12 | A17 | A17 | A17 | |
| C90 X A20 #530 | 1502 | *nip* | 16 | A17 | A17 | A17 | |
| C90 X A20 #530 | 1505 | + | 12 | H | H | H | |
| C90 X A20 #530 | 1506 | + | 31 | H | H | H | |
| C90 X A20 #530 | 1509 | + | 30 | H | H | H | |
| C90 X A20 #530 | 1510 | + | 30 | H | H | H | |
| C90 X A20 #533 | 1511 | + | 16,30 | H | H | H | |
| C90 X A20 #533 | 1513 | + | 31 | H | H | H | |
| C90 X A20 #533 | 1514 | *nip* | 31 | A17 | A17 | A17 | |
| C90 X A20 #533 | 1515 | + | 31 | H | H | H | |
| C90 X A20 #533 | 1516 | + | 31 | H | H | H | |
| C90 X A20 #533 | 1517 | *nip* | 12 | A17 | A17 | A17 | |
| C90 X A20 #389 | 1518 | + | 31 | H | H | H | |
| C90 X A20 #389 | 1519 | + | 31 | H | H | H | |
| C90 X A20 #389 | 1520 | + | 30 | A20 | A20 | A20 | |
| C90 X A20 #389 | 1521 | *nip* | 30 | A17 | A17 | A17 | |
| C90 X A20 #389 | 1522 | *nip* | 30 | A17 | A17 | A17 | |
| C90 X A20 #389 | 1523 | + | 30 | H | H | H | |
| C90 X A20 #389 | 1524 | + | 30 | H | H | H | |
| C90 X A20 #389 | 1525 | *nip* | 30 | A17 | A17 | A17 | |
| C90 X A20 #389 | 1526 | *nip* | 31 | A17 | A17 | A17 | |
| C90 X A20 #389 | 1527 | + | 30 | A20 | A20 | A20 | |
| C90 X A20 #389 | 1528 | + | 30 | A20 | A20 | A20 | |
| C90 X A20 #389 | 1532 | + | 6 | H | H | H | |
| C90 X A20 #389 | 1533 | + | 6 | A20 | A20 | A20 | |

Table 1

| Phenotyping And Genotyping Data For The *Nip* Mapping Population (F2 Generation) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Parents | Plant # | Phenotype | Plate # | 146o17 | ENBP | 23c16 | Comments |
| C90 X A20 #391 | 1534 | + | 6 | A20 | A20 | A20 | |
| C90 X A20 #391 | 1535 | + | 6 | H | H | H | |
| C90 X A20 #391 | 1537 | *nip* | 6 | A17 | | A17 | |
| C90 X A20 #391 | 1538 | + | 6 | A20 | A20 | A20 | |
| C90 X A20 #391 | 1539 | + | 6 | H | H | H | |
| C90 X A20 #391 | 1540 | + | 6 | H | H | H | |
| C90 X A20 #391 | 1542 | *nip* | 6,20,30 | A17 | A17 | A17 | |
| C90 X A20 #391 | 1543 | + | 6,20,30 | H | H | H | |
| C90 X A20 #391 | 1544 | + | 6 | H | H | H | |
| C90 X A20 #391 | 1545 | + | 6 | H | H | H | |
| C90 X A20 #391 | 1547 | *nip* | 6 | A17 | A17 | A17 | |
| C90 X A20 #391 | 1548 | + | 6 | H | H | H | |
| C90 X A20 #391 | 1549 | + | 6,20 | A20 | A20 | A20 | |
| C90 X A20 #391 | 1550 | + | 6 | A20 | A20 | A20 | |
| C90 X A20 #361 | 1551 | + | 6 | H | H | H | |
| C90 X A20 #361 | 1552 | + | 6,20 | A20 | A20 | A20 | |
| C90 X A20 #361 | 1553 | + | 6 | H | H | H | |
| C90 X A20 #361 | 1554 | + | 6 | H | H | H | |
| C90 X A20 #361 | 1555 | + | 20,30 | H | H | H | |
| C90 X A20 #361 | 1556 | + | 20 | H | H | H | |
| C90 X A20 #361 | 1557 | + | 30 | H | H | H | |
| C90 X A20 #361 | 1558 | *?* | 20 | H | H | H | |
| C90 X A20 #361 | 1559 | + | 23 | H | H | H | |
| C90 X A20 #361 | 1560 | + | 20 | A20 | A20 | A20 | |
| C90 X A20 #361 | 1561 | *nip* | 23 | A17 | A17 | A17 | |
| C90 X A20 #361 | 1562 | + | 23 | A20 | A20 | A20 | |
| C90 X A20 #361 | 1563 | + | 23 | H | H | H | |
| C90 X A20 #361 | 1564 | + | 20,30 | H | H | H | |
| C90 X A20 #361 | 1565 | + | 20 | H | H | H | |
| C90 X A20 #361 | 1566 | + | 20 | H | H | H | |
| C90 X A20 #361 | 1567 | + | 20 | A20 | A20 | A20 | |
| C90 X A20 #361 | 1568 | + | 23 | H | H | H | |
| C90 X A20 #361 | 1569 | + | 23 | A20 | A20 | A20 | |
| C90 X A20 #361 | 1570 | + | 23 | H | H | H | |
| C90 X A20 #358 | 1572 | + | 23 | H | H | H | |
| C90 X A20 #358 | 1573 | + | 23 | H | H | H | |
| C90 X A20 #358 | 1574 | + | 20,30 | A20 | A20 | H | redo |
| C90 X A20 #358 | 1575 | + | 23,30 | H | H | H | |
| C90 X A20 #527 | 1576 | + | 20 | A20 | A20 | A20 | |
| C90 X A20 #527 | 1577 | + | 20 | H | H | H | |
| C90 X A20 #527 | 1578 | *nip* | 12 | A17 | A17 | A17 | |
| C90 X A20 #527 | 1579 | + | 20,30 | H | H | H | |
| C90 X A20 #527 | 1580 | + | 20 | H | H | H | |
| C90 X A20 #527 | 1582 | + | 16 | H | | H | |
| C90 X A20 #527 | 1583 | + | 20,30 | H | H | H | |
| C90 X A20 #527 | 1584 | + | 12 | A20 | A20 | A20 | |
| C90 X A20 #527 | 1586 | + | 23 | H | H | H | |
| C90 X A20 #527 | 1587 | + | 23 | A20 | A20 | A20 | |
| C90 X A20 #527 | 1588 | + | 23 | A20 | A20 | A20 | |
| C90 X A20 #527 | 1589 | *nip* | 12 | A17 | A17 | A17 | |
| C90 X A20 #527 | 1590 | + | 20,30 | A20 | A20 | A20 | |
| C90 X A20 #527 | 1591 | + | 12,30 | A20 | A20 | H | confirmed |
| C90 X A20 #527 | 1592 | + | 23 | H | H | H | |
| C90 X A20 #527 | 1593 | + | 20 | H | H | H | |

Table 1

| Phenotyping And Genotyping Data For The *Nip* Mapping Population (F2 Generation) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Parents | Plant # | Phenotype | Plate # | 146o17 | ENBP | 23c16 | Comments |
| C90 X A20 #527 | 1594 | + | 20 | H | H | H | |
| C90 X A20 #512 | 1595 | + | 20 | A20 | A20 | A20 | |
| C90 X A20 #512 | 1596 | *nip* | 23 | A17 | A17 | A17 | |
| C90 X A20 #512 | 1597 | + | 23 | H | H | H | |
| C90 X A20 #512 | 1598 | + | 20 | H | H | H | |
| C90 X A20 #512 | 1599 | + | 23 | H | H | H | |
| C90 X A20 #512 | 1600 | *nip* | 20 | A17 | A17 | A17 | |
| C90 X A20 #512 | 1601 | + | 20 | H | H | H | |
| C90 X A20 #512 | 1602 | + | 20 | H | H | H | |
| C90 X A20 #512 | 1603 | + | 20 | H | H | H | |
| C90 X A20 #512 | 1604 | + | 20 | H | H | H | |
| C90 X A20 #512 | 1605 | + | 20,9 | A20 | A20 | A20 | |
| C90 X A20 #512 | 1606 | + | 20 | H | H | H | |
| C90 X A20 #512 | 1607 | + | 20 | H | H | H | |
| C90 X A20 #512 | 1608 | + | 20 | H | H | H | |
| C90 X A20 #512 | 1609 | + | 20 | H | H | H | |
| C90 X A20 #512 | 1610 | *nip* | 23 | A17 | A17 | A17 | |
| C90 X A20 #512 | 1611 | + | 20 | A20 | A20 | H | redo |
| C90 X A20 #512 | 1612 | + | 20 | H | H | H | |
| C90 X A20 #512 | 1613 | + | 20 | H | H | H | |
| C90 X A20 #512 | 1614 | + | 21 | H | H | H | |
| C90 X A20 #512 | 1616 | + | 21,30 | A20 | A20 | A20 | |
| C90 X A20 #512 | 1617 | + | 23 | A20 | A20 | A20 | |
| C90 X A20 #512 | 1618 | *nip* | 23 | A17 | A17 | A17 | |
| C90 X A20 #512 | 1619 | + | 21 | A20 | A20 | A20 | |
| C90 X A20 #512 | 1620 | + | 23 | H | H | H | |
| C90 X A20 #512 | 1621 | + | 21 | H | H | H | |
| C90 X A20 #509 | 1622 | + | 21 | H | H | H | |
| C90 X A20 #509 | 1624 | *nip* | 23 | A17 | A17 | A17 | |
| C90 X A20 #509 | 1625 | + | 21,38 | A20 | A20 | A20 | |
| C90 X A20 #509 | 1626 | + | 21 | H | H | H | |
| C90 X A20 #509 | 1627 | + | 21 | H | H | H | |
| C90 X A20 #509 | 1628 | + | 21 | A20 | A20 | A20 | |
| C90 X A20 #509 | 1629 | + | 21 | H | H | H | |
| C90 X A20 #509 | 1630 | + | 21 | H | H | H | |
| C90 X A20 #509 | 1632 | *nip* | 23 | A17 | A17 | A17 | |
| C90 X A20 #568 | 1634 | + | 6 | H | H | H | |
| C90 X A20 #568 | 1635 | + | 21,30,27 | H | H | H | |
| C90 X A20 #568 | 1641 | + | 21 | A20 | A20 | A20 | |
| C90 X A20 #568 | 1642 | + | 21 | H | H | H | |
| C90 X A20 #540 | 1644 | + | 21 | H | H | H | |
| C90 X A20 #540 | 1650 | + | 21,31,27 | H | H | H | |
| C90 X A20 #540 | 1651 | + | 21,31,27 | H | H | H | |
| C90 X A20 #540 | 1652 | *nip* | 21 | A17 | A17 | A17 | |
| C90 X A20 #540 | 1653 | + | 21 | H | H | H | |
| C90 X A20 #540 | 1654 | + | 21 | H | H | H | |
| C90 X A20 #540 | 1655 | + | 23 | A20 | A20 | A20 | |
| C90 X A20 #540 | 1656 | *nip* | 31 | A17 | A17 | A17 | |
| C90 X A20 #540 | 1657 | + | 21 | H | ? | H | |
| C90 X A20 #539 | 1658 | + | 21,31 | A20 | A20 | A20 | |
| C90 X A20 #539 | 1659 | + | 21 | A20 | A20 | A20 | |
| C90 X A20 #539 | 1660 | + | 21 | A20 | A20 | A20 | |
| C90 X A20 #539 | 1661 | + | 21 | A20 | A20 | A20 | |
| C90 X A20 #539 | 1662 | + | 6 | A20 | A20 | A20 | |

Table 1

| Phenotyping And Genotyping Data For The *Nip* Mapping Population (F2 Generation) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Parents | Plant # | Phenotype | Plate # | 146o17 | ENBP | 23c16 | Comments |
| C90 X A20 #539 | 1663 | + | 21 | A20 | A20 | A20 | |
| C90 X A20 #539 | 1664 | + | 21 | A20 | A20 | A20 | |
| C90 X A20 #539 | 1666 | + | 21,31 | A20 | A20 | A20 | |
| C90 X A20 #539 | 1667 | + | 21 | A20 | A20 | A20 | |
| C90 X A20 #539 | 1668 | + | 21 | A20 | A20 | A20 | |
| C90 X A20 #539 | 1669 | + | 6 | A20 | A20 | A20 | |
| C90 X A20 #539 | 1670 | + | 21 | A20 | A20 | A20 | |
| C90 X A20 #539 | 1671 | + | 6 | A20 | A20 | A20 | |
| C90 X A20 #590 | 1675 | + | 6 | A20 | A20 | A20 | |
| C90 X A20 #590 | 1676 | + | 6 | H | H | H | |
| C90 X A20 #590 | 1677 | + | 23 | H | H | H | |
| C90 X A20 #590 | 1678 | *nip* | 6 | A17 | A17 | A17 | |
| C90 X A20 #590 | 1679 | *nip* | 21 | A17 | A17 | A17 | |
| C90 X A20 #590 | 1681 | *nip* | 6 | A17 | A17 | A17 | |
| C90 X A20 #590 | 1682 | + | 6,21 | A17 | H | H | confirmed |
| C90 X A20 #590 | 1683 | *nip* | 6,21 | A17 | A17 | A17 | |
| C90 X A20 #590 | 1687 | + | 6,23,21 | A20 | H | H | confirmed |
| C90 X A20 #590 | 1688 | + | 6 | H | H | H | |
| C90 X A20 #590 | 1689 | + | 6 | H | H | H | |
| C90 X A20 #590 | 1690 | + | 6 | H | H | H | |
| C90 X A20 #590 | 1691 | *nip* | 6 | A17 | A17 | A17 | |
| C90 X A20 #590 | 1692 | *nip* | 6 | A17 | A17 | A17 | |
| C90 X A20 #590 | 1693 | *nip* | 6 | A17 | A17 | A17 | |
| C90 X A20 #590 | 1694 | + | 6 | A20 | A20 | A20 | |
| C90 X A20 #590 | 1695 | *nip* | 6 | A17 | A17 | A17 | |
| C90 X A20 #590 | 1696 | *nip* | 6 | A17 | A17 | A17 | |
| C90 X A20 #590 | 1697 | *nip* | 21 | A17 | A17 | A17 | |
| C90 X A20 #590 | 1698 | *nip* | 21 | A17 | A17 | A17 | |
| C90 X A20 #561 | 1699 | + | 21 | H | H | H | |
| C90 X A20 #561 | 1701 | + | 21 | H | H | H | |
| C90 X A20 #561 | 1702 | + | 21 | H | H | H | |
| C90 X A20 #561 | 1703 | + | 21,27 | A20 | A20 | H | confirmed |
| C90 X A20 #561 | 1704 | + | 21,27 | A20 | A20 | H | confirmed |
| C90 X A20 #561 | 1705 | + | 21 | H | H | H | |
| C90 X A20 #561 | 1706 | + | 21 | H | H | H | |
| C90 X A20 #561 | 1707 | + | 21 | H | H | H | |
| C90 X A20 #555 | 1708 | + | 21 | H | H | H | |
| C90 X A20 #555 | 1709 | *nip* | 21 | A17 | A17 | A17 | |
| C90 X A20 #555 | 1710 | + | 21 | H | H | H | |
| C90 X A20 #555 | 1711 | + | 21 | H | H | H | |
| C90 X A20 #550 | 1712 | + | 21 | H | H | H | |
| C90 X A20 #550 | 1714 | + | 21 | A20 | A20 | A20 | |
| C90 X A20 #550 | 1715 | + | 21 | H | H | H | |
| C90 X A20 #550 | 1716 | + | 21 | H | H | H | |
| C90 X A20 #550 | 1717 | *nip* | 21 | A17 | A17 | A17 | |
| C90 X A20 #550 | 1718 | *nip* | 21 | A17 | A17 | A17 | |
| C90 X A20 #550 | 1719 | + | 21 | A20 | A20 | A20 | |
| C90 X A20 #550 | 1720 | *nip* | 21 | A17 | A17 | A17 | |
| C90 X A20 #560 | 1721 | + | 21,30 | H | H | H | |
| C90 X A20 #560 | 1722 | + | 21,30 | H | H | H | |
| C90 X A20 #560 | 1723 | + | 21 | H | H | H | |
| C90 X A20 #560 | 1724 | + | 21 | H | H | H | |
| C90 X A20 #560 | 1725 | + | 23 | A20 | A20 | A20 | |
| C90 X A20 #560 | 1726 | + | 21 | H | H | H | |

Table 1

| Phenotyping And Genotyping Data For The *Nip* Mapping Population (F2 Generation) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Parents | Plant # | Phenotype | Plate # | 146o17 | ENBP | 23c16 | Comments |
| C90 X A20 #560 | 1727 | *nip* | 21 | A17 | A17 | A17 | |
| C90 X A20 #560 | 1728 | + | 21 | H | H | H | |
| C90 X A20 #560 | 1729 | *nip* | 21 | A17 | A17 | A17 | |
| C90 X A20 #560 | 1731 | *nip* | 21 | A17 | A17 | A17 | |
| C90 X A20 #552 | 1733 | + | 21 | H | H | H | |
| C90 X A20 #552 | 1734 | + | 21 | H | H | H | |
| C90 X A20 #552 | 1735 | + | 21 | H | H | H | |
| C90 X A20 #552 | 1737 | + | 23,27 | H | H | A20 | confirmed |
| C90 X A20 #552 | 1739 | + | 21,27 | A20 | A20 | A20 | |
| C90 X A20 #542 | 1740 | + | 21 | H | H | H | |
| C90 X A20 #542 | 1741 | + | 21 | H | H | H | |
| C90 X A20 #542 | 1742 | + | 21 | H | H | H | |
| C90 X A20 #542 | 1743 | *nip* | 21 | A17 | A17 | A17 | |
| C90 X A20 #567 | 1746 | + | 21,27 | H | A20 | A20 | confirmed |
| C90 X A20 #567 | 1747 | + | 21 | H | H | H | |
| C90 X A20 #567 | 1748 | + | 21 | A20 | A20 | A20 | |
| C90 X A20 #567 | 1749 | + | 21 | H | H | H | |
| C90 X A20 #567 | 1750 | + | 21 | A20 | A20 | A20 | |
| C90 X A20 #567 | 1751 | + | 21 | A20 | A20 | A20 | |
| C90 X A20 #567 | 1752 | + | 21 | H | H | H | |
| C90 X A20 #567 | 1753 | *nip* | 27,21 | A17 | A17 | A17 | |
| C90 X A20 #567 | 1754 | + | 21 | H | H | H | |
| C90 X A20 #567 | 1755 | *nip* | 27,21 | A17 | A17 | A17 | |
| C90 X A20 #567 | 1756 | *nip* | 27,21 | A17 | A17 | A17 | |
| C90 X A20 #567 | 1757 | + | 27,21 | H | H | H | |
| C90 X A20 #567 | 1758 | + | 27,21 | A20 | A20 | A20 | |
| C90 X A20 #567 | 1759 | *nip* | 27 | A17 | A17 | A17 | |
| C90 X A20 #567 | 1760 | *nip* | 27,21 | A17 | A17 | A17 | |
| C90 X A20 #567 | 1761 | + | 23 | A20 | A20 | A20 | |
| C90 X A20 #559 | 1762 | + | 23 | H | H | H | |
| C90 X A20 #559 | 1763 | *nip* | 23 | A17 | A17 | A17 | |
| C90 X A20 #559 | 1764 | *nip* | 23,27 | H | H | A17 | confirmed |
| C90 X A20 #559 | 1765 | *nip* | 27 | A17 | A17 | A17 | |

Key for the Table 2

| | |
|---|---|
| WT | Plants with wild-type nodulation phenotype |
| ***nip*** | Plants with *nip* nodulation phenotype |
| ? | Plants with undetermined nodulation phenotype |
| **A17** | Plants with A17 genotype at a particular locus |
| **A20** | Plants with A20 genotype at a particular locus |
| **H** | Plants with both A20 and A17 genotypes at a particular locus |
| redo | Plants that tested positive for recombination event once, and no leaf material was found to retest them for recombination |
| confirmed | Recombinant plants that tested positive for recombination a second time |

Note: plants that died before leaf material could be collected, and therefore before they could yield any genotyping data, are not shown in the table.

