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Field Screening of Diverse Soybean Cultivars for Flood Tolerance

Jane Achando Khatenje Mokua
University of Arkansas, Fayetteville

Field Screening of Diverse Soybean Cultivars for Flood Tolerance

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By

Jane Mokua
Arkansas State University
Master of Science in Agriculture, 2010
Egerton University
Bachelor of Science in Horticulture, 2006

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University of Arkansas

This thesis is approved for recommendation to the Graduate Council.

Dr. Pengyin Chen
Thesis Director

Dr. Edward E. Gbur, JR.
Committee Member

Dr. John R. Clark
Committee Member

Dr. Kristofor R. Brye
Committee Member

Abstract

Flooding can significantly reduce soybean growth, development, and yield. Therefore, screening and identification of flood-tolerant soybeans will enhance development of cultivars that are well suited for flood-prone areas. Sets of screening tests were conducted in Stuttgart, Arkansas using three separate but related experiments, with the purpose of establishing effective flood tolerance screening protocol that can identify tolerant and sensitive cultivars. Each experiment was completely randomized with three replications. The first experiment involved screening of 256 maturity group (IV and V) cultivars. Flooding was imposed at the fifth-node (V5) or first-bloom (R1) stage for ten days. Post-flood visual ratings and stand counts were done three times every 3-5 days interval. Flood responses differed significantly among cultivars, within MG, and between growth stages (GS). Soybeans were more sensitive to flooding at V5 than R1. Maturity group had no main effect on flood damage; however, the severity of flood damage at a particular GS was dependent on the MG. In the second experiment, 30 cultivars were subjected to 5, 10, and 15-day floods at R1 and post-flood visual ratings and stand counts done on the 1^{st}, 3^{rd}, and 6^{th} day. In the final experiment, 40 cultivars were subjected to 3, 6, 9, 12, and 15-day floods at V5 and R1 followed by flood damage ratings on the 2^{nd}, 4^{th}, 6^{th}, and 8^{th} day. Flood duration, scoring time, and GS had a significant effect on genotypic response to flooding. Damage caused by flood increased linearly with flood duration and scoring time after flood removal. Plants were more sensitive to flooding at R1 than V5. Significant reduction of chlorophyll content was observed in plants subjected to longer flooding durations. Significant correlation between visual scores and percent dead plants can support decisions in identifying flood-tolerant cultivars. Cultivars with extreme responses to flood stress were identified and will have utility in future genetic studies for tolerance mechanisms and breeding for flood-tolerant

cultivars. Five effective and relatively inexpensive screening methodologies for flood tolerance in the field at the V5 and R1 were established. However, the established methodologies need to be assessed under different soil types and environmental conditions.

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CHAPTER I

GENERAL INTRODUCTION AND LITERATURE REVIEW

General Introduction

The occurrence of floods is one of the limiting factors for sustainable crop production in most parts of the world (Wollenweber et al., 2003). Since nearly all crops are intolerant to floods, the devastating effect of flood on plant growth and development impacts overall global food production (Normile, 2008). Flooding has been ranked as the second major constraint to crop production after drought, and it affects approximately 16% of production area (Boyer, 1982). In the regions of Eastern Europe and Russia 20% of land area is affected by floods (FAO, 2002). In the Midwest of the United States, soybean and maize harvests were reduced by 70% as a result of floods and droughts. Flooding is increasingly becoming a matter of concern in Europe, India, China and Pakistan where production of wheat (*Triticum*), cotton (*Gossypium hirsutum*), and rice (*Oryza sativa*) (Ghassemi et al., 1995) are common.

Flooding is often used to refer to different situations in which water excess can range from water saturation (waterlogging) to deep water causing complete submergence of plants (anoxia, and hypoxia) (Stricker, 2012). Causes of flooding include, 1) heavy rainfalls exceeding surface and subsurface drainage capabilities especially on poorly drained soils , 2) over irrigation of farmlands or/and rainfall following irrigation, 3) fluctuation of water tables (Stanley et al., 1980; Sullivan et al., 2001), streams/rivers overflowing its basin, and cultural practices such as rice-soybean rotation (Boyer, 1982; Heatherly and Spurlock, 2000; Sullivan et al., 2001).

In the Mississippi Delta of Arkansas, a significant portion of the harvested soybeans is grown in rotation with rice. For the most part, these crops are grown on poorly drained alluvial slowly permeable soils and irrigated by the flood method (Scott, 1998). The most common irrigation methods for soybean production in this region are flood irrigation and row-and-furrow irrigation (Hill et al., 2003). Flood irrigation involves use of contour-flood-irrigation or straightlevee-flood irrigation. Both of these methods involve pulling of levees to separate areas of different elevation into smaller more uniform flat portions to allow application of water at a more consistent depth and duration. The areas with low elevation at the field can result in waterlogged conditions. Use of poly-pipes can also result in excessive irrigation causing waterlogged conditions (Heathery and Spurlock, 2000).

Therefore, soybeans grown in the Mississippi River Delta Region are often prone to periodic flooding, thus soybean producers need flood-tolerant cultivars that maintain production under flooding conditions (Henshaw et al., 2007b). However, the process of identifying such cultivars has been a slow and arduous process for soybean breeders. The lack of appropriate flood tolerance screening protocol, changes in the seasonal patterns, and the complexity of the trait are among the few current limitations affecting identification and ranking of reliable flood tolerance in crops (Colmer and Voesenek, 2009; Stricker et al., 2005). Improving our ability to screen and identify sources of flood tolerance in soybean is the first step towards developing cultivars which are well-suited for flood-prone areas. In the process of evaluating flood tolerance in crops, assessment of factors affecting genotypic flood tolerance response using different criterion of evaluation is of great importance. Studies on the effects of the duration of the flooding stress (Van Toai et al., 1994; Heatherly and Pringle, 1991), growth stage at initiation of the flood (Scott et al., 1989; Scott et al.,1990), soil texture (Rhine et al., 2010), and the environmental conditions (Van Toai et al., 2001) are important.

Soybean Industry in the United States

Soybean is an economically important crop in the world. Soybean seeds are important for both protein meal and vegetable oil. Soybean has risen to one of the top-traded commodities in the world and as a result, approximately 6% of the world's arable land area is under production of soybeans. Since the 1970s, the area in soybean production has the highest percentage increase compared to any other major crop (Hartman et al., 2011; USDA ERS, 2014; Masuda and Goldsmith, 2008). In the United States, it is the second largest field crop planted after corn. Currently, the United States is the largest producer and second largest exporter of soybeans in the world (USDA ERS, 2014).

Soybeans were established in the United States in the1880's from Northwest China. However, the importance of this crop was not realized until the 20th century when the soybean industry boomed. This was as a result of introduction of the Roundup Ready soybean cultivars, improvements from narrow rowed seeding practices, and increased planting flexibility such as 50-50 corn-soybean or rice-soybean rotation. Most soybean production in the United States is concentrated in the upper Midwest. However, concentrations have expanded in the upper Corn Belt region of the Great Plains and the southern part of the Mississippi Delta River region (Wilcox, 2004). In 2015, approximately 83.5 million acres of soybeans were planted nationwide in the United States (USDA-ERS, 2015). Arkansas grew 1.34 million hectares of soybeans in 2014 and the yields averaged to 2,424 kg/ha. Twenty counties within its Delta produced soybeans in excess of 54 million kg, which placed Arkansas in the first ranking among the states located within the delta region (National Agricultural Statistics Service, 2014).

Cultural Practices of Soybean Production in the Mississippi Delta Region of Arkansas

Between 55% and 60% of the land area in the Delta is utilized by cropland. Soybeans, rice, corn, cotton, sugar cane, and feed grains are produced in the Delta farms (Zhang et al., 2001). In 2013, the Arkansas soybean industry ranked eighth in the nation with more than 6,800 farmers producing about 110 million bushels (Coats and Ashlock, 2000; National Agricultural Statistics Service, 2014). Of the three Delta states, Arkansas ranks first in total receipts in soybean sales, followed by Mississippi and Louisiana (Coats and Ashlock, 2000). Soybean production is highly concentrated in the eastern half of the state comprising of the Mississippi Delta Region with over 45 counties under production. However, significant yields of soybeans are also produced in the counties that lie in the Arkansas River Valley and in the Southwestern of the state (Scott et al., 1998).

The cultural practices for soybean production in Arkansas depend on factors such as the soil texture, cropping practices, and availability of farming equipment. Significant portions of irrigated soybeans in the Mississippi Delta of Arkansas are grown in rotation with rice, and as a result the fields are relatively shaped flat to accommodate flood irrigation (Kebede et al., 2014). Intensive irrigation of cropland ranks Arkansas sixth in the USA in the total cropland area under irrigation. Common sources of water for irrigation include groundwater and farm surface sources (Scott, 1998). Furrow irrigation is the most common irrigation system in soybean production with 50-70% efficiency; however, flood, furrow, row-and-furrow irrigation, and border irrigation systems are still in use (Hill et al., 2003; Kebede et al., 2014). Rice and soybeans are planted on 1:1 or 1:2 year, which allow use of the same well and equipment in the same field over years Also, double-cropping of soybeans with small grain crops is a successful cropping system in the southern USA (Synder and Slaton, 2001; Scott et al., 1998; Daniels and Scott, 1991).

Adoption of an early soybean production system (ESPS) that focus on early maturity group cultivars has maximized yields in this region. Initially, a traditional soybean production system involved planting the late maturity groups V, VI, and VII during the months of May and June, and this system resulted in low yields caused by low rainfall from July to September.

General Overview of the Mississippi Delta Region

The Mississippi Delta is a distinct agricultural area in the United States with an area of more than 4 million acres (Cobb, 1999). The Delta's mild climate, extended growing season, and resources such as fertile alluvial soils and adequate precipitation, all make it a favorable agronomic productive region especially under proper management (Scott, 1998).

Most of the area of the Delta is rolling, but some parts are nearly flat. The elevation of the region ranges from 24.4 to 501.6m above the sea level. The deep nutrient rich alluvial soils were developed from glaciers and many years of seasonal flooding of the Mississippi River and its tributaries. With close proximity to lakes, there is an adequate water supply for irrigation of farmlands. The climate regime is favorable. For example, the average annual temperature is moderate with a range of 1.8-2.1**°C**. Rainfall is abundant and well distributed throughout the year. Annual precipitation ranges from about 1143mm in the northern delta to 1525mm in the southern delta. Yield losses in most of historic crops (soybeans, rice, cotton, and corn) are due to flooding and waterlogging because of prevalence of heavy clay soils, poor soil structure, poor surface drainage in areas with limited slope, heavy rains, and cropping practices (Scott et al., 1998).

General Effects of Flooding on Crops

Plants are aerobic organisms that essentially need carbon dioxide (CO_2) and oxygen (O_2) with their environment. Plants also require sufficient water to satisfy growth, development, and evapotranspiration. Lack of balance between these requirements can lead to adverse effects, often leading to stressful conditions and consequently to loss of crop productivity (Voesenek et al., 2006). One of a biotic factor leading to a lack of balance among these requirements is flooding. General consequences of flooding in susceptible crops as observed on soybeans and other plant species may include the following: inhibition of seed germination, reduced root growth and nodulation (Purcell et al., 1997), stunted growth (Oosterhuis et al., 1990), promotion of early senescence (Linkermer et al., 1998), leaf chlorosis, defoliation, plant death, and overall yield loss (Kozlowski, 1984b ; Van Toai et al., 1994). However, these responses vary with many factors including plant species, timing, age of the plant, and environmental conditions at flooding (Scott et al., 1989; Van Toai et al., 1994).

Excess water in the soil affects directly plant roots and indirectly the shoots (Hanshwa et al., 2007a). Flooding, whether temporary or continuous, causes severe injury and affects metabolism and functioning to crop plants (Jackson and Ricard, 2003). When plant roots are deprived of O_2, the gaseous exchange between plant roots, soil, and atmosphere is limited leading to decline in photosynthesis, and eventually plant death (Drew, 1997). Plants growing in flooded condition switch to anaerobic respiration giving out products inadequate in supporting prolonged plant growth (Kozlowski, 2002). Flooding affects plants root systems due to proximity of the stress to the roots. As environmental sensors that regulate biochemical signals within the plant, the effects of stress are reflected on whole-plant processes seen in plant shoots, leaves, flowers, and fruits (Drew, 1997). Potential symptoms of the effects on these plant structures are depicted through chlorosis, disruption of cell membranes, leaf wilting, epinasty, and cellular death (Linkermer et al., 1998; Purcell et al., 1997).

Due to slow diffusion of O_2 in undisturbed water, the smaller amount of O_2 available is quickly depleted by root and microorganism respiration. As a result, excess accumulation of methane, carbon dioxide (CO_2), and other gases in in the soil facilitates increase of ethylene in submerged tissues (Boru, 1997; Greenway et al., 2006; Scott et al., 1989). The effect is observed on physiological processes such as stomata closure negatively affect water relation, mineral nutrient uptake and transport, carbohydrate and hormone relationship, photosynthesis and respiration with an overall decline in yields (Bacanamo and Purcell, 1999; Kozlowiski, 1984; Barrick and Noble, 1993).

Nitrogen (N), a major limiting nutrient in crop productivity and is primarily lost through leaching if flooding occurs on sandy soils or loss through denitrification on clay soils. A decreased of nitrogen accumulation has been identified as a limiting factor to growth in flooded soybean plants (Bacanamo and Purcell, 1999). Lack of O_2 in the root system of soybean inhibit symbiotic N fixation, N uptake, and decreased nitrogenase activity thus diminish root growth and nodulation (Bacanamwo and Purcell, 1999a; Sallam and Scott, 1987). Sullivan et al., (2001) observed that after flooding soybean plants for seven days at first trifoliate (V1) stage, leaf nitrogen was reduced to below the deficiency levels which inhibited soybean nodulation; however, recovery was observed after four days of flooding. Similarly, Minchin and Summerfield (1976) observed decreased symbiotic N fixation and decreased vegetative growth of the cowpea plant at flooding.

Flood intolerance studies have also shown that concentrations of nutrients such as potassium (K), phosphorous (P), manganese (Mn), zinc (Zn), magnesium (Mg), iron (Fe), Aluminum (Al) calcium (Ca), and sulfur (S) are either increased or decreased in the leaf tissues. For instance, a high concentration of Mn, Fe, and Al have been observed in the shoot tissues of plants under water-saturated conditions, and the toxicity of these elements may interfere with structure and cell function (Fausey et al. ,1985). Decreased nutrient availability as well as high concentrations of some macronutrients may affect the overall growth of the plant (Rhine et al., 2010; Stevens et al., 2010; Board, 2008)

Mechanism and Adaptation of Plants to Waterlogging

Flood/waterlogging tolerance is defined in different ways by various researchers and professionals. Physiological studies define flood tolerance as the adaptation of a particular plant species to survive anoxic conditions, toxic substances, and other changes in soil properties induced by flooding from seedling stage to maturity during the growing season (Unger et al., 2008; Drew, 1997; Greenway and Gibbs, 2003). Flooding-intolerant plants have been observed to withstand anoxia temporarily but not for prolonged periods. Agronomists define flood/waterlogging tolerance as the ability of plants to survive and maintain growth rate and higher grain yield under flooding relative to non-flooded conditions. In this case, flood tolerance ranking is normally based on seed quality and yields (Setter and Waters, 2003; VanToai et al., 1994).

Some crops such as rice, dry beans, soybeans, oats, lentils, wheat, corn, barley, canola, and peas can differ in their tolerance to flooding/waterlogging through different adaptive mechanism. Depending on the plant species, responses may be simultaneous and complex, as a result, no single mechanism ensures long term survival post-flood (Colmer and Vosenek, 2009). Studies show that tolerant plants develop a set of physiological, morphological, and anatomical responses to cope with low concentration of O_2 in the flooded soils (Striker et al., 2005; Colmer and Voesenek, 2009; Boru et al., 2003; Thomas et al., 2005).

In soil waterlogging and partial submergence, flood-tolerant plants develop adaptive traits which increase the oxygenation of submerged tissues and enhance the ability of leaves above water to continue with carbon fixation. The strategies include adventitious root, radial oxygen loss, and formation of aeranchyma tissues. These are the most common responses that facilitate longitudinal O_2 transport that sustains root aeration (Striker et al., 2005; Colmer and Voesenek, 2009).

Flood-tolerant plants form aeranchyma tissues that facilitate internal O_2 exchange from shoot to roots. The functions of this tissues are twofold, to allow root growth and soil exploration in partially submerged soils and to enhance the role of ethylene activity in flooded soybeans (Bacanamwo and Purcell, 199b; Evans, 2003). There are two types of aeranchyma: the cortical (lysigenous or schizogenous) and the secondary aeranchyma. The cortical aeranchyma are mostly formed in the roots of wheat maize, rice, and barley crops (Colmer, 2003a; Seago et al., 2005; Kawai et al., 1998; Huang et al., 1994; Laan et al., 1989). Whereas, secondary aeranchyma are formed in the root nodules, tap roots, and stems, and is common in some crops such as Glycine species grown in flooded areas (Arikado, 1954).

At the morphological level, tolerant plants respond to partial flooding by forming adventitious roots near aerated soil surface (Li et al., 2008; Pires et al., 2002; Bucanamo and Purcell, 199a, b). The ability to form adventitious roots in tolerant plants ensure continued water and nutrient uptake (Colmer, 2003a; Seago et al., 2005). Kozlowski and Pallardy, (1984) and Cox et al., (2004) found in their studies that cotyledodonous species that form adventitious roots during flooding often grow taller than their non-flooded counterparts do.

Radial Oxygen Loss (ROL), root apex oxygenation, and root elongation are also important mechanisms that enable plant survival under partial submergence. The above ground biomass captures atmospheric oxygen and transports it to the root in order to avoid anoxia. The presence of barriers against ROL impedes oxygen leakage towards the soil thus avoiding oxygen loss in flooded conditions (Colmer, 2003a).

Plants experiencing complete submergence are subjected to both O_2 deficiency in the root zone and aerial tissues. As a result, aerobic metabolism for energy production shifts to fermentation pathway, a pathway known to be less efficient in energy production (Vashist et al., 2011; Colmer and Pedersen, 2008; Kulichikhin et al., 2009; Voesenek et al., 2006). However, plants tend to adopt two strategies/mechanisms to cope up with the water stress. These include LOQS (low oxygen quiescence syndrome) and LOES (low oxygen escape syndrome) (Hattori et al., 2010).

The sit and wait strategy, low oxygen quiescence syndrome (LOQS) is mostly adopted by species coping with deep short-term flooding of less than two weeks. Low oxygen quiescence syndrome ensures a plant remains quiescent during the submerged period by use of less ATP while boosting the efficiency of enzymes involved in the production of ATP. Plants with this kind of mechanism avoid elongating their organs underneath water and also produce important molecules to avoid modifications thus, preserving energy and carbohydrates (Colmer and Voesenek, 2009; Setter and Laureles, 1996). On the other hand, the LOES strategy is a common in crops adapted to environments prone to shallow but prolonged floods. This strategy enables faster upward shoot elongation to enhance restoration of leaf contact with the atmosphere thus, facilitating the entrance of O_2 and ventilation of gases in submerged tissues. New structures such as aeranchyma are created to transport gases within the plant and the surrounding environment through a process of radical oxygen loss (Striker et al., 2011b; Thomas et al., 2005)

Flood Tolerance Screening Methodology

The term flooding is often used to describe different situations of water excess ranging from water saturation at the root system-waterlogging- to deep water where most plants are submerged (Stricker et al., 2005). Flood tolerance is defined as the ability of a plant to survive or maintain high growth rates and yields at flooded relative to non-flooded conditions (Setter and Waters, 2003).

In the process of identifying flood-tolerant crops, field, greenhouse, and genetic studies have been carried out. The diversity and complexity of the trait, as seen in factors such as genetic makeup (Rhine, 2010; Riche, 2004), flood timing relative to the plant growth stage (Scott et al., 1989; Scott et al., 1990), duration of the stress (Van Toai et al., 1994; Heatherly and Pringle, 1991), soil type (Rhine et al., 2010), environmental conditions, and severity of the flooding stress, has been a major challenge for researchers in identifying flood-tolerant crops (Setter and Walter, 2003; Van Toai et al., 1994; Colmer and Voesenek, 2009; Armstrong et al., 1994; Scott et al., 1987). Additionally, physical and chemical changes associated with flooded soil may cause these diversities (Kirk et al., 2003). These factors affect cultivar ranking for the trait which affects repeatability of experiments and the selection of truly tolerant crops (Rayna et al., 2003).

In soybeans, studies have also shown that flood tolerance responses are not uniform across growth stages. Linkemer et al., (1998) observed variation in yield loss at V2, R1, R3, and R5 growth stages with greater loss observed at reproductive than vegetative stages. Nevertheless, Scott et al., (1989) also found greater yield loss per day of stress at the reproductive than vegetative stage. Rhine et al., (2010) observed less yield loss per day of stress of soybeans flooded on Crowley silt loam as compared to Sharkey clay.

Different methods and criteria are being used by researchers to screen for flood tolerance. One method that has recently gained popularity in selecting cultivars for flood tolerance is screening plants based on different plant adaptive features and mechanisms that enhance plants survival under hypoxia (Bacanamwo and Purcell 1999a,b). These features include, formation of aerachyma (Bacanamo and Purcell, 1999a, b; Mochizuki, 2000; Asch-smiti et al., 2003), growth of adventitious roots at the soil surface during flooding (Mano and Oyanagi, 2009), tolerance to toxin elements such as Fe^{2+} (Ponnam and Perurra, 1984), and shallow root system and barrier to radial oxygen loss. Other studies have used different indices in screening and identification of soybean waterlogging tolerance. For instance, plant parameters such as growth rate, number of nodes and pods per plant and yield have been evaluated in flooded soybeans (Malik et al., 2011; Van Toai et al., 2010; Van Toai et al., 2001; Van Toai et al., 2010; Cornelious, 2003; Oosterhuis et al., 1990; Sullivan et al., 2001). Also, use of early visual plant behavior such as plant height, chlorophyll content, leaf color, plant death, and shoot and root biomass have been used because of the possibility of reducing time and expenses associated with genotypic flood tolerance identification (Linkemer et al., 1998; Visser et al., 1996; Yu et al., 2012; Cornelions, 2003). Some studies have established a strong correlation between early-season flood tolerance and grain yield (Van Toai et al., 2010; Linkemer et al., 1998).

Since flood tolerance can also be attributed to genetic traits, genetic studies on identification of Quantitative Trait Loci (OTL) underlying flood tolerance have been conducted in soybeans (Cornelious et al., 2003; Reyne et al., 2003), maize (Mano et al., 2007) and barley (Zhou, 2011; Li et al., 2008) and many other crops. However, the use of this method to develop flood-tolerant varieties has yet to be fully successful due to limited research (Van Toai et al., 2001).

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CHAPTER II

FIELD SCREENING OF DIVERSE SOYBEAN CULTIVARS FOR FLOOD TOLERANCE AT THE V5 AND RI GROWTH STAGES

ABSTRACT

Soybean [*Glycine max* (L.) Merr.] is often grown in regions prone to periodic flooding and most soybeans are intolerant to flooding across all growth stages. It is important to know the growth stages soybean may be more tolerant or sensitive to flood injury in breeding cultivars that maintain production under flooding conditions. This study utilized early screening criteria of foliar visual injury and percentage of dead plants to differentiate genotypic responses (tolerant vs. sensitive) of diverse soybean cultivars to a 10-day flooding stress at two growth stages. Two hundred and fifty six commercial soybean cultivars were screened for flood tolerance in their respective maturity groups (MG) at vegetative or reproductive stage at Stuttgart, AR in 2012 and 2013. In each year, the experimental design was a split-plot with whole-plot being randomized complete block design (RCBD) with growth stage as a factor. The split-plot factors were MG and cultivars (MG). Flooding was imposed at the fifth-node (V5) or first-bloom (R1) growth stage for 10 days. A visual rating on a scale of 0 to 9, based on foliar chlorosis /necrosis and plant death, was done for each plot after the removal of flood and repeated three times every at 3-5 day intervals. Flood responses differed significantly among cultivars, within MG, and between growth stages. Soybeans were more sensitive to flooding at V5 than R1. Maturity group had no main effect on flood damage; however, the severity of flood damage at a particular growth stage was dependent on MG. The percentage of dead plants ranged from 46 to 100% and 38 to 97% at V5 and R1 respectively. Positive correlations among foliar visual scores and percent dead plants were observed. Cultivars with extreme responses to flood stress were identified in this study and will have utility in future genetic studies for tolerance mechanisms and breeding for flood-tolerant cultivars. Screening for foliar visual symptoms and percent dead plants were good methods for early flood tolerance screening in soybeans.

INTRODUCTION

The risk of flooding has risen over the past decades as a result of anthropogenically-induced global climate change (Bailey-Serres et al., 2012). Additionally, the occurrence of flooded conditions is seen as the second highest cause of yield loss in the USA (Wollenweber et al., 2003). Flooding can be induced by an abundance of soil water caused by excessive amounts of rainfall, and/or irrigation especially in areas of poorly drained soils. Soils which have been under prolonged flooded conditions become depleted of oxygen, which results in changes in the metabolism and morphology of the plants (Jackson and Colmer, 2005; Kozlowski, 1997). Overall yield reductions have been documented in several crops due to reduced shoot and root growth and dry matter accumulation (Bacanamwo and Purcell, 1999; Malik et al., 2001). For instance, about 20-50% reduction of grain yields in wheat was observed in North America, UK, Asia, and Australia (Dennis et al., 2000; Cannell et al., 1984; Jiang et al., 2008; Zhang et al., 2006). Approximately 25% of soybean yield losses in the USA have been due to flooding (Van Toai et al., 2010).