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20 #517 | 3000 | WT | | 7 | A20 | A20 |
| C90XA20 #517 | 3001 | WT | | 7 | A20 | A20 |
| C90XA20 #517 | 3002 | WT | | 7 | A20 | A20 |
| C90XA20 #517 | 3003 | WT | | 7 | A20 | A20 |
| C90XA20 #517 | 3004 | WT | | 7 | A20 | A20 |
| C90XA20 #517 | 3005 | WT | | 7 | A20 | A20 |
| C90XA20 #517 | 3006 | WT | | 7 | A20 | A20 |
| C90XA20 #517 | 3007 | WT | | 7 | A20 | A20 |
| C90XA20 #517 | 3008 | WT | | 7 | A20 | A20 |
| C90XA20 #517 | 3009 | WT | | 7 | A20 | A20 |
| C90XA20 #517 | 3010 | WT | | 7 | A20 | A20 |
| C90XA20 #517 | 3011 | WT | | 7 | A20 | A20 |
| C90XA20 #517 | 3012 | WT | | 7 | A20 | A20 |
| C90XA20 #517 | 3013 | WT | | 7 | A20 | A20 |
| C90XA20 #517 | 3014 | WT | | 7 | A20 | A20 |
| C90XA20 #401 | 3015 | WT | | 7 | A20 | A20 |
| C90XA20 #133#4 | 3016 | WT | confirmed | 11,7,16 | A20 | A17 |
| C90XA20 #133#4 | 3017 | *nip* | | 11,12,7 | A20 | A20 |
| C90XA20 #133#4 | 3018 | WT | confirmed | 11,7,16 | A20 | A17 |
| C90XA20 #133#4 | 3019 | *nip* | confirmed | 11,7,16 | A20 | A17 |
| C90XA20 #133#4 | 3020 | WT | Confirmed | 7,18 | A20 | H |
| C90XA20 #133#4 | 3021 | *nip* | confirmed | 11,7,16 | A20 | A17 |
| C90XA20 #162 | 3022 | *nip* | | 7 | A17 | A17 |
| C90XA20 #162 | 3023 | *nip* | | 7 | A17 | A17 |
| C90XA20 #162 | 3024 | *nip* | | 7 | A17 | A17 |
| C90XA20 #162 | 3025 | *nip* | | 7 | A17 | A17 |
| C90XA20 #279 | 3026 | *nip* | | 7 | A17 | A17 |
| C90XA20 #279 | 3027 | *nip* | | 7 | A17 | A17 |
| C90XA20 #279 | 3028 | *nip* | | 7 | A17 | A17 |
| C90XA20 #655 | 3030 | WT | | 7 | A20 | A20 |
| C90XA20 #655 | 3031 | WT | | 7 | A17 | A17 |
| C90XA20 #655 | 3032 | ? | | 17 | A17 | A17 |
| C90XA20 #655 | 3033 | WT | | 7 | A20 | A20 |
| C90XA20 #368 | 3035 | *nip* | Confirmed | 12,18 | A20 | A17 |
| C90XA20 #368 | 3037 | *nip* | | 11 | A17 | A17 |
| C90XA20 #521 | 3038 | WT | | 11 | A20 | A20 |
| C90XA20 #521 | 3039 | WT | | 11 | A20 | A20 |
| C90XA20 #521 | 3040 | WT | | 11 | A20 | A20 |
| C90XA20 #521 | 3041 | WT | | 11 | A20 | A20 |
| C90XA20 #521 | 3042 | WT | | 11 | A20 | A20 |
| C90XA20 #521 | 3043 | WT | | 11 | A20 | A20 |
| C90XA20 #521 | 3044 | WT | | 12 | A20 | A20 |
| C90XA20 #521 | 3045 | WT | | 11 | A20 | A20 |
| C90XA20 #521 | 3046 | WT | | 11 | A20 | A20 |
| C90XA20 #521 | 3048 | WT | | 11 | A20 | A20 |
| C90XA20 #515 | 3049 | WT | | 7 | A20 | A20 |
| C90XA20 #515 | 3050 | WT | | 7 | A20 | A20 |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20 #515 | 3053 | WT | | 7 | A20 | A20 |
| C90XA20 #515 | 3054 | WT | | 7 | A20 | A20 |
| C90XA20 #515 | 3055 | WT | | 7 | A20 | A20 |
| C90XA20 #515 | 3056 | WT | | 7 | A20 | A20 |
| C90XA20 #515 | 3057 | WT | | 7 | A20 | A20 |
| C90XA20 #515 | 3058 | WT | | 7 | A20 | A20 |
| C90XA20 #515 | 3059 | WT | | 7 | A20 | A20 |
| C90XA20 #515 | 3060 | WT | | 7 | A20 | A20 |
| C90XA20 #514 | 3062 | *nip* | | 17 | A17 | A17 |
| C90XA20 #514 | 3069 | WT | | 17,18 | A17 | A17 |
| C90XA20 #514 | 3074 | WT | | 17 | H | H |
| C90XA20 #514 | 3075 | *nip* | | 17,18 | A17 | A17 |
| C90XA20 #514 | 3076 | WT | | 17 | A20 | A20 |
| C90XA20 #514 | 3079 | WT | | 17 | A20 | A20 |
| C90XA20 #514 | 3080 | WT | | 7 | A20 | A20 |
| C90XA20 #514 | 3082 | WT | | 7 | A20 | A20 |
| C90XA20 #514 | 3083 | WT | | 7 | H | H |
| C90XA20 #514 | 3084 | WT | | 7 | H | H |
| C90XA20 #514 | 3088 | WT | | 7 | A20 | A20 |
| C90XA20 #368 | 3090 | *nip* | confirmed | 11,12 | H | A17 |
| C90XA20 #368 | 3091 | *nip* | confirmed | 11,7,16 | H | A17 |
| C90XA20 #368 | 3093 | *nip* | confirmed | 11,7,16 | H | A17 |
| C90XA20 #827 | 3094 | *nip* | | 17 | A17 | A17 |
| C90XA20 #827 | 3095 | *nip* | | 17 | A17 | A17 |
| C90XA20 #520 | 3096 | WT | | 7 | A20 | A20 |
| C90XA20 #520 | 3097 | WT | | 11 | A20 | A20 |
| C90XA20 #520 | 3098 | WT | | 11 | A20 | A20 |
| C90XA20 #520 | 3099 | WT | | 11 | A20 | A20 |
| C90XA20 #520 | 3100 | WT | | 11 | A20 | A20 |
| C90XA20 #520 | 3101 | WT | | 11 | A20 | A20 |
| C90XA20 #520 | 3102 | WT | | 11 | A20 | A20 |
| C90XA20 #520 | 3103 | WT | | 11,7 | A20 | A20 |
| C90XA20 #520 | 3104 | WT | | 11,7 | A20 | A20 |
| C90XA20 #520 | 3105 | WT | | 11 | A20 | A20 |
| C90XA20 #520 | 3106 | WT | | 11 | A20 | A20 |
| C90XA20 #520 | 3108 | WT | | 11 | A20 | A20 |
| C90XA20 #520 | 3109 | WT | | 11 | A20 | A20 |
| C90XA20 #520 | 3110 | WT | | 11 | A20 | A20 |
| C90XA20 #520 | 3111 | WT | | 17 | A20 | A20 |
| C90XA20 #520 | 3113 | WT | | 11 | A20 | A20 |
| C90XA20 #520 | 3114 | WT | | 12,7 | A20 | A20 |
| C90XA20 #520 | 3118 | WT | | 11,7 | A20 | A20 |
| C90XA20 #520 | 3119 | WT | | 11,7 | A20 | A20 |
| C90XA20 #520 | 3120 | WT | | 11,7 | A20 | A20 |
| C90XA20 #520 | 3122 | WT | | 11 | A20 | A20 |
| C90XA20 #520 | 3123 | WT | | 11 | A20 | A20 |
| C90XA20 #520 | 3124 | WT | | 11 | A20 | A20 |
| C90XA20 #520 | 3125 | WT | | 11 | A20 | A20 |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20 #520 | 3126 | WT | | 11 | A20 | A20 |
| C90XA20 #520 | 3130 | WT | | 17 | A20 | A20 |
| C90XA20 #520 | 3131 | WT | | 11 | A20 | A20 |
| C90XA20 #520 | 3132 | WT | | 8 | A20 | A20 |
| C90XA20 #520 | 3133 | WT | | 17 | A20 | A20 |
| C90XA20 #520 | 3134 | WT | | 17 | A20 | A20 |
| C90XA20 #520 | 3137 | WT | | 8 | A20 | A20 |
| C90XA20 #520 | 3138 | WT | | 11 | H | H |
| C90XA20 #520 | 3139 | WT | | 8 | A20 | A20 |
| C90XA20 #520 | 3140 | WT | | 17 | H | H |
| C90XA20 #520 | 3141 | WT | | 8 | A20 | A20 |
| C90XA20 #675 | 3150 | *nip* | | 17 | A17 | A17 |
| C90XA20 #675 | 3151 | WT | | 8 | A20 | A20 |
| C90XA20 #675 | 3152 | WT | | 8 | A20 | A20 |
| C90XA20 #675 | 3153 | WT | | 8 | A20 | A20 |
| C90XA20 #675 | 3154 | WT | | 8,12 | H | H |
| C90XA20 #675 | 3155 | WT | | 8,12 | H | H |
| C90XA20 #675 | 3157 | WT | | 8 | A20 | A20 |
| C90XA20 #675 | 3158 | WT | | 11 | H | H |
| C90XA20 #675 | 3159 | WT | | 12 | A17 | A17 |
| C90XA20 #755 | 3161 | WT | | 8 | A20 | A20 |
| C90XA20 #755 | 3163 | *nip* | | 8 | A17 | A17 |
| C90XA20 #755 | 3164 | WT | | 17 | A17 | A17 |
| C90XA20 #755 | 3166 | WT | | 8 | H | H |
| C90XA20 #755 | 3167 | WT | | 17 | A17 | A17 |
| C90XA20 #755 | 3169 | WT | | 17 | A20 | A20 |
| C90XA20 #755 | 3172 | WT | | 8 | A20 | A20 |
| C90XA20 #755 | 3173 | *nip* | | 8 | A20 | A20 |
| C90XA20 #755 | 3174 | WT | | 8 | H | H |
| C90XA20 #755 | 3175 | WT | | 8 | H | H |
| C90XA20 #755 | 3178 | WT | | 8 | A20 | A20 |
| C90XA20 #937 | 3184 | WT | | 8 | A20 | A20 |
| C90XA20 #401 | 3190 | WT | | 8 | H | H |
| C90XA20 #401 | 3191 | WT | | 11,12 | A20 | A20 |
| C90XA20 #401 | 3193 | WT | | 16,17 | H | H |
| C90XA20 #401 | 3194 | WT | | 8 | H | H |
| C90XA20 #401 | 3196 | WT | | 17 | H | H |
| C90XA20 #401 | 3198 | *nip* | | 9 | A17 | A17 |
| C90XA20 #401 | 3201 | *nip* | | 17 | A17 | A17 |
| C90XA20 #390 | 3205 | WT | | 17 | A17 | A17 |
| C90XA20 #390 | 3207 | WT | confirmed | 9,16 | A17 | H |
| C90XA20 #390 | 3208 | WT | confirmed | 9,18 | A17 | H |
| C90XA20 #390 | 3209 | WT | confirmed | 9,18 | A17 | A20 |
| C90XA20 #390 | 3210 | WT | confirmed | 9,18 | A17 | A20 |
| C90XA20 #390 | 3212 | WT | confirmed | 9,23 | A17 | A20 |
| C90XA20 #390 | 3213 | WT | confirmed | 11,15 | A17 | H |
| C90XA20 #390 | 3214 | WT | confirmed | 9,16 | A17 | H |
| C90XA20 #390 | 3215 | *nip* | | 17 | A17 | A17 |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20 #390 | 3216 | *nip* | | 17 | A17 | A17 |
| C90XA20 #390 | 3217 | *nip* | | 17,18 | A17 | A17 |
| C90XA20 #390 | 3219 | WT | confirmed | 9,23 | A17 | A20 |
| C90XA20 #390 | 3220 | WT | confirmed | 9,23 | A17 | A20 |
| C90XA20 #390 | 3221 | WT | confirmed | 9,12,16 | A17 | H |
| C90XA20 #390 | 3222 | WT | confirmed | 11,15,16 | A17 | A20 |
| C90XA20 #390 | 3225 | WT | | 9 | H | H |
| C90XA20 #390 | 3231 | WT | redo | 9 | A17 | H |
| C90XA20 #390 | 3239 | WT | confirmed | 9 | A17 | A20 |
| C90XA20 #390 | 3241 | *nip* | | 9 | A17 | A17 |
| C90XA20 #390 | 3242 | WT | redo | 9 | A17 | A20 |
| C90XA20 #390 | 3243 | WT | confirmed | 9 | A17 | H |
| C90XA20 #390 | 3245 | WT | redo | 9 | A17 | H |
| C90XA20 #390 | 3248 | WT | | 9 | H | H |
| C90XA20 #390 | 3255 | WT | redo | 9 | A17 | H |
| C90XA20 #390 | 3259 | *nip* | | 11 | A17 | A17 |
| C90XA20 #390 | 3261 | WT | confirmed | 11,15 | A17 | H |
| C90XA20 #660 | 3265 | WT | confirmed | 11,15 | A20 | H |
| C90XA20 #660 | 3266 | WT | confirmed | 11,15 | A20 | H |
| C90XA20 #660 | 3267 | WT | confirmed | 11,15 | A20 | H |
| C90XA20 #660 | 3269 | WT | confirmed | 11,12,18 | A20 | A17 |
| C90XA20 #660 | 3270 | WT | confirmed | 11,12,15 | A20 | H |
| C90XA20 #660 | 3271 | WT | confirmed | 11,12,15 | A20 | H |
| C90XA20 #517 | 3274 | WT | | 17 | A20 | A20 |
| C90XA20 #517 | 3275 | WT | | 17 | A20 | A20 |
| C90XA20 #517 | 3276 | WT | | 17,.18 | A20 | A20 |
| C90XA20 #517 | 3287 | WT | | 17 | A20 | A20 |
| C90XA20 #517 | 3293 | WT | | 9 | A20 | A20 |
| C90XA20 #517 | 3294 | WT | | 9 | A20 | A20 |
| C90XA20 #517 | 3298 | WT | | 9 | A20 | A20 |
| C90XA20 #517 | 3299 | WT | | 9 | A20 | A20 |
| C90XA20 #517 | 3300 | WT | | 9 | A20 | A20 |
| C90XA20 #517 | 3302 | WT | | 16 | A20 | A20 |
| C90XA20 #517 | 3303 | WT | | 9 | A20 | A20 |
| C90XA20 #517 | 3304 | WT | | 9 | A20 | A20 |
| C90XA20 #517 | 3305 | WT | | 9 | A20 | A20 |
| C90XA20 #517 | 3306 | WT | | 9 | A20 | A20 |
| C90XA20 #517 | 3308 | WT | | 9 | A20 | A20 |
| C90XA20 #517 | 3309 | WT | | 9 | A20 | A20 |
| C90XA20 #517 | 3310 | WT | | 9 | A20 | A20 |
| C90XA20 #517 | 3311 | WT | | 9 | A20 | A20 |
| C90XA20 #517 | 3314 | WT | | 9 | A20 | A20 |
| C90XA20 #517 | 3320 | WT | | 9 | A20 | A20 |
| C90XA20 #517 | 3323 | WT | | 9 | A20 | A20 |
| C90XA20 #517 | 3325 | WT | | 9 | A20 | A20 |
| C90XA20 #531 | 3328 | WT | Confirmed | 17,18,23 | A20 | A17 |
| C90XA20 #531 | 3329 | WT | Confirmed | 11,12,18 | H | A17 |
| C90XA20 #531 | 3333 | WT | | 23 | A17 | A17 |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20 #521 | 3341 | WT | | | A20 | A20 |
| C90XA20 #521 | 3342 | WT | | | A20 | A20 |
| C90XA20 #521 | 3345 | WT | | | A20 | A20 |
| C90XA20 #521 | 3346 | WT | | | A20 | A20 |
| C90XA20 #521 | 3348 | WT | | | A20 | A20 |
| C90XA20 #521 | 3349 | WT | | 12 | A20 | A20 |
| C90XA20 #521 | 3351 | WT | | 11,12 | A20 | A20 |
| C90XA20 #521 | 3352 | WT | | 11,12 | A20 | A20 |
| C90XA20 #162 | 3355 | *nip* | | | A17 | A17 |
| C90XA20 #162 | 3362 | *nip* | | 17 | A17 | A17 |
| C90XA20 #515 | 3369 | WT | | 12 | A20 | A20 |
| C90XA20 #515 | 3370 | WT | | | A20 | A20 |
| C90XA20 #515 | 3373 | WT | | | A20 | A20 |
| C90XA20 #515 | 3374 | WT | | | A20 | A20 |
| C90XA20 #515 | 3376 | WT | | | A20 | A20 |
| C90XA20 #515 | 3377 | WT | | | A20 | A20 |
| C90XA20 #655 | 3382 | *nip* | | 17 | A17 | A17 |
| C90XA20 #655 | 3383 | WT | | 17 | H | H |
| C90XA20 #655 | 3384 | *nip* | | | H | H |
| C90XA20 #278 | 3393 | *nip* | Confirmed | 18 | A17 | A20 |
| C90XA20 #278 | 3396 | *nip* | | | A17 | A17 |
| C90XA20 #278 | 3399 | *nip* | Confirmed | 17,18 | A17 | A20 |
| C90XA20 #133#4 | 3405 | WT | Confirmed | 17,18 | A20 | H |
| C90XA20 #133#4 | 3406 | *nip* | Confirmed | 17,18 | A20 | A17 |
| C90XA20 #133#4 | 3408 | WT | Confirmed | 17,18 | A20 | H |
| C90XA20 #133#4 | 3409 | WT | Confirmed | 17,18 | A20 | H |
| C90XA20 #133#4 | 3411 | WT | Confirmed | 17,18 | A20 | H |
| C90XA20 #133#4 | 3412 | WT | confirmed | 17,18 | A20 | H |
| C90XA20 #133#4 | 3414 | WT | | 16 | A20 | A20 |
| C90XA20 #133#4 | 3415 | WT | | 17,18 | A20 | A20 |
| C90XA20 #368 | 3418 | *nip* | | 17 | A17 | A17 |
| C90XA20 #368 | 3422 | *nip* | Confirmed | 17,18 | H | A17 |
| C90XA20 #279 | 3423 | WT | | | A17 | A17 |
| C90XA20 #279 | 3424 | *nip* | | | A17 | A17 |
| C90XA20 #279 | 3425 | WT | | 16 | A17 | A17 |
| C90XA20 #279 | 3426 | ? | | 12 | A17 | A17 |
| C90XA20 #279 | 3428 | *nip* | | | A17 | A17 |
| C90XA20 #279 | 3430 | *nip* | | 17 | A17 | A17 |
| C90XA20 #279 | 3432 | *nip* | | | A17 | A17 |
| C90XA20 #279 | 3433 | *nip* | | 12 | A17 | A17 |
| C90XA20 #279 | 3435 | *nip* | | 12,18 | A17 | A17 |
| C90XA20 #279 | 3437 | *nip* | | | A17 | A17 |
| C90XA20 #279 | 3439 | *nip* | | | A17 | A17 |
| C90XA20 #279 | 3441 | *nip* | | 12 | A17 | A17 |
| C90XA20 #155 | 3442 | WT | | 11,12 | H | H |
| C90XA20 #155 | 3443 | WT | | | H | H |
| C90XA20 #155 | 3444 | WT | | 12 | H | H |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20 #155 | 3445 | WT | | | H | H |
| C90XA20 #155 | 3446 | WT | | | A17 | A17 |
| C90XA20 #155 | 3447 | WT | confirmed | 16,17 | A20 | H |
| C90XA20 #155 | 3448 | WT | | 17 | A20 | A20 |
| C90XA20 #155 | 3449 | WT | | 17 | H | H |
| C90XA20 #155 | 3450 | WT | | 17 | H | H |
| C90XA20 #155 | 3451 | WT | | 17 | H | H |
| C90XA20 #155 | 3452 | WT | | 17 | A17 | A17 |
| C90XA20 #155 | 3453 | WT | | 17 | H | H |
| C90XA20 #155 | 3455 | WT | | 17 | H | H |
| C90XA20 #155 | 3456 | WT | | 17 | H | H |
| C90XA20 #155 | 3458 | WT | | 17 | H | H |
| C90XA20 #155 | 3459 | *nip* | | 17 | A17 | A17 |
| C90XA20 #155 | 3460 | *nip* | | 17 | A17 | A17 |
| C90XA20 #525 | 3461 | WT | | 17 | A20 | A20 |
| C90XA20 #525 | 3462 | WT | | 17 | A20 | A20 |
| C90XA20 #525 | 3463 | WT | | 17 | A20 | A20 |
| C90XA20 #525 | 3464 | WT | | 17 | A20 | A20 |
| C90XA20 #525 | 3465 | WT | | 17 | A20 | A20 |
| C90XA20 #525 | 3466 | WT | | 17 | A20 | A20 |
| C90XA20 #525 | 3467 | WT | | 17 | A20 | A20 |
| C90XA20 #525 | 3468 | WT | | 17 | A20 | A20 |
| C90XA20 #525 | 3471 | WT | | | A20 | A20 |
| C90XA20 #525 | 3472 | WT | | 12,18 | A20 | A20 |
| C90XA20 #525 | 3475 | WT | | 17 | A20 | A20 |
| C90XA20 #525 | 3476 | WT | | | A20 | A20 |
| C90XA20 #525 | 3477 | WT | | | A20 | A20 |
| C90XA20 #525 | 3478 | WT | | | A20 | A20 |
| C90XA20 #525 | 3480 | WT | | 12 | A20 | A20 |
| C90XA20 #525 | 3481 | WT | | 11,12 | A20 | A20 |
| C90XA20 #525 | 3482 | WT | | | A20 | A20 |
| C90XA20 #525 | 3483 | WT | | 12 | A20 | A20 |
| C90XA20 #525 | 3484 | WT | | | H | H |
| C90XA20 #525 | 3485 | *nip* | | | A17 | A17 |
| C90XA20 #525 | 3486 | WT | | | H | H |
| C90XA20 #525 | 3487 | WT | | 17 | A20 | A20 |
| C90XA20 #525 | 3488 | WT | | | A20 | A20 |
| C90XA20 #525 | 3489 | WT | | | A20 | A20 |
| C90XA20 #525 | 3490 | WT | | | A20 | A20 |
| C90XA20 #525 | 3491 | WT | | 12 | H | H |
| C90XA20 #665 | 3492 | WT | | | A20 | A20 |
| C90XA20 #665 | 3493 | WT | | 12,18 | H | H |
| C90XA20 #665 | 3494 | WT | | 11,12 | H | H |
| C90XA20 #665 | 3495 | WT | | 17 | H | H |
| C90XA20 #368 | 3497 | *nip* | Confirmed | 11,18 | H | A17 |
| C90XA20 #368 | 3498 | *nip* | Confirmed | 11,16 | H | A17 |
| C90XA20 #368 | 3500 | *nip* | | 11 | A17 | A17 |
| C90XA20 #368 | 3511 | *nip* | confirmed | 11,16 | H | A17 |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20 #368 | 3512 | *nip* | | 11 | A17 | A17 |
| C90XA20 #368 | 3513 | *nip* | confirmed | 11,16 | H | A17 |
| C90XA20 #368 | 3514 | *nip* | confirmed | 12,18 | H | A17 |
| C90XA20 #368 | 3515 | *nip* | confirmed | 11,16 | A20 | A17 |
| C90XA20 #368 | 3516 | *nip* | confirmed | 17,18 | H | A17 |
| C90XA20 #368 | 3518 | *nip* | confirmed | 11,16 | H | A17 |
| C90XA20 #368 | 3519 | *nip* | confirmed | 11,16 | H | A17 |
| C90XA20 #368 | 3520 | *nip* | confirmed | 12,18 | H | A17 |
| C90XA20 #368 | 3521 | *nip* | confirmed | 11,15 | A20 | A17 |
| C90XA20 #848 | 3522 | *nip* | | 14 | A17 | A17 |
| C90XA20 #848 | 3523 | *nip* | | 14 | A17 | A17 |
| C90XA20 #848 | 3524 | WT | | 15 | H | H |
| C90XA20 #848 | 3525 | *nip* | | 14 | A17 | A17 |
| C90XA20 #848 | 3526 | WT | | 14 | H | H |
| C90XA20 #848 | 3527 | WT | | 14 | H | H |
| C90XA20 #848 | 3528 | WT | | 14 | H | H |
| C90XA20 #848 | 3529 | *nip* | | 14 | A17 | A17 |
| C90XA20 #848 | 3530 | WT | | 14 | H | H |
| C90XA20 #848 | 3531 | WT | | 14 | A20 | A20 |
| C90XA20 #848 | 3532 | *nip* | | 14 | A17 | A17 |
| C90XA20 #848 | 3533 | WT | | 14 | H | H |
| C90XA20 #848 | 3534 | WT | | 14 | H | H |
| C90XA20 #848 | 3535 | WT | | 14 | H | H |
| C90XA20 #848 | 3536 | WT | | 14 | H | H |
| C90XA20 #848 | 3537 | *nip* | | 14 | A17 | A17 |
| C90XA20 #848 | 3538 | WT | | 14 | H | H |
| C90XA20 #848 | 3539 | *nip* | | 14 | A17 | A17 |
| C90XA20 #749 | 3540 | WT | | 16 | A20 | A20 |
| C90XA20 #749 | 3541 | WT | | 14 | A20 | A20 |
| C90XA20 #749 | 3542 | WT | | | A20 | A20 |
| C90XA20 #749 | 3543 | WT | | | A20 | A20 |
| C90XA20 #749 | 3544 | WT | | | A20 | A20 |
| C90XA20 #749 | 3545 | WT | | | A20 | A20 |
| C90XA20 #749 | 3546 | WT | | | A20 | A20 |
| C90XA20 #749 | 3547 | WT | | | A20 | A20 |
| C90XA20 #749 | 3548 | WT | | | A20 | A20 |
| C90XA20 #749 | 3549 | WT | | | A20 | A20 |
| C90XA20 #749 | 3550 | WT | | | A20 | A20 |
| C90XA20 #749 | 3551 | WT | | 16 | A20 | A20 |
| C90XA20 #749 | 3552 | WT | | 16 | A20 | A20 |
| C90XA20 #749 | 3553 | WT | | 14 | A20 | A20 |
| C90XA20 #749 | 3554 | WT | | 13 | A20 | A20 |
| C90XA20 #749 | 3555 | WT | | 14 | A20 | A20 |
| C90XA20 #749 | 3556 | WT | | 14 | A20 | A20 |
| C90XA20 #754 | 3557 | WT | | 14 | A17 | A17 |
| C90XA20 #754 | 3558 | WT | | 14 | A20 | A20 |
| C90XA20 #754 | 3559 | WT | | 14,16 | H | H |
| C90XA20 #754 | 3560 | WT | | 14 | H | H |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20 #754 | 3561 | WT | | 14 | A20 | A20 |
| C90XA20 #921 | 3562 | WT | | 14 | A20 | A20 |
| C90XA20 #921 | 3563 | WT | | 14 | H | H |
| C90XA20 #921 | 3564 | WT | | 15 | A20 | A20 |
| C90XA20 #921 | 3565 | WT | | 13 | H | H |
| C90XA20 #921 | 3566 | WT | | 14 | H | H |
| C90XA20 #921 | 3567 | WT | | 14 | A20 | A20 |
| C90XA20 #921 | 3568 | WT | | 14 | A20 | A20 |
| C90XA20 #921 | 3569 | WT | | 14 | H | H |
| C90XA20 #921 | 3570 | WT | | 14 | H | H |
| C90XA20 #921 | 3571 | WT | | 14 | H | H |
| C90XA20 #921 | 3572 | WT | | 14 | H | H |
| C90XA20 #921 | 3573 | WT | | 14 | H | H |
| C90XA20 #921 | 3574 | WT | | 14 | A20 | A20 |
| C90XA20 #921 | 3575 | WT | | 15 | A20 | A20 |
| C90XA20 #921 | 3576 | WT | | 15 | H | H |
| C90XA20 #921 | 3577 | WT | | 14 | H | H |
| C90XA20 #921 | 3578 | WT | | 14 | H | H |
| C90XA20 #921 | 3579 | WT | | 15 | H | H |
| C90XA20 #921 | 3580 | *nip* | | 15 | A17 | A17 |
| C90XA20 #921 | 3581 | *nip* | | 15 | A17 | A17 |
| C90XA20 #921 | 3582 | *nip* | | 15 | A17 | A17 |
| C90XA20 #921 | 3583 | *nip* | | 15 | A17 | A17 |
| C90XA20 #921 | 3584 | *nip* | | 15 | A17 | A17 |
| C90XA20 #921 | 3585 | *nip* | | 15 | A17 | A17 |
| C90XA20 #921 | 3586 | *nip* | | 15 | A17 | A17 |
| C90XA20 #681 | 3587 | WT | | 15 | A17 | A17 |
| C90XA20 #681 | 3588 | WT | | 15 | H | H |
| C90XA20 #681 | 3589 | WT | | 15 | A20 | A20 |
| C90XA20 #681 | 3590 | WT | | 15 | A20 | A20 |
| C90XA20 #681 | 3591 | WT | | 15 | H | H |
| C90XA20 #681 | 3592 | WT | | 15 | H | H |
| C90XA20 #681 | 3593 | WT | | 15 | H | H |
| C90XA20 #681 | 3594 | WT | | 15 | H | H |
| C90XA20 #681 | 3595 | WT | | 15 | A20 | A20 |
| C90XA20 #681 | 3596 | WT | | 15 | A20 | A20 |
| C90XA20 #681 | 3597 | WT | | 15 | H | H |
| C90XA20 #681 | 3598 | WT | | 15 | A20 | A20 |
| C90XA20 #681 | 3599 | WT | | 15 | A20 | A20 |
| C90XA20 #681 | 3600 | WT | | 15 | H | H |
| C90XA20 #681 | 3601 | WT | | 15 | A20 | A20 |
| C90XA20 #681 | 3602 | WT | | 14 | H | H |
| C90XA20 #681 | 3603 | WT | | 14 | H | H |
| C90XA20 #681 | 3604 | WT | | 14 | H | H |
| C90XA20 #681 | 3605 | WT | | 14 | H | H |
| C90XA20 #948 | 3606 | WT | | 14 | H | H |
| C90XA20 #948 | 3607 | WT | | 14 | H | H |
| C90XA20 #948 | 3608 | WT | | 14 | H | H |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20 #948 | 3609 | WT | | 14 | H | H |
| C90XA20 #948 | 3610 | WT | | 14 | H | H |
| C90XA20 #948 | 3611 | WT | | 13 | A20 | A20 |
| C90XA20 #948 | 3612 | WT | | 13 | H | H |
| C90XA20 #948 | 3613 | WT | | 13 | A20 | A20 |
| C90XA20 #948 | 3614 | WT | | 13 | H | H |
| C90XA20 #948 | 3615 | WT | | 15 | H | H |
| C90XA20 #948 | 3616 | WT | | 13 | H | H |
| C90XA20 #948 | 3617 | WT | | 16 | H | H |
| C90XA20 #948 | 3618 | WT | | 16 | A20 | A20 |
| C90XA20 #948 | 3619 | WT | | 14 | H | H |
| C90XA20 #948 | 3620 | WT | | 14 | H | H |
| C90XA20 #948 | 3621 | *nip* | | 14 | A17 | A17 |
| C90XA20 #948 | 3622 | *nip* | | 14 | A17 | A17 |
| C90XA20 #948 | 3623 | *nip* | | 16 | A17 | A17 |
| C90XA20 #754 | 3624 | WT | | 14 | A20 | A20 |
| C90XA20 #754 | 3625 | WT | | 14 | H | H |
| C90XA20 #754 | 3626 | WT | | 14 | A20 | A20 |
| C90XA20 #754 | 3627 | WT | | 13 | H | H |
| C90XA20 #754 | 3628 | WT | | 13 | H | H |
| C90XA20 #754 | 3629 | WT | | 13 | A20 | A20 |
| C90XA20 #754 | 3630 | WT | | 13 | H | H |
| C90XA20 #754 | 3631 | WT | | 13 | H | H |
| C90XA20 #754 | 3632 | WT | | 13 | A20 | A20 |
| C90XA20 #754 | 3633 | WT | | 13 | H | H |
| C90XA20 #754 | 3634 | *nip* | | 13 | A17 | A17 |
| C90XA20 #754 | 3635 | *nip* | | 13 | A17 | A17 |
| C90XA20 #698 | 3636 | WT | | 13 | H | H |
| C90XA20 #698 | 3637 | WT | | 15 | A20 | A20 |
| C90XA20 #698 | 3638 | WT | | 13 | H | H |
| C90XA20 #698 | 3639 | WT | | 13 | A20 | A20 |
| C90XA20 #698 | 3640 | WT | | 15 | H | H |
| C90XA20 #698 | 3641 | WT | | 13 | H | H |
| C90XA20 #698 | 3642 | WT | | 13 | A20 | A20 |
| C90XA20 #698 | 3643 | WT | | 13 | H | H |
| C90XA20 #698 | 3644 | WT | | 13 | H | H |
| C90XA20 #698 | 3645 | WT | | 13 | A20 | A20 |
| C90XA20 #698 | 3646 | WT | | 13 | H | H |
| C90XA20 #698 | 3647 | WT | | 13 | H | H |
| C90XA20 #698 | 3648 | WT | | 13 | A20 | A20 |
| C90XA20 #698 | 3649 | WT | | 13 | A20 | A20 |
| C90XA20 #698 | 3650 | WT | | 13 | H | H |
| C90XA20 #698 | 3651 | WT | confirmed | 13,15,16 | H | A20 |
| C90XA20 #698 | 3652 | WT | | 13 | A20 | A20 |
| C90XA20 #698 | 3653 | *nip* | | 13 | A17 | A17 |
| C90XA20 #698 | 3654 | *nip* | | 13 | A17 | A17 |
| C90XA20 #698 | 3655 | *nip* | | 13 | A17 | A17 |
| C90XA20 #698 | 3656 | *nip* | | 13 | A17 | A17 |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20 #698 | 3657 | *nip* | | 13 | A17 | A17 |
| C90XA20 #698 | 3658 | *nip* | | 13,15 | A17 | A17 |
| C90XA20 #731 | 3659 | WT | | 14 | A20 | A20 |
| C90XA20 #731 | 3660 | WT | | 14 | H | H |
| C90XA20 #731 | 3661 | WT | | 14 | H | H |
| C90XA20 #731 | 3662 | WT | | 14 | H | H |
| C90XA20 #731 | 3663 | WT | | 14 | H | H |
| C90XA20 #731 | 3664 | WT | | 14 | H | H |
| C90XA20 #731 | 3665 | WT | | 14 | H | H |
| C90XA20 #731 | 3666 | WT | | 14 | H | H |
| C90XA20 #731 | 3667 | WT | | 14 | H | H |
| C90XA20 #731 | 3668 | *nip* | | 14 | A17 | A17 |
| C90XA20 #731 | 3669 | *nip* | | 14 | A17 | A17 |
| C90XA20 #731 | 3670 | *nip* | | 16 | A17 | A17 |
| C90XA20 #731 | 3671 | *nip* | | 14 | A17 | A17 |
| C90XA20 #731 | 3672 | *nip* | | 14 | A17 | A17 |
| C90XA20 #850 | 3673 | WT | | 14 | A20 | A20 |
| C90XA20 #850 | 3674 | WT | | 14 | H | H |
| C90XA20 #850 | 3675 | WT | | 15 | A20 | A20 |
| C90XA20 #850 | 3676 | WT | | 14 | A20 | A20 |
| C90XA20 #850 | 3677 | WT | | 14 | A20 | A20 |
| C90XA20 #850 | 3678 | *nip* | | 14 | A17 | A17 |
| C90XA20 #850 | 3679 | *nip* | | 14 | A17 | A17 |
| C90XA20 #850 | 3680 | *nip* | | 14 | A17 | A17 |
| C90XA20 #850 | 3681 | WT | | 14 | H | H |
| C90XA20 #850 | 3682 | WT | | 14 | A20 | A20 |
| C90XA20 #850 | 3683 | WT | | 15 | A20 | A20 |
| C90XA20 #850 | 3684 | WT | | 15 | A20 | A20 |
| C90XA20 #850 | 3685 | WT | | 15 | A20 | A20 |
| C90XA20 #850 | 3686 | WT | | 15 | H | H |
| C90XA20 #850 | 3687 | WT | | 15 | H | H |
| C90XA20 #850 | 3688 | WT | confirmed | 15,16 | H | A20 |
| C90XA20 #850 | 3689 | WT | | 15 | H | H |
| C90XA20 #850 | 3690 | WT | | 15 | H | H |
| C90XA20 #850 | 3691 | *nip* | | 15 | A17 | A17 |
| C90XA20 #850 | 3692 | *nip* | | 15 | A17 | A17 |
| C90XA20 #850 | 3693 | *nip* | | 15 | A17 | A17 |
| C90XA20 #850 | 3694 | *nip* | | 15 | A17 | A17 |
| C90XA20 #850 | 3695 | *nip* | | 15 | A17 | A17 |
| C90XA20 #683 | 3696 | WT | | 15 | A20 | A20 |
| C90XA20 #683 | 3697 | WT | | 13 | H | H |
| C90XA20 #683 | 3698 | WT | | 13 | H | H |
| C90XA20 #683 | 3699 | WT | | 13 | A20 | A20 |
| C90XA20 #683 | 3700 | WT | | 13 | A20 | A20 |
| C90XA20 #683 | 3701 | WT | | 13 | H | H |
| C90XA20 #683 | 3702 | WT | | 13 | A20 | A20 |
| C90XA20 #683 | 3703 | WT | | 13 | H | H |
| C90XA20 #683 | 3704 | WT | | 13 | A20 | A20 |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20 #683 | 3705 | WT | Confirmed | 13,15,16 | H | A17 |
| C90XA20 #683 | 3706 | WT | | 13 | A20 | A20 |
| C90XA20 #683 | 3707 | WT | | 13 | A20 | A20 |
| C90XA20 #683 | 3708 | WT | | 13 | A20 | A20 |
| C90XA20 #683 | 3709 | WT | | 13 | A20 | A20 |
| C90XA20 #683 | 3710 | WT | | 13 | A20 | A20 |
| C90XA20 #683 | 3711 | *nip* | | 15 | A17 | A17 |
| C90XA20 #683 | 3712 | *nip* | confirmed | 13,15,16 | A17 | H |
| C90XA20 #683 | 3713 | *nip* | | 15 | A17 | A17 |
| C90XA20 #683 | 3714 | *nip* | | 13 | A17 | A17 |
| C90XA20 #681 | 3715 | WT | | 13 | H | H |
| C90XA20 #681 | 3716 | *nip* | | 13 | A17 | A17 |
| C90XA20 #1111 | 3717 | WT | | 22 | A20 | A20 |
| C90XA20 #993 | 3718 | WT | | 22 | A20 | A20 |
| C90XA20 #993 | 3719 | WT | Confirmed | 22,24 | H | A20 |
| C90XA20 #993 | 3720 | WT | | 22 | H | H |
| C90XA20 #993 | 3721 | ? | | 22 | A17 | A17 |
| C90XA20 #993 | 3723 | ? | | 22 | A17 | A17 |
| C90XA20 #993 | 3724 | WT | | 22,23,24 | H | H |
| C90XA20 #993 | 3725 | WT | | 22 | H | H |
| C90XA20 #993 | 3726 | WT | | 22 | H | H |
| C90XA20 #993 | 3729 | WT | | 22,23 | H | H |
| C90XA20 #816 | 3730 | WT | | 22,23 | A20 | A20 |
| C90XA20 #816 | 3731 | WT | Confirmed | 22,23,24 | A17 | H |
| C90XA20 #816 | 3732 | WT | | 22 | H | H |
| C90XA20 #816 | 3733 | ? | | 23 | H | H |
| C90XA20 #816 | 3734 | ? | | 23 | H | H |
| C90XA20 #1013 | 3735 | ? | | 23 | H | H |
| C90XA20 #1013 | 3736 | WT | | 22 | A20 | A20 |
| C90XA20 #1013 | 3737 | WT | | 22 | H | H |
| C90XA20 #1030 | 3742 | WT | | 22 | H | H |
| C90XA20 #1030 | 3743 | WT | | 22 | H | H |
| C90XA20 #1030 | 3744 | WT | | 22 | A20 | A20 |
| C90XA20 #1030 | 3745 | WT | | 22 | H | H |
| C90XA20 #1030 | 3746 | ? | | 23 | A17 | A17 |
| C90XA20 #1030 | 3747 | WT | | 22,23 | A20 | A20 |
| C90XA20 #1030 | 3748 | *nip* | | 22 | A17 | A17 |
| C90XA20 #1030 | 3749 | *nip* | Confirmed | 22,23 | A20 | H |
| C90XA20 #1030 | 3750 | ? | | 22 | H | H |
| C90XA20 #1030 | 3751 | WT | | 22 | H | H |
| C90XA20 #1030 | 3752 | WT | | 22 | A20 | A20 |
| C90XA20 #1030 | 3753 | *nip* | | 23 | H | H |
| C90XA20 #1030 | 3755 | WT | | 22 | A20 | A20 |
| C90XA20 #1030 | 3756 | *nip* | | 22 | A20 | A20 |
| C90XA20 #1163 | 3757 | WT | | 22 | H | H |
| C90XA20 #1163 | 3758 | WT | | 22 | H | H |
| C90XA20 #1163 | 3759 | WT | | 22 | A20 | A20 |
| C90XA20 #1163 | 3760 | WT | | 22 | A20 | A20 |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20 #1163 | 3761 | WT | | 22 | A20 | A20 |
| C90XA20 #1163 | 3762 | WT | | 22 | H | H |
| C90XA20 #1163 | 3763 | WT | | 22 | H | H |
| C90XA20 #1163 | 3764 | WT | | 22 | H | H |
| C90XA20 #1163 | 3765 | *nip* | | 22 | A17 | A17 |
| C90XA20 #1163 | 3766 | WT | | 22 | A20 | A20 |
| C90XA20 #1163 | 3767 | WT | | 22 | A20 | A20 |
| C90XA20 #1163 | 3768 | WT | | 22 | H | H |
| C90XA20 #1163 | 3769 | WT | | 22 | H | H |
| C90XA20 #1163 | 3770 | WT | | 22 | H | H |
| C90XA20 #1163 | 3771 | WT | | 22 | H | H |
| C90XA20 #1163 | 3772 | WT | | 22 | A20 | A20 |
| C90XA20 #1163 | 3773 | ? | | 22 | H | H |
| C90XA20 #1163 | 3774 | WT | | 22 | A20 | A20 |
| C90XA20 #1163 | 3775 | ? | | 22 | H | H |
| C90XA20 #1163 | 3776 | WT | | 22 | A17 | A17 |
| C90XA20 #1163 | 3777 | WT | | 22 | A20 | A20 |
| C90XA20 #1163 | 3778 | WT | | 22 | A17 | A17 |
| C90XA20 #1163 | 3779 | ? | | 22 | H | H |
| C90XA20 #1163 | 3780 | WT | | 22 | A20 | A20 |
| C90XA20 #1163 | 3781 | ? | | 22 | A17 | A17 |
| C90XA20 #1163 | 3782 | WT | | 22 | H | H |
| C90XA20 #1163 | 3783 | WT | | 22 | H | H |
| C90XA20 #1179 | 3784 | WT | | 22 | H | H |
| C90XA20 #1179 | 3785 | WT | | 22,23 | H | H |
| C90XA20 #1179 | 3786 | WT | | 22 | H | H |
| C90XA20 #1179 | 3787 | WT | | 22 | A20 | A20 |
| C90XA20 #1179 | 3788 | WT | | 22 | A20 | A20 |
| C90XA20 #1179 | 3789 | WT | | 22 | H | H |
| C90XA20 #1179 | 3790 | WT | | 22 | A20 | A20 |
| C90XA20 #1018 | 3791 | *nip* | | 22 | A20 | A20 |
| C90XA20 #1018 | 3794 | *nip* | | 22 | H | H |
| C90XA20 #1018 | 3795 | ? | | 22 | A20 | A20 |
| C90XA20 #1018 | 3796 | ? | | 22 | A17 | A17 |
| C90XA20 #1106 | 3798 | *nip* | | 22 | A17 | A17 |
| C90XA20 #1106 | 3799 | WT | | 22 | H | H |
| C90XA20 #1106 | 3800 | WT | | 22 | H | H |
| C90XA20 #1106 | 3801 | *nip* | | 22 | H | H |
| C90XA20 #1106 | 3802 | WT | | 22 | H | H |
| C90XA20 #1106 | 3803 | WT | | 22 | H | H |
| C90XA20 #1106 | 3804 | *nip* | | 22 | A17 | A17 |
| C90XA20 #1106 | 3805 | ? | | 22 | A17 | A17 |
| C90XA20 #1106 | 3806 | *nip* | | 22 | A17 | A17 |
| C90XA20 #1106 | 3807 | WT | | 22,23 | H | H |
| C90XA20 #1106 | 3808 | *nip* | | 22 | A17 | A17 |
| C90XA20 #1106 | 3809 | WT | | 22 | H | H |
| C90XA20 #1106 | 3810 | *nip* | | 22 | A17 | A17 |
| C90XA20 #1106 | 3811 | WT | | 22 | H | H |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20 #1106 | 3812 | ? | | 22 | H | H |
| C90XA20 #1106 | 3813 | ? | | 23 | H | H |
| C90XA20 #1106 | 3814 | WT | | 22 | H | H |
| C90XA20 #1106 | 3815 | WT | | 22 | H | H |
| C90XA20 #1106 | 3816 | ? | | 22 | H | H |
| C90XA20 #1106 | 3817 | *nip* | | 22 | A17 | A17 |
| C90XA20 #1106 | 3818 | ? | | 22 | H | H |
| C90XA20 #1106 | 3819 | WT | | 22 | A20 | A20 |
| C90XA20 #1106 | 3820 | ? | | 22 | A20 | A20 |
| C90XA20 #1106 | 3821 | ? | Confirmed | 22,23 | H | A20 |
| C90XA20 #1106 | 3822 | *nip* | | 22 | H | H |
| C90XA20#1112 | 3823 | WT | | 25 | H | H |
| C90XA20#1112 | 3824 | WT | | 25 | A20 | A20 |
| C90XA20#1112 | 3825 | WT | | 25 | A20 | A20 |
| C90XA20#1112 | 3826 | *nip* | | 25 | A17 | A17 |
| C90XA20#1112 | 3827 | WT | | 25 | H | H |
| C90XA20#1112 | 3828 | *nip* | Confirmed | 25,27 | A17 | H |
| C90XA20#1112 | 3829 | *nip* | | 25 | A20 | A20 |
| C90XA20#1112 | 3830 | WT | | 24,26 | H | H |
| C90XA20#1112 | 3831 | WT | | 24 | A20 | A20 |
| C90XA20#1112 | 3832 | WT | | 24 | H | H |
| C90XA20#1112 | 3833 | WT | | 24 | H | H |
| C90XA20#1112 | 3834 | WT | | 24 | A20 | A20 |
| C90XA20#1082 | 3835 | WT | | 24,26 | A17 | A17 |
| C90XA20#1082 | 3836 | WT | | 24 | H | H |
| C90XA20#1082 | 3837 | ? | | 24 | A20 | A20 |
| C90XA20#1082 | 3838 | ? | | 24 | A20 | A20 |
| C90XA20#1082 | 3839 | WT | | 24 | A20 | A20 |
| C90XA20#1082 | 3840 | WT | | 24,26 | H | H |
| C90XA20#1082 | 3841 | WT | | 24 | H | H |
| C90XA20#1082 | 3842 | WT | | 24,26 | H | H |
| C90XA20#1082 | 3843 | WT | | 24,26 | H | H |
| C90XA20#1082 | 3844 | WT | Confirmed | 24,26 | H | A20 |
| C90XA20#1082 | 3845 | WT | | 24 | H | H |
| C90XA20#1082 | 3846 | ? | | 24 | H | H |
| C90XA20#1082 | 3847 | WT | | 24 | A20 | A20 |
| C90XA20#1082 | 3848 | WT | | 24 | H | H |
| C90XA20#1082 | 3849 | WT | | 24 | A17 | A17 |
| C90XA20#1082 | 3850 | WT | | 24 | H | H |
| C90XA20#1082 | 3851 | WT | | 24 | H | H |
| C90XA20#1082 | 3852 | WT | | 24 | A20 | A20 |
| C90XA20#1082 | 3853 | WT | | 24,26 | H | H |
| C90XA20#1082 | 3854 | WT | | 24 | H | H |
| C90XA20#1082 | 3855 | WT | | 24 | H | H |
| C90XA20#1082 | 3856 | WT | | 24,26 | H | H |
| C90XA20#1082 | 3857 | *nip* | | 24 | A17 | A17 |
| C90XA20#1082 | 3858 | WT | | 24 | H | H |
| C90XA20#1082 | 3859 | WT | | 24 | H | H |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20#1082 | 3860 | WT | | 24 | H | H |