For many years, Arkansas has been a major soybean producing states in the United States. Production is mainly concentrated in the Mississippi Delta region of Arkansas with approximate 3.2 million acres under production (Coats and Aschlock, 2000). Producers in this region are faced with flood problems, as most parts of Mississippi Delta flood plains are prone to prolonged flooding. For instance, approximately 30% of soybeans are produced under irrigation on heavy-textured clay soil known to have poor surface and internal drainage. Additionally, some cropping practices in this region, such as monocultures of flood-irrigated paddy rice and rice-soybean rotation are common (Coleman et al., 1998; Scott et al., 1998). In order to increase soybean yield in these conditions, producers may plant soybean cultivars that known to be flood tolerant. However, identifying such cultivars has been a slow and arduous process for soybean breeders. Improving the ability to screen and identify sources of flood tolerance in soybean is the first step towards developing cultivars that are well suited for flood-prone areas.

Research on flood tolerance in crops has been conducted in greenhouses, fields, growth chambers, and laboratories (Boru et al., 2003; Van Toai et al., 2010; Zhou et al., 2011). However, the selection of flood-tolerant cultivars is still a challenge due to the complexity of this trait that involves many morphological, anatomical, and physiological characteristics (Colmer and Voesenek, 2009; Mano and Takeda, 2012; Striker et al., 2005). In addition, changes in seasonal patterns and lack of appropriate screening techniques for ranking a particular cultivar in terms of tolerance to flooding are just few of the current limitations of identifying flood tolerance in crops. Since varietal response to flooding for this trait constantly change with growth stages, Oyanagi (2011) and Mano and Oyanagi (2009) highlighted the importance of evaluating flood tolerance at each growth stage to identify cultivars tolerant to flooding. Some researchers have looked into flood tolerance in soybeans at germination (Sayama et al., 2009; Nakayama et al., 2004), mid-vegetative stages (Cho et al., 2013), and early reproductive stages (Van Toai et al., 2001; Van Toai et al., 2010). Despite this effort, it is still a challenge to select reliable tolerance since multiple factors related to flooding under field conditions reduce repeatability of experiments (Van Toai et al., 1994; Scott et al., 1989; Rhine et al., 2010). As a result, inconsistencies in interpretation of the data among researchers have been reported (Dickin et al., 2009; Zhou et al., 2007).

In order to identify soybean cultivars tolerant to flooding in different growth stages, this study utilized early screening criterion of foliar injury and percentage of dead plants (%DP) to differentiate genotypic responses (tolerant vs. sensitive) of 256 diverse soybean cultivars to a 10-

days flooding stress; and to relate flood responses at vegetative and reproductive stages. This chapter addresses the following questions: (1) Is there genetic variation among cultivars in foliar injury visual scores and %DP after being exposed to a 10-day flooding in the field? (2) Is it possible to screen at the fifth-foliate (V5) or the beginning to bloom (R1) growth stages to identify differences in flood tolerance in the field? (3) Is there a correlation between the scoring criteria?

MATERIALS AND METHODS

Plant Materials

Two hundred and fifty six conventional diverse soybean cultivars obtained from different companies and institutions across the southern United States were screened for flood tolerance. These cultivars are with a range of genetic backgrounds and high potential yield across different geographical regions of Arkansas. According to the 2011 Soybean Performance Trials, the cultivars ranged from early MG IV to late MG V (www.Arkansasvarietytesting.com). In this experiment, cultivars were separated by MG and grouped into two distinct test sets, MG IV and MG V, each consisting of 125 and 131 cultivars respectively (Appendices 1a, b and 2a, b). Each MG test set was then screened for flood tolerance at the V5 growth stage (fifth-node) and R1 (first-bloom) independently, resulting in four maturity group by growth stage (MG X GS) combinations (MG IV-V5, MG IV-R1, MG V-V5, MG V-R1) grown each year.

Site Description

A flood tolerance study was established during the summer of 2012 and 2013 at the Rice Research and Extension Center near Stuttgart, AR 34˚469′N, 91˚420′W. Stuttgart was the ideal location for the study because of a high frequency of rice-soybean rotation, the soil type, and its topography. The soil type is Dewitt silt loam (fine, smectitic, thermic Typic Albaqualfs), known to be deep, poorly drained, and very slowly permeable with a plow pan at 0.4m. Stuttgart has a level to gently sloping flood plain with a 0.25% slope (Scott 1998; Sallam and Scott, 1987). The climate in this area is characterized by hot humid summers and generally mild to cool winters. Lower monthly rainfall is experienced in the summer months of June, July, and August compared to the rest of the year. Daily temperatures recorded from the National Oceanic and

Atmosphere Administration (NOAA) weather station located at the station are characterized by maximum monthly air temperature ranging from 10 to 30°C during the growing season. Relative humidity ranged between near 50 to 90% as shown in Table 2.

Cultural Practices Treatments and Experimental Design

Normal cultural practices such as disking, floating, and fertilization were done before planting. The fields were floated twice in order to smooth and fill the holes. Pre-emergence herbicide of Valor XLT Soybean Herbicide at 3 to 5 oz/A was sprayed to suppress weeds. Plots were planted on raised beds on June 12 and May 22 in 2012 and 2013 respectively at the seeding rate of 100 seeds per plot. The area of the field was divided into two equal-sized parts, each part assigned to a different MG. Within each MG, the area was further subdivided into two equal-sized treatments. The first treatment received a 10-day flood treatment at V5 and the second 10-day flood treatment at R1. Each plot (a single cultivar) consisted of a single row 3m long and 1.5m between row spacing. Genotypes were replicated three times. Rows within each maturity group x growth stage combination were planted 20 plots across. A buffer was planted as the first and last range within each bay. All plots were treated as normal irrigated plots until 50% of the soybeans reached their respective stages of treatment. Before flood treatments, levees were constructed surrounding each MG x growth stage (GS) combination as shown in Fig. 1. The initial stand count was done before imposing the stress. Flooding was imposed at V5 and R1 growth stages and water was maintained continuously at two thirds height above the plants for 10 days. At the end of the 10^{th} day, the levees were removed and the water was allowed to drain from the soil surface. Visual score was determined from each plot and the number of live plants counted at 3-5 day intervals.

In each year, the experiment was arrayed in a split-plot experimental design with whole-plot being randomized complete block design (RCBD) with growth stage as a factor. The split-plot factors were MG and cultivar (MG). Cultivars had a factorial structure: Cultivar x MG and Cultivar x growth stage.

Data Collection and Statistical Analysis

The initial stand counts were recorded the week before flooding treatment was applied to the plots. At post-flood, visual foliar injury score (visual symptoms of foliar burning, wilting, chlorosis, yellowing, plant death, browning and necrosis) were determined from each plot at three times with 3-5 days between viewing. For example, first score (SC 1) was taken immediately or the same day the flood was removed and the second score (SC 2) was taken three days after the flood removal. A 0 to 9 scale as per protocol described in Cornelius (2003) was used to rate flood damage, 0 being no flood damage and 9 being ≥ 90% of plants dead. Rating was done on a continuous scale however, classification of flood damage was considered numerical in three distinct categories: 1) tolerant 0-4 or ≤ 30% dead plants, 2) moderate tolerant 5-6 or ≥ 30-60% dead plants, and 3) sensitive 7-9 or ≥ 70% dead plants (Table 1). Therefore, genotypic flood tolerance was determined based on these categories. The number of plants that survived at post-flood was recorded at each scoring period and the percentage dead plants (% DP) was calculated according to the formula:

$$\%DP = \left\{\frac{(Initial\ stand\ count - Plants\ alive\ at\ each\ scoring\ period)}{\text{Initial stand count}}\right\} X\ 100$$

We considered year and blocks as random while genotypes and MG as fixed effects. Two years of flood test data was combined and statistically analyzed with PROC GLIMMIX of SAS® PC Version 9.3 (SAS institute Inc., Cary, NC) to compute the differences in the means of foliar visual scores and % DP among cultivars. Further analysis to determine growth stage differences between MG were determined using Turkeys HSD. In order to determine if there was relationship between the effects of flooding on the % DP and foliar visual scores, correlation coefficients were calculated using Pearson correlation analyses PROC CORR. Foliar visual scores were treated as numerical.

RESULTS

Two years of flood test showed consistent results for the cultivars screened, therefore, data were combined from both years in an ANOVA and correlation analysis. The degree of flood tolerance differed significantly among cultivars and between growth stages, while maturity group effect was significant on % DP, but not on foliar visual scores after 10 days of flooding. Variation in flood tolerance was largely attributed to the stage of the genotypes at flooding and it was generally greater compared to MG, MG x stage, and genotype x stage interaction effects for both foliar visual scores and % DP (Table 4 and 5).

The Effects of Flooding on Foliar Visual Scores

Significant ($P < 0.0001$) differences in flood tolerance based on foliar visual scores were observed among cultivars at both the V5 and R1 growth stages (Table 4 and 5). Most of the tested cultivars were sensitive, as expected, to flooding in both growth stages, however, the effects were more pronounced in cultivars flooded at V5 compared to R1 at the visual rating done immediately after flood removal (SC 1) (Tables 6, 8, 9, and Fig. 3). The magnitude of the effect of flooding on visual scores was observed to worsen, as expected, with time after flood removal (Table 6). It should be noted that interpretation of this data was based on SC1 due to the consistence observed in the analyses. In addition, visual rating done three days after the flood removal (SC 2) did not show differences in foliar visual scores between V5 and R1, and the average of SC 1 and SC 2 (MSC) was as representative as SC 1(Tables 5 and 6). Therefore, SC1 appeared to be important and timely for scoring genotypic responses to flooding. Differences in visual scores among soybean MG were non-significant for SC 1, SC 2, and MSC. However, flood damage at different growth stages was dependent on the soybean MG and cultivars ($P < 0.0001$) (Table 4 and 5).

The differences in visual scores for cultivars within MG between flooding at the V5 and R1 growth stages, resulted to grouping of cultivars into three distinct classes (tolerant, moderate tolerant, and sensitive) based on the foliar visual scores at the V5 and R1 growth stage (Tables 8 and 9). However, a few cultivars with differential flood responses (tolerant and sensitive) were also identified at both V5 and R1 growth stage. There were five MG IV and seven MG V cultivars identified as tolerant to moderate tolerant to flooding at V5, whereas eight MG IV and nine MG V were tolerant to flooding at R1 (Tables 10 and 11). For example, for the cultivars tested in MG IV, NK S48-P4 Brand (4.7) and Willcross RY2460S (4.0) were observed to be the most tolerant in V5 and R1 flooding stages respectively (Table 2-10). For MG V cultivars, Progeny 5160LL (3.3) and AvDX - E112 (3.9) were observed to be the most tolerant in the V5 and R1 stages respectively (Table 11). Although most of the extreme rating cultivars were not consistent in response to flooding at both V5 and R1 stages as shown in Table 10, some showed similar responses between V5 and R1 (Table 11). For instance, Ozark, Halo 5:25, Halo5:45, and AvDX-E112 were tolerant at both V5 and R1 growth stages, and all sensitive cultivars were consistently sensitive at V5 and R1 growth stages (Table 11).

As a results of significant cultivar (MG) x growth stage interaction, there were three distinct response combination types to flooding at V5 and R1growth stages: low foliar visual scores at both V5 and R1, high foliar visual score at V5 but low score at R1, and high foliar visual scores at both V5 and R1 (Table 12). For instance, for the MG IV cultivars, NK S48-P4 Brand exhibited low visual scores at V5 (4.7) and R1 (6.5) growth stages, while Willcross RR2477N had the high visual scores of (8.8, 8.7) at both V5 and R1 growth stages respectively. However, Willcross RY2460S had high foliar visual score at V5 (8.7) but low R1 (4.0). For MG V cultivars, Progeny 5160LL exhibited low visual scores at V (3.3) and R1 (5.3) growth stages, while Delta Grow 4990LL had high visual scores of 8.8 and 8.8 at both V5 and R1 growth stages respectively. However, NK S56-G6 Brand had high visual score at V5 (8.8) but low R1 (4.6) growth stages. It is worth noting that only a few cultivars in either MG IV or MG V were tolerant to moderately tolerant to flooding at either V5 or R1 stage (Tables 10, 11, and 12).

The Effects of Flooding on Percent Dead Plant

Significant (*P <0.0001*) differences in the percent dead plants (% DP) were observed between V5 and R1 growth stages and across soybean MG (Table 4 and 5). The majority of the tested genotypes had high % DP, as expected, to flooding in both growth stages. However, the mortality was more pronounced in cultivars flooded at V5 than R1 growth stage (Tables 7, 13, 14, and Fig. 4). The magnitude of effect of flooding on % DP was observed to worsen, as expected, with time after flood removal across MG and growth stages as shown in (Table 7).

Cultivars in MG V were identified in three distinct classes (tolerant, moderate tolerant, and sensitive) based on the % DP at V5 and R1 growth stage and the trend was similar for MG IV (Tables 13 and 14). In addition, few cultivars with differential flood tolerance responses (tolerant and sensitive) were identified at both V5 and R1 growth stage (Tables 15 and 16). Three and six cultivars in MG IV and MG V were observed to be tolerant to moderate tolerant, at both V5 and R1 growth stages as shown in Tables 15 and 16. For example, LG C4625R2 (65.9%) and Willcross RY2460S (45.5%) cultivars in MG IV were observed to be the most tolerant in V5 and R1 growth stages respectively (Table 2-15). Progeny 5160LL (46.1%) and Hutcheson (38.2%) were the most tolerant in MG V cultivars at the V5 and R1 growth stages respectively (Table 16). Few cultivars such as Halo 5:25, Progeny 5160LL, and Dyna-Grow 34LL53 showed consistent responses at the V5 and R1 growth stages (Table 16).

As a result of significant cultivar (MG) x stage interaction, there were four distinct response combination types to flooding at V5 and R1 growth stages: low % DP at both V5 and R1, high % DP at V5 but low % DP at R1, low % DP at V5 but high % DP at R1, and high % DP at both V5 and R1 growth stages (Table 17). In MG IV cultivars, LG C4625R2 showed low % DP at the V5 (65.1%) and R1 (68.6%) growth stages. REV®46R73™ had high % DP in V5 (86.7 %) but low in R1 (47.3%). Dyna-Grow 31RY45 (69.1%, 72.1%) had low % DP at V5 but high at R1 stages respectively, and USG 74E88 had high % DP at both V5 (100%) and R1 (89.6%) stages. Similar responses were identified in MG V cultivars as shown in Table 17.

Relationship between Visual Scores and Percent Dead Plants Scoring Criteria

Correlations were analyzed between foliar visual scores and % DP across growth stages over time of 256 soybean cultivars (Tables 18 and 19). Visual scores were significantly ($P < 0.0001$) correlated with % DP in V5 and R1 growth stages. First scoring (SC1) was highly correlated with, SC 2 (r = 0.85, r = 0.63), MSC (r = 0.96, r = 0.94), % DP SC1 (r = 0.72, r = 0.51), %DP SC2 (r = 0.75, r = 0.41), and %MDP (r = 0.72, r = 0.52) (Tables 18 and 19).

DISCUSSION

While field screening and identifying of sources of flood tolerance in crops is still a challenge, research on utilization of early screening techniques such as foliar visual scores and % DP in the process of differentiating genotypic response to flood tolerance among crops has gained popularity (Visser et al., 1996; Yu et al., 2012; Cornelius, 2003; Sayama et al., 2009; Nakayama et al., 2004; Van Toai et al., 2001; Van Toai et al., 2010). Some of these studies have screened for flood tolerance in soybeans in diverse environments, using small-sized populations, different flood timings, and had different growth stages. In agreement with the previous studies, this study employed early screening criterion of foliar visual score and % DP to screen for flood tolerance in a field of diverse Arkansas commercial soybean cultivars at V5 and R1 growth stages.

Cultivars responded similarly to flooding in the year of 2012 and 2013 and this was probably a result of similar weather conditions in both years (Table 2). My results suggested substantial genetic variation in flood tolerance as shown in foliar visual scores and % DP (Table 4). Cultivars in this experiment had diverse pedigrees, thus, the range of variation likely enabled some plants to survive and function under flooded conditions (Jackson and Drew 1984; Evans.2003; Bacanamwo and Purcell 1999a, b; Van Toai et al., 1994; 2001, Reyna et al., 2003). Additionally, these results are in agreement with past research that has reported flood tolerance variation in several plant species such as *Gycine* max (Van Toai et al., 1994, Van Toai et al., 2001, 2010), barley (Setter et al., 1999), *Tricum aestivum* (Boru et al., 2003), and Zea mays (Van Toai et al., 1988).

Even though cultivars differed significantly in the overall foliar visual scores, all genotypes showed similar injury characteristics such as wilting, chlorosis, stunting, and necrosis, similar to previous reports (Linkermer et al., 1998; Purcell et al., 1997; Oosterhuis et al., 1990). Foliar visual scores and % DP identified some cultivars as tolerant or moderately tolerant to flooding, whereas majority of the cultivars were identified to be sensitive (Tables 8, 9, 13, 14, Fig. 3, and Fig. 4). These results are in agreement with past research stating that most soybean cultivars from the United States are generally intolerant to flooding stress (Van Toai et al., 2010; Oosterhius et al., 1990). Extreme weather conditions during the growing seasons of the study could also have contributed to the severity of the stress during and after flooding as higher temperatures leads to increased injury (Van Toai et al., 2001). Other non-measured factors such as the rate of drying and duration of flooding could have contributed to the effects (Van Toai et al., 1994; Scott et al., 1989).

The V5 growth stage was more susceptible to flooding compared to the R1 across MG as shown in Table 7 and Fig. 4. These results are contradictory to past research that has shown flood damage is more severe at reproductive growth stage than vegetative growth stage (Linkemer et al., 1998). However, in the early vegetative growth stage of soybean, flooding stress can delay the phase of rapid growth of important adaptive structures such as aeranchyma and adventitious roots. As a result of this delay, the plants cannot acclimate as well to the flooding stress and as a result, severe injury can observed (Sun-Guang et al., 1996; Pang et al., 2004). The mean average visual scores and % DP increased linearly with time after the removal of the flood, as expected, as higher temperatures and relative humidity after the removal of flood might have accelerated flood damage. As a result, this may have increased the inability of the tested cultivars to recover following the flooding (Kramer, 1951).

The study established positive correlations between visual scores and % DP in V5 and R1 growth stages, indicating cultivars with higher visual score had higher numbers of dead plants under flooding. Therefore, either of the criteria can provide good indicators for flood tolerance when screening soybeans at early growth stages.

CONCLUSION AND BREEDING IMPLICATIONS

Breeders and researchers have concentrated flood tolerance screening efforts to soybean reproductive growth stage because past research found that damage from flooding is generally more severe in the reproductive growth stage than vegetative stages. This has enhanced development of breeding lines tolerant at reproductive stages. This study was able to find some flood–tolerant and flood-sensitive soybean cultivars at the V5 and R1 growth stages. These cultivars could provide new germplasm resources to breed for cultivars that are tolerant up to 10-day flooding at the V5 and R1growth stages across all maturity groups.

Additionally, genotypes identified expressing similar or contrasting flood tolerance responses at different growth stages suggest that the mechanisms for flood tolerance at the V5 and R1 growth stages are unique and independent from one another. Thus, these genotypes can be used in breeding programs to identify the genes associated with each mechanism in the process of breeding cultivars tolerant to flooding across growth stages.

High correlations observed between visual scores and % DP screening criteria indicate consistencies in the two procedures thus, provided good support for early flood tolerance screening in soybeans. However, I will not use either of the screening criteria to predict the other. Identifying flood tolerant cultivars immediately after the removal of flood saves time, energy, and financial resources when compared to later flood tolerance screening techniques.

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Table 1. Scoring system used in classification of soybean genotypes for flood tolerance in the field screening.

Score	Class	Percentage of plants with foliar symptoms due to flood Injury
0	Tolerant	The plot appears healthy with no observable symptoms of flooding stress with 100% of plants alive
1		The plot is beginning to show mild chlorosis in some parts of the plant with no plants dead
2		Mild chlorosis is easily observable throughout the plot, lower branches begin to droop, with estimated 10% dead plants
3		Mild to moderate chlorosis is present throughout the plot, plants appear stunted and or droopy, lower leaves are becoming necrotic and abscising with estimated 20% dead plants
4		Mild to moderate chlorosis is present throughout the plot, plants appear stunted and or droopy, lower leaves are becoming necrotic and abscising with estimated 30% dead plants
5	Moderate Tolerant	Moderate symptoms present include prevalent chlorosis and necrosis throughout the plot with estimated 30 to 50% dead plants
6		Moderate symptoms present include prevalent chlorosis and necrosis throughout the plot with estimated 50 to 60% dead plants
7	Sensitive	The plot is severely damaged, visual symptoms present include prevalent chlorosis and necrosis throughout the plot with estimated plot death ranging > 70%
8		The plot is severely damaged, visual symptoms present include prevalent chlorosis and necrosis throughout the plot with estimated plot death ranging > 70 to 80%
9		The plot is severely damaged, visual symptoms present include prevalent chlorosis and necrosis throughout the plot with estimated plot death ≥ 90%

Cornelious (2003): 0 = most tolerant, 9 = most sensitive to flooding.
Fields were flooded at V5 (fifth-node) and R1 (First-bloom) for 10 days.
The percentages approximately correspond to the number of dead plants observed visually.

Table 2. Monthly mean weather over the course of the 2012 and 2013 screening seasons at the Rice Research and Extension centre in Stuttgart, AR.

2012

Month	Precipitation (in)	Temperature (°F)	Relative humidity (%)	Wind Speed (mph)
May	0.1	(84.6; 67.1)	(89.6; 53.6)	(16.8; 0.5)
June	0.1	(82.7; 63.5)	(87.3; 47.9)	(13.9; 0.3)
July	0.0	(94.3; 73.6)	(88.0; 43.0)	(12.0; 0.0)
August	0.0	(94.2; 74.5)	(89.7;48.7)	(11.3;0.2)

2013

Month	Precipitation (in)	Temperature (°F)	Relative humidity (%)	Wind Speed (mph)
May	0.1	(67.6; 50.4)	(92.3; 58.8)	(15.7; 0.0)
June	0.1	(81.7; 65.4)	(90.0; 55.1)	(13.7; 0.7)
July	0.0	(85.9; 66.3)	(88.6; 43.4)	(11.7; 0.0)
August	0.0	(91.2; 72.3)	(92.9; 54.9)	(12.5; 0.2)

Minimum and maximum precipitation, temperature, relative humidity, and wind speed are presented in parenthesis.
Source: http://www.ars.usda.gov/main/docs.htm?docid = 23623.

Table 3. Summary of percent moisture content for 2013 screening season at Rice Research and Extension Center in Stuttgart, AR.

Scoring time	Percent moisture content	
	V5 field	R1 field
0	43.7	46.1
3	28.3	31.3
6	17.6	19.1

The average % moisture content of 10 random samples taken after the removal a flood.
0 (SC 1) = immediately after flood removal.
3 (SC 2) = the third day after flood removal.
6 (SC 3) = the sixth day after flood removal.

Table 4. Overall Analysis of Variance and P values for the effect 10d flooding on the mean foliar visual scores and percent dead plants of 256 soybean cultivars evaluated in flood tests in Stuttgart, AR in 2012 and 2013.

Visual scores			
Source of Variation	**DF**	**MS**	**P Value**
Stage***	1	1147.5	<.0001
MG	1	2.5	0.2676
MG x Stage	1	113.2	<.0001
Cultivars (MG)	254	8.0	<.0001
Cultivars x Stage (MG)	254	4.9	<.0001
Percent dead plants			
Source of Variation	**DF**	**MS**	**P Value**
Stage***	1	169228.0	<.0001
MG	1	22298.6	<.0001
MG x Stage	1	5834.0	0.0046
Cultivars (MG)	254	1120.8	<.0001
Cultivars x Stage (MG)	254	826.2	0.0019

Plots were flooded for 10 days. Data for 2012 and 2013 flood test combined in the overall ANOVA.
*** Significant at the 0.001 probability level.
Stages: V5 (fifth-node) and R1 (First-bloom).
MG: MG IV (125 cultivars) and MG V (131 cultivars).

Table 5. Analysis of Variance for foliar visual scores and percent dead plants over time for 256 soybean cultivars evaluated in flooded tests in Stuttgart, AR in 2012 and 2013

		Visual scores over time											
		SC 1				**SC 2**				**MSC**			
Source of Variation	**DF**	**MS**	**% Var.**	**F-value**	**P-Value**	**MS**	**% Var**	**F-value**	**P-Value**	**MS**	**% Var.**	**F-value**	**P-Value**
Stage	1	1147.5	89.8	575.6	<.0001	0.0	0.1	0.0	0.96	286.2	68.1	219.5	<.0001
MG	1	2.5	0.2	0.9	0.3298	0.2	0.1	0.2	0.65	1.1	0.3	0.8	0.3693
MG x Stage	1	113.2	8.9	55.5	<.0001	134.6	94.6	119.5	<.0001	123.5	29.4	94.7	<.0001
Cultivars (MG)	254	8.0	0.6	4.0	<.0001	3.6	2.5	3.2	<.0001	5.1	1.2	3.9	<.0001
Cultivars x Stage (MG)	254	4.9	0.4	2.4	<.0001	2.8	2	2.5	<.0001	3.1	0.7	2.4	<.0001
Error	2471	2.0	0.2			1.1	0.8			1.3	0.3		

		Percent dead plants											
Source of Variation		**% DP (SC 1)**				**% DP (SC 2)**				**% MDP**			
Stage	1	167006	84.2	261.7	<.0001	1145.0	2.1	9.54	0.002	35793.5	52	25.83	<.0001
MG	1	22868.1	11.5	35.83	<.0001	15092.2	27.4	125.8	<.0001	13020.2	20	9.4	0.0022
MG x Stage	1	5731.0	2.9	8.98	0.0028	38299.7	69.5	319.2	<.0001	14880.4	21.6	10.7	0.0011
Cultivars (MG)	254	1172.5	0.6	1.84	<.0001	262.2	0.5	2.2	<.0001	1925.1	2.9	1.4	<.0001
Cultivars x Stage (MG)	254	826.2	0.4	1.29	0.0019	193.0	0.4	1.6	<.0001	1846.0	2.7	1.3	0.0006
Error	2482	638.3	0.3			119.9	0.2			1385.9	2.0		

Plots were flooded for 10 days. Mean score and average percent dead plants for two scores were used in the overall ANOVA.
*** Significant at the 0.001 probability level.
Stages: V5 (fifth-node) and R1 (First-bloom).
MG: MG IV (125 cultivars) and MG V (131 cultivars).
SC 1, visual rating immediately after the flood removal; SC 2, visual rating three days after the flood removal; MSC, the average of SC 1 and SC 2.
%DP (SC 1), calculated percentage of dead plants at SC 1, %DP (SC 2), calculated percentage of dead plants at SC 2; %MDP average percentage of dead plants at SC 1 and SC 2.

Table 6. LSMeans and ranges for foliar visual scores of 256 soybean cultivars evaluated in flood tests in Stuttgart, AR in 2012 and 2013.

Scoring method†	Fifth-node (V5)		First-bloom (R1)	
	Mean	**Range**	**Mean**	**Range**
SC 1	8.3a‡	3-8	7.0b	4-9
SC 2	8.5a	4-9	8.5a	5-9
MSC	8.4a	4- 9	7.7b	5-9

Plots were flooded for 10 days at V5 (fifth-node) and R1 (First-bloom)
†SC 1 and SC 2 represent means among different cultivars at different measurement time, (SC 1, visual rating immediately after the flood removal; SC 2, visual rating three days after the flood removal).
MSC, the average of SC 1 and SC 2.
‡ Means across growth stages followed by different letters are significantly different ($p<0.05$) at the same measurement time.

Table 7. LSMeans and ranges of percent dead plants of 256 soybean cultivars in maturity groups IV and V evaluated in flood tests in Stuttgart, AR in 2012 and 2013.

Maturity group IV:

	Fifth-node (V5)		**First-bloom (R1)**	
Scoring method†	**Means**	**Range**	**Mean**	**Range**
% DP (SC 1)	92.8a‡	66 - 100	75.1b‡	46 – 93
% DP (SC 2)	100.0a	76 - 100	91.8b	61 – 100
% MDP	94.8a	67 - 100	83.4b	61 – 96

Maturity group V:

Scoring method	**Fifth-node (V5)**		**First-bloom (R1)**	
	Means	**Range**	**Mean**	**Range**
% DP (SC 1)	84.5a‡	46-99	72.3b‡	38-98
% DP (SC 2)	95.1a	80-100	87.7b	49 -100
% MDP	86.2a	63-99	83.7b	48-100

Plots were flooded for 10 days at V5 (fifth-node) and R1 (First-bloom)
† % DP (SC 1) and % DP (SC 2) represent means of the percentage dead plants of soybean cultivars at different measurement time.
% DP (SC1), calculated percentage of dead plants at SC 1, % DP (SC 2), calculated percentage of dead plants at SC 2; % MDP average percentage of dead plants at SC 1 and SC 2.
‡ Means across growth stages followed by different letters are significantly different (*$p<0.05$*) at the same measurement time.

Table 8. Classification of the foliar visual scores of Arkansas soybean cultivars evaluated at V5 in flood tests in Stuttgart, AR in 2012 and 2013.

Cultivars	Class†	Mean	Range
Progeny 5160LL, R09-1607RR, NK S48-P4 Brand, LG C4625R2	tolerant	4.4	3.3 – 4.8
Halo 5:25, JTN-5110, REV®51R53™, Ozark, USG 75Q42R, Halo 5:45, Go Soy 5111 LL, Go Soy 4910 LL, Dyna-Gro 34LL53, AvDX - E112, Delta Grow 4815RR2, Dyna-Gro 31RY45,Progeny 4611RY, MORSOY XTRA 44X82, Progeny 4211RY	moderate tolerant	6.2	5.4 – 6.8
Go Soy 5010 LL, Pioneer 95Y01, NK S51-H9 Brand, Delta Grow 5461LL, HBK RY5221, Progeny 5210RY, MORSOY XTRA 54X41, AGS 554 RR, Dyna-Gro 32RY55, REV®57R21™, Progeny 5811RY, ARMOR 49-C3, Progeny 5388RY, HALO X55, REV®54R84™, Eagle Seed ES5507, AvDX - V411, Armor X1316, Progeny 5460LL, Croplan R2C5081, JTN-4307, ASGROW AG5632, ASGROW AG5533, Eagle Seed ES5519, Progeny 5610RY, JTN-5108, HALO X51, Dyna-Gro 37RY52, S08-X17371, ARMOR X1315, ASGROW AG5332, ARMOR X1217, DB04-10836, REV®56R21™, ARMOR 55-R22, Croplan R2C5371, ARMOR X1312-5, R04-1268RR, USG 75Z98, ARMOR 53-R15, Hutcheson, USG 75B21R, ASGROW AG5532, Delta Grow 5535RR2, Dyna-Gro 35RY51, Delta Grow 5175RR2, Dyna-Gro S54RY43, ASGROW AG5732, Go Soy 4912 LL, Progeny 4928LL, REV®56R63™, R05-3239, Dyna-Gro S53RY23, HALO X50, ARMOR X1314, Glenn, HBK RY5521, Progeny 5711RY, AGS 553 LL, JTN-4408, Go Soy 5410 LL, Delta Grow 5556RR1, Schillinger 557. RC, Willcross RR2507NS, Delta Grow 5625RR2, HALO X48, Go Soy 4711 LL, S08-X6399, Delta Grow 4967LL, REV®55R53™, REV®55R83™, HALO X478, Pioneer 95Y10, ARMOR X1313, AvDX - E513, MorSoy XTRA 51X52, JTN-5203, HBK RY5421, R05-4114, Go Soy 4812 LL, Progeny 5111RY, USG 74G82L, ASGROW AG5633, S08-X7279, Croplan LC4880, MORSOY XTRA 53X82, AGS 597 RR, REV®59R13™, Progeny 4819LL, Delta Grow 4990LL, Willcross RR2544NS, Croplan R2C5482, NK S56-G6 Brand, Eagle Seed ES5400, Eagle Seed ES5650, Willcross RR2547N, Progeny 5655RY, Delta Grow 4867LL, USG 75J62R, ARMOR 50-C3, USG 74G99L, Schillinger 5220.RC, ASGROW AG5233, AgBorn S06-X9464, HALO X49, REV®52R74™, HALO 4:94, Delta Grow 5475RR2, Pioneer 95Y50, MORSOY 5429, Progeny 5412RY, USG 75Q52R, USG 7553nRS, AGS 568 RR, REV®53R23™, DB03-8416, Dyna-Gro S48LL23, Dyna-Gro 39RY57, Eagle Seed LL, NK S41-J6 Brand, REV®49R10™, AvDX - D613,HALO 4:65,Croplan R2T4799S, ARMOR X1311,ASGROW AG4632,HALO X456, ARMOR X1308,Go Soy 4411 LL, ARMOR 46-R42, Delta Grow 4980RR2, ASGROW AG4232, REV®49R22™, AvDX - D812, NK S44-D5 Brand, REV®46R73™, MORSOY XTRA 46X29, ASGROW AG4533, Delta Grow 4825 RR2/STS, ASGROW AG3833,REV®47R53™, Progeny 4814RY, REV®48R10™, HBK RY4620, Pioneer 95Y40 (RR), ARMOR X1304, Dyna-Gro 39RY43, ASGROW AG4633, Pioneer 94Y70, ARMOR 44-R08, Progeny 4510RY, Progeny 4747RY, ARMOR X1303, NK S46-A1 Brand, Delta Grow 4870RR2, ASGROW AG4933, Croplan R2C4541, MORSOY XTRA 46X71, ARMOR X1305, JGL EXP 480, REV®47R74™, MORSOY XTRA 48X02, LG C4780R2, Delta Grow 4670RR2, Willcross RY2460S,ARMOR DK 4744,S08-X14117,LG C4411R2,Croplan 2C4801S, ARMOR 48-R91,Delta Grow 4715RR2, Pioneer 94Y23.MORSOY XTRA 47X12.MORSOY XTRA 48X00, Schillinger 458.RCS,Asgrow AG4932, AgBorn S08-X0448, Croplan R2C4391, Eagle Seed ES4818, ASGROW AG4433, ASGROW AG4531, Delta Grow 4765RR2/STS, LG C4885R2, Willcross RR2477N, ARMOR 46-R64, ARMOR 48-R40, REV®48R22™, ARMOR X1306, Delta Grow 4575RR2, USG 74A79R, USG 74H92R, Schillinger 495.RC, Dyna-Gro S44RS93,Davis 4148RR2Y, Delta Grow 4875RR2/STS, Dyna-Gro 39D48, HBK R4924, Dyna-Gro S47RY13, HBK RY4721, Willcross RR2878NS, ARMOR X1309, REV®49R54™, REV®48R33™, Progeny 4920RY, Eagle Seed ES4998, MORSOY XTRA 47X31, Delta Grow 4970RR, Willcross RY2482N, Schillinger 457.RCP, REV®49R11™, REV®49R43™, Progeny 4850RY, ARMOR X1312, NK S46-T3 Brand, Progeny 4710RY, Dyna-Gro S48RS53, Schillinger 478.RCS, AGS 45R212, Delta Grow 4975RR, ARMOR X1307, AgBorn S08-X27041, Progeny 4900RY, Delta Grow 4880RR, ARMOR X1310, Delta Grow 4755RR2, AgBorn, S08-X78041, Pioneer 94Y40, Delta Grow 4925RR2, S08-X2499, USG 74B81R, USG 74E88, AGS 43R212, AGS 47R212, ASGROW AG4832, Dyna-Gro 33RY47, NK S49-F8 Brand, USG 74A91	sensitive	8.5	7.0 – 9.0

Plots were flooded for 10 days when plants reached V5 (fifth-node). † Flood tolerance response based on the foliar visual injury scores taken immediately after the flood removal at V5; tolerant (0-4.9), moderate tolerant (5-6.9), sensitive (7-9).

Table 9. Classification of the foliar visual scores of Arkansas soybean cultivars evaluated at R1 in flood tests in Stuttgart, AR in 2012 and 2013.

Cultivars	Class†	Mean	Range
AvDX - E112, Halo 5:45, Halo X50, Armor 53-R15, Ozark,, NK S56-G6 Brand, Halo 5:25, Go Soy 5010 LL, Progeny 4928LL, Willcross RY260S, NK S44-D5 Brand, Armor DK 4744, Asgrow AG4632, REV®49R43™, Armor X1303,Croplan R2T4799S, REV®49R11™, REV®48R22™, REV®47R53™	tolerant	4.5	3.9 – 4.8
Halo X55, R04-1268RR, Go Soy 4711 LL, AgBorn S06-X9464, Go Soy 5410 LL, Progeny 5160LL, Dyna-Gro 34LL53, Hutcheson, USG 75Z98, Dyna-Gro S54RY43, Go Soy 5111 LL, Glenn, MorSoy XTRA 53X82, USG 75Q42R, REV®55R53™, REV®54R84™, REV®57R21™, Croplan R2C5482, Halo X49, REV®52R74™, Croplan LC4880, Progeny 5811RY, Asgrow AG5632, DB04-10836, REV®55R83™, Armor X1314, Armor X1217, Armor X1315, S08-X6399, Pioneer 95Y01, Willcross RR2507NS, Dyna-Gro 37RY52, Delta Grow 4967LL, Armor 46-R64, Pioneer 94Y70, REV®46R73™,REV®49R54™,MorSoy XTRA 46X29, NK S46-A1 Brand, S08-X14117,AvDX - D812, HBK R4924,AvDX - D613, AgBorn S08-X78041, AgBorn S08-X27041,Dyna-Gro 31RY45, Progeny 4814RY, Armor 48-R40, REV®49R10™, Armor X1308, LG C4411R2, Schillinger 457.RCP, Dyna-Gro 33RY47, Go Soy 4411 LL, Delta Grow 4980RR2, REV®47R74™, Asgrow AG4533, Asgrow AG4232, LG C4625R2, NK S41-J6 Brand, Halo X456, REV®48R10™, HBK RY4620, Delta Grow 4575RR2, Croplan R2C4541, ASGROW AG4531, NK S48-P4 Brand,Dyna-Gro 39D48, USG 74H92R, Delta Grow 4870RR2, Delta Grow 4970RR, USG 74A79R, Schillinger 478.RCS, JGL EXP 480, Armor 46-R42, Progeny 4510RY, Armor X1309, MorSoy XTRA 44X82, Armor X1306	moderate tolerant	5.6	5.1 – 6.9
REV®51R53™, Eagle Seed ES5507, Progeny 5610RY, REV®56R21™, HBK RY5221, Go Soy 4910 LL, Dyna-Gro S53RY23, Eagle Seed LL, Asgrow AG5532, AvDX - V411, Halo X478, AGS 597 RR, Halo 4:94, MorSoy XTRA 54X41, Asgrow AG5332, Pioneer 95Y10, JTN-5108, Dyna-Gro 39RY57, Asgrow AG5533, Croplan R2C5371, R09-1607RR, JTN-5110, Armor X1316, Halo O X51, Dyna-Gro 32RY55, USG 75Q52R, Delta Grow 5461LL, Delta Grow 5475RR2, REV®56R63™, AGS 553 LL, REV®59R13™, Armor X1313, Progeny 5655RY, AGS 568 RR, Pioneer 95Y50, Schillinger 5220.RC, Schillinger 557. RC, AGS 554 RR, Eagle Seed ES5650, Delta Grow 5625RR2, USG 74G99L, Eagle Seed ES5519, Progeny 5111RY, USG 75B21R, JTN-4408, Progeny 5412RY, MorSoy 5429, S08-X17371, Halo X48, Dyna-Gro S48LL23, Progeny 5388RY, Willcross RR2544NS, Delta Grow 5535RR2, HBK RY5521, AvDX - E513, Go Soy 4912 LL, Delta Grow 5556RR1, Progeny 5210RY, R05-4114, NK S51-H9 Brand, REV®53R23™, Armor X1312-5, Dyna-Gro 35RY51, Armor 50-C3, HBK RY5421, JTN-5203, USG 74G82L, Asgrow AG5233, Progeny 5460LL, Delta Grow 5175RR2, Progeny 4819LL, Progeny 5711RY, MorSoy XTRA 51X52, Asgrow AG5633, Eagle Seed ES5400, USG 7553nRS, R05-3239, Armor 49-C3, Delta Grow 4867LL, Armor 55-R22, USG 75J62R, Asgrow AG5732, DB03-8416, Go Soy 4812 LL, Croplan R2C5081, Delta Grow 4990LL, S08-X7279, Willcross RR2547N, JTN-4307, Willcross RR2878NS, Asgrow AG4832, Croplan R2C4801S, AGS 45R212, Delta Grow 4670RR2, Eagle Seed ES4998, Halo 4:65, Pioneer 95Y40 (RR), Pioneer 94Y23, MorSoy XTRA 46X71, Schillinger458.RCS, REV®48R33™, Progeny 4850RY, NK S46-T3 Brand, HBK RY4721, AGS 47R212, Armor X1311, LG C4780R2, Willcross RY2482N, REV®49R22™, Dyna-Gro S47RY13, Asgrow AG3833, ASGROW AG4933, Progeny 4920RY, Delta Grow 4875RR2/STS, Progeny 4611RY, NK S49-F8 Brand,ASGROW AG4932, Delta Grow 4715RR2, Armor 48-R91, Dyna-Gro S48RS53, Progeny 4710RY, Armor X1312, Armor X1304, Eagle Seed ES4818, Davis 4148RR2Y, Delta Grow 4825 RR2/STS, Dyna-Gro 39RY43, Armor 44-R08, MorSoy XTRA 47X12, Armor X1305, AgBorn S08-X0448, AGS 43R212, USG 74A91, USG 74E88, LG C4885R2, Delta Grow 4975RR, Croplan R2C4391, Pioneer 94Y40, Delta Grow 4815RR2, S08-X2499, Progeny 4211RY, MorSoy XTRA 48X02,Asgrow AG4433, Delta Grow 925RR2, Willcross RR2477N, USG 74B81R, MorSoy XTRA 48X00, Asgrow AG4633, Delta Grow 4765RR2/STS, Delta Grow 4880RR, Armor X1307, Schillinger 495.RC, Progeny 4900RY, Delta Grow 4755RR2, Dyna-Gro S44RS93, Armor X1310,MorSoy XTRA 47X31, Progeny 4747RY	sensitive	8.0	7.0 – 9.0

Plots were flooded for 10 day at R1 (First-bloom). †Flood tolerance response based on the foliar visual injury scores taken immediately after the flood removal; tolerant (0-4.9), moderate tolerant (5-6-9), sensitive (7-9).

Table 10. Differential flood tolerance response in foliar visual scores of MG IV soybean cultivars evaluated at V5 and R1 flood test in Stuttgart, AR in 2012 and 2013.

Cultivar	Flooded at V5 †	Cultivar	Flooded at R1 ‡
NK S48-P4 Brand	4.7	Willcross RY2460S	4.0
LG C4625R2	4.8	NK S44-D5 Brand	4.1
Delta Grow 4815RR2	5.4	Armor DK 4744	4.2
Dyna-Gro 31RY45	5.7	AsgrowAG4632	4.4
Progeny 4611RY	5.9	REV®49R43™	4.7
		Armor X1303	4.7
		Croplan R2T4799S	4.7
		REV®49R11™	4.8
Average	**5.3**		**4.5**
Schillinger 457.RCP	9.0	Schillinger 495.RC	8.2
REV®49R11™	9.0	Progeny 4900RY	8.2
REV®49R43™	9.0	Delta Grow 4755RR2	8.2
Progeny 4850RY	9.0	Dyna-Gro S44RS93	8.2
Armor X1312	9.0	Armor X1310	8.2
NK S46-T3 Brand	9.0	LG C4780R2	8.3
Progeny 4710RY	9.0	MorSoy Extra 47X31	8.3
Dyna-Gro S48RS53	9.0	Armor 44-R08	8.3
Schillinger 478.RCS	9.0	AsgrowAG4633	8.3
AGS 45R212	9.0	Progeny 4747RY	8.3
Delta Grow 4975RR	9.0	AsgrowAG4433	8.4
Armor X1307	9.0	MorSoy Extra 48X02	8.5
AgBorn S08-X27041	9.0	Delta Grow 4925RR2	8.5
Average	**9.0**		**8.3**

† mean foliar visual score after 10 days of flooding at the V5 (fifth-node).
‡ mean foliar visual score after 10 days of flooding at the R1 (First-bloom).
Foliar visual scores taken at SC 1 (immediately after flood removal).

Table 11. Differential flood tolerance response in foliar visual scores of MG V soybean cultivars evaluated at V5 and R1 flood tests in Stuttgart, AR in 2012 and 2013.

Cultivar	Flooded at V5†	Cultivar	Flooded at R1‡
Progeny 5160LL	3.3	AvDX - E112	3.9
R09-1607RR	4.6	Halo 5:45	4.1
Halo 5:25	6.0	Halo X50	4.5
Ozark	6.3	Armor 53-R15	4.5
Halo 5:45	6.5	Ozark	4.6
Dyna-Gro 34LL53	6.7	NK S56-G6 Brand	4.6
AvDX - E112	6.8	Halo 5:25	4.7
		Go Soy 5010 LL	4.8
		Progeny 4928LL	4.8
Average	**5.7**		**4.5**
Dyna-Gro S48LL23	9	Dyna-Gro S48LL23	8.1
Go Soy 4812 LL	8.6	Go Soy 4812 LL	8.8
Go Soy 4912 LL	8.2	Go Soy 4912 LL	8.2
Progeny 4819LL	8.8	Progeny 4819LL	8.5
R05-3239	8.3	R05-3239	8.6
AvDX - E513	8.5	AvDX - E513	8.2
Delta Grow 5535RR2	8.2	Delta Grow 5535RR2	8.2
Eagle Seed ES5400	8.8	Eagle Seed ES5400	8.5
Dyna-Gro 32RY55	7.4	Dyna-Gro 32RY55	7.7
Eagle Seed ES5400	8.8	Eagle Seed ES5400	8.5
Willcross RR2547N	8.8	Willcross RR2547N	8.8
JTN-4408	8.3	JTN-4408	8
Average	**8.5**		**8.3**

† mean foliar visual score after 10 days of flooding at the V5 (fifth-node).
‡ mean foliar visual score after 10 days of flooding at the R1 (First-bloom) .
Foliar visual scores taken at SC 1 (immediately after flood removal).

Table 12. Flood tolerant/sensitive soybean cultivars with contrasting foliar scores across maturity groups and growth stages

MG IV			MG V		
Cultivar	**Flooded at V5**	**Flooded at R1**	**Cultivar**	**Flooded at V5**	**Flooded at R1**
Dyna-Gro 31RY45 †	5.7	5.6	Progeny 5160LL	3.3	5.3
LG C4625R2	4.8	6.2	Halo 5:25	6.0	4.7
NK S48-P4 Brand	4.7	6.5	Ozark	6.3	4.6
			Halo 5:45	6.5	4.1
			AvDX - E112	6.8	3.9
			R09-1607RR	4.6	7.6
Asgrow AG4632‡	7.7	4.4	Progeny 4928LL	8.2	4.8
Armor X1303	8.5	4.7	Armor 53-R15	8.1	4.5
REV®46R73™	8.2	5.2	R04-1268RR	8.0	5
Willcross RY2460S	8.7	4.0	NK S56-G6 Brand	8.8	4.6
Armor DK 4744	8.7	4.2	Go Soy 5010 LL	7.0	4.8
Armor 46-R64	8.8	5.1	Halo X50	8.3	4.5
Asgrow AG4433§	8.7	8.4	Progeny 4819LL	8.8	8.5
Armor X1307	9.0	8.0	R05-3239	8.3	8.6
Delta Grow 4755RR2	9.0	8.2	AvDX - E513	8.5	8.2
Delta Grow 4925RR2	9.0	8.5	Delta Grow 5535RR2	8.2	8.2
Asgrow AG4433	8.7	8.4	Eagle Seed ES5400	8.8	8.5
Willcross RR2477N	8.8	8.7	Delta Grow 4990LL	8.8	8.8
MorSoy XTRA 47X31	8.9	8.3	Eagle Seed ES5400	8.8	8.5

Foliar visual scores at SC 1(immediately after flood removal).
† Low foliar visual scores at both V5 and R1.
‡ High foliar visual score at V5 but low score at R1.
§ High foliar visual scores at V5 and R1.

Table 13. Classification of the percent dead plants of Arkansas soybean cultivars in MG V evaluated at V5 in flood tests in Stuttgart, AR in 2012 and 2013.

Cultivars	Class[†]	Mean	Range
Progeny 5160LL, Halo 5:25, REV®56R63™	Moderate tolerant	54.8	46.1-59.7
Dyna-Gro 34LL53, R09-1607RR, JTN-5110, Halo 5:45, USG 75Q42R, Ozark, Go Soy 4912 LL, HBK RY5221, Go Soy 5111 LL, Go Soy 5010 LL, MorSoy XTRA 54X41, Armor 55-R22, Armor X1217, Hutcheson, Progeny 5210RY, Dyna-Gro 37RY52, AvDX - E112, REV®57R21™, Armor 53-R15, Go Soy 4711 LL, Progeny 5811RY, Delta Grow 5625RR2, REV®51R53™, NK S51-H9 Brand, Croplan R2C5081, Dyna-Gro 32RY55, Asgrow AG5632, Croplan R2C5371, Progeny 5388RY, Pioneer 95Y01, S08-X17371, Go Soy 4910 LL, Halo X51, Armor X1316, AvDX - V411, Progeny 5610RY, REV®56R21™, Armor 49-C3, AgBorn S06-X9464, Progeny 5460LL, Asgrow AG5732, JTN-4307, Asgrow AG5532, AGS 554 RR, REV®54R84™, Halo X55, USG 75B21R, AGS 597 RR, R05-3239, Armor X1314, MorSoy XTRA 53X82, Eagle Seed ES5507, REV®55R83™, Delta Grow 5461LL, Progeny 5711RY, R04-1268RR, Armor X1315, Eagle Seed ES5519, Progeny 5412RY, Go Soy 5410 LL, Progeny 4928LL, Croplan LC4880, HBK RY5521, Halo 4:94, USG 74G99L, Delta Grow 5535RR2, Delta Grow 5175RR2, Delta Grow 5556RR1, REV®59R13™, Dyna-Gro 35RY51, Delta Grow 5475RR2, Asgrow AG5533, USG 75Z98, Willcross RR2507NS, Dyna-Gro S54RY43, Croplan R2C5482, AGS 553 LL, Dyna-Gro S53RY23, Armor X1312-5, MorSoy XTRA 51X52, Delta Grow 4990LL, Halo X48, Willcross RR2547N, DB04-10836, Pioneer 95Y10, Glenn, R05-4114, JTN-5108, Armor 50-C3, Halo X50, REV®55R53™, S08-X6399, JTN-5203, AvDX - E513, Go Soy 4812 LL, Eagle Seed ES5650, JTN-4408, Schillinger 557. RC, HBK RY5421, Progeny 4819LL, Armor X1313, Willcross RR2544NS, Pioneer 95Y50, Halo X478, Halo X49, USG 74G82L, Delta Grow 4967LL, Delta Grow 4867LL, Progeny 5111RY, USG 75Q52R, Asgrow AG5332, NK S56-G6 Brand, Eagle Seed ES5400, Asgrow AG5633, Dyna-Gro 39RY57, S08-X7279, DB03-8416, Progeny 5655RY, Dyna-Gro S48LL23, Eagle Seed LL, USG 75J62R, REV®52R74™, REV®53R23™, MorSoy 5429, Asgrow AG5233, AGS 568 RR, Schillinger 5220.RC, USG 7553nRS	sensitive	85.2	61.0-99.4

Plots were flooded for 10 days when plants reached V5 (fifth-node).
†Flood tolerance response of MG V cultivars based on the foliar visual injury scores taken immediately after the flood removal; tolerant (0-4.9), moderate tolerant (5-6-9), sensitive (7-9).