| C90XA20#1082 | 3861 | WT | | 24,26,27 | H | H |
| C90XA20#1082 | 3862 | WT | | 24 | H | H |
| C90XA20#1082 | 3863 | WT | | 24 | H | H |
| C90XA20#1082 | 3864 | WT | | 24 | A20 | A20 |
| C90XA20#1082 | 3865 | *nip* | | 24 | H | H |
| C90XA20#1082 | 3866 | WT | | 24,26,27 | H | H |
| C90XA20#1186 | 3867 | WT | | 24 | A20 | A20 |
| C90XA20#1186 | 3868 | WT | | 24 | H | H |
| C90XA20#1186 | 3869 | WT | | 24,26 | H | H |
| C90XA20#1186 | 3870 | WT | | 24 | H | H |
| C90XA20#1186 | 3871 | WT | | 24 | A20 | A20 |
| C90XA20#1186 | 3872 | *nip* | | 24 | H | H |
| C90XA20#1186 | 3873 | *nip* | | 24 | H | H |
| C90XA20#1186 | 3874 | WT | | 24 | H | H |
| C90XA20#1186 | 3875 | WT | | 24 | A20 | A20 |
| C90XA20#1186 | 3876 | *nip* | | 24 | A17 | A17 |
| C90XA20#1186 | 3877 | WT | | 24,26 | H | H |
| C90XA20#1013 | 3878 | WT | | 24 | H | H |
| C90XA20#1013 | 3879 | WT | | 24 | H | H |
| C90XA20#1013 | 3880 | WT | | 24 | H | H |
| C90XA20#1013 | 3881 | WT | | 24 | H | H |
| C90XA20#1013 | 3882 | WT | | 24,26,27 | A20 | A20 |
| C90XA20#1013 | 3883 | WT | | 24 | H | H |
| C90XA20#1013 | 3884 | WT | | 24 | H | H |
| C90XA20#1013 | 3885 | *nip* | | 24,26,27 | A17 | A17 |
| C90XA20#1013 | 3886 | WT | | 24,26,27 | A20 | A20 |
| C90XA20#1013 | 3887 | *nip* | | 24 | H | H |
| C90XA20#1013 | 3888 | WT | | 24,26 | A20 | A20 |
| C90XA20#1013 | 3889 | WT | | 24 | A20 | A20 |
| C90XA20#1013 | 3890 | WT | | 24 | H | H |
| C90XA20#1013 | 3891 | WT | | 24 | A20 | A20 |
| C90XA20#1013 | 3892 | WT | | 24 | H | H |
| C90XA20#1013 | 3893 | WT | | 24 | H | H |
| C90XA20#1013 | 3894 | WT | | 24 | A20 | A20 |
| C90XA20#1013 | 3895 | WT | | 24,26 | H | H |
| C90XA20#1013 | 3896 | WT | | 24,26 | A20 | A20 |
| C90XA20#1013 | 3897 | *nip* | | 24 | A17 | A17 |
| C90XA20#1013 | 3898 | WT | | 24 | H | H |
| C90XA20#1013 | 3899 | *nip* | | 24 | A17 | A17 |
| C90XA20#1013 | 3900 | *nip* | | 24,26 | A20 | A20 |
| C90XA20#1013 | 3901 | *nip* | | 24 | A17 | A17 |
| C90XA20#1013 | 3902 | WT | | 24 | A20 | A20 |
| C90XA20#1013 | 3903 | *nip* | | 24 | A17 | A17 |
| C90XA20#1013 | 3904 | WT | | 24 | H | H |
| C90XA20#1013 | 3905 | WT | | 24 | A20 | A20 |
| C90XA20#1013 | 3906 | WT | | 24,26 | A20 | A20 |
| C90XA20#1102 | 3907 | WT | | 24 | H | H |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20#1102 | 3908 | WT | | 24,26 | A20 | A20 |
| C90XA20#1102 | 3909 | WT | | 24 | H | H |
| C90XA20#1102 | 3910 | *nip* | | 24 | A17 | A17 |
| C90XA20#1102 | 3911 | WT | | 24 | A17 | A17 |
| C90XA20#1102 | 3912 | WT | | 24 | A20 | A20 |
| C90XA20#1102 | 3913 | WT | | 24 | H | H |
| C90XA20#1102 | 3914 | WT | Confirmed | 24,26,27 | H | A20 |
| C90XA20#1102 | 3915 | WT | Confirmed | 24,26,27 | H | A17 |
| C90XA20#1102 | 3916 | WT | | 24 | A20 | A20 |
| C90XA20#1101 | 3917 | WT | | 24 | H | H |
| C90XA20#1101 | 3918 | WT | | 25,26,27 | A20 | A20 |
| C90XA20#1101 | 3919 | *nip* | | 25 | A17 | A17 |
| C90XA20#1101 | 3920 | *nip* | | 25 | A17 | A17 |
| C90XA20#1101 | 3921 | WT | | 25 | H | H |
| C90XA20#1101 | 3922 | WT | | 25 | H | H |
| C90XA20#1101 | 3923 | WT | | 25 | H | H |
| C90XA20#1101 | 3924 | WT | | 25 | A20 | A20 |
| C90XA20#1101 | 3925 | WT | | 25 | H | H |
| C90XA20#1101 | 3926 | WT | | 25 | H | H |
| C90XA20#1101 | 3927 | WT | | 25,26 | H | H |
| C90XA20#1101 | 3928 | WT | | 25,26,27 | H | H |
| C90XA20#1101 | 3929 | WT | | 25 | H | H |
| C90XA20#1101 | 3930 | WT | | 25 | H | H |
| C90XA20#1101 | 3931 | WT | | 26 | H | H |
| C90XA20#1101 | 3932 | *nip* | | 25 | A17 | A17 |
| C90XA20#1101 | 3933 | WT | | 25 | H | H |
| C90XA20#1101 | 3934 | WT | | 25 | H | H |
| C90XA20#1101 | 3935 | WT | | 25 | H | H |
| C90XA20#1043 | 3936 | *nip* | | 25 | A17 | A17 |
| C90XA20#1043 | 3937 | *nip* | | 27 | A17 | A17 |
| C90XA20#1043 | 3938 | *nip* | | 27 | A17 | A17 |
| C90XA20#1043 | 3939 | *nip* | | 25 | A17 | A17 |
| C90XA20#1043 | 3940 | *nip* | | 25 | A17 | A17 |
| C90XA20#1043 | 3941 | *nip* | | 25 | A17 | A17 |
| C90XA20#1043 | 3942 | *nip* | Confirmed | 25,26,27 | A17 | H |
| C90XA20#1043 | 3943 | *nip* | Confirmed | 25,26 | A17 | H |
| C90XA20#1043 | 3944 | *nip* | Confirmed | 25,26,27 | A17 | H |
| C90XA20#1043 | 3945 | *nip* | | 25 | A17 | A17 |
| C90XA20#1043 | 3946 | *nip* | confirmed | 25,26 | A17 | A20 |
| C90XA20#1043 | 3947 | *nip* | confirmed | 25,26 | A17 | H |
| C90XA20#1043 | 3948 | *nip* | Confirmed | 25,26 | A17 | H |
| C90XA20#1043 | 3949 | *nip* | | 25 | A17 | A17 |
| C90XA20#1043 | 3950 | *nip* | confirmed | 25,26 | A17 | H |
| C90XA20#1043 | 3951 | *nip* | confirmed | 25,26 | A17 | H |
| C90XA20#1043 | 3953 | *nip* | Confirmed | 25,27 | A17 | H |
| C90XA20#1178 | 3954 | WT | | 25 | H | H |
| C90XA20#1178 | 3955 | WT | | 25 | H | H |
| C90XA20#1178 | 3956 | WT | | 25 | H | H |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20#1178 | 3957 | WT | | 25 | H | H |
| C90XA20#1178 | 3958 | WT | | 25 | A20 | A20 |
| C90XA20#1178 | 3959 | WT | | 25 | H | H |
| C90XA20#1178 | 3960 | WT | | 25,26,27 | H | H |
| C90XA20#1178 | 3961 | WT | | 25 | H | H |
| C90XA20#1178 | 3962 | WT | | 25 | A20 | A20 |
| C90XA20#1178 | 3963 | WT | | 25 | H | H |
| C90XA20#1178 | 3964 | WT | | 25 | H | H |
| C90XA20#1178 | 3965 | ? | Confirmed | 25,26,27 | A17 | H |
| C90XA20#1178 | 3966 | ? | | 25 | H | H |
| C90XA20#1178 | 3967 | *nip* | | 25 | A17 | A17 |
| C90XA20#1178 | 3968 | *nip* | | 25 | A17 | A17 |
| C90XA20#1178 | 3969 | *nip* | | 25 | A17 | A17 |
| C90XA20#1178 | 3970 | *nip* | | 25 | A17 | A17 |
| C90XA20#1178 | 3971 | WT | | 25 | H | H |
| C90XA20#1178 | 3972 | WT | | 25 | H | H |
| C90XA20#1178 | 3973 | WT | | 25 | H | H |
| C90XA20#1178 | 3974 | WT | | 25 | H | H |
| C90XA20#1178 | 3975 | WT | | 25 | H | H |
| C90XA20#1178 | 3976 | WT | | 25 | A20 | A20 |
| C90XA20#1178 | 3977 | WT | | 25,27 | H | H |
| C90XA20#1178 | 3978 | WT | | 25,27 | H | H |
| C90XA20#1016 | 3979 | *nip* | Confirmed | 25,27 | A17 | H |
| C90XA20#1016 | 3980 | WT | | 25 | H | H |
| C90XA20#1016 | 3981 | *nip* | | 25 | A17 | A17 |
| C90XA20#1016 | 3982 | WT | | 25 | H | H |
| C90XA20#1016 | 3983 | WT | | 25 | H | H |
| C90XA20#1016 | 3984 | *nip* | | 25 | A17 | A17 |
| C90XA20#1016 | 3985 | WT | | 25 | H | H |
| C90XA20#1016 | 3986 | WT | | 25 | A20 | A20 |
| C90XA20#1016 | 3987 | *nip* | | 25 | A17 | A17 |
| C90XA20#1016 | 3988 | WT | | 27 | H | H |
| C90XA20#1016 | 3989 | WT | | 26,27 | H | H |
| C90XA20#1016 | 3990 | *nip* | | 26 | A17 | A17 |
| C90XA20#1016 | 3991 | *nip* | | 26 | A17 | A17 |
| C90XA20#1016 | 3992 | WT | | 26 | H | H |
| C90XA20#1016 | 3993 | WT | | 26 | A20 | A20 |
| C90XA20#1016 | 3994 | WT | | 26 | H | H |
| C90XA20#1016 | 3995 | *nip* | | 26 | A17 | A17 |
| C90XA20#1016 | 3996 | WT | | 26 | H | H |
| C90XA20#1016 | 3997 | WT | | 26 | H | H |
| C90XA20#1016 | 3998 | *nip* | | 26 | A17 | A17 |
| C90XA20#1016 | 3999 | *nip* | | 26 | A17 | A17 |
| C90XA20#1016 | 4000 | WT | | 26 | H | H |
| C90XA20#1016 | 4001 | WT | | 26 | H | H |
| C90XA20#1016 | 4002 | WT | | 26 | H | H |
| C90XA20#1016 | 4003 | WT | | 27 | H | H |
| C90XA20#1016 | 4004 | WT | | 26 | A20 | A20 |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20#1016 | 4005 | *nip* | | 26,27 | A17 | A17 |
| C90XA20#1016 | 4006 | WT | | 26 | H | H |
| C90XA20#1016 | 4007 | WT | | 26 | A20 | A20 |
| C90XA20#1016 | 4008 | WT | | 26 | H | H |
| C90XA20#1016 | 4009 | WT | | 26 | H | H |
| C90XA20#1016 | 4010 | WT | | 26 | A20 | A20 |
| C90XA20#1016 | 4011 | WT | | 27 | H | H |
| C90XA20#1016 | 4012 | WT | | 27 | H | H |
| C90XA20#1016 | 4013 | WT | | 26,27 | A20 | A20 |
| C90XA20#1016 | 4014 | WT | | 26 | A20 | A20 |
| C90XA20#1016 | 4015 | WT | | 26 | H | H |
| C90XA20#1113 | 4016 | *nip* | | 28 | A17 | A17 |
| C90XA20#1113 | 4017 | WT | | 28,32 | A20 | A20 |
| C90XA20#1113 | 4018 | WT | | 28,32 | H | H |
| C90XA20#1113 | 4019 | WT | | 28,32 | H | H |
| C90XA20#1113 | 4020 | WT | | 28,32 | H | H |
| C90XA20#1113 | 4021 | *nip* | | 28 | A17 | A17 |
| C90XA20#1113 | 4022 | WT | | 28 | H | H |
| C90XA20#1113 | 4023 | WT | | 28,32 | H | H |
| C90XA20#1113 | 4024 | WT | | 28 | H | H |
| C90XA20#1113 | 4025 | WT | | 28 | H | H |
| C90XA20#1113 | 4026 | WT | | 28,32 | A20 | A20 |
| C90XA20#1113 | 4027 | WT | | 28,32 | H | H |
| C90XA20#1113 | 4028 | WT | | 28 | A20 | A20 |
| C90XA20#1113 | 4029 | *nip* | | 28 | A17 | A17 |
| C90XA20#1113 | 4030 | *nip* | | 28 | A17 | A17 |
| C90XA20#1113 | 4031 | *nip* | | 28 | A17 | A17 |
| C90XA20#1113 | 4032 | *nip* | | 28 | A17 | A17 |
| C90XA20#1113 | 4033 | *nip* | | 28 | H | H |
| C90XA20#1113 | 4034 | WT | | 28,32 | H | H |
| C90XA20#1113 | 4035 | *nip* | | 28 | A17 | A17 |
| C90XA20#1113 | 4036 | *nip* | | 28 | A17 | A17 |
| C90XA20#1113 | 4037 | WT | | 28 | A20 | A20 |
| C90XA20#1113 | 4038 | WT | | 28 | A20 | A20 |
| C90XA20#1113 | 4039 | WT | | 28 | H | H |
| C90XA20#1113 | 4040 | WT | | 28 | H | H |
| C90XA20#1113 | 4041 | WT | | 28 | H | H |
| C90XA20#1113 | 4042 | WT | | 28 | H | H |
| C90XA20#1113 | 4043 | *nip* | | 28 | A17 | A17 |
| C90XA20#1113 | 4044 | *nip* | | 28,32 | A17 | A17 |
| C90XA20#1113 | 4045 | WT | | 28 | H | H |
| C90XA20#1113 | 4046 | WT | | 28 | H | H |
| C90XA20#1113 | 4047 | WT | | 28 | H | H |
| C90XA20#1113 | 4048 | WT | | 28 | A20 | A20 |
| C90XA20#1113 | 4049 | *nip* | | 28 | A17 | A17 |
| C90XA20#1113 | 4050 | WT | | 28 | A20 | A20 |
| C90XA20#1113 | 4051 | WT | | 28 | A20 | A20 |
| C90XA20#1113 | 4052 | *nip* | | 28 | A17 | A17 |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20#1113 | 4053 | *nip* | | 28 | A17 | A17 |
| C90XA20#1113 | 4054 | WT | | 28 | H | H |
| C90XA20#1113 | 4055 | WT | | 28,32 | H | H |
| C90XA20#1113 | 4056 | WT | | 28,32 | H | H |
| C90XA20#1113 | 4057 | WT | | 28 | H | H |
| C90XA20#1113 | 4058 | *nip* | | 28 | A17 | A17 |
| C90XA20#1113 | 4059 | WT | | 28 | A20 | A20 |
| C90XA20#1113 | 4060 | WT | | 28 | H | H |
| C90XA20#1113 | 4061 | WT | | 28,32 | A20 | A20 |
| C90XA20#1113 | 4062 | WT | | 28,32 | H | H |
| C90XA20#1113 | 4063 | *nip* | | 28,32 | A17 | A17 |
| C90XA20#1113 | 4064 | *nip* | | 28 | A17 | A17 |
| C90XA20#1113 | 4065 | WT | | 28,32 | H | H |
| C90XA20#1113 | 4066 | *nip* | | 28 | H | H |
| C90XA20#1113 | 4067 | WT | | 28 | H | H |
| C90XA20#1113 | 4068 | *nip* | | 28 | A17 | A17 |
| C90XA20#1113 | 4069 | *nip* | | 28 | H | H |
| C90XA20#1113 | 4070 | *nip* | | 28,32 | A17 | A17 |
| C90XA20#1113 | 4071 | WT | | 28 | A17 | A17 |
| C90XA20#1113 | 4072 | WT | | 28 | A17 | A17 |
| C90XA20#1113 | 4073 | WT | | 28 | H | H |
| C90XA20#1113 | 4074 | *nip* | Confirmed | 28,38 | A17 | H |
| C90XA20#1163 | 4075 | WT | | 28 | H | H |
| C90XA20#1163 | 4076 | WT | | 28 | A17 | A17 |
| C90XA20#1163 | 4077 | *nip* | | 28 | A17 | A17 |
| C90XA20#1163 | 4078 | WT | | 28 | A20 | A20 |
| C90XA20#1163 | 4079 | WT | | 28 | A20 | A20 |
| C90XA20#1163 | 4080 | WT | | 28 | H | H |
| C90XA20#1163 | 4081 | WT | | 28 | H | H |
| C90XA20#1163 | 4082 | *nip* | | 28 | A17 | A17 |
| C90XA20#1163 | 4083 | WT | | 28 | H | H |
| C90XA20#1163 | 4084 | WT | | 28 | H | H |
| C90XA20#1163 | 4085 | WT | | 28 | H | H |
| C90XA20#1163 | 4086 | WT | | 28 | H | H |
| C90XA20#1163 | 4087 | WT | | 28 | A20 | A20 |
| C90XA20#1163 | 4088 | WT | | 28 | A20 | A20 |
| C90XA20#1163 | 4089 | WT | | 28 | A20 | A20 |
| C90XA20#1163 | 4090 | WT | | 28 | H | H |
| C90XA20#1163 | 4091 | WT | | 28 | H | H |
| C90XA20#1163 | 4092 | WT | Confirmed | 28,38 | H | A20 |
| C90XA20#1163 | 4093 | *nip* | | 28,32 | A17 | A17 |
| C90XA20#1163 | 4094 | WT | | 28 | H | H |
| C90XA20#1163 | 4095 | *nip* | | 28 | A17 | A17 |
| C90XA20#1163 | 4096 | WT | | 28 | H | H |
| C90XA20#1163 | 4097 | *nip* | | 33 | A17 | A17 |
| C90XA20#1163 | 4098 | *nip* | | 33 | A17 | A17 |
| C90XA20#1180 | 4099 | WT | | 28 | A20 | A20 |
| C90XA20#1180 | 4100 | WT | | 28 | H | H |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20#1180 | 4101 | WT | | 28 | H | H |
| C90XA20#1180 | 4102 | WT | | 28 | A20 | A20 |
| C90XA20#1180 | 4103 | WT | | 28,32 | H | H |
| C90XA20#1180 | 4104 | WT | | 28 | H | H |
| C90XA20#1180 | 4105 | WT | | 28 | A20 | A20 |
| C90XA20#1180 | 4106 | WT | | 28 | H | H |
| C90XA20#1180 | 4107 | WT | | 28 | H | H |
| C90XA20#1180 | 4108 | WT | | 28 | H | H |
| C90XA20#1180 | 4109 | *nip* | | 28,32 | A17 | A17 |
| C90XA20#1180 | 4110 | *nip* | | 29 | A17 | A17 |
| C90XA20#1180 | 4111 | *nip* | | 29 | A17 | A17 |
| C90XA20#1180 | 4112 | WT | | 29 | H | H |
| C90XA20#1180 | 4113 | WT | | 29 | H | H |
| C90XA20#1180 | 4114 | *nip* | | 29 | H | H |
| C90XA20#1180 | 4115 | WT | | 29 | H | H |
| C90XA20#1180 | 4116 | *nip* | | 33 | H | H |
| C90XA20#1180 | 4117 | WT | Confirmed | 33,38 | A20 | H |
| C90XA20#1180 | 4118 | *nip* | | 33 | A17 | A17 |
| C90XA20#1180 | 4119 | WT | | 33 | H | H |
| C90XA20#1180 | 4120 | WT | | 33 | H | H |
| C90XA20#1180 | 4121 | WT | | 33 | H | H |
| C90XA20#1180 | 4122 | WT | | 33,37 | H | H |
| C90XA20#1180 | 4123 | WT | Confirmed | 33,38 | A20 | H |
| C90XA20#1180 | 4124 | WT | | 33 | H | H |
| C90XA20#1180 | 4125 | WT | | 33 | H | H |
| C90XA20#1180 | 4126 | WT | | 33 | H | H |
| C90XA20#1180 | 4127 | *nip* | | 33 | A17 | A17 |
| C90XA20#1180 | 4128 | WT | | 33 | A20 | A20 |
| C90XA20#1179 | 4129 | WT | | 33 | A20 | A20 |
| C90XA20#1179 | 4130 | *nip* | | 33 | A17 | A17 |
| C90XA20#1179 | 4131 | WT | | 33 | H | H |
| C90XA20#1179 | 4132 | WT | | 33 | A20 | A20 |
| C90XA20#1179 | 4133 | *nip* | | 33 | A17 | A17 |
| C90XA20#1179 | 4134 | *nip* | | 33 | A17 | A17 |
| C90XA20#1179 | 4135 | WT | Confirmed | 34,38 | H | A20 |
| C90XA20#1179 | 4136 | *nip* | | 29 | A17 | A17 |
| C90XA20#1179 | 4137 | *nip* | | 29 | A17 | A17 |
| C90XA20#1179 | 4138 | *nip* | | 29 | A17 | A17 |
| C90XA20#1179 | 4139 | WT | | 29 | H | H |
| C90XA20#1179 | 4140 | *nip* | | 29 | A17 | A17 |
| C90XA20#1179 | 4141 | WT | | 29 | H | H |
| C90XA20#1179 | 4142 | WT | | 29 | H | H |
| C90XA20#1179 | 4143 | WT | | 29 | H | H |
| C90XA20#1179 | 4144 | WT | | 29 | H | H |
| C90XA20#1179 | 4145 | *nip* | | 29 | A17 | A17 |
| C90XA20#1179 | 4146 | WT | | 29 | H | H |
| C90XA20#1179 | 4147 | *nip* | | 29 | A17 | A17 |
| C90XA20#1179 | 4148 | WT | | 29 | H | H |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20#1179 | 4149 | WT | | 29 | H | H |
| C90XA20#1179 | 4150 | WT | | 29 | H | H |
| C90XA20#1179 | 4151 | WT | | 29 | H | H |
| C90XA20#1179 | 4152 | WT | | 29 | H | H |
| C90XA20#1188 | 4153 | *nip* | | 29 | H | H |
| C90XA20#1188 | 4154 | WT | | 29,33 | H | H |
| C90XA20#1188 | 4155 | WT | | 29 | H | H |
| C90XA20#1188 | 4156 | WT | | 29 | H | H |
| C90XA20#1188 | 4157 | WT | | 29 | H | H |
| C90XA20#1188 | 4158 | *nip* | | 29 | A17 | A17 |
| C90XA20#1188 | 4159 | *nip* | | 29 | A17 | A17 |
| C90XA20#1188 | 4160 | WT | | 29 | H | H |
| C90XA20#1188 | 4161 | WT | | 29 | H | H |
| C90XA20#1188 | 4162 | *nip* | | 29 | A17 | A17 |
| C90XA20#1188 | 4163 | WT | | 29 | A20 | A20 |
| C90XA20#1188 | 4164 | *nip* | | 29 | A17 | A17 |
| C90XA20#1188 | 4165 | *nip* | | 29 | A17 | A17 |
| C90XA20#1188 | 4166 | WT | | 29 | H | H |
| C90XA20#1188 | 4167 | WT | | 29 | A20 | A20 |
| C90XA20#1188 | 4168 | WT | | 29 | H | H |
| C90XA20#1188 | 4169 | WT | | 29 | A20 | A20 |
| C90XA20#1188 | 4170 | *nip* | | 29 | A17 | A17 |
| C90XA20#1188 | 4171 | WT | | 29,33 | H | H |
| C90XA20#1188 | 4172 | WT | | 29 | H | H |
| C90XA20#1188 | 4173 | WT | | 29 | H | H |
| C90XA20#1188 | 4174 | WT | | 29 | H | H |
| C90XA20#1177 | 4175 | WT | Confirmed | 29,34 | A20 | H |
| C90XA20#1177 | 4176 | WT | | 39 | H | H |
| C90XA20#1177 | 4177 | WT | | 36 | H | H |
| C90XA20#1177 | 4178 | *nip* | | 36 | H | H |
| C90XA20#1177 | 4179 | *nip* | | 36 | A17 | A17 |
| C90XA20#1177 | 4180 | WT | | 36 | H | H |
| C90XA20#1177 | 4181 | WT | | 36 | H | H |
| C90XA20#1177 | 4182 | WT | | 36 | A20 | A20 |
| C90XA20#1177 | 4183 | ? | | 36 | H | H |
| C90XA20#1177 | 4184 | WT | | 36,39 | H | H |
| C90XA20#1177 | 4185 | WT | | 36 | A20 | A20 |
| C90XA20#1177 | 4186 | *nip* | | 36 | A17 | A17 |
| C90XA20#1177 | 4187 | WT | | 36 | A20 | A20 |
| C90XA20#1177 | 4188 | *nip* | | 36 | A17 | A17 |
| C90XA20#1177 | 4189 | *nip* | | 36 | A17 | A17 |
| C90XA20#1177 | 4190 | *nip* | | 36 | A17 | A17 |
| C90XA20#1177 | 4191 | WT | | 36 | H | H |
| C90XA20#1177 | 4192 | WT | | 36,39 | H | H |
| C90XA20#1177 | 4193 | *nip* | | 36 | A17 | A17 |
| C90XA20#1177 | 4194 | *nip* | | 36 | A17 | A17 |
| C90XA20#1177 | 4195 | WT | | 36 | A20 | A20 |
| C90XA20#1177 | 4196 | WT | | 29 | A20 | A20 |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20#1177 | 4197 | WT | Confirmed | 29,33 | H | A17 |
| C90XA20#1177 | 4198 | WT | | 29 | A20 | A20 |
| C90XA20#1177 | 4199 | *nip* | | 29 | A17 | A17 |
| C90XA20#1177 | 4200 | WT | | 32 | H | H |
| C90XA20#1177 | 4201 | *nip* | | 29 | A17 | A17 |
| C90XA20#1177 | 4202 | *nip* | | 29 | A17 | A17 |
| C90XA20#1177 | 4203 | *nip* | | 29 | A17 | A17 |
| C90XA20#1177 | 4204 | WT | | 32 | H | H |
| C90XA20#1177 | 4205 | WT | | 29 | H | H |
| C90XA20#1177 | 4206 | WT | | 29 | A20 | A20 |
| C90XA20#1177 | 4207 | *nip* | | 32 | A17 | A17 |
| C90XA20#1177 | 4208 | WT | | 29 | H | H |
| C90XA20#1176 | 4209 | WT | | 33 | H | H |
| C90XA20#1176 | 4210 | WT | | 33 | A20 | A20 |
| C90XA20#1176 | 4211 | WT | | 33 | A20 | A20 |
| C90XA20#1176 | 4212 | WT | | 33 | H | H |
| C90XA20#1176 | 4213 | WT | | 33 | H | H |
| C90XA20#1176 | 4214 | WT | | 33 | H | H |
| C90XA20#1176 | 4215 | *nip* | | 33 | A17 | A17 |
| C90XA20#1176 | 4216 | WT | | 33 | H | H |
| C90XA20#1176 | 4217 | WT | | 33 | H | H |
| C90XA20#1176 | 4218 | *nip* | | 33 | A17 | A17 |
| C90XA20#1176 | 4219 | *nip* | | 33 | A17 | A17 |
| C90XA20#1176 | 4220 | WT | | 33 | A20 | A20 |
| C90XA20#1176 | 4221 | WT | | 33 | H | H |
| C90XA20#1176 | 4222 | *nip* | | 33 | A17 | A17 |
| C90XA20#1176 | 4223 | WT | | 33 | H | H |
| C90XA20#1186 | 4224 | WT | | 37 | H | H |
| C90XA20#1186 | 4225 | *nip* | | 33 | A17 | A17 |
| C90XA20#1186 | 4226 | WT | | 33 | A20 | A20 |
| C90XA20#1186 | 4227 | *nip* | Confirmed | 33,38,40 | A17 | H |
| C90XA20#1186 | 4228 | *nip* | | 33 | A17 | A17 |
| C90XA20#1186 | 4229 | *nip* | | 33 | A17 | A17 |
| C90XA20#1186 | 4230 | *nip* | | 33,37 | A17 | A17 |
| C90XA20#1186 | 4231 | *nip* | | 33 | A17 | A17 |
| C90XA20#1186 | 4232 | WT | | 29,34 | H | H |
| C90XA20#1186 | 4233 | WT | | 29 | H | H |
| C90XA20#1186 | 4234 | WT | | 29 | H | H |
| C90XA20#1186 | 4235 | WT | | 29 | H | H |
| C90XA20#1186 | 4236 | WT | | 29 | H | H |
| C90XA20#1186 | 4237 | WT | | 29 | H | H |
| C90XA20#1186 | 4238 | WT | Confirmed | 29,34 | A20 | H |
| C90XA20#1186 | 4239 | WT | | 29 | A20 | A20 |
| C90XA20#1186 | 4240 | WT | | 29 | H | H |
| C90XA20#1186 | 4241 | WT | | 29 | A20 | A20 |
| C90XA20#1186 | 4242 | WT | | 29 | A20 | A20 |
| C90XA20#1199 | 4243 | WT | | 29 | H | H |
| C90XA20#1199 | 4244 | WT | | 29 | H | H |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20#1199 | 4245 | WT | | 29 | H | H |
| C90XA20#1199 | 4246 | *nip* | | 29 | A17 | A17 |
| C90XA20#1199 | 4247 | *nip* | | 37,39 | A17 | A17 |
| C90XA20#1199 | 4248 | WT | Confirmed | 32,38 | H | A17 |
| C90XA20#1199 | 4249 | WT | | 32 | H | H |
| C90XA20#1199 | 4250 | WT | | 37 | H | H |
| C90XA20#1199 | 4251 | *nip* | | 32 | A17 | A17 |
| C90XA20#1199 | 4252 | *nip* | | 37 | A17 | A17 |
| C90XA20#1199 | 4253 | WT | | 32 | H | H |
| C90XA20#1199 | 4254 | WT | | 32 | H | H |
| C90XA20#1199 | 4255 | WT | Confirmed | 32,38 | H | A20 |
| C90XA20#1199 | 4256 | WT | | 32 | H | H |
| C90XA20#1199 | 4257 | WT | | 32 | H | H |
| C90XA20#1199 | 4258 | WT | | 32 | H | H |
| C90XA20#1199 | 4259 | WT | | 32 | H | H |
| C90XA20#1199 | 4260 | WT | | 32 | H | H |
| C90XA20#1199 | 4261 | *nip* | | 32 | A17 | A17 |
| C90XA20#1199 | 4262 | WT | | 32 | H | H |
| C90XA20#1199 | 4263 | *nip* | | 37 | A17 | A17 |
| C90XA20#1199 | 4264 | WT | | 32 | H | H |
| C90XA20#1199 | 4265 | WT | | 37 | A20 | A20 |
| C90XA20#1199 | 4266 | WT | | 32 | H | H |
| C90XA20#1199 | 4267 | *nip* | | 32 | A17 | A17 |
| C90XA20#1207 | 4268 | WT | | 37 | A20 | A20 |
| C90XA20#1207 | 4269 | *nip* | | 37 | A17 | A17 |
| C90XA20#1207 | 4270 | *nip* | | 37 | A17 | A17 |
| C90XA20#1207 | 4271 | WT | | 37 | H | H |
| C90XA20#1207 | 4272 | WT | | 37,39 | H | H |
| C90XA20#1207 | 4273 | *nip* | | 37 | A17 | A17 |
| C90XA20#1207 | 4274 | *nip* | | 37 | A17 | A17 |
| C90XA20#1207 | 4275 | WT | | 37 | H | H |
| C90XA20#1207 | 4276 | WT | | 37 | H | H |
| C90XA20#1207 | 4277 | WT | | 37,39 | H | H |
| C90XA20#1207 | 4278 | WT | | 37 | H | H |
| C90XA20#1207 | 4279 | WT | | 37 | H | H |
| C90XA20#1207 | 4280 | WT | | 37 | H | H |
| C90XA20#1207 | 4281 | WT | | 37 | A20 | A20 |
| C90XA20#1207 | 4282 | WT | | 37 | A20 | A20 |
| C90XA20#1207 | 4283 | WT | | 37 | H | H |
| C90XA20#1207 | 4284 | WT | | 37 | H | H |
| C90XA20#1207 | 4285 | WT | | 37 | H | H |
| C90XA20#1207 | 4286 | WT | | 37 | H | H |
| C90XA20#1207 | 4287 | WT | Confirmed | 37,38 | A20 | H |
| C90XA20#1207 | 4288 | WT | | 37 | A20 | A20 |
| C90XA20#1207 | 4289 | WT | | 37 | A20 | A20 |
| C90XA20#1207 | 4290 | *nip* | | 37 | A17 | A17 |
| C90XA20#1207 | 4291 | *nip* | | 37 | A17 | A17 |
| C90XA20#1207 | 4292 | *nip* | | 37 | A17 | A17 |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20#1207 | 4293 | WT | | 37 | H | H |
| C90XA20#1207 | 4294 | WT | | 37 | A20 | A20 |
| C90XA20#1207 | 4295 | *nip* | | 37 | A17 | A17 |
| C90XA20#1207 | 4296 | WT | | 37 | A20 | A20 |
| C90XA20#1207 | 4297 | WT | | 37 | H | H |
| C90XA20#1207 | 4298 | WT | | 37 | H | H |
| C90XA20#1207 | 4299 | WT | | 37 | H | H |
| C90XA20#1207 | 4300 | WT | | 37 | A20 | A20 |
| C90XA20#1207 | 4301 | WT | | 37 | H | H |
| C90XA20#1207 | 4302 | WT | | 37 | H | H |
| C90XA20#1207 | 4303 | *nip* | | 37 | A17 | A17 |
| C90XA20#1207 | 4304 | WT | | 37 | H | H |
| C90XA20#1207 | 4305 | WT | | 37 | H | H |
| C90XA20#1207 | 4306 | WT | | 37 | A20 | A20 |
| C90XA20#1207 | 4307 | WT | | 37 | H | H |
| C90XA20#1207 | 4308 | WT | | 36 | H | H |
| C90XA20#1207 | 4309 | WT | | 36 | H | H |
| C90XA20#1207 | 4310 | *nip* | | 36 | A17 | A17 |
| C90XA20#1207 | 4311 | WT | | 36 | H | H |
| C90XA20#1207 | 4312 | *nip* | | 36 | A17 | A17 |
| C90XA20#1207 | 4313 | WT | | 36 | H | H |
| C90XA20#1207 | 4314 | *nip* | | 36 | A20 | A20 |
| C90XA20#1207 | 4315 | *nip* | | 36 | A17 | A17 |
| C90XA20#1207 | 4316 | WT | | 36 | H | H |
| C90XA20#1207 | 4317 | WT | | 36 | H | H |
| C90XA20#1207 | 4318 | *nip* | | 36 | A17 | A17 |
| C90XA20#1207 | 4319 | WT | | 36 | A20 | A20 |
| C90XA20#1207 | 4320 | *nip* | | 36 | A17 | A17 |
| C90XA20#1207 | 4321 | *nip* | | 36 | A17 | A17 |
| C90XA20#1207 | 4322 | WT | | 36 | A20 | A20 |
| C90XA20#1207 | 4323 | *nip* | | 36 | H | H |
| C90XA20#1207 | 4324 | WT | | 36 | A20 | A20 |
| C90XA20#1359 | 4325 | WT | | 36 | H | H |
| C90XA20#1359 | 4326 | WT | | 36 | H | H |
| C90XA20#1359 | 4327 | WT | | 37 | H | H |
| C90XA20#1359 | 4328 | WT | | 37 | H | H |
| C90XA20#1359 | 4329 | *nip* | | 37 | A17 | A17 |
| C90XA20#1359 | 4330 | WT | | 37 | H | H |
| C90XA20#1359 | 4331 | WT | | 37 | H | H |
| C90XA20#1359 | 4332 | WT | | 37 | H | H |
| C90XA20#1359 | 4333 | WT | | 37 | H | H |
| C90XA20#1359 | 4334 | WT | | 37 | H | H |
| C90XA20#1359 | 4335 | WT | | 37 | H | H |
| C90XA20#1359 | 4336 | *nip* | | 37 | A17 | A17 |
| C90XA20#1359 | 4337 | WT | | 37 | H | H |
| C90XA20#1359 | 4338 | *nip* | | 37 | A17 | A17 |
| C90XA20#1359 | 4339 | WT | | 37 | A20 | A20 |
| C90XA20#1359 | 4340 | *nip* | | 37 | A17 | A17 |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20#1359 | 4341 | WT | | 37 | H | H |
| C90XA20#1359 | 4342 | WT | | 37 | H | H |
| C90XA20#1366 | 4343 | *nip* | | 37 | A17 | A17 |
| C90XA20#1366 | 4344 | WT | | 37 | H | H |
| C90XA20#1366 | 4346 | WT | | 32 | A20 | A20 |
| C90XA20#1366 | 4347 | WT | | 32 | H | H |
| C90XA20#1366 | 4348 | WT | | 32,37 | H | H |
| C90XA20#1366 | 4349 | *nip* | | 32 | A17 | A17 |
| C90XA20#1366 | 4350 | WT | | 32 | H | H |
| C90XA20#1366 | 4351 | WT | | 32 | H | H |
| C90XA20#1366 | 4352 | *nip* | | 32 | A17 | A17 |
| C90XA20#1366 | 4353 | WT | | 32 | H | H |
| C90XA20#1366 | 4354 | WT | | 32 | A20 | A20 |
| C90XA20#1366 | 4355 | WT | | 32 | H | H |
| C90XA20#1366 | 4356 | WT | | 32 | H | H |
| C90XA20#1366 | 4357 | WT | | 32 | A20 | A20 |
| C90XA20#1366 | 4358 | WT | | 32 | H | H |
| C90XA20#1366 | 4359 | WT | | 32 | H | H |
| C90XA20#1366 | 4360 | WT | | 32 | H | H |
| C90XA20#1366 | 4361 | WT | | 32 | A17 | A17 |
| C90XA20#1366 | 4362 | *nip* | | 32 | A17 | A17 |
| C90XA20#1366 | 4363 | WT | | 32 | A20 | A20 |
| C90XA20#1366 | 4364 | WT | | 32 | H | H |
| C90XA20#1366 | 4365 | *nip* | | 32 | H | H |
| C90XA20#1366 | 4366 | WT | | 33 | H | H |
| C90XA20#1366 | 4367 | WT | | 33 | H | H |
| C90XA20#1366 | 4368 | WT | | 33 | H | H |
| C90XA20#1366 | 4369 | WT | | 33 | H | H |
| C90XA20#1366 | 4370 | *nip* | | 33 | A17 | A17 |
| C90XA20#1366 | 4371 | WT | | 33 | A20 | A20 |
| C90XA20#1366 | 4372 | WT | | 33 | H | H |
| C90XA20#1366 | 4373 | *nip* | | 33 | A17 | A17 |
| C90XA20#1366 | 4374 | WT | | 33 | A20 | A20 |
| C90XA20#1366 | 4375 | *nip* | | 33 | A17 | A17 |
| C90XA20#1366 | 4376 | WT | | 33 | H | H |
| C90XA20#1366 | 4377 | WT | | 33 | A20 | A20 |
| C90XA20#1366 | 4378 | WT | | 33 | A20 | A20 |
| C90XA20#1366 | 4379 | WT | | 33 | H | H |
| C90XA20#1366 | 4380 | WT | | 33 | H | H |
| C90XA20#1366 | 4381 | *nip* | | 33 | A17 | A17 |
| C90XA20#1366 | 4382 | WT | | 33 | H | H |
| C90XA20#1366 | 4383 | *nip* | | 33 | A17 | A17 |
| C90XA20#1366 | 4384 | WT | | 33 | H | H |
| C90XA20#1366 | 4385 | WT | | 33 | A20 | A20 |
| C90XA20#1366 | 4386 | WT | | 34,37 | H | H |
| C90XA20#1366 | 4387 | WT | | 34,37 | A20 | A20 |
| C90XA20#1366 | 4388 | WT | | 34,37 | A20 | A20 |
| C90XA20#1366 | 4389 | WT | | 34,37 | H | H |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20#1366 | 4390 | WT | | 34 | A20 | A20 |
| C90XA20#1366 | 4391 | *nip* | | 34,37 | A17 | A17 |
| C90XA20#1366 | 4392 | *nip* | | 34 | A17 | A17 |
| C90XA20#1366 | 4393 | *nip* | | 37 | A17 | A17 |
| C90XA20#1366 | 4394 | WT | | 34 | H | H |
| C90XA20#1366 | 4395 | *nip* | | 34 | A17 | A17 |
| C90XA20#1366 | 4396 | WT | | 34,37 | A20 | A20 |
| C90XA20#1366 | 4397 | *nip* | | 34 | A17 | A17 |
| C90XA20#1366 | 4398 | WT | | 34 | H | H |
| C90XA20#1366 | 4399 | WT | | 34,37 | H | H |
| C90XA20#1204 | 4400 | *nip* | | 34,37 | A17 | A17 |
| C90XA20#1204 | 4401 | *nip* | | 34 | A17 | A17 |
| C90XA20#1204 | 4403 | WT | | 34,37,39 | H | H |
| C90XA20#1204 | 4404 | WT | | 34,37 | H | H |
| C90XA20#1204 | 4405 | WT | | 34 | A20 | A20 |
| C90XA20#1204 | 4406 | WT | | 36 | A20 | A20 |
| C90XA20#1204 | 4407 | WT | | 36 | A20 | A20 |
| C90XA20#1204 | 4408 | WT | | 36 | H | H |
| C90XA20#1204 | 4409 | WT | | 36 | H | H |
| C90XA20#1204 | 4410 | WT | | 36 | H | H |
| C90XA20#1204 | 4411 | WT | | 36 | H | H |
| C90XA20#1204 | 4412 | WT | | 36,39 | H | H |
| C90XA20#1204 | 4413 | WT | | 36 | A20 | A20 |
| C90XA20#1204 | 4414 | *nip* | | 36 | A17 | A17 |
| C90XA20#1204 | 4415 | WT | | 37,39 | H | H |
| C90XA20#1204 | 4416 | *nip* | | 37 | A17 | A17 |
| C90XA20#1204 | 4417 | WT | | 37,39 | H | H |
| C90XA20#1204 | 4418 | WT | | 37 | H | H |
| C90XA20#1204 | 4419 | WT | confirmed | 37,39,44 | A17 | H |
| C90XA20#1204 | 4420 | WT | | 37 | H | H |
| C90XA20#1204 | 4421 | WT | | 37 | H | H |
| C90XA20#1204 | 4423 | *nip* | | 37,39 | A17 | A17 |
| C90XA20#1204 | 4424 | *nip* | | 39 | A17 | A17 |
| C90XA20#1204 | 4425 | *nip* | | 39 | A17 | A17 |
| C90XA20#1204 | 4426 | WT | | 39,42 | A20 | A20 |
| C90XA20#1204 | 4427 | WT | | 39 | A20 | A20 |
| C90XA20#1204 | 4428 | WT | | 39 | H | H |
| C90XA20#1204 | 4429 | WT | | 39 | A20 | A20 |
| C90XA20#1204 | 4430 | *nip* | | 39 | A17 | A17 |
| C90XA20#1204 | 4431 | WT | | 39 | A20 | A20 |
| C90XA20#1176 | 4433 | WT | | 39 | H | H |
| C90XA20#1176 | 4434 | WT | | 39 | H | H |
| C90XA20#1176 | 4435 | WT | | 39 | H | H |
| C90XA20#1176 | 4436 | WT | | 39 | H | H |
| C90XA20#1176 | 4437 | *nip* | | 39 | A17 | A17 |
| C90XA20#1176 | 4438 | *nip* | | 39 | A17 | A17 |
| C90XA20#1176 | 4439 | WT | | 39,42 | H | H |
| C90XA20#1176 | 4440 | WT | | 39 | H | H |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20#1176 | 4441 | WT | | 39 | H | H |
| C90XA20#1176 | 4442 | WT | | 39 | A20 | A20 |
| C90XA20#1176 | 4443 | WT | | 39 | A20 | A20 |
| C90XA20#1176 | 4444 | *nip* | | 39 | A17 | A17 |
| C90XA20#1176 | 4445 | *nip* | | 39 | A17 | A17 |
| C90XA20#1216 | 4446 | *nip* | | 32 | A17 | A17 |
| C90XA20#1216 | 4447 | WT | | 32 | H | H |
| C90XA20#1216 | 4448 | WT | | 32 | H | H |
| C90XA20#1216 | 4449 | *nip* | | 32 | A17 | A17 |
| C90XA20#1216 | 4450 | WT | | 39 | H | H |
| C90XA20#1216 | 4451 | WT | | 39 | H | H |
| C90XA20#1216 | 4452 | WT | | 39 | H | H |
| C90XA20#1216 | 4453 | WT | | 39,42 | H | H |
| C90XA20#1216 | 4454 | *nip* | | 39 | A17 | A17 |
| C90XA20#1216 | 4455 | *nip* | | 39 | A17 | A17 |
| C90XA20#1216 | 4456 | WT | | 39 | H | H |
| C90XA20#1216 | 4457 | WT | | 39 | H | H |
| C90XA20#1216 | 4458 | WT | | 39 | H | H |
| C90XA20#1216 | 4459 | WT | | 39 | H | H |
| C90XA20#1216 | 4460 | WT | | 39 | H | H |
| C90XA20#1216 | 4461 | WT | | 39 | A20 | A20 |
| C90XA20#1216 | 4462 | WT | | 39 | H | H |
| C90XA20#1216 | 4464 | WT | | 39,42 | H | H |
| C90XA20#1216 | 4465 | WT | | 39 | H | H |
| C90XA20#1216 | 4466 | *nip* | | 39 | A17 | A17 |
| C90XA20#1216 | 4467 | *nip* | | 39 | A17 | A17 |
| C90XA20#1216 | 4468 | WT | | 39,42 | H | H |
| C90XA20#1216 | 4469 | *nip* | | 39 | A17 | A17 |
| C90XA20#1216 | 4470 | WT | | 39 | H | H |
| C90XA20#1216 | 4471 | WT | | 39 | H | H |
| C90XA20#1216 | 4473 | WT | confirmed | 39,44 | H | A17 |
| C90XA20#1216 | 4474 | WT | | 39 | H | H |
| C90XA20#1216 | 4475 | *nip* | | 39 | A17 | A17 |
| C90XA20#1216 | 4476 | WT | | 39 | H | H |
| C90XA20#1216 | 4477 | WT | | 39 | A20 | A20 |
| C90XA20#1216 | 4478 | WT | | 39 | H | H |
| C90XA20#1216 | 4479 | WT | | 39 | H | H |
| C90XA20#1216 | 4480 | *nip* | | 33 | A17 | A17 |
| C90XA20#1216 | 4481 | WT | | 33 | A20 | A20 |
| C90XA20#1216 | 4482 | WT | | 33 | A17 | A17 |
| C90XA20#1216 | 4483 | WT | | 33 | H | H |
| C90XA20#1216 | 4484 | WT | | 33 | H | H |
| C90XA20#1216 | 4485 | WT | | 33 | H | H |
| C90XA20#1216 | 4486 | WT | | 33 | A20 | A20 |
| C90XA20#1216 | 4487 | WT | | 33 | A20 | A20 |
| C90XA20#1216 | 4488 | WT | | 33 | H | H |
| C90XA20#1216 | 4489 | WT | | 33 | A20 | A20 |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20#1216 | 4490 | *nip* | | 33 | A17 | A17 |
| C90XA201208 | 4491 | *nip* | | 33 | A17 | A17 |
| C90XA201208 | 4492 | *nip* | | 33 | A20 | A20 |
| C90XA201208 | 4493 | WT | | 33 | A17 | A17 |
| C90XA201208 | 4494 | *nip* | | 33 | A17 | A17 |
| C90XA201208 | 4495 | WT | | 33,37 | H | H |
| C90XA201208 | 4496 | WT | | 33 | H | H |
| C90XA201208 | 4497 | WT | | 33 | H | H |
| C90XA201208 | 4498 | WT | | 33,37 | A20 | A20 |
| C90XA201208 | 4499 | WT | | 33,38 | H | H |
| C90XA201208 | 4500 | WT | | 33 | H | H |
| C90XA201208 | 4501 | WT | | 33 | H | H |
| C90XA201208 | 4502 | WT | | 33 | H | H |