Table 14. Classification of the percent dead plants of Arkansas soybean cultivars in MG V evaluated at R1 in flood tests in Stuttgart, AR in 2012 and 2013.

Cultivars	Class†	Mean	Range
Hutcheson	tolerant	38.2	38.2
Halo 5:25, Halo X55, Halo 5:45, Halo X50, Progeny 5160LL, Dyna-Gro 34LL53, Go Soy 5111 LL, HBK RY5221, R04-1268RR, MorSoy XTRA 53X82, AvDX - E112, AgBorn S06-X9464, Ozark, , Croplan R2C5482, Armor X1314, S08-X6399, NK S56-G6 Brand, Dyna-Gro S54RY43, Go Soy 4711 LL, Croplan LC4880, REV®56R21™, Willcross RR2507NS, Dyna-Gro 37RY52, Pioneer 95Y01, Halo X49, Delta Grow 5475RR2, Schillinger 557. RC, AGS 597 RR, REV®55R53™, Dyna-Gro 32RY55, REV®57R21™, Delta Grow 5461LL, USG 75Z98, Progeny 5811RY, REV®55R83™, USG 75Q42R, Go Soy 5410 LL, Progeny 5210RY, Go Soy 4910 LL, Armor 53-R15, DB04-10836, Armor X1217, Progeny 4928LL, Pioneer 95Y10, Go Soy 5010 LL, USG 75Q52R, Asgrow AG5532, Delta Grow 4967LL, Schillinger 5220.RC, Asgrow AG5332	moderate tolerant	59.6	44.6 –68.9
AvDX - E513, REV®51R53™, MorSoy XTRA 54X41, Asgrow AG5533, R05-3239, Dyna-Gro S53RY23, R09-1607RR, Eagle Seed ES5650, Eagle Seed ES5507, NK S51-H9 Brand, Asgrow AG5632, USG 74G82L, Progeny 5412RY, REV®54R84™, Progeny 5610RY, S08-X17371, Glenn, Go Soy 4912 LL, Dyna-Gro S48LL23, AGS 554 RR, Halo 4:94, Armor X1313, MorSoy XTRA 51X52, Progeny 5711RY, JTN-5108, REV®56R63™, Armor X1316, Progeny 5388RY, Armor X1315, Go Soy 4812 LL, Delta Grow 4867LL, REV®52R74™, Progeny 5111RY, Croplan R2C5371, Progeny 5460LL, Eagle Seed LL, Delta Grow 5625RR2, R05-4114, AvDX - V411, USG 75B21R, Delta Grow 5535RR2, JTN-4408, Armor 55-R22, AGS 553 LL, Delta Grow 5175RR2, JTN-5203, Croplan R2C5081, REV®53R23™, Progeny 5655RY, Willcross RR2544NS, REV®59R13™, Armor 50-C3, Halo X48, AGS 568 RR, Dyna-Gro 35RY51, USG 74G99L, MorSoy 5429, Halo X478, Progeny 4819LL, Pioneer 95Y50, Armor X1312-5, Eagle Seed ES5519, Delta Grow 4990LL, Dyna-Gro 39RY57, JTN-5110, Halo X51, HBK RY5521, Armor 49-C3, USG 75J62R, Delta Grow 5556RR1, Asgrow AG5633, Asgrow AG5233, S08-X7279, DB03-8416, Eagle Seed ES5400, Asgrow AG5732, USG 7553nRS, HBK RY5421, Willcross RR2547N, JTN-4307	sensitive	80.7	70.0 – 97.9

Plots were flooded for 10 day at R1, first-bloom.
†Flood tolerance response of MG V cultivars based on the foliar visual injury scores taken immediately after the flood removal; tolerant (0-4.9), moderate tolerant (5-6-9), sensitive (7-9).

Table 15. Differential flood tolerance response in percent dead plants of MG IV soybean cultivars evaluated at V5 and R1 flood tests in Stuttgart, AR in 2012 and 2013.

Flood Screening MG IV			
Cultivar	**Flooded at V5†**	**Cultivar**	**Flooded at R1‡**
LG C4625R2	65.9	Willcross RY2460S	45.5
NK S41-J6 Brand	66.1	Croplan R2T4799S	46.5
Asgrow AG4632	67.5	REV®46R73™	47.3
Average	**66.5**		**46.4**
Armor X1309	98.8	Dyna-Gro S44RS93	88.9
S08-X2499	99.1	Delta Grow 4975RR	89.3
Schillinger 457.RCP	99.2	USG 74E88	89.6
Schillinger 478.RCS	99.2	Progeny 4211RY	89.7
Pioneer 94Y40	99.4	Croplan R2C4391	89.9
Delta Grow 4975RR	99.6	Delta Grow 4755RR2	90.8
Delta Grow 4925RR2	99.7	MorSoy XTRA 48X02	91.4
Progeny 4900RY	99.8	Delta Grow 4765RR2/STS	91.9
USG 74E88	100.0	Delta Grow 4925RR2	93.1
Average	**99.6**		**90.5**

† mean % DP after 10 days of flooding at the V5 (fifth-node) .
‡ mean % DP after 10 days of flooding at the R1 (First-bloom).
Percentage dead plants (% DP SC 1) were taken immediately after flood removal.

Table 16. Differential flood tolerance response in percent dead plants of MG V soybean cultivars evaluated at V5 and R1 flood tests in Stuttgart, AR in 2012 and 2013.

Flood Screening MG V			
Cultivar	**Flooded at V5†**	**Cultivar**	**Flooded at R1‡**
Progeny 5160LL	46.1	Hutcheson	38.2
Halo5:25	58.6	Halo 5:25	44.6
REV®56R63™	59.7	Progeny 5160LL	45.4
Dyna-Gro 34LL53	61.0	Halo 5:45	45.6
R09-1607RR	65.8	Dyna-Gro 34LL53	48.3
JTN-5110	66.0	Go Soy 5111 LL	49.4
Average	**59.4**		**46.1**
REV®52R74™	97.4	Asgrow AG5233	91.7
REV®53R23™	97.4	S08-X7279	92.1
MorSoy 5429	97.6	DB03-8416	92.4
Asgrow AG5233	98.4	Eagle Seed ES5400	92.7
AGS 568 RR	98.7	Asgrow AG5732	92.8
Schillinger 5220.RC	99.4	USG 7553nRS	93.0
USG 7553nRS	99.4	HBK RY5421	93.1
Average	**98.3**		**92.5**

† mean % DP after 10 days of flooding at the V5 (fifth-node).
‡ mean % DP after 10 days of flooding at the R1 (First-bloom).
Percentage dead plants (% DP SC 1) were taken immediately after flood removal.

Table 17. Flood tolerant/sensitive soybean cultivars with contrasting response in percent dead plants across maturity groups and growth stages.

MG IV			MG V		
Cultivar	Flooded at V5	Flooded at R1	Cultivar	Flooded at V5	Flooded at R1
NK S41-J6 Brand	66.1	69.5	Halo5:25	58.6	44.6
LG C4625R2†	65.9	68.6	Progeny 5160LL	46.1	45.4
Willcross RY2460S‡	85.7	45.5	Dyna-Gro 34LL53	61	48.3
Croplan R2T4799S	82	46.5	Go Soy 5111 LL	69.9	49.4
REV®46R73™	86.7	47.3	R04-1268RR	85.3	50.4
MorSoy XTRA 46X29	84.9	49.8	AgBorn S06-X9464	81.1	54.5
Dyna-Gro 31RY45§	69.1	72.1	JTN-5110	66	86.4
Delta Grow 4880RR¶	98.8	86.6	USG 75J62R	97	88.4
Delta Grow 4975RR	99.6	89.3	Asgrow AG5633	94.8	89.3
Delta Grow 4925RR2	99.7	93.1	S08-X7279	95.1	92.1
USG 74E88	100	89.6	DB03-8416	95.4	92.4

Percentage dead plants (% DP SC 1) taken immediately after flood removal.
† Low % DP at both V5 and R1.
‡High % DP at V5 but low at R1.
§ Low % DP at V5 but high at R1.
¶ High % DP at V5 and R1.

Table 18. Correlation coefficients among mean values for visual scores and percentage dead plants in 256 soybean cultivars evaluated in flooded tests at V5 growth stage in Stuttgart, AR in 2012 and 2013.

Scoring method	SC 2	MSC	%DP (SC 1)	%DP (SC 2)	%MDP
SC 1	0.85***	0.96***	0.72***	0.75***	0.72***
SC 2		0.95***	0.70***	0.74***	0.70***
MSC			0.74***	0.76***	0.74***
%DP (SC 1)				0.67***	0.95***
%DP (SC 2)					0.47***

*** Significant at the <0.001 levels of probability.
SC 1, visual rating immediately after the flood removal; SC 2, visual rating three days after the flood removal; MSC, the average of SC 1 and SC 2.
%DP (SC 1), calculated percentage of dead plants at SC 1, %DP (SC 2), calculated percentage of dead plants at SC 2; %DP average percentage of dead plants at SC 1 and SC 2.

Table 19. Correlation coefficients among mean values for visual scores and percentage dead plants in 256 soybean cultivars evaluated in flooded tests at R1 growth stage in Stuttgart, AR in 2012 and 2013.

Scoring method	SC 2	MSC	% DP (SC 1)	%DP (SC 2)	%DP
SC 1	0.63***	0.94***	0.51***	0.41***	0.52***
SC 2		0.84***	0.47***	0.53***	0.53***
MSC			0.55***	0.50***	0.58***
% DP (SC 1)				0.64***	0.96***
% DP (SC 2)					0.81***

*** Significant at the <0.001 levels of probability.
SC 1, visual rating immediately after the flood removal; SC 2, visual rating three days after the flood removal; MSC, the average of SC 1 and SC 2.
%DP (SC 1), calculated percentage of dead plants at SC 1, %DP (SC 2), calculated percentage of dead plants at SC 2; %DP average percentage of dead plants at SC 1 and SC 2.

Fig. 1. Field layout for the flood tests in Stuttgart, AR (Jane Mokua).

Fig. 2. Dramatic comparison of visual scores between extreme genotypes in response to flooding in the field after flood was removed (Jane Mokua).

1= tolerant
9= sensitive

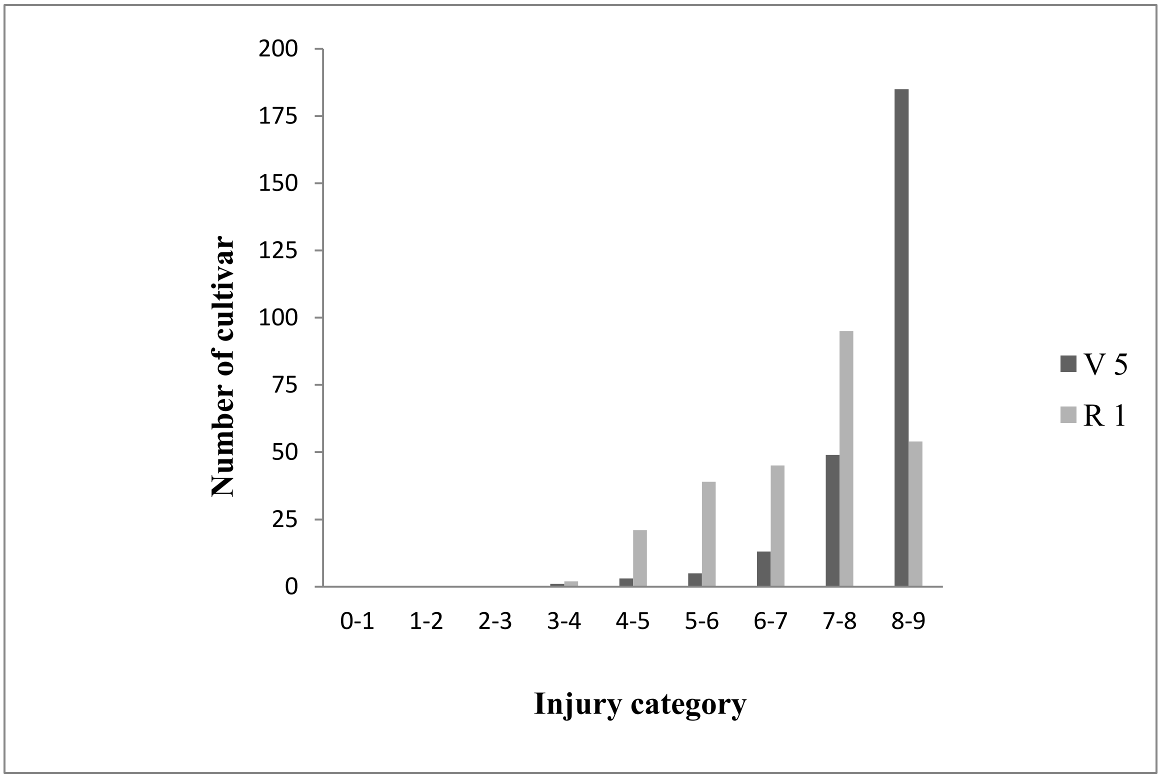

Fig. 3. Frequency distribution of foliar visual scores in 256 soybean cultivars evaluated at the removal of 10-day flooding (first scoring) at V5 or R1 in flood tests in Stuttgart, AR.

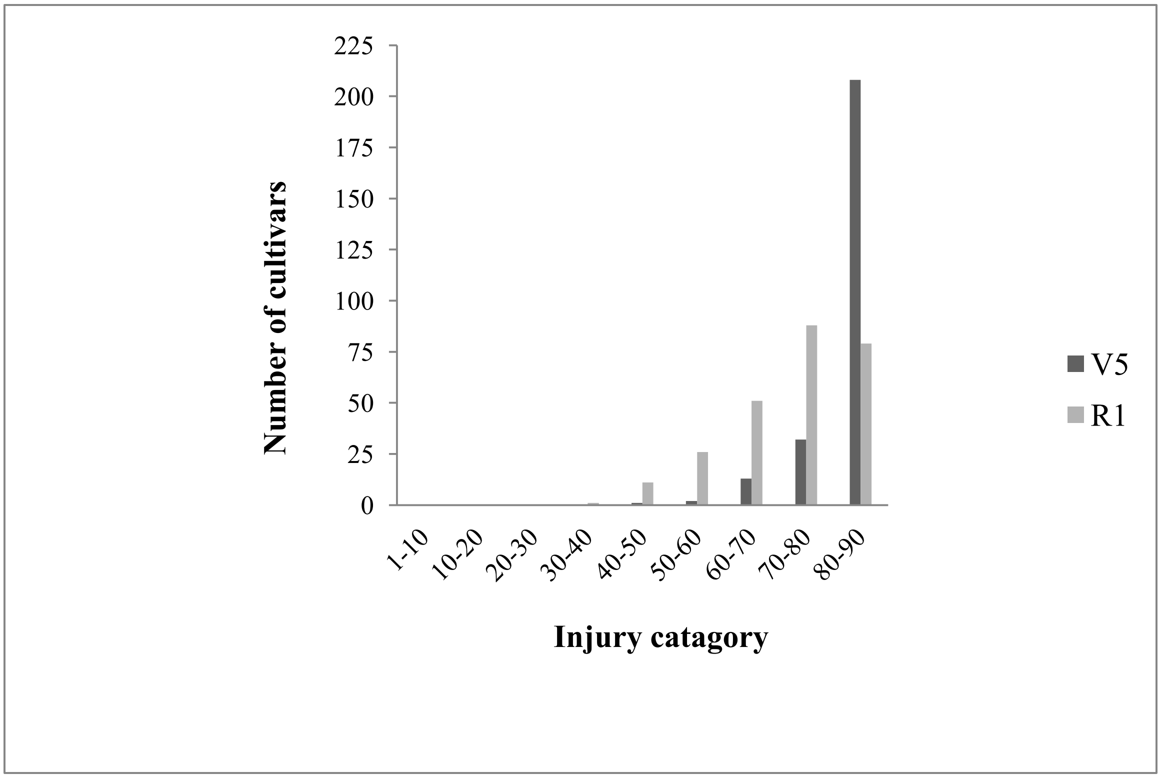

Fig. 4. Frequency distribution of the percentage of dead plants in 256 soybean cultivars evaluated at the removal of 10-day flooding (first scoring) at V5 or R1 in flood tests in Stuttgart, AR.

CHAPTER III

FIELD SCREENING FOR FLOOD TOLERANCE IN SOYBEAN CULTIVARS AT DIFFERENT FLOOD DURATIONS

ABSTRACT

The influence of factors such as flooding duration, plant growth stage, site characteristics, and environmental conditions on crop survival following flooding have limited researcher's ability to select flood tolerant crops. Although the effect of length of flooding has been documented in various crops, ranging from a few hours to several days, flood responses have been poorly documented. Sets of screening tests for flood tolerance were conducted in the field in Stuttgart, AR in 2013 and 2014 with the purpose of establishing an effective flood tolerance screening protocol in soybeans. In the 2013 flood test, thirty soybean cultivars were subjected to 5, 10, and 15-day flood duration treatments at R1 and scored for the flood damage on the 1st, 3rd, and 6th day after the removal of flood. In 2014, forty cultivars were subjected to 3, 6, 9, 12, and 15-day flooding duration treatments at V5 and R1 and flood damage scored on the 2nd, 4th, 6th, and 8th day after removal of flood. Flood duration, scoring time, and growth stage had a significant effect on genotypic scoring response to flooding. Damage caused by flood increased linearly with flood duration and time after flood removal. Plants were more sensitive to flooding at R1 than V5 in their foliar visual scores and percent dead plants. Significant reduction of chlorophyll content was observed in plants subjected to longer flooding durations. Data for foliar visual scores and percent dead plants can support decisions in identifying flood-tolerant cultivars. Five flood tolerance screening methods in soybeans were established: a 5-day flood at R1 growth stage following flood damage ratings a week after flood removal, a 10-day flood at R1 growth stage and flood damage ratings done immediately after flood removal, a 6-day flood at the R1 growth stage, 9-day flood at the V5 growth stage and measurement of leaf chlorophyll content before and after flood.

INTRODUCTION

Over past decades, there has been considerable progress by plant breeders to increase adaptability of crops to a biotic stresses such as droughts and floods (Voesenek and Bailey-Serres, 2013). In soybeans, flood tolerance screening research has been done extensively under field, greenhouse, and growth chamber/laboratory conditions (Van Toai et al., 2010). However, the effort of selecting flood- tolerant cultivars for breeding purposes has been hindered by lack of enough data and efficient screening techniques (Singh et al, .1997b). Although significant variations in flood tolerance have been observed among cultivars, plant species and root stocks, the ability to identify true flood- tolerant species has been highly influenced by the following factors; timing and duration of flooding, plant age, site characteristics, and environmental conditions (Keneni et al., 2001; Van Toai et al., 1994; Colmer and Voesenek, 2009; Scott et al., 1989; Kozlowski and Pallardy, 1997b).

Previous studies have evaluated flood tolerance in soybean cultivars under different durations, ranging from shorter to longer periods of flood, whether from flood irrigation, rainfall or pond water. Flooding at any duration can be detrimental to soybeans, although, some soybean cultivars acclimate to flooding stress by resuming normal growth and development after the stress is varied (Troedson et al., 1989). Shorter flooding durations are presumed to be less injurious compared to longer durations as less energy is required for biochemical mechanisms and morphological adaptation (Bacanamo and Purcell, 1999b: Kirk et al., 2003). Several researchers have documented specific effects of flooding durations on soybeans. Heatherly and Pringle (1991) reported 1 to 2 days of flood irrigation did not impact soybean yield. However, they proposed that longer periods of flood might result in yield loss. Scott et al. (1989; 1990) observed variation in dry weight, canopy height, and seed yield when soybeans were flooded between 2-14 days or for 7 continuous days, depending on growth stage. While Van Toai et al., (1994) observed yield loss averaging to 25% loss in 84 soybean genotypes flooded for 4 weeks. On the other hand, Henshaw et al., (2007) observed that flooding for up to 4 weeks does not result in plant death in either tolerant or susceptible soybean genotypes.

It is of great importance to establish the appropriate flooding duration for screening of flood tolerance among soybean cultivars. Most of the past research has evaluated flood tolerance based on yield criterion which is time consuming and expensive. The development of flood-tolerant cultivars through early selection criteria and breeding is of significant economic value for increasing production in areas prone to flooding and poor drainage.

In the present study, I build my work from the previous chapter, extending my research on early reliable criteria of screening and identification of flood-tolerant soybean genotypes by conducting a comprehensive evaluation on genotypic response of soybean cultivars to flooding duration and subsequent post- flood response at the V5 and R1growth stages.

MATERIALS AND METHODS

Plant Materials

Thirty (2013) and forty (2014) soybean cultivars with contrasting responses to flood (based on a preliminary screening; data not shown) were selected from the UA soybean breeding program, plant introductions (PI), and companies across the United States for independent flood tolerance studies. The cultivars from both years were grouped into two categories. For instance, for the 2013 cultivars, fifteen were tolerant and the other fifteen sensitive to flood. These cultivars ranged from early maturity group (MG) IV to late V (Appendices 3 and 4).

Site Description

Two independent flood- tolerance studies were established during the summer of 2013 and 2014 at the Rice Research and Extension Center near Stuttgart, AR 34˚469′N, 91˚420′W. The soil type is Dewitt silt loam (fine, smectitic, thermic Typic Albaqualfs), known to be deep, poorly drained, and very slowly permeable with a plow pan at 0.4m Stuttgart has a level to gently sloping flood plain with a 0.25% slope (Scott 1998; Oosterhuis et al., 1989; Sallam and Scott, 1987). The climate in this area is characterized by hot humid summers and generally mild to cool winters. Lower monthly rainfall is experienced in the summer months of June, July, and August compared to the rest of the year. Daily temperatures recorded from the National Oceanic and Atmosphere Administration (NOAA) weather station located at the station are characterized by maximum monthly air temperature ranging from 10 to 30°C during the growing season. Relative humidity ranged between near 50 to 90% as shown in Table 2.

Cultural Practices Treatments and Experimental Design

In 2013 and 2014, cultural practices such as disking, floating, and fertilization were done before planting. Floating is a practice done on the field to smoothen and fill the holes. Pre-emergence herbicide of Valor XLT Soybean Herbicide at 3 to 5 oz/A was sprayed to suppress weeds. Plots were planted on raised beds on May 22 and May 16 in 2013 and 2014 respectively, at the seeding rate of 100 seeds per plot. Each plot consisted a single cultivar that was replicated 3 times. Row spacing was 3m long and 1.5m between row spacing. All plots were treated as normal irrigated plots until 50% of soybeans reached their respective stage of treatment. Before flood treatments, leaves were constructed surrounding each of the flooding duration and growth stage. The initial stand count was done before imposing the stress.

In the 2013 study, the area of the field was divided into three equal-sized parts, each part assigned to a different flooding duration. The first treatment received a 5-day flood treatment R1, the second 10-day flood treatment at R1, and the third 15-day flood treatment R1. Flood damage for foliar visual damage and percent dead plants (% DP) for each plot were rated three times (1, 3, 6-day interval or SC 1, SC 2, SC 3) in 3-day interval following post-flood removal. Soil moisture content was measured at each rating time (Table 20).

Similarly, in 2014 study, the field area was divided into five equal-sized parts, each part assigned to a different flooding duration. The treatments were 3, 6, 9, 12, and 15-day flood at V5 and R1 growth stages. Flood damage for foliar visual damage and % DP for each plot were rated at 2-day intervals four times (2, 4, 6, 9-days or SC 1, SC 2, SC 3, SC 4) following post-flood removal.

The 2013 study, the experiment was arranged in randomized complete block design (RCBD) for each of the flood duration. The experimental design for the 2014 was a spit-plot with growth stage as the whole-plot factor. The whole-plot was RCBD. The split-plot factor was flooding duration. The factorial structure included duration x growth stage, cultivar x growth stage, duration x genotype, and duration x growth stage x cultivar.

Data Collection and Statistical Analysis

The initial stand counts were recorded a week before flooding treatment was applied to the plots. At post-flood, visual foliar injury score based on visual symptoms of foliar burning, wilting, chlorosis, yellowing, plant death, browning, and necrosis, were determined from each plot at three times with three days between viewing and four times with 2 days between viewing in 2013 and 2014 respectively. For instance, in the 2013 study first score (SC 1) was taken immediately or the same day the flood was removed, second score (SC 2) three days after the flood removal, and third score (SC 2) six days after the flood removal. A 0 to 9 scale as per protocol described in Cornelius (2003) was used to rate flood damage, 0 being no flood damage and 9 being ≥ 90% of plants dead. Rating was done on a continuous scale however, classification of flood damage was considered numerical in three distinct categories: 1) tolerant 0-4 or ≤ 30% dead plants, 2) moderate tolerant 5-6 or ≥ 30-60% dead plants, and 3) sensitive 7-9 or ≥ 70% dead plants (Table 1). Therefore, genotypic flood tolerance was determined based on these categories. The number of plants that survived at post-flood was recorded at each scoring period and the percentage dead plants (% DP) was calculated according to the formula:

$$\%DP = \left\{\frac{(Initial\ stand\ count - Plants\ alive\ at\ each\ scoring\ period)}{\text{Initial stand count}}\right\} X\ 100$$

Six top extensive leaf points/cultivars in each treatment were used to analyze leaf chlorophyll content before and after flood using the SPAD 502 as a diagnostic tool for the evaluation of soybean chlorophyll content. The results in each of the flooding duration were averaged and the results were compared to the checks in each of the treatment (Table 38).

Data for each year was statistically analyzed independently with PROC GLM of SAS Version 9.3 (SAS institute Inc., Cary, NC) to compute the differences in the means of visual scores and % DP among cultivars. Statistical significance among flooding durations and scoring time treatments were determined using Tukeys HSD. Correlation coefficients were calculated using Pearson correlation analyses PROC CORR to determine if there was relationship between the scoring methods (foliar visual scores and % DP).

RESULTS

In 2013, thirty soybean cultivars with differential flood responses (15 tolerant or 15 susceptible) were subjected to a field flood screening at 5, 10, and 15-day flooding durations. Whereas in 2014, forty soybean cultivars with differential flood responses (20 tolerant or 20 susceptible) were subjected to a field flood screening at 3, 6, 9, 12, 15-day flooding durations in V5 and R1 growth stages. Analyses of variance showed that degree of flood tolerance differed significantly among cultivars, across durations, growth stages and their interactions in individual foliar visual scores and % DP. Variation in flood tolerance was largely attributed to the duration of flooding which was generally greater compared to cultivar, duration x cultivar, stage, duration x stage, stage x cultivar, duration x cultivar, duration x stage x cultivar interaction effects of both visual scores and % DP (Tables 21, 22, 23, and 24).

Flooding Duration Effects on Foliar Visual Ratings, Percent Dead Plants and Chlorophyll Content

Significant differences in flood tolerance based on foliar visual scores and % DP were observed among cultivars at flooding durations in both years (Tables 21, 23, Figs. 5, 6, and 7). Post-flood scoring time for the visual scores and the % DP was done cumulatively at 0, 3, and 6-day intervals and 2, 4, 6, and 8-days in 2013 and 2014 respectively. Significant ($P \leq .0001$) differences were observed in scoring time, duration, and scoring time x duration interaction effects (Table 25). Foliar visual ratings and % DP, as expected, increased linearly with scoring time and flooding durations (Tables 26 and 27). Some cultivars responded similar in different flood durations and scoring time as shown in Table 28. It should be noted that similar trend was observed in growth stages however, the effect on visual scores and % DP were more pronounced in cultivars flooded at the R1 than V5 across flooding duration (Tables 29 and 30). Reduction in chlorophyll content was observed in all flood treatment however, greater reduction rate was observed in cultivars flooded for 9-day flood compared to the rest of flood treatments (Table 38).

The Effects of Flooding Duration, Growth Stages and Post Flood Scoring Time

In 2013 and 2014, sets of cultivars with differential flood responses (tolerant and sensitive) were subjected to field screening in different flooding durations and growth stages. Flood damage was evaluated at different times following drainage: 1, 3, and 6-days and 2, 4, 6, and 8-days in 2013 and 2014 respectively. Flood duration by post-scoring time had a significant ($P < 0.0001$) effect on genotypic selection for flood tolerance for the visual scores and % DP. However, the mean visual scores and % DP varied within flooding durations and post-scoring time. For example, genotypes flooded for 10-days and scored immediately after flood removal (0 day) responded similar with those flooded for 5-days and scored 6 days post-flood removal (Tables 28, 29, and 30).

As a result of significant flooding duration x post scoring time interaction, 10 cultivars with consistent flood response in each of the category were selected (Tables 34, 35, and 36). It should be noted that selection of these cultivars was based on 5-day flood at 6th day scoring time or 10-day flood scored immediately after the flood removal because most differences among genotypes were observed at these durations and post scoring time. The mean visual scores and % DP increased with scoring time across flooding durations regardless of the category of the cultivars (Tables 34, 36, and 37). Correlations analysis of visual scores and % DP over time showed that visual scores were significantly (P 0.0001) correlated with % DP in 5-day, 10-day, and 15-day durations (Tables 31, 32, and 33).

DISCUSSION

Although the effect of flooding has been documented in various crops ranging from a few hours to several days, flood responses or effects after the flooding have been poorly documented (Van Toai et al., 1994; Scott et al., 1989). Screening tests for flood tolerance were conducted in the field in Stuttgart, AR in 2013 and 2014 with the purpose of establishing an effective field flood tolerance screening protocol. In the 2013 flood test, thirty soybean cultivars (fifteen tolerant and fifteen sensitive) were subjected to 5-day, 10-day, and 15-day flood duration treatments at R1 and scored for the flood damage at the 0th, 3rd, and 6th day after the removal of flood. In 2014, forty cultivars (twenty tolerant and twenty sensitive) were subjected to 3, 6, 9, 12, and 15-day flooding duration treatments at V5 and R1 and flood damage scored at the at 2th, 4th, 6th, and 8th day after removal of flood. Note only six genotypes were evaluated in both years (Tables 36 and 37). Results suggest substantial genotypic variation in flood tolerance across flooding durations and post-flood scoring time. These results are in agreement with past research that has reported flood tolerance variation in several plant species such as *Gycine* max (Van Toai et al., 1994, Van Toai et al., 2001, 2010). In addition, Bacanamo and Purcell (1999b) found that shorter flooding durations might be less injurious to plants than longer flooding durations. This is because plants flooded at shorter duration require less energy for biochemical mechanism and morphological adaptation that enhance its survival in the time of the flood stress.

My 2013 results showed that the optimal flood treatments for field screening for flood tolerance is either 5-day flood at 6 day scoring time or 10-day flood scored immediately after the flood removal at R1 growth stage because most differences among cultivars are visible for foliar visual damage and % DP. For instance, in the 5-day flooding duration, across scoring time, all cultivars evaluated appeared to be tolerant to flood stress (Tables 27, 28, and fig. 5), whereas in the 15-day flood most cultivars appeared to be sensitive to flood stress across scoring time (Table 28 and fig. 7). Flooding for 10 days and scoring on the 3rd or 6th day after flood removal did not give a good representation of the tested cultivars because majority of them appeared to be sensitive. These results suggest that these three treatments are not useful to distinguish tolerant from intolerant genotypes at R1 growth stage.

Results from 2014 showed that the optimum flood treatment for cultivar screening in the field is either 6-day of flood at R1 or 9-day flood at V5 stage (Table 30). In the 6-day flood, thirty-nine and one cultivars appeared tolerant and sensitive respectively while the trend was reverse to a 9-day flooding at R1 (Table 30). Flooding for 3 days at V5 and R1 growth stages showed all cultivars were tolerant to flood stress suggesting that most soybeans are able to survive 3-day flooding. Nevertheless, 15-day flood at V5 and R1 growth stages showed all cultivars were sensitive. Most cultivars were sensitive to flood in the 12 and 15-day flooding both growth stages. Thus, these treatments cannot distinguish between tolerant and sensitive soybean cultivars (Table 30). This suggests that most soybean plants will not be able to survive after 12 days of flooding in the field. Reduction in chlorophyll content has been observed in the past and literature indicates that flooded plants tend to be deficient of zinc, iron, and manganese thus interferes with the pathway for chlorophyll synthesis (Kobraee et al., 2011).

CONCLUSION AND BREEDING IMPLICATIONS

This study successfully developed an effective and relatively inexpensive screening methodology for flood tolerance in the field at the V5 and R1 growth stages. These methods include the following:

1. A 5-day flood at R1 growth stage following flood damage ratings a week after flood removal.
2. A 10-day flood at R1 growth stage following flood damage ratings the same day flood is removed.
3. 6- day flood at the R1 growth stage.
4. 9-day flood at the V5 growth stage.
5. Measure leaf chlorophyll content before and after flood treatment.

These methods will allow identification of new sources of flood tolerance from diverse soybean cultivars, which can be incorporated into high-yielding background in the process of developing cultivars that will maintain high yield under flooding stress. However, the proposed screening methodologies need to be assessed under different soil types and environmental conditions. Significant correlation established between visual scores and % DP is an indication of consistencies in the two procedures and provide criteria for early flood tolerance screening.

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Table 20. Summary of percent soil moisture content for 2013 screening seasons at Rice Research and Extension Center in Stuttgart, AR.

Scoring time	Percent moisture content	
	V5 field	R1 field
1	43.7	46.1
3	28.3	31.3
6	17.6	19.1

The average % moisture content of 10 random samples taken after the removal a flood.
1 (SC 1) = immediately after flood removal.
3 (SC 2) = the third day after flood removal.
6 (SC 3) = the sixth day after flood removal.

Table 21. Analysis of Variance and P values for the effect of flooding on visual scores of 30 soybean cultivars evaluated in flood test at the R1 in Stuttgart, AR in 2013.

Source of Variation	DF	MS	% Var.	F Value	P Value
SC 1					
Duration	2	264.7	89.6	16.8	0.0038
Cultivar	29	9.1	3.1	5.07	<.0001
Duration x Cultivar	58	3.5	1.2	1.93	0.0007
Error	160	1.8	0.6		
SC 2					
Duration	2	545.7	96.1	50.4	0.0002
Cultivar	29	6.3	1.1	3.73	<.0001
Duration x Cultivar	58	3.1	0.5	1.84	0.0016
Error	159	1.7	0.3		
SC 3					
Duration	2	391	95.5	50.1	0.0001
Cultivar	29	6.9	1.7	4.93	<.0001
Duration x Cultivar	58	3.2	0.8	2.3	<.0001
Error	156	1.4	0.3		
MSC					
Duration	2	391.4	94.9	37.1	0.0004
Cultivar	29	6.8	1.6	5.3	<.0001
Duration x Cultivar	58	2.2	0.5	1.7	0.0032
Error	162	1.26	0.3		

Duration: (5, 10 and 15, days).
Cultivars :(15 tolerant and 15 sensitive).
DF: degrees of freedom, MS: mean squares.
R1, (fifth-node).
SC 1, visual rating immediately after the flood removal; SC 2, visual rating three days after the flood removal; SC 3, visual rating six days after the flood removal; MSC, the average of SC 1, SC 2 and SC 3.

Table 22. Analysis of Variance and P values for the effect of flooding on percent dead plants of 30 soybean cultivars evaluated in flood test at the in Stuttgart, AR in 2013.

Source of Variation	DF	MS	% Var.	F-ratio	P-value
% DP (SC 1)					
Duration	2	71256	95.7	35.79	0.0005
Cultivar	29	543.2	0.7	2.31	0.0005
Duration x Cultivar	58	413.1	0.6	1.76	0.003
Error	161	234.7	0.3		
% DP (SC 2)					
Duration	2	11417	76.3	48.97	0.0002
Cultivar	29	635.9	4.2	2.96	<.0001
Duration x Cultivar	58	353.1	2.4	1.64	0.0082
Error	160	214.9	1.4		
% DP (SC 3)					
Duration	2	56028	96.2	59.98	0.0001
Cultivar	29	725.7	1.2	4.78	<.0001
Duration x Cultivar	57	355.8	0.6	2.34	<.0001
Error	155	151.8	0.3		
%MDP					
Duration	2	75365	97.4	62.71	<.0001
Cultivar	29	472.9	0.6	3.71	<.0001
Duration x Cultivar	57	178	0.2	1.4	0.0554
Error	155	127.4	0.2		

Duration: (5, 10 and 15, days).
Cultivars :(15 tolerant and 15 sensitive).
DF: degrees of freedom.
% DP (SC 1), calculated percentage of dead plants at SC 1, % DP (SC 2), calculated percentage of dead plants at SC 2; % DP (SC 3), calculated percentage of dead plants at SC 3; % MDP average percentage of dead plants at SC 1, SC 2 and SC 3.

Table 23. Overall Analysis of Variance and P values for the effect of flood duration on mean visual scores of 40 soybean cultivars evaluated at R1 and V5 growth stages in Stuttgart, AR in 2014.

Source	DF	MS	% Var.	F Value	P Value
Duration	4	1770.5	67.2	2070.4	<.0001
Stage	1	793.5	30.1	927.9	<.0001
Cultivar	39	12.5	0.5	14.6	<.0001
Duration*stage	4	43.3	1.6	50.6	<.0001
Stage*Cultivar	39	3.0	0.1	3.5	<.0001
Duration*Cultivar	156	2.0	0.1	2.3	<.0001
Duration*stage*Cultivar	156	1.6	0.1	1.9	<.0001

Duration: 3, 6, 9, 12, and 15 days.
Cultivars: 20 tolerant and 20 sensitive.
Stages: V5 (fifth-trifoliate), R1 (fifth-node).
DF: degrees of freedom.
*** Significant at the 0.0001 probability level.

Table 24. Overall Analysis of Variance and P values for the effect of flood duration on percent dead plants of 40 soybean cultivars evaluated at R1 and V5 growth stages in Stuttgart, AR in 2014.

Source	DF	MS	F Value	P Value
Duration	4	270530.9	2164.1	<.0001
Stage	1	108020.9	864.1	<.0001
Cultivar	39	1659.8	13.3	<.0001
Duration*stage	4	5759.6	46.1	<.0001
Stage*Cultivar	39	358.4	2.9	<.0001
Duration*Cultivar	156	305.2	2.4	<.0001
Duration*stage*Cultivar	156	267.5	2.1	<.0001

Duration: 3, 6, 9, 12, and 15 days.
Cultivars: 20 tolerant and 20 sensitive.
Stages: V5 (fifth-trifoliate), R1 (fifth-node).
DF: degrees of freedom.
*** Significant at the 0.0001 probability level.

Table 25. Analysis of Variance for effect of scoring time on visual scores and percent dead plants in 30 soybean cultivars evaluated in flooded tests in Stuttgart, AR in 2013.

Visual scores:

Source of Variation	**DF**	**MS**	**% Var.**	**F-ratio**	**P Value**
Scoring time†	2	384.4	24.1	130.0	<.0001
Duration‡	2	1189.1	74.6	403.9	<.0001
Scoring time x Duration	4	17.1	1.1	5.8	<.0001
Error	754	2.9	0.2		

Percentage dead plants:

Source of Variation	**DF**	**MS**	**% Var.**	**F-ratio**	**P Value**
Scoring time	2	119462.8	33.0	357.2	<.0001
Duration	2	238922.8	66.0	7.1	<.0001
Scoring time x Duration	4	3528.4	1.0	10.6	<.0001
Error	754	334.5	0.1		

† SC 1, SC 2, and SC 3.
‡ 5, 10, 15 days.
Flooding stage: R1 (fifth-node).
DF: degrees of freedom.
*** Significant at the 0.001 probability level.
SC 1, visual rating immediately after the flood removal; SC 2, visual rating three days after the flood removal; SC 3, visual rating six days after the flood removal; MSC, the average of SC 1, SC 2 and SC 3.
‡Flooding duration (5, 10, and 15 days).

Table 26. The effect of the flooding duration on mean visual scores and percent dead plants of 30 soybean cultivars evaluated at the R1 in Stuttgart, AR in 2013.

	Means	
Duration (days)	Visual score (0-9)	Percent dead plants
5	3.65c	23.95c
10	6.30b	63.01b
15	7.89a	83.91a

* Values followed by the same letters within a column are not significantly different across flooding duration and scoring method (P<0.05).
R1, (fifth-node).

Table 27. Mean for scoring time in 30 soybean cultivars evaluated for flood tolerance at the R1 in Stuttgart, AR in 2013.

	Means	
Scoring time (days)	**Visual score (0-9)**	**Percent dead plants**
1	4.58c	33.69c
3	6.28b	60.62b
6	6.97a	76.62a

* Values followed by the same letters are not significantly different within scoring time and scoring method (P< 0.05).
1 (SC 1) = immediately after flood removal.
3 (SC 2) = the third day after flood removal.
6 (SC 3) = the sixth day after flood removal.
R1, (fifth-node).

Table 28. The effect of the flooding duration by scoring time interaction on mean visual scores and percent dead plants of 30 soybean cultivars evaluated at R1 in Stuttgart, AR in 2013.

Duration (days)	Scoring time (days)		
	Visual scores		
	1	3	6
5	2.67f	3.73e	4.56d
10	4.96d	6.38c	7.55b
15	6.12c	8.75a	8.8a
	Percent dead plants		
	1	3	6
5	2.47f	22.49f	46.87d
10	39.88e	64.05c	86b
15	59.42c	95.33a	96.98a

* Values followed by the same letters are not significantly different within flooding duration and scoring time (P<0.05).
1 (SC 1) = immediately after flood removal.
3 (SC 2) = the third day after flood removal.
6 (SC 3) = the sixth day after flood removal.
R1, (fifth-node).

Table 29. Overall means for flood durations of 40 soybeans cultivars evaluated in flood test in Stuttgart, AR in 2014.

Duration (Days)	Stage	Visual scores	%DP	Number of cultivars		
				Tolerant	Moderate tolerant	Sensitive
3	V5	1.1a	0.6b	40	0	0
3	R1	1.7a	13.5a	40	0	0
6	V5	3.2b	30.9b	31	8	1
6	R1	4.6a	46.1a	15	17	8
9	V5	5.3b	58.0b	11	19	10
9	R1	7.5a	84.1a	0	1	39
12	V5	6.0b	63.9b	2	19	19
12	R1	8.7a	96.0a	0	0	40
15	V5	7.3b	83.5b	0	6	34
15	R1	8.4a	92.0a	0	0	40

Average genotypic response among 40 soybean genotypes flooded at V5 (fifth-node) and R1 (first bloom).

* Values followed by the same letters in a column are not significantly different within flooding duration and growth stages ($P<0.05$).

Table 30. The effect of flooding duration by scoring time interaction on the visual scores and percent dead plants of 40 soybean cultivars evaluated in flood test in Stuttgart, AR in 2014.

		Visual scores				
					Scoring time	
Duration	**Stage**	**2**	**4**	**6**	**8**	**MSC**
3	**V5**	1	1	1.1	1.1	1
3	**R1**	1.3	1.5	1.8	2	1.7
6	**V5**	1.8	3.4	3.5	4.3	3.2
6	**R1**	1.7	4.9	5.7	6.1	4.6
9	**V5**	3.9	5	5.5	6.6	5.3
9	**R1**	6	7.4	8	8.6	7.5
12	**V5**	3.5	4.9	7.6	7.9	6
12	**R1**	8.2	8.8	8.9	8.9	8.7
15	**V5**	7.2	7.3	7.4	7.4	7.3
15	**R1**	7.9	8.5	8.6	8.8	8.5

		Percent dead Plants				
	Stage	**%DP(SC 1)**	**%DP(SC 2)**	**%DP(SC 3)**	**%DP(SC 4)**	**MPDP**
3	**V5**	0.6	0.6	0.7	0.7	0.6
3	**R1**	7.7	11.2	15	20	13.5
6	**V5**	11.3	31.3	35.2	45.6	30.9
6	**R1**	9.1	51.8	59.2	64.3	46.1
9	**V5**	39.5	55	61.5	75.9	58
9	**R1**	67.2	83.4	90.4	95.7	84.1
12	**V5**	32.3	52.8	83.9	86.7	63.9
12	**R1**	91.4	96.4	98	98.2	96
15	**V5**	81.5	83.2	84.5	85.2	83.6
15	**R1**	86.3	91.9	93.8	96.2	92

Average genotypic response among 40 soybean genotypes flooded at V5 (fifth-node) and R1 (first bloom).

Table 31. Correlation coefficients among mean values for visual scores and percent dead plants of 30 soybean genotypes evaluated at 5 days duration in Stuttgart, AR in 2013.

Scoring method	SC 2	SC 3	MSC	%DP (SC 1)	% DP (SC 2)	% DP (SC 3)	%MDP
SC 1	0.89***	O.56***	0.90***	0.46***	0.60***	0.48***	0.61***
SC 2		0.66***	0.94***	0.38**	0.66***	0.60***	0.70***
SC 3			0.85***	0.16**	0.52***	0.84***	0.77***
MSC				0.37**	0.65***	0.73***	0.79***
% DP (SC 1)					0.3**	0.19**	0.34**
% DP (SC 2)						0.64***	0.87***
% DP(SC 3)							0.93***

,*, Significant at the P<.01 and P <.001 respectively.

SC 1, visual rating immediately after the flood removal; SC 2, visual rating three days after the flood removal; SC 3, visual rating six days after the flood removal; MSC, the average of SC 1, SC 2 and SC 3.

% DP (SC 1), calculated percentage of dead plants at SC 1, % DP (SC 2), calculated percentage of dead plants at SC 2; % DP (SC 3), calculated percentage of dead plants at SC 3; % MDP average percentage of dead plants at SC 1, SC 2 and SC 3.

Table 32. Correlation coefficients among mean values for visual scores and percent dead plants of 30 soybean cultivars evaluated at 10 days duration in Stuttgart, AR in 2013.

Scoring method	SC2	SC3	MSC	%DP (SC1)	% DP (SC2)	% DP (SC3)	% MDP
SC 1	0.78***	0.58***	0.88***	0.82***	0.70***	O.51***	0.78***
SC 2		0.77***	0.95***	0.61***	0.75***	0.66***	0.74***
SC 3			0.85***	0.45***	0.57***	0.73***	0.61***
MSC				0.69***	0.73***	0.67***	0.77***
% DP (SC 1)					0.77***	0.52***	0.90***
% DP (SC 2)						0.75***	0.95***
% DP(SC 3)							0.80***

*** Significant P <.0001.

SC 1, visual rating immediately after the flood removal; SC 2, visual rating three days after the flood removal; SC 3, visual rating six days after the flood removal; MSC, the average of SC 1, SC 2 and SC 3.

% DP (SC 1), calculated percentage of dead plants at SC 1, % DP (SC 2), calculated percentage of dead plants at SC 2; % DP (SC 3), calculated percentage of dead plants at SC 3; % MDP average percentage of dead plants at SC 1, SC 2 and SC 3.

Table 33. Correlation coefficients among mean values for visual scores and percent dead plants of 30 soybean cultivars evaluated at 15 days duration in Stuttgart, AR in 2013.

Scoring method	SC 2	SC 3	MSC	%DP (SC 1)	% DP (SC 2)	% DP (SC 3)	%MDP
SC 1	0.47***	0.39***	0.87**	0.84***	0.51***	0.47***	0.84***
SC 2		0.81***	0.82***	0.39***	0.86***	0.84***	0.70***
SC 3			0.75***	0.27**	0.81***	0.92***	0.62***
MSC				0.72***	0.80***	0.80***	0.90***
% DP (SC 1)					0.40***	0.35***	0.89***
% DP (SC 2)						0.94***	0.76***
% DP(SC 3)							0.72***

*** Significant at the P <.0001.

SC 1, visual rating immediately after the flood removal; SC 2, visual rating three days after the flood removal; SC 3, visual rating six days after the flood removal; MSC, the average of SC 1, SC 2 and SC 3.

% DP (SC 1), calculated percentage of dead plants at SC 1, % DP (SC 2), calculated percentage of dead plants at SC 2; % DP (SC 3), calculated percentage of dead plants at SC 3; % MDP average percentage of dead plants at SC 1, SC 2 and SC 3.

Table 34. The effect of flooding duration on mean foliar visual score of 20 soybean cultivars evaluated at R1 in flood tests in Stuttgart, AR in 2013.

		5 days				10 days				15 days			
Cultivar	**Type**	**SC1**	**SC2**	**SC3**	**MSC**	**SC1**	**SC2**	**SC3**	**MSC**	**SC1**	**SC2**	**SC3**	**MSC**
RM-1639	T	1.5	1.5	2.0	1.5	3.0	4.3	7.0	4.8	3.0	8.3	8.7	7.1
R10-5450	T	1.7	3	2.5	2.4	3.7	5.0	7.3	5.3	3.7	8.3	8.0	7.5
RO7-7775	T	1.7	2.7	2.7	2.3	4.3	5.0	5.3	4.9	4.3	9.0	9.0	8.2
Pickett 71	T	1.4	1.5	3.3	2.9	6.0	7.7	8.3	7.3	6.0	9.0	9.0	8.2
Armor DK 4744	T	2.7	3.3	3.6	3.2	3.0	6.5	8.5	5.9	3.0	9.0	9.0	8.0
MorSoy XTRA 46 X29	T	3.3	3.7	3.6	3.5	5.0	6.7	8.7	6.8	5.0	9.0	8.7	7.5
Osage	T	1.0	2.0	3.6	2.2	4.3	4.3	5.0	4.4	4.3	8.0	9.0	6.8
Ozark	T	1.6	3.0	3.6	2.7	4.3	5.0	5.5	4.5	4.3	9.0	9.0	8.0
PI-471931	T	1.0	2.0	3.6	2.23	4.3	5.0	6.6	5.5	4.3	8.3	9.0	7.4
Average		**1.8b**	**2.5b**	**3.2b**	**2.6b**	**4.2b**	**5.5b**	**6.9b**	**5.5b**	**4.2b**	**8.7a**	**8.8a**	**7.6a**
Halo 4:65	S	3.7	5.0	4.6	4.4	3.7	4.7	6.0	4.8	3.7	8.3	9.0	7.2
Pioneer 95Y01	S	4.3	5.6	4.6	4.9	4.7	6.3	7.7	6.2	4.7	9.0	8.0	7.1
Uark 5896	S	2.3	4.3	4.7	3.8	5.0	6.0	8.0	6.3	5.0	8.7	8.7	8.0
Schillinger 5220.RC	S	3.7	4.7	5.0	4.4	6.7	7.5	8.5	7.6	6.7	9.0	9.0	8.1
S08-X7279	S	3.3	4.3	5.7	4.4	7.6	9.0	9.0	8.6	7.6	9.0	9.0	8.5
RO5-3239	S	3.3	4.0	6.0	4.4	6.7	8.7	9.0	8.1	6.7	9.0	9.0	8.1
Willcross RR2477N	S	5.0	5.7	8.0	6.2	7.0	8.3	9.0	8.1	7.0	9.0	9.0	8.5
JTN-4307	S	2.7	4.7	8.6	5.3	7.8	9.0	9.0	8.7	7.8	9.0	9.0	8.2
Willcross RR2547N	S	6.0	7.6	8.7	7.4	8.6	9.0	9.0	9.0	8.6	9.0	9.0	9.0
Average		**3.8a**	**5.1a**	**6.2a**	**5.0a**	**6.4a**	**7.6a**	**8.4a**	**7.5a**	**6.4a**	**8.9a**	**8.9a**	**8.1a**

Type: (T = Tolerant, S = susceptible).