| C90XA201208 | 4503 | WT | | 33 | A20 | A20 |
| C90XA201208 | 4504 | WT | | 33 | H | H |
| C90XA201208 | 4505 | ? | | 33 | H | H |
| C90XA201208 | 4506 | WT | | 44 | H | H |
| C90XA201208 | 4507 | *nip* | | 44 | A17 | A17 |
| C90XA201208 | 4508 | WT | | 39 | A20 | A20 |
| C90XA201208 | 4509 | WT | | 39 | A20 | A20 |
| C90XA201208 | 4510 | WT | | 39 | A20 | A20 |
| C90XA201208 | 4511 | *nip* | | 39 | A17 | A17 |
| C90XA201208 | 4512 | WT | | 39,42 | H | H |
| C90XA201208 | 4513 | WT | | 39 | H | H |
| C90XA201208 | 4514 | WT | | 39,42 | H | H |
| C90XA201208 | 4515 | WT | | 39 | H | H |
| C90XA201208 | 4516 | *nip* | | 39 | A20 | A20 |
| C90XA201208 | 4517 | WT | | 39 | A17 | A17 |
| C90XA201208 | 4518 | WT | | 39 | H | H |
| C90XA201208 | 4519 | WT | | 39,44 | H | H |
| C90XA201208 | 4520 | WT | | 39 | H | H |
| C90XA20#1308 | 4521 | WT | confirmed | 39,44 | H | A17 |
| C90XA20#1308 | 4522 | *nip* | | 39 | A17 | A17 |
| C90XA20#1308 | 4524 | WT | | 39,42 | H | H |
| C90XA20#1308 | 4525 | WT | | 39 | H | H |
| C90XA20#1308 | 4526 | WT | | 39 | H | H |
| C90XA20#1308 | 4527 | WT | | 39 | H | H |
| C90XA20#1308 | 4528 | WT | | 39 | H | H |
| C90XA20#1308 | 4529 | *nip* | | 39 | H | H |
| C90XA20#1308 | 4530 | WT | | 39,42 | H | H |
| C90XA20#1308 | 4531 | WT | | 39 | H | H |
| C90XA20#1308 | 4532 | WT | | 39 | H | H |
| C90XA20#1308 | 4533 | WT | | 39 | H | H |
| C90XA20#1308 | 4534 | WT | confirmed | 39,44 | A20 | H |
| C90XA20#1308 | 4535 | *nip* | | 39 | A17 | A17 |
| C90XA20#1308 | 4536 | WT | | 39 | A20 | A20 |
| C90XA20#1308 | 4537 | WT | | 39 | H | H |
| C90XA20#1308 | 4538 | *nip* | | 40 | A17 | A17 |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20#1308 | 4539 | WT | | 40 | H | H |
| C90XA20#1309 | 4540 | WT | | 40 | A17 | A17 |
| C90XA20#1309 | 4541 | *nip* | | 40 | H | H |
| C90XA20#1309 | 4542 | WT | | 40 | A17 | A17 |
| C90XA20#1309 | 4543 | WT | | 40 | H | H |
| C90XA20#1309 | 4544 | WT | | 40 | H | H |
| C90XA20#1309 | 4545 | WT | | 40 | H | H |
| C90XA20#1309 | 4546 | WT | | 40,42 | H | H |
| C90XA20#1309 | 4547 | WT | | 40 | H | H |
| C90XA20#1309 | 4548 | WT | | 40 | H | H |
| C90XA20#1309 | 4549 | *nip* | | 40 | A17 | A17 |
| C90XA20#1309 | 4550 | WT | | 40 | H | H |
| C90XA20#1309 | 4551 | WT | confirmed | 38,44 | A20 | H |
| C90XA20#1309 | 4552 | WT | confirmed | 38,44 | A20 | H |
| C90XA20#1309 | 4553 | WT | | 38 | H | H |
| C90XA20#1309 | 4554 | WT | | 38 | H | H |
| C90XA20#1309 | 4555 | *nip* | | 38 | A17 | A17 |
| C90XA20#1309 | 4556 | *nip* | | 38 | A17 | A17 |
| C90XA20#1309 | 4557 | WT | | 38 | H | H |
| C90XA20#1309 | 4558 | WT | | 38 | H | H |
| C90XA20#1309 | 4559 | *nip* | | 38 | A17 | A17 |
| C90XA20#1309 | 4560 | WT | | 38 | H | H |
| C90XA20#1309 | 4561 | WT | | 38 | H | H |
| C90XA20#1309 | 4562 | WT | | 38 | H | H |
| C90XA20#1309 | 4563 | WT | | 38 | H | H |
| C90XA20#1309 | 4564 | *nip* | | 38 | A17 | A17 |
| C90XA20#1309 | 4565 | WT | | 38,44 | H | H |
| C90XA20#1309 | 4566 | WT | | 38,44 | H | H |
| C90XA20#1309 | 4567 | *nip* | | 38 | A17 | A17 |
| C90XA20#1309 | 4568 | WT | | 38,42 | H | H |
| C90XA20#1309 | 4569 | *nip* | | 38 | A17 | A17 |
| C90XA20#1309 | 4570 | WT | | 38 | H | H |
| C90XA20#1309 | 4571 | WT | | 40 | H | H |
| C90XA20#1309 | 4572 | WT | | 40 | H | H |
| C90XA20#1309 | 4573 | WT | | 40 | H | H |
| C90XA20#1309 | 4574 | WT | | 40 | H | H |
| C90XA20#1309 | 4575 | WT | | 40 | H | H |
| C90XA20#1309 | 4576 | WT | | 40 | H | H |
| C90XA20#1203 | 4577 | WT | | 40,42 | H | H |
| C90XA20#1203 | 4578 | WT | | 40 | H | H |
| C90XA20#1203 | 4579 | WT | | 40 | A17 | A17 |
| C90XA20#1203 | 4580 | WT | | 40 | H | H |
| C90XA20#1203 | 4581 | WT | | 40 | H | H |
| C90XA20#1203 | 4582 | WT | | 40 | H | H |
| C90XA20#1203 | 4583 | WT | | 40 | H | H |
| C90XA20#1203 | 4584 | WT | | 40 | H | H |
| C90XA20#1203 | 4585 | WT | | 40 | H | H |
| C90XA20#1203 | 4586 | *nip* | | 40 | H | H |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20#1203 | 4587 | WT | | 40 | A20 | A20 |
| C90XA20#1203 | 4588 | *nip* | | 40 | H | H |
| C90XA20#1203 | 4589 | WT | | 40 | A17 | A17 |
| C90XA20#1203 | 4590 | WT | | 40 | H | H |
| C90XA20#1203 | 4591 | WT | | 40 | H | H |
| C90XA20#1203 | 4592 | WT | | 40 | H | H |
| C90XA20#1203 | 4593 | *nip* | | 40 | A17 | A17 |
| C90XA20#1383 | 4594 | WT | | 34 | H | H |
| C90XA20#1383 | 4595 | WT | | 34 | H | H |
| C90XA20#1383 | 4596 | WT | | 34 | H | H |
| C90XA20#1383 | 4597 | WT | | 34 | H | H |
| C90XA20#1383 | 4598 | WT | | 34 | H | H |
| C90XA20#1383 | 4599 | WT | | 34 | H | H |
| C90XA20#1383 | 4600 | WT | | 34 | H | H |
| C90XA20#1383 | 4601 | WT | | 34 | H | H |
| C90XA20#1383 | 4602 | WT | | 34 | A20 | A20 |
| C90XA20#1383 | 4603 | WT | | 34,38 | A20 | A20 |
| C90XA20#1383 | 4604 | WT | | 34 | A20 | A20 |
| C90XA20#1383 | 4605 | *nip* | | 34 | A17 | A17 |
| C90XA20#1383 | 4606 | WT | | 34 | H | H |
| C90XA20#1383 | 4607 | WT | | 34 | H | H |
| C90XA20#1383 | 4608 | WT | | 34 | A20 | A20 |
| C90XA20#1383 | 4609 | WT? | | 34 | A20 | A20 |
| C90XA20#1383 | 4610 | *nip* | | 34 | A17 | A17 |
| C90XA20#1383 | 4611 | WT | | 34 | H | H |
| C90XA20#1383 | 4612 | *nip* | | 34 | A17 | A17 |
| C90XA20#1383 | 4613 | WT | | 34 | A20 | A20 |
| C90XA20#1383 | 4614 | WT | | 36 | H | H |
| C90XA20#1383 | 4615 | *nip* | | 36 | A17 | A17 |
| C90XA20#1383 | 4616 | WT | | 36 | H | H |
| C90XA20#1383 | 4617 | WT | | 36 | H | H |
| C90XA20#1383 | 4618 | WT | | 36 | H | H |
| C90XA20#1383 | 4619 | WT | | 36 | A20 | A20 |
| C90XA20#1383 | 4620 | *nip* | | 36 | A17 | A17 |
| C90XA20#1383 | 4621 | WT | | 36 | A20 | A20 |
| C90XA20#1383 | 4622 | WT | | 36 | A20 | A20 |
| C90XA20#1383 | 4623 | WT | | 36 | A20 | A20 |
| C90XA20#1383 | 4624 | WT | | 36 | H | H |
| C90XA20#1383 | 4625 | WT | | 36 | H | H |
| C90XA20#1381 | 4626 | ? | | 36 | A20 | A20 |
| C90XA20#1381 | 4627 | WT | | 36 | H | H |
| C90XA20#1381 | 4628 | WT | | 36 | H | H |
| C90XA20#1381 | 4629 | WT | | 36 | H | H |
| C90XA20#1381 | 4630 | *nip* | | 36,40 | A17 | A17 |
| C90XA20#1381 | 4631 | WT | | 36 | A20 | A20 |
| C90XA20#1381 | 4632 | WT | | 36 | H | H |
| C90XA20#1381 | 4633 | WT | | 36 | H | H |
| C90XA20#1381 | 4634 | *nip* | | 34 | A17 | A17 |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20#1381 | 4635 | *nip* | | 34 | A17 | A17 |
| C90XA20#1381 | 4636 | WT | | 34 | H | H |
| C90XA20#1381 | 4637 | WT | | 34 | H | H |
| C90XA20#1381 | 4638 | WT | | 34 | H | H |
| C90XA20#1381 | 4639 | *nip* | | 34 | A17 | A17 |
| C90XA20#1381 | 4640 | *nip* | | 34 | A17 | A17 |
| C90XA20#1381 | 4641 | WT | Confirmed | 34,38 | H | A20 |
| C90XA20#1381 | 4642 | WT | | 34 | H | H |
| C90XA20#1381 | 4643 | WT | | 34 | A17 | A17 |
| C90XA20#1381 | 4644 | WT | | 34 | H | H |
| C90XA20#1381 | 4645 | WT | | 34 | H | H |
| C90XA20#1381 | 4646 | WT | | 34 | H | H |
| C90XA20#1381 | 4647 | WT | | 34 | H | H |
| C90XA20#1381 | 4648 | WT | | 34 | A17 | A17 |
| C90XA20#1381 | 4649 | WT | | 34 | H | H |
| C90XA20#1381 | 4650 | WT | | 34 | A20 | A20 |
| C90XA20#1381 | 4651 | WT | | 34 | H | H |
| C90XA20#1381 | 4652 | WT | | 34 | H | H |
| C90XA20#1381 | 4653 | *nip* | | 34 | A17 | A17 |
| C90XA20#1381 | 4654 | WT | | 34 | H | H |
| C90XA20#1381 | 4655 | WT | | 34 | H | H |
| C90XA20#1381 | 4656 | *nip* | | 34 | A17 | A17 |
| C90XA20#1381 | 4657 | WT | | 34 | A20 | A20 |
| C90XA20#1381 | 4658 | WT | | 34 | A20 | A20 |
| C90XA20#1381 | 4659 | WT | | 34 | A20 | A20 |
| C90XA20#1381 | 4660 | WT | | 34 | H | H |
| C90XA20#1381 | 4661 | *nip* | | 34 | A17 | A17 |
| C90XA20#1381 | 4662 | WT | | 34 | H | H |
| C90XA20#1381 | 4663 | *nip* | | 34 | A17 | A17 |
| C90XA20#1381 | 4664 | *nip* | | 34 | A20 | A20 |
| C90XA20#1381 | 4665 | WT | | 34 | H | H |
| C90XA20#1381 | 4666 | WT | | 34 | H | H |
| C90XA20#1381 | 4667 | WT | | 34 | A20 | A20 |
| C90XA20#1381 | 4668 | WT | | 34 | H | H |
| C90XA20#1381 | 4669 | WT | | 34 | H | H |
| C90XA20#1381 | 4670 | WT | | 34 | H | H |
| C90XA20#1381 | 4671 | WT | | 34 | H | H |
| C90XA20#1381 | 4672 | WT | | 34 | A20 | A20 |
| C90XA20#1381 | 4673 | WT | | 34 | H | H |
| C90XA20#1381 | 4674 | WT | | 36 | A20 | A20 |
| C90XA20#1381 | 4675 | WT | | 36 | H | H |
| C90XA20#1381 | 4676 | WT | | 36 | A20 | A20 |
| C90XA20#1381 | 4677 | WT | | 36 | H | H |
| C90XA20#1381 | 4678 | WT | | 36 | A20 | A20 |
| C90XA20#1381 | 4679 | *nip* | | 36,40 | A17 | A17 |
| C90XA20#1389 | 4680 | WT | Confirmed | 36,38 | H | A17 |
| C90XA20#1389 | 4681 | WT | | 36 | A20 | A20 |
| C90XA20#1389 | 4682 | *nip* | | 36 | A17 | A17 |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20#1389 | 4683 | WT | | 36 | H | H |
| C90XA20#1389 | 4684 | WT | | 36 | H | H |
| C90XA20#1389 | 4685 | WT | | 36 | H | H |
| C90XA20#1389 | 4686 | WT | | 36 | A20 | A20 |
| C90XA20#1389 | 4687 | *nip* | | 36 | A17 | A17 |
| C90XA20#1389 | 4688 | WT | | 36 | H | H |
| C90XA20#1389 | 4689 | WT | | 36 | H | H |
| C90XA20#1389 | 4690 | WT | | 36 | H | H |
| C90XA20#1389 | 4691 | WT | | 36 | H | H |
| C90XA20#1389 | 4692 | WT | | 36 | H | H |
| C90XA20#1389 | 4693 | *nip* | | 36 | A17 | A17 |
| C90XA20#1389 | 4694 | *nip* | | 38 | A17 | A17 |
| C90XA20#1389 | 4695 | WT | | 38 | H | H |
| C90XA20#1389 | 4696 | WT | | 38 | A20 | A20 |
| C90XA20#1389 | 4697 | WT | | 38 | H | H |
| C90XA20#1389 | 4698 | WT | | 38 | H | H |
| C90XA20#1389 | 4699 | *nip* | | 38 | A17 | A17 |
| C90XA20#1126 | 4700 | WT | | 38 | A20 | A20 |
| C90XA20#1126 | 4701 | WT | | 38 | A20 | A20 |
| C90XA20#1126 | 4702 | WT | | 38 | A20 | A20 |
| C90XA20#1126 | 4703 | WT | | 38,42 | A20 | A20 |
| C90XA20#1126 | 4704 | WT | | 38 | A20 | A20 |
| C90XA20#1126 | 4705 | ? | | 38 | A20 | A20 |
| C90XA20#1126 | 4706 | WT | | 38 | A20 | A20 |
| C90XA20#1126 | 4707 | WT | | 38 | A20 | A20 |
| C90XA20#1126 | 4708 | WT | | 38 | A20 | A20 |
| C90XA20#1126 | 4709 | WT | | 38 | A20 | A20 |
| C90XA20#1126 | 4710 | WT | | 38 | A20 | A20 |
| C90XA20#1126 | 4711 | WT | | 38 | A20 | A20 |
| C90XA20#1126 | 4712 | WT | | 38 | A20 | A20 |
| C90XA20#1126 | 4713 | WT | | 38 | A20 | A20 |
| C90XA20#1126 | 4714 | WT | | 34 | A20 | A20 |
| C90XA20#1126 | 4715 | WT | | 34 | A20 | A20 |
| C90XA20#1126 | 4716 | WT | | 34 | A20 | A20 |
| C90XA20#1126 | 4717 | WT | | 40 | A20 | A20 |
| C90XA20#1126 | 4718 | WT | | 40 | A20 | A20 |
| C90XA20#1126 | 4719 | WT | | 40 | A20 | A20 |
| C90XA20#1126 | 4720 | ? | | 40 | A17 | A17 |
| C90XA20#1126 | 4721 | WT | | 34,38,42 | A20 | A20 |
| C90XA20#1126 | 4722 | WT | | 34 | A20 | A20 |
| C90XA20#1126 | 4723 | WT | | 34 | A20 | A20 |
| C90XA20#1126 | 4724 | WT | | 34 | A20 | A20 |
| C90XA20#1126 | 4725 | WT | | 34 | A20 | A20 |
| C90XA20#1126 | 4726 | ? | | 34 | A20 | A20 |
| C90XA20#1126 | 4727 | *nip* | | 35 | A20 | A20 |
| C90XA20#1126 | 4728 | WT | | 35 | A17 | A17 |
| C90XA20#1126 | 4729 | WT | | 35 | A20 | A20 |
| C90XA20#1126 | 4731 | WT | | 35 | A20 | A20 |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20#1126 | 4732 | WT | | 35 | A20 | A20 |
| C90XA20#1126 | 4733 | WT | | 35 | H | H |
| C90XA20#1126 | 4734 | WT | | 35 | A20 | A20 |
| C90XA20#1126 | 4735 | WT | | 35 | A20 | A20 |
| C90XA20#1126 | 4736 | WT | | 35 | A20 | A20 |
| C90XA20#1126 | 4737 | WT | | 35,38,44 | A20 | A20 |
| C90XA20#1126 | 4738 | WT | | 35 | A20 | A20 |
| C90XA20#1219 | 4739 | WT | | 35 | A20 | A20 |
| C90XA20#1219 | 4740 | ? | | 35 | A20 | A20 |
| C90XA20#1219 | 4741 | WT | | 35 | H | H |
| C90XA20#1219 | 4742 | WT | | 35 | H | H |
| C90XA20#1219 | 4743 | *nip* | | 35 | A17 | A17 |
| C90XA20#1219 | 4744 | WT | | 35 | H | H |
| C90XA20#1219 | 4745 | WT | | 35 | A20 | A20 |
| C90XA20#1219 | 4746 | WT | | 35 | A20 | A20 |
| C90XA20#1219 | 4747 | WT | | 35 | H | H |
| C90XA20#1219 | 4748 | WT | | 35 | A20 | A20 |
| C90XA20#1219 | 4749 | *nip* | | 35 | A17 | A17 |
| C90XA20#1219 | 4750 | WT | | 38,40 | H | H |
| C90XA20#1219 | 4751 | WT | | 35 | H | H |
| C90XA20#1219 | 4752 | WT | | 35 | H | H |
| C90XA20#1219 | 4753 | WT | Confirmed | 35,40 | H | A17 |
| C90XA20#1219 | 4754 | WT | | 35 | H | H |
| C90XA20#1219 | 4755 | WT | | 35 | A20 | A20 |
| C90XA20#1219 | 4756 | WT | | 35 | A20 | A20 |
| C90XA20#1219 | 4757 | WT | | 35 | H | H |
| C90XA20#1219 | 4758 | WT | | 35 | A20 | A20 |
| C90XA20#1219 | 4759 | WT | | 35 | A20 | A20 |
| C90XA20#1219 | 4760 | WT | | 35 | H | H |
| C90XA20#1219 | 4761 | WT | | 35 | A20 | A20 |
| C90XA20#1219 | 4762 | WT | | 35 | A20 | A20 |
| C90XA20#1219 | 4763 | WT | | 35 | H | H |
| C90XA20#1219 | 4764 | *nip* | Confirmed | 35,38 | H | A17 |
| C90XA20#1219 | 4765 | WT | | 35 | H | H |
| C90XA20#1219 | 4766 | WT | | 35,38,40 | A20 | A20 |
| C90XA20#1219 | 4767 | WT | | 35,38,40 | A20 | A20 |
| C90XA20#1219 | 4768 | WT | | 35 | A20 | A20 |
| C90XA20#1219 | 4769 | *nip* | Confirmed | 35,38 | A17 | H |
| C90XA20#1219 | 4770 | WT | | 35 | H | H |
| C90XA20#1209 | 4771 | *nip* | | 35,38,40 | A17 | A17 |
| C90XA20#1209 | 4772 | WT | | 35 | A20 | A20 |
| C90XA20#1209 | 4773 | WT | | 35 | H | H |
| C90XA20#1209 | 4774 | *nip* | | 35 | A17 | A17 |
| C90XA20#1209 | 4775 | WT | | 35 | A20 | A20 |
| C90XA20#1209 | 4776 | WT | | 35 | A20 | A20 |
| C90XA20#1209 | 4777 | *nip* | | 35 | A17 | A17 |
| C90XA20#1209 | 4778 | WT | | 35 | H | H |
| C90XA20#1209 | 4779 | WT | | 35 | H | H |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20#1209 | 4780 | WT | | 35 | A20 | A20 |
| C90XA20#1209 | 4781 | WT | | 35 | H | H |
| C90XA20#1209 | 4782 | *nip* | | 35 | A17 | A17 |
| C90XA20#1209 | 4783 | *nip* | | 35 | A17 | A17 |
| C90XA20#1209 | 4784 | WT | | 42 | H | H |
| C90XA20#1209 | 4785 | WT | | 35 | H | H |
| C90XA20#1209 | 4786 | WT | | 35 | H | H |
| C90XA20#1209 | 4787 | WT | | 35,38 | A20 | A20 |
| C90XA20#1209 | 4788 | WT | | 35 | H | H |
| C90XA20#1209 | 4789 | WT | | 35 | H | H |
| C90XA20#1209 | 4790 | WT | | 35 | H | H |
| C90XA20#1209 | 4791 | WT | | 35 | H | H |
| C90XA20#1209 | 4792 | WT | | 35 | A20 | A20 |
| C90XA20#1209 | 4793 | WT | | 35 | H | H |
| C90XA20#1388 | 4794 | WT | | 35 | H | H |
| C90XA20#1388 | 4795 | *nip* | | 35 | A17 | A17 |
| C90XA20#1388 | 4796 | WT | | 35 | H | H |
| C90XA20#1388 | 4797 | WT | | 35 | H | H |
| C90XA20#1388 | 4798 | WT | | 35 | H | H |
| C90XA20#1388 | 4799 | *nip* | | 35 | A17 | A17 |
| C90XA20#1388 | 4800 | WT | | 35 | H | H |
| C90XA20#1388 | 4801 | WT | | 35 | H | H |
| C90XA20#1388 | 4802 | *nip* | | 35 | H | H |
| C90XA20#1388 | 4803 | *nip* | | 35 | A17 | A17 |
| C90XA20#1388 | 4804 | WT | | 35 | A20 | A20 |
| C90XA20#1388 | 4805 | WT | | 35 | H | H |
| C90XA20#1388 | 4806 | WT | | 35 | H | H |
| C90XA20#1388 | 4807 | WT | | 35 | H | H |
| C90XA20#1388 | 4808 | WT | | 35 | H | H |
| C90XA20#1388 | 4809 | WT | | 35 | A20 | A20 |
| C90XA20#1388 | 4810 | *nip* | | 35 | A17 | A17 |
| C90XA20#1388 | 4811 | *nip* | | 35 | A17 | A17 |
| C90XA20#1388 | 4812 | WT | | 35 | H | H |
| C90XA20#1388 | 4813 | *nip* | | 35 | A17 | A17 |
| C90XA20#1388 | 4814 | *nip* | | 35 | A17 | A17 |
| C90XA20#1388 | 4815 | *nip* | | 35 | A17 | A17 |
| C90XA20#1388 | 4816 | WT | | 35,38 | H | H |
| C90XA20#1388 | 4817 | *nip* | | 35 | A17 | A17 |
| C90XA20#1388 | 4818 | WT | | 35,38 | H | H |
| C90XA20#1388 | 4819 | WT | | 42 | H | H |
| C90XA20#1388 | 4820 | WT | | 38 | A20 | A20 |
| C90XA20#1388 | 4821 | WT | | 38 | H | H |
| C90XA20#1388 | 4822 | WT | | 38 | H | H |
| C90XA20#1388 | 4823 | WT | | 38 | A20 | A20 |
| C90XA20#1388 | 4824 | WT | | 38 | H | H |
| C90XA20#1388 | 4825 | *nip* | | 38 | A17 | A17 |
| C90XA20#1388 | 4826 | WT | | 38 | H | H |
| C90XA20#1388 | 4827 | *nip* | | 38 | A17 | A17 |

Table 2.

Phenotyping And Genotyping Data For F3 Generation Of The *NIP* Mapping Population

| Parents | Plant # | Phenotype | Notes | Plate # | 146o17 | 23c16 |
|---|---|---|---|---|---|---|
| C90XA20#1388 | 4828 | WT | | 38 | A20 | A20 |
| C90XA20#1388 | 4829 | *nip* | | 38 | A17 | A17 |
| C90XA20#1388 | 4830 | WT | | 38 | A20 | A20 |
| C90XA20#1388 | 4831 | WT | | 38 | A20 | A20 |
| C90XA20#1388 | 4832 | WT | Confirmed | 38,44 | H | A20 |
| C90XA20#1388 | 4833 | *nip* | | 38 | A17 | A17 |
| C90XA20#1388 | 4834 | *nip* | | 36 | A17 | A17 |
| C90XA20#1388 | 4835 | *nip* | | 40 | A17 | A17 |
| C90XA20#1388 | 4836 | WT | | 38 | H | H |

Table 3. Phenotype And Genotyping Data For Recombinant Plants From F2 and F3 Generations From *NIP* Mapping Population

| Genotype | Phenotype | Plant# | Notes | 146o17 | ENBP | 2D12 | 4L4 | 164n9 | 80720 | 23c16d |
|---|---|---|---|---|---|---|---|---|---|---|
| Recombinant Plants Obtained From F2 Generation of The *Nip* Mapping Population | | | | | | | | | | |
| C90XA20#133 | *WT* | 964 | REDO | A20 | H | | | | | H |
| C90XA20#133 | *WT* | 965 | REDO | A20 | H | | | | | H |
| C90XA20#133 | *WT* | 967 | REDO | A20 | H | | | | | H |
| C90XA20#133 | *WT* | 970 | confirmed | A20 | H | | | | | H |
| C90XA20#133 | *WT* | 973 | confirmed | A20 | H | | H | H | H | H |
| C90XA20#133 | *WT* | 974 | confirmed | A20 | H | | H | H | H | H |
| C90XA20#133 | *WT* | 975 | REDO | A20 | H | | | | | H |
| C90XA20 281#2 | *WT* | 1007 | REDO | A20 | H | | | | | A20 |
| C90XA20 278# | *nip* | 1038 | confirmed | A17 | A17 | | | | | H |
| C90XA20 278# | *nip* | 1040 | confirmed | A17 | A17 | | | | | H |
| C90XA20 278# | *nip* | 1041 | confirmed | A17 | A17 | | | | | H |
| C90XA20 278# | *nip* | 1042 | confirmed | A17 | A17 | | A17 | A17 | H | H |
| C90XA20 278# | *nip* | 1043 | confirmed | A17 | A17 | | A17 | A17 | H | H |
| C90XA20 278# | *nip* | 1045 | confirmed | A17 | A17 | | | | | H |
| C90XA20 278# | *nip* | 1046 | REDO | A17 | A17 | | | | | H |
| C90XA20 278# | *nip* | 1047 | confirmed | A17 | A17 | | | | | H |
| C90XA20 278# | *nip* | 1048 | REDO | H | A17 | | | | | H |
| C90XA20 278# | *nip* | 1049 | REDO | A17 | A17 | | | | | H |
| C90XA20 278# | *nip* | 1050 | REDO | A17 | A17 | | | | | H |
| C90XA20 278# | *nip* | 1051 | REDO | A17 | A17 | | | | | H |
| C90XA20 278# | *nip* | 1052 | confirmed | A17 | A17 | | | | | H |
| C90XA20 133#3 | *WT* | 1091 | confirmed | H | H | | A20 | A20 | A20 | A20 |
| C90XA20 133#3 | *WT* | 1133 | REDO | A20 | A20 | | A20 | H | H | H |
| C90XA20 133#1 | *WT* | 1172 | confirmed | A20 | A20 | | A20 | A20 | H | H |
| C90XA20 133#4 | *WT* | 1264 | confirmed | A20 | H | | | | | H |
| C90XA20 133#4 | *WT* | 1266 | confirmed | A20 | H | | | | | H |
| C90XA20 133#4 | *WT* | 1267 | confirmed | A20 | H | | | | | H |
| C90XA20 133#4 | *WT* | 1268 | confirmed | A20 | H | | | | | H |
| C90XA20 133#4 | *WT* | 1270 | confirmed | A20 | H | | | H | | H |
| C90XA20 133#4 | *WT* | 1271 | confirmed | A20 | H | | H | H | H | H |
| C90XA20 133#4 | *WT* | 1272 | confirmed | A20 | H | | | | | H |

Table 3. Phenotype And Genotyping Data For Recombinant Plants From F2 and F3 Generations From *NIP* Mapping Population

| Genotype | Phenotype | Plant# | Notes | 146o17 | ENBP | 2D12 | 4L4 | 164n9 | 80720 | 23c16d |
|---|---|---|---|---|---|---|---|---|---|---|
| C90XA20 133#4 | *WT* | 1273 | confirmed | A20 | H | | | | | H |
| C90XA20 133#4 | *WT* | 1275 | confirmed | A20 | H | | | | | H |
| C90XA20 133#4 | *WT* | 1278 | confirmed | A20 | H | | | | | H |
| C90XA20 133#4 | *WT* | 1279 | confirmed | A20 | H | | | | | H |
| C90XA20 133#4 | *WT* | 1280 | confirmed | A20 | A20 | | | | | H |
| C90XA20 133#4 | *WT* | 1281 | confirmed | A20 | H | | | | | H |
| C90XA20 133#4 | *WT* | 1292 | confirmed | A20 | H | | | | | H |
| C90XA20 133#4 | *WT* | 1297 | REDO | A20 | H | | | | | H |
| C90XA20 133#4 | *WT* | 1298 | REDO | A20 | H | | | | | H |
| C90XA20 #511 | *WT* | 1458 | Confirmed | A20 | A20 | | A20 | A20 | H | H |
| C90XA20 #511 | *WT* | 1465 | confirmed | A20 | A20 | | A20 | A20 | H | H |
| C90XA20 #362 | *WT* | 1484 | REDO | H | A20 | | | A20 | | A20 |
| C90XA20 #362 | *WT* | 1485 | confirmed | A20 | A20 | | H | H | H | H |
| C90XA20 #530 | *WT* | 1492 | confirmed | A20 | A20 | | H | H | | H |
| C90XA20 #358 | *WT* | 1574 | REDO | A20 | A20 | | A20 | A20 | | H |
| C90XA20#527 | *WT* | 1591 | confirmed | A20 | A20 | | H | H | | H |
| C90XA20# 512 | *WT* | 1611 | REDO | A20 | A20 | | | H | | H |
| C90XA20#590 | *WT* | 1682 | confirmed | A17 | H | | H | H | | H |
| C90XA20#590 | *WT* | 1687 | confirmed | A20 | H | | H | H | | H |
| C90XA20#561 | *WT* | 1703 | confirmed | A20 | A20 | | H | H | | H |
| C90XA20#561 | *WT* | 1704 | confirmed | A20 | A20 | | A20 | A20 | | H |
| C90XA20#552 | *WT* | 1737 | confirmed | H | H | | A20 | A20 | A20 | A20 |
| C90XA20#567 | *WT* | 1746 | confirmed | H | A20 | | A20 | A20 | A20 | A20 |
| C90XA20#559 | *nip* | 1764 | confirmed | H | H | | | | | A17 |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

Table 3. Phenotype And Genotyping Data For Recombinant Plants From F2 and F3 Generations From *NIP* Mapping Population

| Genotype | Phenotype | Plant# | Notes | 146o17 | ENBP | 2D12 | 4L4 | 164n9 | 80720 | 23c16d |
|---|---|---|---|---|---|---|---|---|---|---|
| Recombinant Plants Obtained From F3 Generation of The *Nip* Mapping Population | | | | | | | | | | |
| C90XA20#133#4 | *wt* | 3016 | confirmed | A20 | | A17 | A17 | A17 | A17 | A17 |
| C90XA20#133#4 | *wt* | 3018 | confirmed | A20 | | A17 | A17 | A17 | A17 | A17 |
| C90XA20#133#4 | *nip* | 3019 | confirmed | A20 | | A17 | A17 | A17 | A17 | A17 |
| C90XA20#133#4 | *wt* | 3020 | confirmed | A20 | H | H | H | H | H | H |
| C90XA20#133#4 | *nip* | 3021 | confirmed | A20 | | A17 | A17 | A17 | A17 | A17 |
| C90XA20#133#4 | *wt* | 3405 | confirmed | A20 | H | H | H | H | H | H |
| C90XA20#133#4 | *nip* | 3406 | confirmed | A20 | A17 | A17 | A17 | A17 | A17 | A17 |
| C90XA20#133#4 | *wt* | 3408 | confirmed/dead, pods | A20 | H | H | H | H | H | H |
| C90XA20#133#4 | *wt* | 3409 | confirmed/dead, pods | A20 | H | H | H | H | H | H |
| C90XA20#133#4 | *wt* | 3411 | confirmed/dead, pods | A20 | H | H | H | H | H | H |
| C90XA20#133#4 | *wt* | 3412 | confirmed/dead, pods | A20 | H | H | H | H | | H |
| C90XA20 #368 | *nip* | 3035 | confirmed/dead , pods | A20 | A20 | A20 | A20 | A17 | | A17 |
| C90XA20 #368 | *nip* | 3090 | confirmed | H | | H | H | A17 | A17 | A17 |
| C90XA20 #368 | *nip* | 3091 | confirmed | H | | H | H | A17 | A17 | A17 |
| C90XA20 #368 | *nip* | 3093 | confirmed | H | | H | H | A17 | A17 | A17 |
| C90XA20 #368 | *nip* | 3422 | confirmed/dead,pods | H | H | | H | A17 | A17 | A17 |
| C90XA20 #368 | *nip* | 3497 | confirmed | H | H | H | H | H | A17 | A17 |
| C90XA20 #368 | *nip* | 3498 | Confirmed/dead 1 pod | H | H | H | H | A17 | A17 | A17 |
| C90XA20 #368 | *nip* | 3511 | confirmed | H | H | | H | A17 | A17 | A17 |
| C90XA20 #368 | *nip* | 3513 | Confirmed | H | H | H | H | A17 | A17 | A17 |
| C90XA20 #368 | *nip* | 3514 | dead/3 pods, Redo | H | H | | | | | A17 |
| C90XA20 #368 | *nip* | 3515 | Confirmed | A20 | A20 | A20 | A20 | A17 | A17 | A17 |
| C90XA20 #368 | *nip* | 3516 | confirmed | H | H | H | H | A17 | A17 | A17 |
| C90XA20 #368 | *nip* | 3518 | confirmed | H | H | H | H | A17 | A17 | A17 |
| C90XA20 #368 | *nip* | 3519 | confirmed | H | | H | H | H | A17 | A17 |
| C90XA20 #368 | *nip* | 3520 | REDO | H | H | | | | | A17 |
| C90XA20 #368 | *nip* | 3521 | confirmed/dead,pods | A20 | A20 | A20 | A20 | A17 | A17 | A17 |
| C90XA20 #390 | *wt* | 3207 | confirmed | A17 | | A17 | A17 | H | H | H |
| C90XA20 #390 | *wt* | 3208 | confirmed/dead pods | A17 | A17 | A17 | A17 | H | H | H |
| C90XA20 #390 | *wt* | 3209 | confirmed | A17 | A17 | A17 | A17 | A20 | A20 | A20 |
| C90XA20 #390 | *wt* | 3210 | confirmed | A17 | A17 | A17 | A17 | A20 | A20 | A20 |