SC 1, visual rating immediately after the flood removal; SC 2, visual rating three days after the flood removal; SC 3, visual rating six days after the flood removal; MSC, the average of SC 1, SC 2 and SC 3.

Table 35. The effect of flooding duration on mean percent dead plant ratings of 20 soybean cultivars evaluated at R1 growth stage in flood tests in Stuttgart, AR in 2013.

		5 days				10 days				15 days			
Cultivar	**Type**	**SC1**	**SC2**	**SC3**	**%MDP**	**SC1**	**SC2**	**SC3**	**%MDP**	**SC1**	**SC2**	**SC3**	**%MDP**
RM-1639	T	0	10.0	19.1	6.3	12.5	39.1	78.8	43.5	42.7	90.3	94.0	75.6
R10-5450	T	2.1	23.4	25.7	8.5	21.8	40.4	89.0	50.3	68.4	91.1	93.0	84.0
RO7-7775	T	0.0	14.0	17.1	10.6	49.0	65.2	76.8	63.6	76.9	95.0	98.0	89.9
Pickett 71	T	0.0	3.4	18.2	7.5	52.2	86.1	73.0	78.3	70.5	99.5	100.0	89.8
Armor DK 4744	T	2.1	30.1	42.1	24.8	34.8	56.8	95.6	62.4	61.9	98.2	100.0	86.6
MorSoy XTRA 46 X29	T	2.3	17.0	32.8	17.4	31.1	59.7	96.1	57.6	56.7	94.3	96.0	82.3
Osage	T	0.0	22.3	64.1	28.8	40.8	58.1	76.0	65.0	25.3	90.1	98.0	71.0
Ozark	T	3.4	25.8	49.1	26	39.8	55.9	87.0	59.0	58.5	98.7	100.0	85.7
PI-471931	T	0.0	16.6	47	21.2	47.7	69.5	97.0	68.1	33.6	91.1	98.0	74.1
Average		**1.1b**	**18.1b**	**35.0b**	**16.8b**	**36.6b**	**59.0b**	**85.5a**	**60.9a**	**54.9b**	**94.3a**	**97.4a**	**82.1a**
Halo 4:65	S	1.2	25.7	38.5	21.8	32.3	44.9	66.8	48.0	40.8	91.6	97.0	76.2
Pioneer 95Y01	S	1.0	20.9	46.8	22.9	25.9	87.5	76.7	48.9	57.4	92.2	94.0	81.0
Uark 5896	S	0.0	15.6	37.0	17.5	36.0	55.9	82.6	57.2	62.6	87.9	90.5	80.4
Schillinger 5220.RC	S	8.8	32.0	58.0	33.0	53.7	59.3	73.7	64.1	48.2	100.0	100.0	82.7
S08-X7279	S	6.0	19.0	60.0	28.4	68.3	79.3	92.1	79.9	72.2	98.9	99.0	90.0
RO5-3239	S	1.3	2.8	49.9	18.0	41.9	85.5	98.3	75.2	61.2	96.2	98.0	85.1
Willcross RR2477N	S	2.6	45.3	76.1	41.3	52.9	82.7	99.0	78	73.2	100	100.0	91.0
JTN-4307	S	0.7	17.3	89.5	35.8	76.7	89.8	82.2	0.0	62.6	98.6	100.0	86.0
Willcross RR2547N	S	2.7	63.7	93.1	53.1	66.9	95.2	98.0	88.6	91.6	100.0	100.0	97.2
Average		**2.7a**	**26.9a**	**61.0a**	**30.2a**	**50.5a**	**75.6a**	**85.5a**	**60.0a**	**63.3a**	**96.2a**	**97.6a**	**85.5a**

Type: (T = Tolerant, S = sensitive).

% DP (SC 1), calculated percentage of dead plants at SC 1, % DP (SC 2), calculated percentage of dead plants at SC 2; % DP (SC 3), calculated percentage of dead plants at SC 3; % MDP average percentage of dead plants at SC 1, SC 2 and SC 3.

Table 36. Mean visual scores of six cultivars evaluated in flood test at R1 growth stage in Stuttgart, AR in 2013 and 2014.

Days	**5**				**10**				**15**			
Cultivar	**SC 1**	**SC 2**	**SC 3**	**MSC**	**SC 1**	**SC 2**	**SC 3**	**MSC**	**SC 1**	**SC 2**	**SC 3**	**MSC**
Walters	2.5	3.0	3.4	3.0	6.7	7.9	9.0	7.7	8.0	9.0	9.0	8.0
Osage	1.5	1.5	2.0	1.5	4.3	6.8	8.7	6.2	8.3	9.0	9.0	8.2
RO7-2001	2.6	4.7	8.7	5.3	7.8	8.9	9.0	8.5	6.5	9.1	9.0	8.1
Ozark	2.3	4.0	4.0	3.4	5.3	7.0	7.3	6.5	6.3	9.0	9.0	6.9
RM-1639	1.0	2.0	3.7	2.2	4.3	4.3	5.2	4.4	3.7	8.0	9.0	5.0
R10-4892	3.6	4.7	2.7	3.4	5.3	6.3	6.3	6.0	3.3	5.7	6.0	8.7

2014

Days	**6**					**9**					**15**				
Cultivar	**SC 1**	**SC 2**	**SC 3**	**SC 4**	**MSC**	**SC 1**	**SC 2**	**SC 3**	**SC 4**	**MSC**	**SC 1**	**SC 2**	**SC 3**	**SC 4**	**MSC**
Walters	1.7	4.3	6.0	6.0	4.5	7.0	8.0	8.7	9.0	8.2	8.7	9.0	9.0	9.0	8.9
Osage	1.0	5.0	6.3	6.3	4.7	4.3	6.0	7.0	7.7	6.3	7.0	7.7	8.0	8.7	7.8
R07-2001	2.0	5.3	6.3	6.3	5.0	5.7	7.0	8.0	8.7	7.4	8.7	9.0	9.0	9.0	8.9
Ozark	1.3	2.7	3.3	3.3	2.7	5.0	6.7	7.7	8.3	7.0	7.0	7.7	8.0	8.0	7.7
RM-1639	1.3	2.3	3.3	3.3	2.6	5.7	7.3	7.3	8.0	7.1	7.7	8.3	8.3	8.7	8.3
R10-4892	1.0	2.3	3.7	4.3	2.8	7.0	8.0	9.0	9.0	8.3	7.7	8.7	8.7	8.7	8.4

SC 1, visual rating immediately after the flood removal; SC 2, visual rating three days after the flood removal; SC 3, visual rating six days after the flood removal; MSC, the average of SC 1, SC 2 and SC 3.

Table 37. Mean percent dead plants of six cultivars evaluated in flood test at R1 growth stage in Stuttgart, AR in 2013 and 2014.

Days	5				10				15			
Cultivars	%DP (SC 1)	%DP (SC 2)	%DP (SC 3)	%MPD	%DP (SC 1)	%DP (SC 2)	%DP (SC 3)	MPDP	%DP (SC 1)	%DP (SC 2)	%DP (SC 3)	% MDP
Walters	0.0	15.6	27.9	14.5	48.2	78.0	94.0	74.0	72.0	100.0	100.0	91.0
Osage	2.1	30.1	42.1	24.8	34.8	57.0	95.0	62.0	62.0	98.0	100.0	87.0
RO7-2001	0.7	17.0	89.0	35.8	84.5	95.0	100.0	93.0	63.0	98.0	100.0	87.0
Ozark	1.2	27.4	57.3	28.7	49.1	81.0	85.0	72.0	70.0	99.0	100.0	89.0
RM-1639	0.0	22.3	64.0	29.0	40.8	58.0	96.0	65.0	25.0	90.0	98.0	71.0
R10-4892	13.5	17.0	27.0	19.0	39.9	55.0	77.0	57.0	38.0	68.0	70.0	59.0

2014

Days	6					9					15				
Cultivars	%DP (SC 1)	%DP (SC 2)	%DP (SC 3)	%DP (SC 4)	MPDP	%DP (SC 1)	%DP (SC 2)	%DP (SC 3)	%DP (SC 4)	MSC	%DP (SC 1)	%DP (SC 2)	%DP (SC 3)	%DP (SC 4)	% MDP
Walters	9.3	51.3	72.2	72.2	51.2	81.4	91.8	96.5	99.1	92.2	94.5	95.2	96.1	97.4	95.8
Osage	3.5	57.6	71.7	73.7	51.6	52.2	71.3	79.5	86.8	72.4	76.8	86.6	89.6	92.8	86.4
R07-2001	10.9	55.5	70.4	73.9	52.7	69.8	84.3	91.0	96.4	85.4	93.5	97.6	100.0	100.0	97.8
Ozark	9.4	20.3	29.6	33.1	23.1	62.7	82.2	90.9	95.0	82.7	80.8	87.4	90.4	91.6	87.5
RM-1639	2.1	25.3	5.0	8.3	10.2	63.7	81.5	82.4	90.4	79.5	81.0	89.9	91.5	95.7	89.5
R10-4892	2.0	16.5	29.7	34.7	20.7	76.6	87.5	100.0	100.0	91.0	82.8	93.3	94.7	96.3	91.8

% DP (SC 1), calculated percentage of dead plants at SC 1, % DP (SC 2), calculated percentage of dead plants at SC 2; % DP (SC 3), calculated percentage of dead plants at SC 3; % MDP average percentage of dead plants at SC 1, SC 2 and SC 3.

Table 38. Summary of the mean chlorophyll content in 40 soybean cultivars evaluated at R1 in flood test in Stuttgart, AR in 2014.

	Chlorophyll SPAD		
Duration (days)	**CK (SPAD)**	**Treatment (SPAD)**	**% Decrease (SPAD)**
3	32.3	25.6	20.7
6	32.1	23.5	26.7
9	32.2	18.8	41.6
12	31.9	21.3	33.2
15	33.0	22.6	31.5
Average	**32.3**	**22.4**	**30.7**

Six top extensive leaf points/cultivars were used, CK = check average, Treatment = 3, 6, 9, 12, and 15 days flooding.

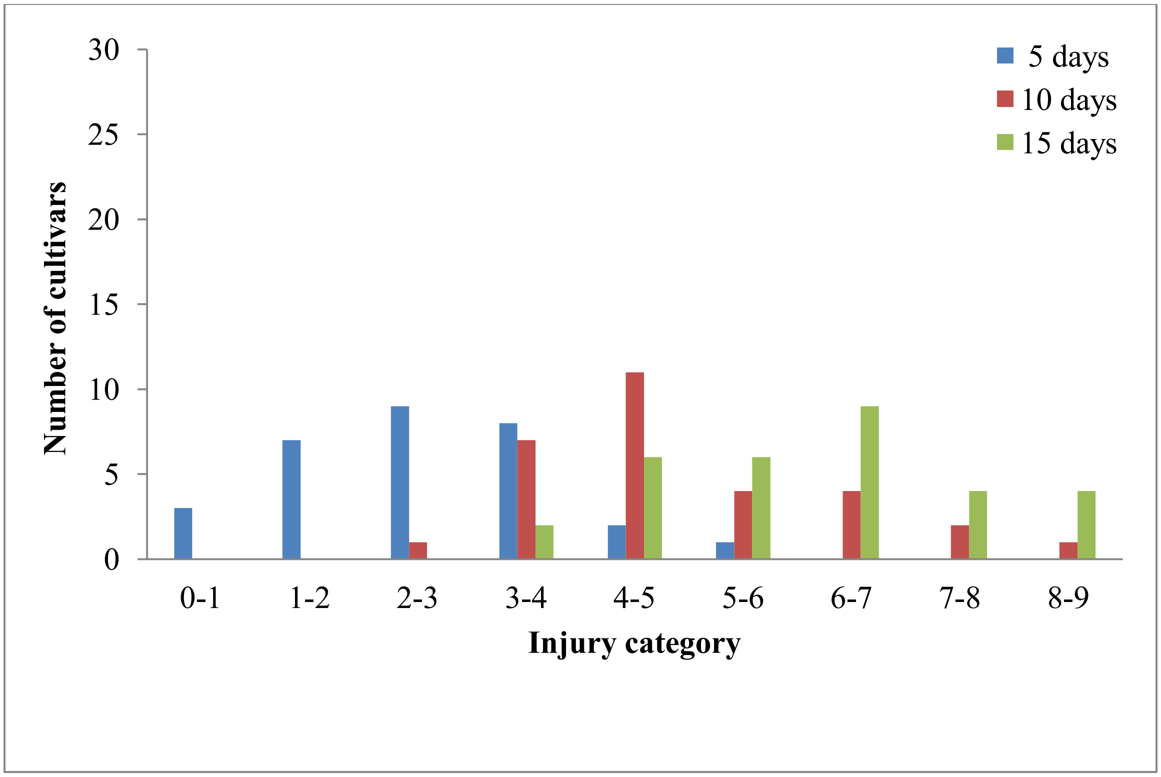

Fig. 5. Frequency distribution of visual scores for 30 soybean cultivars evaluated at the same day after removal 5, 10, and 15 days of flood tests in Stuttgart, AR in 2013.

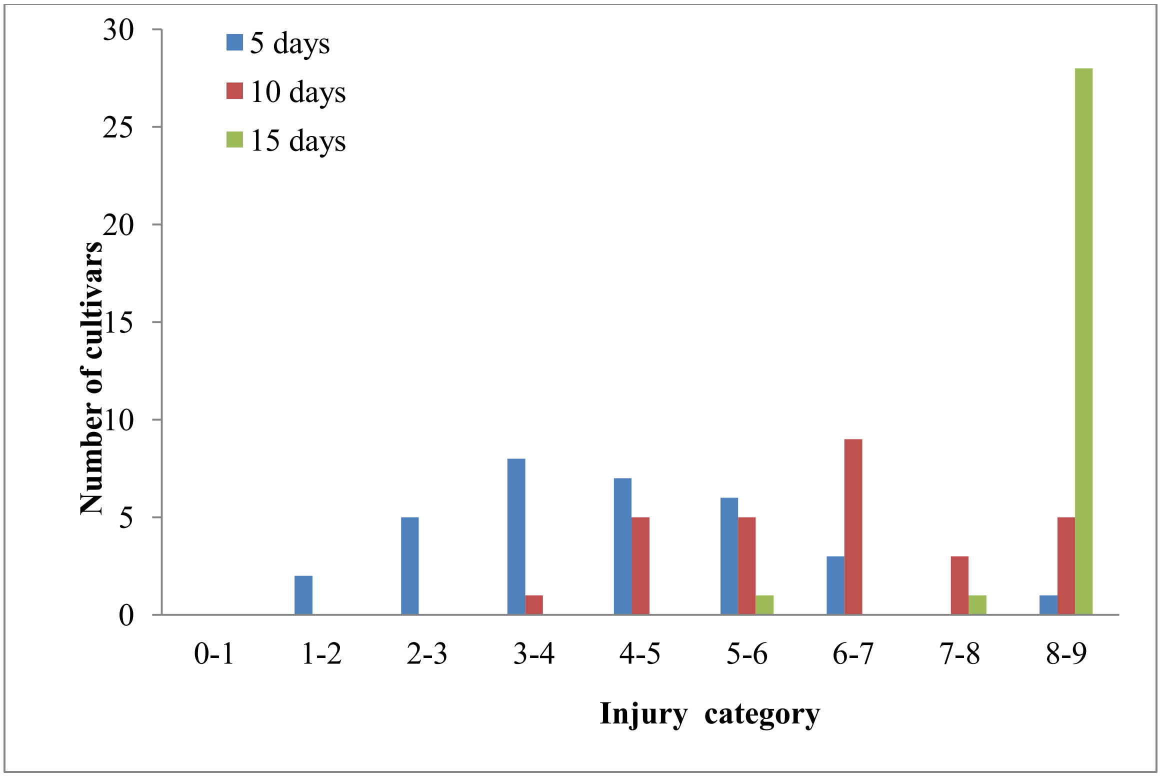

Fig. 6. Frequency distribution of foliar visual scores for 30 soybean cultivars evaluated three days after removal 5, 10, and 15 days of flood in Stuttgart, AR in 2013.

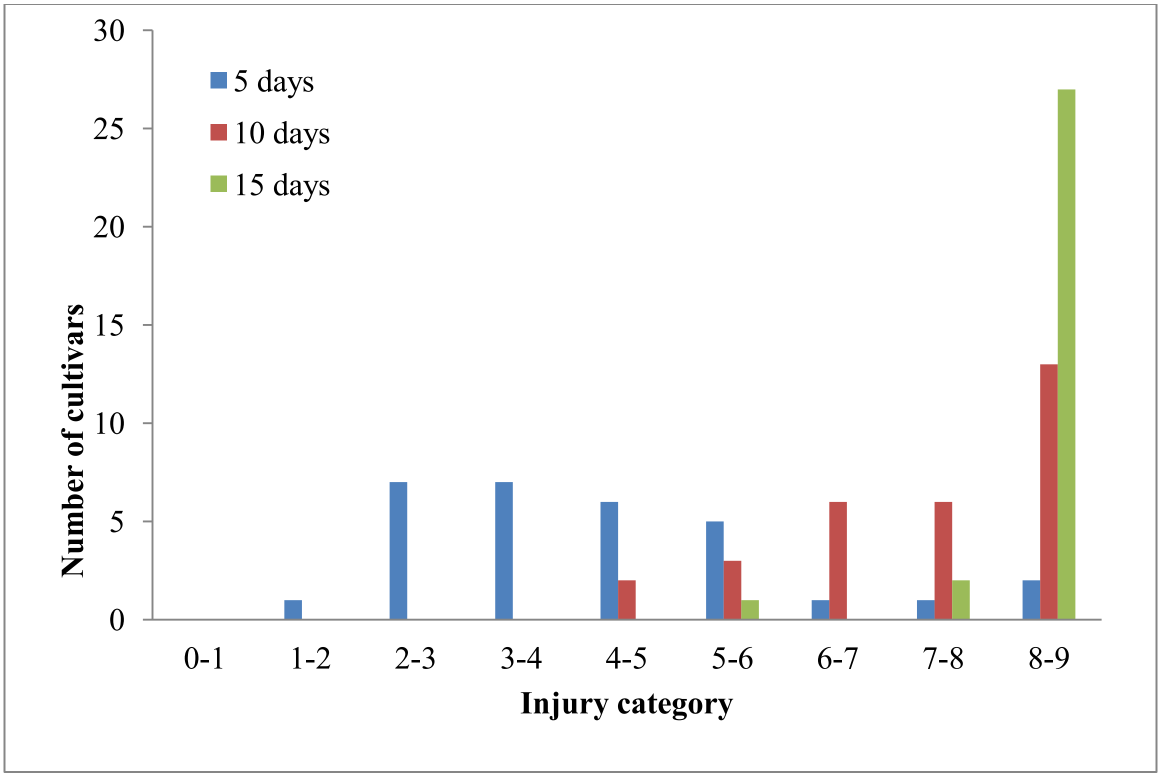

Fig. 7. Frequency distribution of flood injury scores for 30 soybean cultivars evaluated six days after removal 5, 10, and 15 days of flood in Stuttgart, AR in 2013.

Fig. 8. Foliar visual scores (Jane Mokua)

APPENDICES

This section includes a list of soybean cultivars and their means at different flooding stages and durations.

Appendix 1 a. Means of visual scores and percent dead plants of soybean cultivars evaluated in MG IV flood test at V5 in Stuttgart, AR in 2012 and 2013.

Ent	Name	ID	Source	SC 1	SC 2	MSC	%DP (SC 1)	%DP (SC 2)	%MDP
1	Go Soy 4411 LL	NRR 4 Early	Stratton Seed Company	7.8	8.3	8.1	87.0	93.2	87.6
2	Halo 4:65	NRR 4 Early	US Seeds, Inc.	7.3	7.5	7.4	82.0	85.1	83.3
3	Halo X456	NRR 4 Early	US Seeds, Inc.	7.7	7.7	7.7	79.6	81.5	81.0
4	Pioneer 95Y40 (RR)	NRR 4 Early	Pioneer Hi-Bred International, Inc.	8.3	8.7	8.5	89.6	97.9	91.1
5	Armor 44-R08	EPT 4 Early	Armor	8.3	8.8	8.6	93.7	107.9	94.3
6	Armor 46-R42	EPT 4 Early	Armor	7.8	8.5	8.2	89.2	103.4	90.4
7	Armor 46-R64	EPT 4 Early	Armor	8.8	8.8	8.8	92.2	101.8	93.6
8	Armor X1303	EPT 4 Early	Armor	8.5	8.8	8.7	95.0	106.3	95.0
9	Armor X1304	EPT 4 Early	Armor	8.3	9.0	8.7	94.9	104.0	94.6
10	Armor X1305	EPT 4 Early	Armor	8.5	8.8	8.7	90.2	108.6	90.2
11	Asgrow AG3833	EPT 4 Early	Monsanto	8.2	8.3	8.2	84.3	106.0	85.3
12	Asgrow AG4232	EPT 4 Early	Monsanto	8.0	8.8	8.4	90.4	98.5	91.1
13	Asgrow AG4531	EPT 4 Early	Monsanto	8.7	8.9	8.8	85.0	105.6	86.2
14	Asgrow AG4632	EPT 4 Early	Monsanto	7.7	7.8	7.7	67.5	72.3	68.1
15	Croplan R2C4391	EPT 4 Early	Croplan Genetics	8.7	8.7	8.7	85.3	103.0	87.2
16	Croplan R2C4541	EPT 4 Early	Croplan Genetics	8.5	8.7	8.6	83.7	100.4	85.5
17	Delta Grow 4575RR2	EPT 4 Early	Delta Grow Seed	8.8	8.8	8.8	94.6	104.4	94.6
18	Delta Grow 4670RR2	EPT 4 Early	Delta Grow Seed	8.6	8.8	8.7	92.2	109.0	93.3
19	Dyna-Gro 31RY45	EPT 4 Early	CPS Dyna-Gro Seed	5.7	7.7	6.7	69.1	105.9	70.1
20	Dyna-Gro 39RY43	EPT 4 Early	CPS Dyna-Gro Seed	8.3	8.7	8.5	92.0	104.9	93.3
21	LG C4411R2	EPT 4 Early	LG Seeds	8.7	8.8	8.7	87.3	102.8	88.7
22	LG C4625R2	EPT 4 Early	LG Seeds	4.8	4.9	4.9	65.9	97.2	66.8
23	MorSoy XTRA 44X82	EPT 4 Early	Cache River Valley Seed, LLC	6.0	5.7	5.9	83.3	106.4	83.7
24	MorSoy XTRA 46X29	EPT 4 Early	Cache River Valley Seed, LLC	8.2	9.0	8.6	84.9	101.4	85.8
25	MorSoy XTRA 46X71	EPT 4 Early	Cache River Valley Seed, LLC	8.5	9.0	8.7	89.4	107.0	90.2
26	Progeny 4211RY	EPT 4 Early	Progeny AG products	6.8	9.0	7.9	91.7	108.5	91.9

Appendix 1 a. Means of visual scores and percent dead plants of soybean cultivars evaluated in MG IV flood test at V5 in Stuttgart, AR in 2012 and 2013 (Cont.