Table 3. Phenotype And Genotyping Data For Recombinant Plants From F2 and F3 Generations From *NIP* Mapping Population

| Genotype | Phenotype | Plant# | Notes | 146o17 | ENBP | 2D12 | 4L4 | 164n9 | 80720 | 23c16d |
|---|---|---|---|---|---|---|---|---|---|---|
| C90XA20 #390 | *wt* | 3212 | confirmed | A17 | | A17 | A17 | A20 | A20 | A20 |
| C90XA20 #390 | *wt* | 3213 | confirmed | A17 | A17 | A17 | A17 | H | H | H |
| C90XA20 #390 | *wt* | 3214 | confirmed/dead,pods | A17 | | A17 | A17 | H | H | H |
| C90XA20 #390 | *wt* | 3219 | confirmed | A17 | | A17 | A17 | A20 | A20 | A20 |
| C90XA20 #390 | *wt* | 3220 | confirmed | A17 | | A17 | A17 | A20 | A20 | A20 |
| C90XA20 #390 | *wt* | 3221 | confirmed | A17 | A17 | A17 | A17 | H | H | H |
| C90XA20 #390 | *wt* | 3222 | confirmed | A17 | | H | H | H | H | A20 |
| C90XA20 #390 | *wt* | 3231 | DEAD | A17 | | | | | | H |
| C90XA20 #390 | *wt* | 3239 | REDO | A17 | | | | | | A20 |
| C90XA20 #390 | *wt* | 3242 | DEAD | A17 | | | | | | A20 |
| C90XA20 #390 | *wt* | 3243 | REDO | A17 | | | | | | H |
| C90XA20 #390 | *wt* | 3245 | DEAD | A17 | | | | | | H |
| C90XA20 #390 | *wt* | 3255 | DEAD | A17 | | | | | | H |
| C90XA20 #390 | *wt* | 3261 | Confirmed/DEAD 8PODS | A17 | | A17 | A17 | H | H | H |
| C90XA20 #660 | *wt* | 3265 | confirmed/dead 3pods | A20 | | A20 | A20 | A20 | H | H |
| C90XA20 #660 | *wt* | 3266 | confirmed | A20 | | A20 | A20 | A20 | H | H |
| C90XA20 #660 | *wt* | 3267 | confirmed | A20 | | A20 | A20 | A20 | H | H |
| C90XA20 #660 | *wt* | 3269 | confirmed | A20 | A20 | A20 | A20 | A20 | A17 | 17 |
| C90XA20 #660 | *wt* | 3270 | confirmed/dead 6pods | A20 | A20 | A20 | A20 | A20 | H | H |
| C90XA20 #660 | *wt* | 3271 | confirmed | A20 | A20 | A20 | A20 | A20 | H | H |
| C90XA20 #531 | *wt* | 3329 | confirmed/dead16pods | H | H | H | H | H | A17 | A17 |
| C90XA20 #531 | *wt* | 3328 | confirmed | A20 | A20 | | | | | A17 |
| C90XA20 #278 | *nip* | 3393 | confirmed | A17 | A17 | A17 | A17 | A17 | A20 | A20 |
| C90XA20 #278 | *nip* | 3399 | confirmed/dead,pods | A17 | A17 | A17 | A17 | A17 | A20 | A20 |
| C90XA20 #155 | *wt* | 3447 | confirmed/dead,pods | A20 | A20 | A20 | A20 | A20 | H | H |
| C90XA20 #698 | *wt* | 3651 | confirmed | H | H | H | H | H | A20 | A20 |
| C90XA20 #850 | *wt* | 3688 | confirmed | H | H | H | H | H | A20 | A20 |
| C90XA20 #683 | *wt* | 3705 | confirmed | H | H | H | H | H | A17 | A17 |
| C90XA20 #683 | *nip* | 3712 | confirmed | A17 | | A17 | A17 | A17 | H | H |
| C90XA20 #993 | *wt* | 3719 | | H | | | A20 | | A20 | A20 |
| C90XA20 #816 | *wt* | 3731 | | A17 | | | H | | H | H |
| C90XA20 #1030 | *nip* | 3749 | | A20 | | | A20 | | H | H |

Table 3. Phenotype And Genotyping Data For Recombinant Plants From F2 and F3 Generations From *NIP* Mapping Population

| Genotype | Phenotype | Plant# | Notes | 146o17 | ENBP | 2D12 | 4L4 | 164n9 | 80720 | 23c16d |
|---|---|---|---|---|---|---|---|---|---|---|
| C90XA20 #1106 | *wt?* | 3821 | | H | | | H | | A20 | A20 |
| C90XA20 #1112 | *nip* | 3828 | | A17 | | | H | | H | H |
| C90XA20 #1082 | *wt* | 3844 | | H | | | A20 | | A20 | A20 |
| C90XA20 #1102 | *wt* | 3914 | | H | | | H | | A20 | A20 |
| C90XA20 #1102 | *wt* | 3915 | | H | | | H | | A17 | A17 |
| C90XA20 #1043 | *nip* | 3942 | | A17 | | | A17 | | H | H |
| C90XA20 #1043 | *nip* | 3943 | | A17 | | | A17 | | H | H |
| C90XA20 #1043 | *nip* | 3944 | | A17 | | | A17 | | H | H |
| C90XA20 #1043 | *nip* | 3946 | | A17 | | | A17 | | A20 | A20 |
| C90XA20 #1043 | *nip* | 3947 | | A17 | | | A17 | | H | H |
| C90XA20 #1043 | *nip* | 3948 | | A17 | | | A17 | | H | H |
| C90XA20 #1043 | *nip* | 3950 | | A17 | | | A17 | | H | H |
| C90XA20 #1043 | *nip* | 3951 | | A17 | | | A17 | | H | H |
| C90XA20 #1043 | *nip* | 3953 | | A17 | | | A17 | | H | H |
| C90XA20 #1178 | *?* | 3965 | | A17 | | | | | A17 | H |
| C90XA20 #1016 | *nip* | 3979 | | A17 | | | A17 | | H | H |
| | | | | | | | | | | |

TABLE 4 RECOMBINANT PLANTS THAT WERE SELECTED FOR FURTHER TESTING

| F2 GENERATION RECOMBINANT PLANTS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Genotype | Phenotype | plant# | 146o17 | ENBP | 2D12 | 4L4 | 164N9 | 80720 | 23c16d | NOTES |
| C90XA20 281#2 | WT | 1007 | A20 | H | | | | | A20 | Confirm, progeny, genotype |
| C90XA20 278# | nip | 1043 | A17 | A17 | | A17 | A17 | H | H | see 3946, progeny of this plant |
| C90XA20 133#3 | WT | 1133 | A20 | A20 | | A20 | H | H | H | progeny and genotype |
| C90XA20 133#1 | WT | 1172 | A20 | A20 | | A20 | A20 | H | H | progeny and genotype |
| C90XA20 #511 | WT | 1458 | A20 | A20 | | A20 | A20 | H | H | progeny and genotype, 78L20 |
| C90XA20 #511 | WT | 1465 | A20 | A20 | | A20 | A20 | H | H | progeny and genotype, 78L21 |
| C90XA20 #358 | WT | 1574 | A20 | A20 | | A20 | A20 | | H | get 8o7 data |
| C90XA20# 512 | WT | 1611 | A20 | A20 | | H | H | | H | get 4L4 phenotype |
| C90XA20#561 | WT | 1704 | A20 | A20 | | A20 | A20 | | H | get 8o7 data |
| C90XA20#559 | nip | 1764 | H | H | | A17 | A17 | | A17 | get 4L4, 164n9, 8o7 data |
| F3 GENERATION RECOMBINANT PLANTS | | | | | | | | | | |
| Genotype | Phenotype | plant# | 146o17 | ENBP | 2D12 | 4L4 | 164N9 | 80720 | 23c16d | |
| C90XA20 #368 | nip | 3035 | A20 | A20 | A20 | A20 | A17 | | A17 | further genotyping between 4L4 and 164n9 |
| C90XA20 #368 | nip | 3090 | H | | H | H | A17 | A17 | A17 | further genotyping between 4L4 and 164n10 |
| C90XA20 #368 | nip | 3515 | A20 | A20 | A20 | A20 | A17 | A17 | A17 | further genotyping between 4L4 and 164n10 |
| C90XA20 #368 | nip | 3521 | A20 | A20 | A20 | A20 | A17 | A17 | A17 | use if problems with 3035, 3090, 3515 |
| C90XA20 #390 | wt | 3209 | A17 | A17 | A17 | A17 | A20 | A20 | A20 | further genotyping between 4L4 and 164n10 |
| C90XA20 #390 | wt | 3210 | A17 | A17 | A17 | A17 | A20 | A20 | A20 | further genotyping between 4L4 and 164n10 |
| C90XA20 #390 | wt | 3212 | A17 | | A17 | A17 | A20 | A20 | A20 | further genotyping between 4L4 and 164n10 |
| C90XA20 #660 | wt | 3265 | A20 | | A20 | A20 | A20 | H | H | could be back-up for 3269 |
| C90XA20 #660 | wt | 3266 | A20 | | A20 | A20 | A20 | H | H | could be back-up for 3269 |
| C90XA20 #660 | wt | 3267 | A20 | | A20 | A20 | A20 | H | H | could be back-up for 3269 |
| C90XA20 #660 | wt | 3269 | A20 | A20 | A20 | A20 | A20 | A17 | 17 | 78L20* |
| C90XA20 #660 | wt | 3270 | A20 | A20 | A20 | A20 | A20 | H | H | could be back-up for 3269 |
| C90XA20 #660 | wt | 3271 | A20 | A20 | A20 | A20 | A20 | H | H | could be back-up for 3269 |
| C90XA20 #531 | wt | 3329 | H | H | H | H | H | A17 | A17 | 78L20* progeny and genotype |
| C90XA20 #531 | wt | 3328 | A20 | A20 | | A20 | | | A17 | rest of genotype |
| C90XA20 #278 | nip | 3393 | A17 | A17 | A17 | A17 | A17 | A20 | A20 | 78L20* |
| C90XA20 #278 | nip | 3399 | A17 | A17 | A17 | A17 | A17 | A20 | A20 | back up for 3393 |

TABLE 4 RECOMBINANT PLANTS THAT WERE SELECTED FOR FURTHER TESTING

| F2 GENERATION RECOMBINANT PLANTS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Genotype | Phenotype | plant# | 146o17 | ENBP | 2D12 | 4L4 | 164N9 | 80720 | 23c16d | NOTES |
| C90XA20 #155 | wt | 3447 | A20 | A20 | A20 | A20 | A20 | H | H | progeny and 78L20 2nd priority 78L20 |
| C90XA20 #698 | wt | 3651 | H | H | H | H | H | A20 | A20 | progeny and 78L20 2nd priority 78L20 |
| C90XA20 #850 | wt | 3688 | H | H | H | H | H | A20 | A20 | progeny and 78L20 2nd priority 78L20 |
| C90XA20 #683 | wt | 3705 | H | H | H | H | H | A17 | A17 | 78L20* |
| C90XA20 #683 | nip | 3712 | A17 | | A17 | A17 | A17 | H | H | 78L20* |
| C90XA20 #1030 | nip | 3749 | A20 | | | A20 | | H | H | do 164N9, maybe 78L20, progeny needed |
| C90XA20 #1106 | wt? | 3821 | H | | | H | H | A20 | A20 | do 164N9, maybe 78L20, progeny needed |
| C90XA20 #1112 | nip | 3828 | A17 | | | H | H | H | H | do 164N9, maybe 78L20, progeny needed |
| C90XA20 #1082 | wt | 3844 | H | | | A20 | | A20 | A20 | maybe progeny |
| C90XA20 #1102 | wt | 3914 | H | | | H | H | A20 | A20 | do 164N9, maybe 78L20, progeny needed |
| C90XA20 #1102 | wt | 3915 | H | | | H | H | A17 | A17 | do 164N9, definitely 78L20* |
| C90XA20 #1043 | nip | 3942 | A17 | | | A17 | H | H | H | back up for 3946 |
| C90XA20 #1043 | nip | 3943 | A17 | | | A17 | A17 | H | H | back up for 3947 |
| C90XA20 #1043 | nip | 3944 | A17 | | | A17 | | H | H | back up for 3948 |
| C90XA20 #1043 | nip | 3946 | A17 | | | A17 | A17 | A20 | A20 | do 164N9, definitely 78L20* |
| C90XA20 #1043 | nip | 3947 | A17 | | | A17 | | H | H | back up for 3946 |
| C90XA20 #1043 | nip | 3948 | A17 | | | A17 | | H | H | back up for 3947 |
| C90XA20 #1043 | nip | 3950 | A17 | | | A17 | | H | H | back up for 3948 |
| C90XA20 #1043 | nip | 3951 | A17 | | | A17 | | H | H | back up for 3949 |
| C90XA20 #1043 | nip | 3953 | A17 | | | A17 | | H | H | back up for 3950 |
| C90XA20 #1016 | nip | 3979 | A17 | | | A17 | A17 | H | H | do 164N9, definitely 78L20* |

# BIBLIOGRAPHY


Aldrich J, Cullis CA (1993) RAPD analysis in flax: optimization of yield and reproducibility using Klen*Taq* I polymerase, Chelex 100, and gel purification of genomic DNA. Plant Mol Biol Rep 11: 128-141

Arrighi JF, Barre A, Ben Amor B, Bersoult A, Soriano LC, Mirabella R, de Carvalho-Niebel F, Journet EP, Gherardi M, Huguet T, Geurts R, Denarie J, Rouge P, Gough C (2006) The Medicago truncatula lysine motif-receptor-like kinase gene family includes NFP and new nodule-expressed genes. Plant Physiol 142: 265-279

Brewin N (2004) Plant Cell Wall Remodelling in the Rhizobium-Legume Symbiosis. Critical Reviews in Plant Sciences 23, no 4: 293-316 (224 pages)

Bright LJ, Liang Y, Mitchell DM, Harris JM (2005) The LATD gene of Medicago truncatula is required for both nodule and root development. Mol Plant Microbe Interact 18: 521-532

Catalano CM, Czymmek KJ, Gann JG, Sherrier DJ (2006) Medicago truncatula syntaxin SYP132 defines the symbiosome membrane and infection droplet membrane in root nodules. Planta

Choi HK, Kim D, Uhm T, Limpens E, Lim H, Mun JH, Kalo P, Penmetsa RV, Seres A, Kulikova O, Roe BA, Bisseling T, Kiss GB, Cook DR (2004) A sequence-based genetic map of *Medicago truncatula* and comparison of marker colinearity with *M. sativa*. Genetics 166: 1463-1502

Cullimore J, Denarie J (2003) Plant sciences. How legumes select their sweet talking symbionts. Science 302: 575-578

Gage DJ (2004) Infection and invasion of roots by symbiotic, nitrogen-fixing rhizobia during nodulation of temperate legumes. Microbiol Mol Biol Rev 68: 280-300

Galibert F, Finan TM, Long SR, Puhler A, Abola P, Ampe F, Barloy-Hubler F, Barnett MJ, Becker A, Boistard P, Bothe G, Boutry M, Bowser L, Buhrmester J, Cadieu E, Capela D, Chain P, Cowie A, Davis RW, Dreano S, Federspiel NA, Fisher RF, Gloux S, Godrie T, Goffeau A, Golding B, Gouzy J, Gurjal M, Hernandez-Lucas I, Hong A, Huizar L, Hyman RW, Jones T, Kahn D, Kahn ML, Kalman S, Keating DH, Kiss E, Komp C, Lelaure V, Masuy D, Palm C, Peck MC, Pohl TM, Portetelle D, Purnelle B, Ramsperger U, Surzycki R, Thebault P, Vandenbol M, Vorholter FJ, Weidner S, Wells DH, Wong K, Yeh KC, Batut J (2001) The composite genome of the legume symbiont Sinorhizobium meliloti. Science 293: 668-672

Gleason C, Chaudhuri S, Yang T, Munoz A, Poovaiah BW, Oldroyd GE (2006) Nodulation independent of rhizobia induced by a calcium-activated kinase lacking autoinhibition. Nature 441: 1149-1152

Griffiths AJG, Gelbart WM, Miller JH, Lewontin RC (2002) Modern Genetic Analysis. W.H. Freeman and Co., New York

Haynes JG, Czymmek KJ, Carlson CA, Veereshlingam H, Dickstein R, Sherrier DJ (2004) Rapid analysis of legume root nodule development using confocal microscopy. New Phytologist 163: 661-668

Hirsch AM (1992) Developmental biology of legume nodulation. The New phytologist 122: 211-237

Kalo P, Gleason C, Edwards A, Marsh J, Mitra RM, Hirsch S, Jakab J, Sims S, Long SR, Rogers J, Kiss GB, Downie JA, Oldroyd GE (2005) Nodulation signaling in legumes requires NSP2, a member of the GRAS family of transcriptional regulators. Science 308: 1786-1789

Kuppusamy KT, Endre G, Prabhu R, Penmetsa RV, Veereshlingam H, Cook DR, Dickstein R, Vandenbosch KA (2004) *LIN*, a *Medicago truncatula* gene required for nodule differentiation and persistence of rhizobial infections. Plant Physiol 136: 3682-3691

Mitra RM, Gleason CA, Edwards A, Hadfield J, Downie JA, Oldroyd GE, Long SR (2004) A Ca2+/calmodulin-dependent protein kinase required for symbiotic nodule development: Gene identification by transcript-based cloning. Proc Natl Acad Sci U S A 101: 4701-4705

Murray JD, Karas BJ, Sato S, Tabata S, Amyot L, Szczyglowski K (2007) A cytokinin perception mutant colonized by Rhizobium in the absence of nodule organogenesis. Science 315: 101-104

Mylona P, Pawlowski K, Bisseling T (1995) Symbiotic Nitrogen Fixation. Plant Cell 7: 869-885

Oldroyd GE (2007) Plant science. Nodules and hormones. Science 315: 52-53

Penmetsa RV, Cook DR (2000) Production and characterization of diverse developmental mutants of Medicago truncatula. Plant Physiol 123: 1387-1398

Sambrook J, Fritsch EF, Maniatis T (1989) Molecular cloning : a laboratory manual, Ed 2nd. Cold Spring Harbor Laboratory, Cold Spring Harbor, N.Y.

Sanchez PA (2002) Ecology. Soil fertility and hunger in Africa. Science 295: 2019-2020

Smit P, Raedts J, Portyanko V, Debelle F, Gough C, Bisseling T, Geurts R (2005) *NSP1* of the GRAS protein family is essential for rhizobial Nod factor-induced transcription. Science 308: 1789-1791

Thoquet P, Gherardi M, Journet EP, Kereszt A, Ane JM, Prosperi JM, Huguet T (2002) The molecular genetic linkage map of the model legume *Medicago truncatula*: an essential tool for comparative legume genomics and the isolation of agronomically important genes. BMC Plant Biol 2: 1

Tirichine L, Sandal N, Madsen LH, Radutoiu S, Albrektsen AS, Sato S, Asamizu E, Tabata S, Stougaard J (2007) A gain-of-function mutation in a cytokinin receptor triggers spontaneous root nodule organogenesis. Science 315: 104-107

Udvardi MK, Scheible WR (2005) Plant science. GRAS genes and the symbiotic green revolution. Science 308: 1749-1750

Vasse J, de Billy F, Camut S, Truchet G (1990) Correlation between ultrastructural differentiation of bacteroids and nitrogen fixation in alfalfa nodules. J Bacteriol 172: 4295-4306

Veereshlingam H, Haynes JG, Penmetsa RV, Cook DR, Sherrier DJ, Dickstein R (2004) *nip*, a symbiotic *Medicago truncatula* mutant that forms root nodules with aberrant infection threads and plant defense-like response. Plant Physiol

Young ND, Cannon SB, Sato S, Kim D, Cook DR, Town CD, Roe BA, Tabata S (2005) Sequencing the genespaces of *Medicago truncatula* and *Lotus japonicus*. Plant Physiol 137: 1174-1181