Ent	Name	ID	Source	SC 1	SC 2	MSC	%DP (SC 1)	%DP (SC 2)	%MDP
27	Progeny 4510RY	EPT 4 Early	Progeny AG products	8.4	7.8	8.1	91.6	106.7	91.9
28	Progeny 4611RY	EPT 4 Early	Progeny AG products	5.9	8.9	7.4	86.1	107.2	86.8
29	S08-X14117	EPT 4 Early	University of Missouri	8.7	8.7	8.7	90.0	104.4	90.0
30	Schillinger 458.RCS	EPT 4 Early	Stratton Seed Company	8.7	8.7	8.7	90.8	100.9	91.6
31	AgBorn S08-X0448	FST 4 Early	AgBorn Inc	8.7	8.8	8.7	91.8	95.3	91.9
32	AGS 43R212	FST 4 Early	Ag South Genetics	9.0	9.0	9.0	96.6	102.8	96.6
33	AGS 45R212	FST 4 Early	Ag South Genetics	9.0	9.0	9.0	97.9	106.5	97.8
34	Asgrow AG4433	FST 4 Early	Monsanto	8.7	8.7	8.7	93.2	99.0	93.8
35	Asgrow AG4533	FST 4 Early	Monsanto	8.2	8.3	8.2	80.4	84.5	82.0
36	Asgrow AG4633	FST 4 Early	Monsanto	8.3	8.7	8.5	86.7	90.2	88.5
37	AvDX - D613	FST 4 Early	Dulaney Seed/Agventure	7.3	8.2	7.7	78.2	80.8	80.7
38	Dyna-Gro S44RS93	FST 4 Early	CPS Dyna-Gro Seed	8.8	8.8	8.8	94.7	99.9	94.7
39	HBK RY4620	FST 4 Early	Bayer/Hornbeck	8.3	8.7	8.5	89.4	94.5	90.9
40	NK S41-J6 Brand	FST 4 Early	Syngenta	7.2	7.0	7.1	66.1	60.6	67.4
41	NK S44-D5 Brand	FST 4 Early	Syngenta	8.2	8.5	8.3	88.9	95.8	90.2
42	NK S46-A1 Brand	FST 4 Early	Syngenta	8.5	8.7	8.6	89.4	96.7	90.2
43	NK S46-T3 Brand	FST 4 Early	Syngenta	9.0	9.0	9.0	95.7	105.2	95.7
44	Pioneer 94Y23	FST 4 Early	Pioneer Hi-Bred International, Inc.	8.7	9.0	8.8	97.5	108.5	97.3
45	Pioneer 94Y40	FST 4 Early	Pioneer Hi-Bred International, Inc.	9.0	9.0	9.0	99.4	109.6	99.7
46	REV®46R73™	FST 4 Early	Terral Seed	8.2	8.8	8.5	86.7	101.1	86.9
47	Schillinger 457.RCP	FST 4 Early	Stratton Seed Company	9.0	9.0	9.0	99.2	109.6	99.2
48	Willcross RY2460S	FST 4 Early	Willcross Seeds, Inc.	8.7	9.0	8.8	85.7	104.7	87.6
49	Armor 48-R40	EPT 4 Late	Armor	8.8	9.0	8.9	93.3	105.6	94.8
50	Armor 48-R91	EPT 4 Late	Armor	8.7	9.0	8.8	97.2	108.3	98.0
51	Armor DK 4744	EPT 4 Late	Armor	8.7	8.7	8.7	87.4	102.0	89.2
52	Armor X1306	EPT 4 Late	Armor	8.8	8.7	8.7	90.9	108.1	92.2
53	Armor X1307	EPT 4 Late	Armor	9.0	9.0	9.0	98.1	107.3	98.2
54	Armor X1308	EPT 4 Late	Armor	7.8	8.2	8.0	82.5	86.5	84.2
55	ARMOR X1309	EPT 4 Late	Armor	8.9	8.9	8.9	98.8	106.9	99.4

Appendix 1 a. Means of visual scores and percent dead plants of soybean cultivars evaluated in MG IV flood test at V5 in Stuttgart, AR in 2012 and 2013 (Cont.).

Ent	Name	ID	Source	SC 1	SC 2	MSC	%DP (SC 1)	%DP (SC 2)	%MDP
56	Armor X1310	EPT 4 Late	Armor	9.0	9.0	9.0	97.0	106.1	97.2
57	Armor X1311	EPT 4 Late	Armor	7.5	8.2	7.8	88.9	103.4	88.4
58	Armor X1312	EPT 4 Late	Armor	9.0	9.0	9.0	98.1	109.1	98.2
59	Asgrow AG4933	EPT 4 Late	Monsanto	8.5	9.0	8.7	96.3	108.0	96.3
60	AvDX - D812	EPT 4 Late	Dulaney Seed/Agventure	8.1	8.5	8.3	85.6	99.5	85.8
61	Croplan R2C4801S	EPT 4 Late	Croplan Genetics	8.7	8.8	8.7	94.2	100.1	94.6
62	Croplan R2T4799S	EPT 4 Late	Croplan Genetics	7.5	7.9	7.7	82.0	98.2	82.4
63	Delta Grow 4715RR2	EPT 4 Late	Delta Grow Seed	8.7	8.7	8.7	96.5	99.7	95.8
64	Delta Grow 4755RR2	EPT 4 Late	Delta Grow Seed	9.0	9.0	9.0	98.1	106.6	98.2
65	Delta Grow 4765RR2/STS	EPT 4 Late	Delta Grow Seed	8.8	9.0	8.9	88.0	87.1	88.4
66	Delta Grow 4815RR2	EPT 4 Late	Delta Grow Seed	5.4	8.6	7.0	77.3	99.1	78.1
67	Delta Grow 4825 RR2/STS	EPT 4 Late	Delta Grow Seed	8.2	8.7	8.4	94.6	108.7	94.9
68	Delta Grow 4870RR2	EPT 4 Late	Delta Grow Seed	8.5	8.7	8.6	92.3	98.8	93.1
69	Delta Grow 4880RR	EPT 4 Late	Delta Grow Seed	9.0	9.0	9.0	98.8	108.4	98.8
70	Delta Grow 4925RR2	EPT 4 Late	Delta Grow Seed	9.0	9.0	9.0	99.7	108.3	99.5
71	Delta Grow 4970RR	EPT 4 Late	Delta Grow Seed	8.9	8.9	8.9	97.2	106.3	97.4
72	Delta Grow 4975RR	EPT 4 Late	Delta Grow Seed	9.0	9.0	9.0	99.6	109.6	99.6
73	Delta Grow 4980RR2	EPT 4 Late	Delta Grow Seed	8.0	8.2	8.1	282.4	121.5	470.9
74	Dyna-Gro S48RS53	EPT 4 Late	CPS Dyna-Gro Seed	9.0	9.0	9.0	88.1	90.7	89.2
75	LG C4780R2	EPT 4 Late	LG Seeds	8.6	9.0	8.8	95.6	112.1	95.6
76	LG C4885R2	EPT 4 Late	LG Seeds	8.8	8.8	8.8	94.5	104.5	95.2
77	MorSoy XTRA 47X12	EPT 4 Late	Cache River Valley Seed, LLC	8.7	8.8	8.7	94.0	99.5	94.0
78	MorSoy XTRA 48X00	EPT 4 Late	Cache River Valley Seed, LLC	8.7	9.0	8.8	91.9	94.1	92.1
79	MorSoy XTRA 48X02	EPT 4 Late	Cache River Valley Seed, LLC	8.6	9.0	8.8	95.8	105.7	96.2
80	Progeny 4710RY	EPT 4 Late	Progeny AG products	9.0	9.0	9.0	97.3	103.0	96.8
81	Progeny 4747RY	EPT 4 Late	Progeny AG products	8.5	8.9	8.7	91.7	95.7	91.9
82	Progeny 4814RY	EPT 4 Late	Progeny AG products	8.3	8.8	8.6	91.6	106.9	92.1
83	Progeny 4850RY	EPT 4 Late	Progeny AG products	9.0	9.0	9.0	85.0	81.7	85.5
84	Progeny 4900RY	EPT 4 Late	Progeny AG products	9.0	9.0	9.0	99.8	109.6	99.8
85	Progeny 4920RY	EPT 4 Late	Progeny AG products	8.9	8.9	8.9	94.0	101.4	94.6
86	REV®47R53™	EPT 4 Late	Terral Seed	8.3	8.7	8.5	90.2	96.1	90.5

Appendix 1 a. Means of visual scores and percent dead plants of soybean cultivars evaluated in MG IV flood test at V5 in Stuttgart, AR in 2012 and 2013 (Cont.).

Ent	Name	ID	Source	SC 1	SC 2	MSC	%DP (SC 1)	%DP (SC 2)	%MDP
87	REV®48R10™	EPT 4 Late	Terral Seed	8.3	8.3	8.3	93.4	107.9	93.9
88	REV®48R22™	EPT 4 Late	Terral Seed	8.8	8.8	8.8	97.3	106.6	97.8
89	REV®48R33™	EPT 4 Late	Terral Seed	8.9	8.9	8.9	96.6	107.7	96.8
90	REV®49R10™	EPT 4 Late	Terral Seed	7.3	8.5	7.9	84.0	97.0	85.4
91	REV®49R11™	EPT 4 Late	Terral Seed	9.0	9.0	9.0	98.0	109.1	98.0
92	REV®49R43™	EPT 4 Late	Terral Seed	9.0	9.0	9.0	96.8	109.6	97.5
93	REV®49R54™	EPT 4 Late	Terral Seed	8.9	8.9	8.9	95.6	108.4	95.9
94	S08-X2499	EPT 4 Late	University of Missouri	9.0	9.0	9.0	99.1	108.1	99.1
95	Schillinger 478.RCS	EPT 4 Late	Stratton Seed Company	9.0	9.0	9.0	99.2	107.9	99.2
96	Schillinger 495.RC	EPT 4 Late	Stratton Seed Company	8.8	9.0	8.9	97.4	108.2	97.8
97	USG 74A79R	EPT 4 Late	UniSouth Genetics, Inc.	8.8	8.8	8.8	92.8	101.4	92.8
98	USG 74B81R	EPT 4 Late	UniSouth Genetics, Inc.	9.0	9.0	9.0	98.5	107.2	98.5
99	USG 74E88	EPT 4 Late	UniSouth Genetics, Inc.	9.0	9.0	9.0	100.0	109.6	100.0
100	USG 74H92R	EPT 4 Late	UniSouth Genetics, Inc.	8.8	8.8	8.8	91.6	102.6	93.8
101	AgBorn S08-X27041	FST 4 Late	AgBorn Inc	9.0	9.0	9.0	97.6	106.0	97.8
102	AgBorn S08-X78041	FST 4 Late	AgBorn Inc	9.0	9.0	9.0	97.8	107.2	97.8
103	AGS 47R212	FST 4 Late	Ag South Genetics	9.0	8.8	8.9	92.4	104.6	92.4
104	Asgro AG4832	FST 4 Late	Monsanto	9.0	9.0	9.0	98.7	109.6	99.0
105	Asgrow AG4932	FST 4 Late	Monsanto	8.7	9.0	8.8	80.2	104.7	81.4
106	Davis 4148RR2Y	FST 4 Late	Davis seed company	8.8	8.8	8.8	95.1	108.7	95.3
107	Delta Grow 4875RR2/STS	FST 4 Late	Delta Grow Seed	8.8	9.0	8.9	94.2	104.0	95.4
108	Dyna-Gro 33RY47	FST 4 Late	CPS Dyna-Gro Seed	9.0	9.0	9.0	97.7	105.2	97.3
109	Dyna-Gro 39D48	FST 4 Late	CPS Dyna-Gro Seed	8.8	8.8	8.8	93.4	103.5	93.5
110	Dyna-Gro S47RY13	FST 4 Late	CPS Dyna-Gro Seed	8.8	9.0	8.9	97.7	107.4	98.1
111	Eagle Seed ES4818	FST 4 Late	Eagle Seed	8.7	8.8	8.7	96.4	101.8	96.2
112	Eagle Seed ES4998	FST 4 Late	Eagle Seed	8.9	8.9	8.9	88.8	105.1	88.9
113	HBK R4924	FST 4 Late	Bayer/Hornbeck	8.8	9.0	8.9	96.8	105.2	97.0
114	HBK RY4721	FST 4 Late	Bayer/Hornbeck	8.8	8.8	8.8	96.2	104.9	96.8
115	JGL EXP 480	FST 4 Late	JGL, Inc.	8.5	9.0	8.7	95.9	106.0	96.1
116	MorSoy XTRA 47X31	FST 4 Late	Cache River Valley Seed, LLC	8.9	8.9	8.9	96.9	106.1	97.4
117	NK S48-P4 Brand	FST 4 Late	Syngenta	4.7	5.1	4.9	72.8	104.0	72.8

Appendix 1 a. Means of visual scores and percent dead plants of soybean cultivars evaluated in MG IV flood test at V5 in Stuttgart, AR in 2012 and 2013 (Cont.).

Ent	Name	ID	Source	SC 1	SC 2	MSC	%DP (SC 1)	%DP (SC 2)	%MDP
118	NK S49-F8 Brand	FST 4 Late	Syngenta	9.0	9.0	9.0	95.6	102.7	95.6
119	Pioneer 94Y70	FST 4 Late	Pioneer Hi-Bred International, Inc.	8.3	8.7	8.5	89.3	97.2	89.4
120	REV®47R74™	FST 4 Late	Terral Seed	8.5	8.5	8.5	92.3	96.0	92.7
121	REV®49R22™	FST 4 Late	Terral Seed	8.0	8.5	8.2	88.6	91.4	88.4
122	USG 74A91	FST 4 Late	UniSouth Genetics, Inc.	9.0	8.8	8.9	95.3	102.7	95.5
123	Willcross RR2477N	FST 4 Late	Willcross Seeds, Inc.	8.8	9.0	8.9	96.9	112.1	96.7
124	Willcross RR2878NS	FST 4 Late	Willcross Seeds, Inc.	8.8	8.8	8.8	95.0	97.5	94.4
125	Willcross RY2482N	FST 4 Late	Willcross Seeds, Inc.	9.0	9.0	9.0	83.1	91.4	83.6

Appendix 1b. Means of visual scores and percent dead plants of soybean cultivars evaluated in MG IV flood test at R1 in Stuttgart, AR in 2012 and 2013.

Ent	Name	ID	Source	SC 1	SC 2	MSC	%DP (SC 1)	%DP (SC 2)	%MDP
1	Go Soy 4411 LL	NRR 4 Early	Stratton Seed Company	5.8	8.1	7.0	57.0	82.2	69.6
2	Halo 4:65	NRR 4 Early	US Seeds, Inc.	7.2	8.2	7.7	73.8	90.6	82.2
3	Halo X456	NRR 4 Early	US Seeds, Inc.	6.2	8.5	7.3	73.6	93.5	83.5
4	Pioneer 95Y40 (RR)	NRR 4 Early	Pioneer Hi-Bred International, Inc.	7.2	8.3	7.7	77.2	94.8	86.0
5	Armor 44-R08	EPT 4 Early	Armor	8.3	9.0	8.7	80.6	87.7	84.1
6	Armor 46-R42	EPT 4 Early	Armor	6.7	8.0	7.3	76.1	89.6	82.8
7	Armor 46-R64	EPT 4 Early	Armor	5.1	7.8	6.5	55.0	76.9	65.9
8	Armor X1303	EPT 4 Early	Armor	4.7	5.7	5.2	54.5	85.6	70.1
9	Armor X1304	EPT 4 Early	Armor	7.6	8.8	8.2	76.5	90.6	83.5
10	Armor X1305	EPT 4 Early	Armor	7.7	9.0	8.3	83.6	94.4	89.0
11	Asgrow AG3833	EPT 4 Early	Monsanto	7.3	8.7	8.0	81.3	97.8	89.6
12	Asgrow AG4232	EPT 4 Early	Monsanto	6.1	8.3	7.2	70.4	89.3	79.9
13	Asgrow AG4531	EPT 4 Early	Monsanto	6.3	8.0	7.2	72.8	92.8	82.7
14	Asgrow AG4632	EPT 4 Early	Monsanto	4.4	8.0	6.2	68.1	88.9	78.5
15	Croplan R2C4391	EPT 4 Early	Croplan Genetics	7.8	8.3	8.1	89.9	96.7	93.3
16	Croplan R2C4541	EPT 4 Early	Croplan Genetics	6.3	8.4	7.4	71.4	88.7	80.0
17	Delta Grow 4575RR2	EPT 4 Early	Delta Grow Seed	6.3	8.3	7.3	73.2	90.5	81.8
18	Delta Grow 4670RR2	EPT 4 Early	Delta Grow Seed	7.0	8.5	7.7	78.7	93.9	86.3
19	Dyna-Gro 31RY45	EPT 4 Early	CPS Dyna-Gro Seed	5.6	6.7	6.2	72.1	87.7	79.9
20	Dyna-Gro 39RY43	EPT 4 Early	CPS Dyna-Gro Seed	7.7	8.7	8.2	84.5	95.3	89.9
21	LG C4411R2	EPT 4 Early	LG Seeds	5.8	7.2	6.5	73.7	89.7	81.7
22	LG C4625R2	EPT 4 Early	LG Seeds	6.2	8.3	7.2	68.6	84.6	76.6
23	MorSoy XTRA 44X82	EPT 4 Early	Cache River Valley Seed, LLC	6.8	8.3	7.6	66.4	93.6	80.0
24	MorSoy XTRA 46X29	EPT 4 Early	Cache River Valley Seed, LLC	5.3	6.3	5.8	49.8	85.4	67.6
25	MorSoy XTRA 46X71	EPT 4 Early	Cache River Valley Seed, LLC	7.2	8.7	7.9	79.3	91.1	85.1
26	Progeny 4211RY	EPT 4 Early	Progeny AG products	8.0	9.0	8.5	89.7	97.2	93.5
27	Progeny 4510RY	EPT 4 Early	Progeny AG products	6.7	8.2	7.4	80.4	92.3	86.4
28	Progeny 4611RY	EPT 4 Early	Progeny AG products	7.4	8.7	8.1	78.1	90.0	84.0
29	S08-X14117	EPT 4 Early	University of Missouri	5.3	8.5	6.9	73.8	89.9	81.8
30	Schillinger 458.RCS	EPT 4 Early	Stratton Seed Company	7.2	8.8	8.0	75.2	94.7	84.9
31	AgBorn S08-X0448	FST 4 Early	AgBorn Inc	7.7	8.6	8.1	74.3	88.1	81.2

Appendix 1b. Means of visual scores and percent dead plants of soybean cultivars evaluated in MG IV flood test at R1 in Stuttgart, AR in 2012 and 2013 (Cont.).

Ent	Name	ID	Source	SC 1	SC 2	MSC	%DP (SC 1)	%DP (SC 2)	%MDP
32	AGS 43R212	FST 4 Early	Ag South Genetics	7.7	8.3	8.0	79.0	95.5	87.3
33	AGS 45R212	FST 4 Early	Ag South Genetics	7.0	8.5	7.7	80.4	93.6	87.0
34	Asgrow AG4433	FST 4 Early	Monsanto	8.4	8.8	8.6	82.3	94.9	88.6
35	Asgrow AG4533	FST 4 Early	Monsanto	6.0	7.8	6.9	66.9	92.3	79.6
36	Asgrow AG4633	FST 4 Early	Monsanto	8.3	8.8	8.6	88.0	97.8	92.9
37	AvDX - D613	FST 4 Early	Dulaney Seed/Agventure	5.5	7.8	6.7	55.7	79.6	67.6
38	Dyna-Gro S44RS93	FST 4 Early	CPS Dyna-Gro Seed	8.2	8.7	8.4	88.9	94.8	91.8
39	HBK RY4620	FST 4 Early	Bayer/Hornbeck	6.3	9.0	7.6	76.4	97.7	87.0
40	NK S41-J6 Brand	FST 4 Early	Syngenta	6.2	8.3	7.2	69.5	92.5	81.0
41	NK S44-D5 Brand	FST 4 Early	Syngenta	4.1	7.8	6.0	63.4	86.4	74.9
42	NK S46-A1 Brand	FST 4 Early	Syngenta	5.3	8.7	7.0	62.6	97.6	80.1
43	NK S46-T3 Brand	FST 4 Early	Syngenta	7.2	8.5	7.8	67.5	90.3	78.9
44	Pioneer 94Y23	FST 4 Early	Pioneer Hi-Bred International, Inc.	7.2	8.8	8.0	82.9	94.9	88.9
45	Pioneer 94Y40	FST 4 Early	Pioneer Hi-Bred International, Inc.	7.8	9.0	8.4	87.2	97.9	92.5
46	REV®46R73™	FST 4 Early	Terral Seed	5.2	6.0	5.6	47.3	85.9	66.6
47	Schillinger 457.RCP	FST 4 Early	Stratton Seed Company	5.8	9.0	7.4	59.2	87.4	73.3
48	Willcross RY2460S	FST 4 Early	Willcross Seeds, Inc.	4.0	5.4	4.7	45.5	80.9	63.2
49	Armor 48-R40	EPT 4 Late	Armor	5.7	7.0	6.3	68.7	94.5	81.6
50	Armor 48-R91	EPT 4 Late	Armor	7.5	9.0	8.2	83.4	97.6	90.5
51	Armor DK 4744	EPT 4 Late	Armor	4.2	5.1	4.6	57.2	88.7	72.9
52	Armor X1306	EPT 4 Late	Armor	6.8	8.7	7.7	82.0	94.3	88.1
53	Armor X1307	EPT 4 Late	Armor	8.0	8.7	8.3	83.9	95.3	89.6
54	Armor X1308	EPT 4 Late	Armor	5.8	8.7	7.3	61.1	88.6	74.9
55	ARMOR X1309	EPT 4 Late	Armor	6.7	8.8	7.7	72.2	88.9	80.5
56	Armor X1310	EPT 4 Late	Armor	8.2	9.0	8.6	88.1	95.6	91.8
57	Armor X1311	EPT 4 Late	Armor	7.3	8.6	7.9	68.4	86.0	77.3
58	Armor X1312	EPT 4 Late	Armor	7.5	8.7	8.1	82.2	96.5	89.3
59	Asgrow AG4933	EPT 4 Late	Monsanto	7.3	8.7	8.0	82.0	93.4	87.7
60	AvDX - D812	EPT 4 Late	Dulaney Seed/Agventure	5.3	6.8	6.1	55.7	82.3	69.0
61	Croplan R2C4801S	EPT 4 Late	Croplan Genetics	7.0	8.0	7.5	71.7	89.2	80.4
62	Croplan R2T4799S	EPT 4 Late	Croplan Genetics	4.7	5.8	5.2	46.5	75.7	61.1

Appendix 1b. Means of visual scores and percent dead plants of soybean cultivars evaluated in MG IV flood test at R1 in Stuttgart, AR in 2012 and 2013 (Cont.).

Ent	Name	ID	Source	SC 1	SC 2	MSC	%DP (SC 1)	%DP (SC 2)	%MDP
63	Delta Grow 4715RR2	EPT 4 Late	Delta Grow Seed	7.5	8.5	8.0	79.9	95.4	87.6
64	Delta Grow 4755RR2	EPT 4 Late	Delta Grow Seed	8.2	8.8	8.5	90.8	97.2	94.0
65	Delta Grow 4765RR2/STS	EPT 4 Late	Delta Grow Seed	8.0	8.7	8.3	91.9	97.3	94.6
66	Delta Grow 4815RR2	EPT 4 Late	Delta Grow Seed	7.9	9.0	8.5	77.9	85.4	81.6
67	Delta Grow 4825 RR2/STS	EPT 4 Late	Delta Grow Seed	7.7	8.8	8.2	85.7	95.7	90.7
68	Delta Grow 4870RR2	EPT 4 Late	Delta Grow Seed	6.5	8.5	7.5	65.8	88.2	77.0
69	Delta Grow 4880RR	EPT 4 Late	Delta Grow Seed	8.0	9.0	8.5	86.6	97.2	91.9
70	Delta Grow 4925RR2	EPT 4 Late	Delta Grow Seed	8.5	9.0	8.7	93.1	99.1	95.6
71	Delta Grow 4970RR	EPT 4 Late	Delta Grow Seed	6.5	8.0	7.2	75.2	87.9	81.5
72	Delta Grow 4975RR	EPT 4 Late	Delta Grow Seed	7.8	8.8	8.3	89.3	95.7	92.5
73	Delta Grow 4980RR2	EPT 4 Late	Delta Grow Seed	5.8	6.5	6.2	58.8	83.3	71.1
74	Dyna-Gro S48RS53	EPT 4 Late	CPS Dyna-Gro Seed	7.5	8.7	8.1	82.7	95.2	89.0
75	LG C4780R2	EPT 4 Late	LG Seeds	8.3	8.7	8.5	88.3	95.2	91.7
76	LG C4885R2	EPT 4 Late	LG Seeds	7.8	8.7	8.2	84.3	94.1	89.2
77	MorSoy XTRA 47X12	EPT 4 Late	Cache River Valley Seed, LLC	7.7	8.8	8.2	82.6	95.9	89.2
78	MorSoy XTRA 48X00	EPT 4 Late	Cache River Valley Seed, LLC	8.0	9.0	8.5	84.9	99.3	92.1
79	MorSoy XTRA 48X02	EPT 4 Late	Cache River Valley Seed, LLC	8.5	9.0	8.7	91.4	99.5	95.4
80	Progeny 4710RY	EPT 4 Late	Progeny AG products	7.5	8.8	8.2	83.6	94.2	88.8
81	Progeny 4747RY	EPT 4 Late	Progeny AG products	8.3	8.8	8.6	81.7	94.8	88.3
82	Progeny 4814RY	EPT 4 Late	Progeny AG products	5.7	8.7	7.2	77.3	93.9	85.6
83	Progeny 4850RY	EPT 4 Late	Progeny AG products	7.2	8.7	7.9	78.2	95.7	86.9
84	Progeny 4900RY	EPT 4 Late	Progeny AG products	8.2	8.8	8.5	88.4	96.9	92.7
85	Progeny 4920RY	EPT 4 Late	Progeny AG products	7.3	8.3	7.8	77.4	91.4	84.4
86	REV®47R53™	EPT 4 Late	Terral Seed	4.8	6.2	5.5	61.6	81.3	71.5
87	REV®48R10™	EPT 4 Late	Terral Seed	6.2	7.7	6.9	65.5	84.1	74.8
88	REV®48R22™	EPT 4 Late	Terral Seed	4.8	8.0	6.4	73.1	93.9	83.5
89	REV®48R33™	EPT 4 Late	Terral Seed	7.2	9.0	8.1	77.3	90.8	84.0
90	REV®49R10™	EPT 4 Late	Terral Seed	5.8	6.7	6.3	56.0	90.7	73.3
91	REV®49R11™	EPT 4 Late	Terral Seed	4.8	5.2	5.0	55.7	84.0	69.8
92	REV®49R43™	EPT 4 Late	Terral Seed	4.7	5.7	5.2	64.3	86.9	75.6
93	REV®49R54™	EPT 4 Late	Terral Seed	5.2	7.8	6.5	58.1	94.5	76.3

Appendix 1b. Means of visual scores and percent dead plants of soybean cultivars evaluated in MG IV flood test at R1 in Stuttgart, AR in 2012 and 2013 (Cont.).

Ent	Name	ID	Source	SC 1	SC 2	MSC	%DP (SC 1)	%DP (SC 2)	%MDP
94	S08-X2499	EPT 4 Late	University of Missouri	7.9	9.0	8.5	73.9	89.4	81.6
95	Schillinger 478.RCS	EPT 4 Late	Stratton Seed Company	6.6	8.7	7.6	80.1	94.5	87.3
96	Schillinger 495.RC	EPT 4 Late	Stratton Seed Company	8.2	9.0	8.6	85.1	97.3	91.2
97	USG 74A79R	EPT 4 Late	UniSouth Genetics, Inc.	6.6	9.0	7.8	83.2	97.8	90.5
98	USG 74B81R	EPT 4 Late	UniSouth Genetics, Inc.	8.0	9.0	8.5	84.4	92.9	88.7
99	USG 74E88	EPT 4 Late	UniSouth Genetics, Inc.	7.8	8.8	8.3	89.6	95.0	92.3
100	USG 74H92R	EPT 4 Late	UniSouth Genetics, Inc.	6.5	8.0	7.2	76.9	92.2	84.5
101	AgBorn S08-X27041	FST 4 Late	AgBorn Inc	5.5	8.2	6.8	61.0	86.2	73.6
102	AgBorn S08-X78041	FST 4 Late	AgBorn Inc	5.5	6.6	6.0	70.7	88.0	79.4
103	AGS 47R212	FST 4 Late	Ag South Genetics	7.3	9.0	8.1	75.3	95.4	85.4
104	Asgrow AG4832	FST 4 Late	Monsanto	7.0	8.3	7.7	86.5	95.3	90.9
105	Asgrow AG4932	FST 4 Late	Monsanto	7.5	8.8	8.2	80.4	97.6	89.0
106	Davis 4148RR2Y	FST 4 Late	Davis seed company	7.7	9.0	8.3	84.5	98.5	91.5
107	Delta Grow 4875RR2/STS	FST 4 Late	Delta Grow Seed	7.4	8.3	7.9	77.5	92.5	85.0
108	Dyna-Gro 33RY47	FST 4 Late	CPS Dyna-Gro Seed	5.8	8.5	7.2	71.3	92.1	81.7
109	Dyna-Gro 39D48	FST 4 Late	CPS Dyna-Gro Seed	6.5	8.0	7.2	77.0	88.2	82.6
110	Dyna-Gro S47RY13	FST 4 Late	CPS Dyna-Gro Seed	7.3	8.7	8.0	83.1	96.5	89.8
111	Eagle Seed ES4818	FST 4 Late	Eagle Seed	7.7	8.7	8.2	81.3	91.0	86.1
112	Eagle Seed ES4998	FST 4 Late	Eagle Seed	7.2	7.7	7.4	77.8	88.2	83.0
113	HBK R4924	FST 4 Late	Bayer/Hornbeck	5.4	8.7	7.1	64.7	94.1	79.4
114	HBK RY4721	FST 4 Late	Bayer/Hornbeck	7.3	8.8	8.0	76.3	92.1	84.2
115	JGL EXP 480	FST 4 Late	JGL, Inc.	6.7	8.2	7.4	82.3	92.3	87.3
116	MorSoy XTRA 47X31	FST 4 Late	Cache River Valley Seed, LLC	8.3	8.8	8.6	82.9	90.5	86.7
117	NK S48-P4 Brand	FST 4 Late	Syngenta	6.5	8.2	7.3	76.0	92.4	84.2
118	NK S49-F8 Brand	FST 4 Late	Syngenta	7.5	7.8	7.7	78.6	89.8	84.2
119	Pioneer 94Y70	FST 4 Late	Pioneer Hi-Bred International, Inc.	5.2	7.2	6.2	67.0	89.7	78.3
120	REV®47R74™	FST 4 Late	Terral Seed	6.0	8.5	7.3	66.0	90.5	78.3
121	REV®49R22™	FST 4 Late	Terral Seed	7.3	8.7	8.0	77.5	95.8	86.6
122	USG 74A91	FST 4 Late	UniSouth Genetics, Inc.	7.8	9.0	8.4	76.4	94.8	85.6
123	Willcross RR2477N	FST 4 Late	Willcross Seeds, Inc.	8.7	9.0	8.8	84.8	95.3	90.0
124	Willcross RR2878NS	FST 4 Late	Willcross Seeds, Inc.	7.0	7.8	7.4	78.8	91.0	84.9
125	Willcross RY2482N	FST 4 Late	Willcross Seeds, Inc.	7.3	8.3	7.8	84.3	93.3	88.8

Appendix 2a. Means of visual scores and percent dead plants of soybean cultivars evaluated in MG V flood test at V5 in Stuttgart, AR in 2012 and 2013.

Ent	Name	ID	Source	SC 1	SC 2	MSC	%DP (SC 1)	%DP (SC 2)	%MDP
1	Armor 49-C3	NRR 4 Late	Armor	7.6	7.6	7.6	80.8	83.4	82.1
2	Croplan LC4880	NRR 4 Late	Croplan Genetics	8.7	8.9	8.8	86.3	86.6	86.5
3	Delta Grow 4867LL	NRR 4 Late	Delta Grow Seed	8.9	8.9	8.9	93.5	93.7	94.4
4	Delta Grow 4967LL	NRR 4 Late	Delta Grow Seed	8.5	8.5	8.5	93.5	94.8	94.1
5	Delta Grow 4990LL	NRR 4 Late	Delta Grow Seed	8.8	8.6	8.7	89.6	87.3	88.6
6	Dyna-Gro S48LL23	NRR 4 Late	CPS Dyna-Gro Seed	9.0	9.0	9.0	95.9	96.9	96.6
7	Go Soy 4711 LL	NRR 4 Late	Stratton Seed Company	8.5	8.2	8.4	76.6	83.1	79.9
8	Go Soy 4812 LL	NRR 4 Late	Stratton Seed Company	8.6	8.4	8.5	91.0	91.5	91.5
9	Go Soy 4910 LL	NRR 4 Late	Stratton Seed Company	6.6	6.8	6.7	78.8	83.5	81.1
10	Go Soy 4912 LL	NRR 4 Late	Stratton Seed Company	8.2	8.3	8.2	69.6	74.9	72.3
11	Halo 4:94	NRR 4 Late	US Seeds, Inc.	9.0	9.0	9.0	86.8	88.1	87.4
12	Halo X478	NRR 4 Late	US Seeds, Inc.	8.5	8.7	8.6	92.9	94.0	93.4
13	Halo X48	NRR 4 Late	US Seeds, Inc.	8.5	8.8	8.6	89.7	93.2	91.5
14	Halo X49	NRR 4 Late	US Seeds, Inc.	9.0	9.0	9.0	93.0	96.2	94.6
15	Progeny 4819LL	NRR 4 Late	Progeny AG products	8.8	8.7	8.7	92.0	93.0	92.5
16	Progeny 4928LL	NRR 4 Late	Progen AG products	8.2	8.2	8.2	86.2	90.0	88.1
17	R05-3239	NRR 4 Late	University of Arkansas	8.3	8.3	8.3	83.8	87.4	85.6
18	R05-4114	NRR 4 Late	University of Arkansas	8.6	8.4	8.5	89.9	91.2	90.8
19	USG 74G82L	NRR 4 Late	UniSouth Genetics, Inc.	8.7	9.0	8.8	93.2	94.7	94.0
20	USG 74G99L	NRR 4 Late	UniSouth Genetics, Inc.	8.9	8.9	8.9	86.8	88.0	87.4
21	Armor X1312-5	EPT 5	Armor	8.0	8.0	8.0	89.4	89.1	89.5
22	Asgrow AG5332	EPT 5	Monsanto	8.0	8.8	8.4	94.0	95.8	94.9
23	AvDX - E112	EPT 5	Dulaney Seed/Agventure	6.8	7.2	7.0	74.9	82.1	78.5
24	Croplan R2C5081	EPT 5	Croplan Genetics	7.7	7.0	7.3	77.7	79.6	78.6
25	Croplan R2C5371	EPT 5	Croplan Genetics	8.0	8.0	8.0	77.9	80.3	79.3
26	Delta Grow 5175RR2	EPT 5	Delta Grow Seed	8.2	8.3	8.2	87.1	92.5	89.7
27	Dyna-Gro 35RY51	EPT 5	CPS Dyna-Gro Seed	8.2	8.5	8.3	87.8	93.9	90.9
28	Dyna-Gro S53RY23	EPT 5	CPS Dyna-Gro Seed	8.3	8.0	8.2	89.4	94.0	91.7
29	Progeny 5111RY	EPT 5	Progeny AG products	8.6	8.9	8.8	93.7	92.4	93.9
30	Progeny 5210RY	EPT 5	Progeny AG products	7.2	7.7	7.4	74.2	80.0	77.1
31	Progeny 5388RY	EPT 5	Progeny AG products	7.6	7.6	7.6	78.2	81.5	80.1

Appendix 2a. Means of visual scores and percent dead plants of soybean cultivars evaluated in MG V flood test at V5 in Stuttgart, AR in 2012 and 2013 (Cont.).

Ent	Name	ID	Source	SC 1	SC 2	MSC	%DP (SC 1)	%DP (SC 2)	%MDP
32	REV®51R53™	EPT 5	Terral Seed	6.3	7.0	6.6	77.6	78.2	77.9
33	REV®52R74™	EPT 5	Terral Seed	9.0	9.0	9.0	97.4	98.5	97.9
34	REV®53R23™	EPT 5	Terral Seed	9.0	9.0	9.0	97.4	98.2	97.8
35	S08-X6399	EPT 5	University of Missouri	8.5	8.7	8.6	90.8	91.1	91.0
36	S08-X7279	EPT 5	University of Missouri	8.7	8.8	8.7	95.1	95.6	95.4
37	Schillinger 5220.RC	EPT 5	Stratton Seed Company	9.0	9.0	9.0	99.4	99.9	99.6
38	AgBorn S06-X9464	FST 5 Early	AgBorn Inc	9.0	9.0	9.0	81.1	83.0	82.0
39	AGS 554 RR	FST 5 Early	Ag South Genetics	7.4	7.8	7.6	82.5	84.6	83.7
40	Armor 53-R15	FST 5 Early	Armor	8.1	8.1	8.1	76.3	79.0	77.6
41	Armor 55-R22	FST 5 Early	Armor	8.0	8.2	8.1	71.4	77.2	74.3
42	Armor X1217	FST 5 Early	Armor	8.0	8.0	8.0	71.5	83.0	77.3
43	Armor X1313	FST 5 Early	Armor	8.5	8.7	8.6	92.0	95.5	93.7
44	Armor X1314	FST 5 Early	Armor	8.3	8.5	8.4	83.9	91.2	87.5
45	Armor X1315	FST 5 Early	Armor	8.0	8.0	8.0	85.5	85.5	85.6
46	Armor X1316	FST 5 Early	Armor	7.7	7.8	7.7	80.0	84.2	82.1
47	Asgrow AG5233	FST 5 Early	Monsanto	9.0	9.0	9.0	98.4	100.0	99.2
48	Asgrow AG5532	FST 5 Early	Monsanto	8.2	8.5	8.3	82.2	88.0	85.1
49	Asgrow AG5533	FST 5 Early	Monsanto	7.8	8.2	8.0	88.2	89.9	89.0
50	AvDX - E513	FST 5 Early	Dulaney Seed/Agventure	8.5	8.7	8.6	90.9	94.0	92.5
51	AvDX - V411	FST 5 Early	Dulaney Seed/Agventure	7.7	8.2	7.9	80.1	86.8	83.5
52	Croplan R2C5482	FST 5 Early	Croplan Genetics	8.8	8.7	8.7	88.8	91.6	90.2
53	Delta Grow 5475RR2	FST 5 Early	Delta Grow Seed	9.0	9.0	9.0	87.9	88.9	88.4
54	Delta Grow 5535RR2	FST 5 Early	Delta Grow Seed	8.2	8.5	8.3	87.1	89.7	88.4
55	Delta Grow 5556RR1	FST 5 Early	Delta Grow Seed	8.4	8.4	8.4	87.2	87.4	88.3
56	Dyna-Gro 32RY55	FST 5 Early	CPS Dyna-Gro Seed	7.4	8.0	7.7	77.8	85.7	82.0
57	Dyna-Gro 37RY52	FST 5 Early	CPS Dyna-Gro Seed	7.9	8.1	8.0	74.8	81.0	78.5
58	Dyna-Gro S54RY43	FST 5 Early	CPS Dyna-Gro Seed	8.2	8.8	8.5	88.7	92.2	90.7
59	Eagle Seed ES5400	FST 5 Early	Eagle Seed	8.8	9.0	8.9	94.7	95.2	94.9
60	Eagle Seed ES5507	FST 5 Early	Eagle Seed	7.7	8.2	7.9	84.5	87.2	85.9
61	Eagle Seed ES5519	FST 5 Early	Eagle Seed	7.8	8.3	8.1	85.6	90.3	87.9
62	HBK RY5221	FST 5 Early	Bayer/Hornbeck	7.1	7.9	7.5	69.9	74.5	72.7

Appendix 2a. Means of visual scores and percent dead plants of soybean cultivars evaluated in MG V flood test at V5 in Stuttgart, AR in 2012 and 2013 (Cont.).

Ent	Name	ID	Source	SC 1	SC 2	MSC	%DP (SC 1)	%DP (SC 2)	%MDP
63	HBK RY5421	FST 5 Early	Bayer/Hornbeck	8.6	8.6	8.6	91.8	93.2	92.7
64	HBK RY5521	FST 5 Early	Bayer/Hornbeck	8.3	8.5	8.4	86.6	89.6	88.1
65	MorSoy 5429	FST 5 Early	Cache River Valley Seed, LLC	9.0	9.0	9.0	97.6	98.9	98.2
66	MorSoy XTRA 51X52	FST 5 Early	Cache River Valley Seed, LLC	8.5	8.5	8.5	89.5	91.1	90.3
67	MorSoy XTRA 53X82	FST 5 Early	Cache River Valley Seed, LLC	8.7	8.8	8.7	84.0	88.5	86.2
68	MorSoy XTRA 54X41	FST 5 Early	Cache River Valley Seed, LLC	7.2	7.4	7.3	71.1	79.0	75.3
69	NK S51-H9 Brand	FST 5 Early	Syngenta	7.0	7.8	7.4	77.6	85.6	81.6
70	Pioneer 95Y01	FST 5 Early	Pioneer Hi-Bred International, Inc.	7.0	8.3	7.6	78.3	88.2	83.2
71	Pioneer 95Y10	FST 5 Early	Pioneer Hi-Bred International, Inc.	8.5	8.5	8.5	89.8	92.4	91.1
72	Pioneer 95Y50	FST 5 Early	Pioneer Hi-Bred International, Inc.	9.0	9.0	9.0	92.6	95.7	94.1
73	Progeny 5412RY	FST 5 Early	Progeny AG products	9.0	9.0	9.0	85.9	88.8	87.4
74	R04-1268RR	FST 5 Early	University of Arkansas	8.0	8.2	8.1	85.3	89.6	87.7
75	R09-1607RR	FST 5 Early	University of Arkansas	4.6	5.1	4.8	65.8	73.2	69.5
76	REV®54R84™	FST 5 Early	Terral Seed	7.7	7.8	7.7	82.6	87.8	85.2
77	REV®55R53™	FST 5 Early	Terral Seed	8.5	8.8	8.7	90.8	94.6	92.7
78	REV®55R83™	FST 5 Early	Terral Seed	8.5	8.7	8.6	84.9	89.0	86.9
79	Schillinger 557. RC	FST 5 Early	Stratton Seed Company	8.4	8.4	8.4	91.6	90.6	91.3
80	USG 7553nRS	FST 5 Early	UniSouth Genetics, Inc.	9.0	9.0	9.0	99.4	99.7	99.6
81	USG 75B21R	FST 5 Early	UniSouth Genetics, Inc.	8.1	8.7	8.4	83.2	87.5	86.2
82	USG 75Q42R	FST 5 Early	UniSouth Genetics, Inc.	6.3	6.3	6.3	67.3	68.2	67.8
83	USG 75Q52R	FST 5 Early	UniSouth Genetics, Inc.	9.0	9.0	9.0	93.9	95.9	94.9
84	Willcross RR2507NS	FST 5 Early	Willcross Seeds, Inc.	8.4	8.4	8.4	88.6	89.4	89.2
85	Willcross RR2544NS	FST 5 Early	Willcross Seeds, Inc.	8.8	9.0	8.9	92.3	92.9	92.8
86	Willcross RR2547N	FST 5 Early	Willcross Seeds, Inc.	8.8	9.0	8.9	89.8	94.6	92.2
87	AGS 568 RR	FST 5 Late	Ag South Genetics	9.0	9.0	9.0	98.7	98.5	98.6
88	AGS 597 RR	FST 5 Late	Ag South Genetics	8.8	8.7	8.7	83.6	82.6	83.1
89	Asgrow AG5632	FST 5 Late	Monsanto	7.8	8.0	7.9	77.8	84.5	81.3
90	Asgrow AG5633	FST 5 Late	Monsanto	8.7	8.8	8.7	94.8	96.5	95.6
91	Asgrow AG5732	FST 5 Late	Monsanto	8.2	8.6	8.4	81.6	88.2	85.1
92	Delta Grow 5625RR2	FST 5 Late	Delta Grow Seed	8.5	8.9	8.7	77.1	83.6	80.8
93	Dyna-Gro 39RY57	FST 5 Late	CPS Dyna-Gro Seed	9.0	9.0	9.0	95.0	94.8	95.1
94	Eagle Seed ES5650	FST 5 Late	Eagle Seed	8.8	8.8	8.8	91.4	94.4	92.9
95	NK S56-G6 Brand	FST 5 Late	Syngenta	8.8	9.0	8.9	94.5	93.7	94.1

Appendix 2a. Means of visual scores and percent dead plants of soybean cultivars evaluated in MG V flood test at V5 in Stuttgart, AR in 2012 and 2013 (Cont.).

Ent	Name	ID	Source	SC 1	SC 2	MSC	%DP (SC 1)	%DP (SC 2)	%MDP
96	Progeny 5610RY	FST 5 Late	Progeny AG products	7.8	8.0	7.9	80.6	85.3	82.9
97	Progeny 5655RY	FST 5 Late	Progeny AG products	8.8	9.0	8.9	95.6	98.3	97.0
98	Progeny 5711RY	FST 5 Late	Progeny AG products	8.3	8.5	8.4	85.0	89.1	87.1
99	Progeny 5811RY	FST 5 Late	Progeny AG products	7.5	8.2	7.8	76.9	84.3	80.6
100	REV®56R21™	FST 5 Late	Terral Seed	8.0	8.7	8.3	80.7	86.0	83.4
101	REV®56R63™	FST 5 Late	Terral Seed	8.3	8.7	8.5	59.7	82.8	71.2
102	REV®57R21™	FST 5 Late	Terral Seed	7.4	7.8	7.6	74.9	84.0	79.7
103	REV®59R13™	FST 5 Late	Terral Seed	8.8	9.0	8.9	87.2	90.7	89.0
104	USG 75J62R	FST 5 Late	UniSouth Genetics, Inc.	8.9	8.9	8.9	97.0	97.5	97.7
105	USG 75Z98	FST 5 Late	UniSouth Genetics, Inc.	8.0	8.2	8.1	88.2	89.3	89.0
106	AGS 553 LL	NRR 5 Early	Ag South Genetics	8.3	8.3	8.3	89.0	92.3	90.6
107	Armor 50-C3	NRR 5 Early	Armor	8.9	8.9	8.9	90.0	92.7	91.8
108	DB03-8416	NRR 5 Early	USDA-ARS Stoneville, MS	9.0	8.8	8.9	95.4	96.5	95.9
109	DB04-10836	NRR 5 Early	USDA-ARS Stoneville, MS	8.0	8.2	8.1	89.8	92.1	91.0
110	Delta Grow 5461LL	NRR 5 Early	Delta Grow Seed	7.0	7.0	7.0	85.0	90.1	87.5
111	Dyna-Gro 34LL53	NRR 5 Early	CPS Dyna-Gro Seed	6.7	6.8	6.8	61.0	52.1	56.8
112	Eagle Seed LL	NRR 5 Early	Eagle Seed	9.0	9.0	9.0	96.2	97.3	96.9
113	Glenn	NRR 5 Early	Virginia Tech	8.3	8.5	8.4	89.9	92.2	91.0
114	Go Soy 5010 LL	NRR 5 Early	Stratton Seed Company	7.0	6.8	6.9	70.6	74.9	72.7
115	Go Soy 5111 LL	NRR 5 Early	Stratton Seed Company	6.5	6.4	6.5	69.9	74.4	72.2
116	Go Soy 5410 LL	NRR 5 Early	Stratton Seed Company	8.4	8.2	8.3	86.2	83.9	86.0
117	Halo 5:25	NRR 5 Early	US Seeds, Inc.	6.0	3.7	4.9	58.6	63.9	61.3
118	Halo 5:45	NRR 5 Early	US Seeds, Inc.	6.5	7.2	6.9	66.7	74.0	70.3
119	Halo X50	NRR 5 Early	US Seeds, Inc.	8.3	8.3	8.3	90.7	94.2	92.5
120	Halo X51	NRR 5 Early	US Seeds, Inc.	7.8	8.3	8.1	79.0	80.5	79.7
121	Halo X55	NRR 5 Early	US Seeds, Inc.	7.7	8.0	7.8	82.9	91.1	87.0
122	Hutcheson	NRR 5 Early	University of Arkansas	8.1	8.3	8.2	72.5	74.3	73.4
123	JTN-4307	NRR 5 Early	USDA-ARS Jackson, TN	7.8	8.0	7.9	81.9	84.3	83.3
124	JTN-4408	NRR 5 Early	USDA-ARS Jackson, TN	8.3	8.7	8.5	91.5	92.6	92.0
125	JTN-5108	NRR 5 Early	USDA-ARS Jackson, TN	7.8	8.3	8.1	90.0	93.5	91.7
126	JTN-5110	NRR 5 Early	USDA-ARS Jackson, TN	6.0	6.3	6.2	66.0	73.2	69.6
127	JTN-5203	NRR 5 Early	USDA-ARS Jackson, TN	8.5	8.8	8.7	90.9	93.5	92.2
128	Ozark	NRR 5 Early	University of Arkansas	6.3	6.8	6.6	69.0	73.9	71.4
129	Progeny 5160LL	NRR 5 Early	Progeny AG products	3.3	5.0	4.1	46.1	49.0	47.5
130	Progeny 5460LL	NRR 5 Early	Rogeny AG products	7.7	8.0	7.8	81.2	82.5	81.9
131	S08-X17371	NRR 5 Early	University of Missouri	8.0	8.3	8.1	78.5	81.3	79.9

Appendix 2b. Means of visual scores and percent dead plants of soybean cultivars evaluated in MG V flood test at R1 in Stuttgart, AR in 2012 and 2013.

Ent	Name	ID	Source	SC 1	SC 2	MSC	%DP (SC 1)	%DP (SC 2)	%MDP
1	Armor 49-C3	NRR 4 Late	Armor	8.6	9.1	8.8	87.3	98.5	92.9
2	Croplan LC4880	NRR 4 Late	Croplan Genetics	6.1	8.5	7.6	59.2	88.2	73.7
3	Delta Grow 4867LL	NRR 4 Late	Delta Grow Seed	8.7	8.7	8.7	77.5	96.2	86.8
4	Delta Grow 4967LL	NRR 4 Late	Delta Grow Seed	6.9	8.2	7.5	67.2	80.9	74.1
5	Delta Grow 4990LL	NRR 4 Late	Delta Grow Seed	8.8	9.1	8.9	86.1	98.8	92.3
6	Dyna-Gro S48LL23	NRR 4 Late	CPS Dyna-Gro Seed	8.1	8.7	8.4	75.2	92.6	83.9
7	Go Soy 4711 LL	NRR 4 Late	Stratton Seed Company	5.0	8.1	6.5	58.6	89.3	74.0
8	Go Soy 4812 LL	NRR 4 Late	Stratton Seed Company	8.8	9.0	8.9	77.4	96.3	86.8
9	Go Soy 4910 LL	NRR 4 Late	Stratton Seed Company	7.1	7.8	7.5	64.5	91.2	77.8
10	Go Soy 4912 LL	NRR 4 Late	Stratton Seed Company	8.2	9.1	8.6	74.9	97.2	86.0
11	Halo 4:94	NRR 4 Late	US Seeds, Inc.	7.3	8.3	7.8	75.6	93.5	84.5
12	Halo X478	NRR 4 Late	US Seeds, Inc.	7.3	8.8	8.1	84.8	97.4	91.1
13	Halo X48	NRR 4 Late	US Seeds, Inc.	8.0	9.1	8.5	82.7	98.7	90.5
14	Halo X49	NRR 4 Late	US Seeds, Inc.	6.0	8.8	7.4	61.5	89.8	75.6
15	Progeny 4819LL	NRR 4 Late	Progeny AG products	8.5	9.0	8.7	85.1	97.1	91.1
16	Progeny 4928LL	NRR 4 Late	Progen AG products	4.8	8.6	6.7	66.4	88.7	77.6
17	R05-3239	NRR 4 Late	University of Arkansas	8.6	9.0	8.8	71.2	94.2	82.7
18	R05-4114	NRR 4 Late	University of Arkansas	8.3	9.0	8.6	79.8	96.7	88.2
19	USG 74G82L	NRR 4 Late	UniSouth Genetics, Inc.	8.4	8.9	8.7	73.9	83.3	78.6
20	USG 74G99L	NRR 4 Late	UniSouth Genetics, Inc.	8.0	8.7	8.3	83.6	93.8	88.7
21	Armor X1312-5	EPT 5	Armor	8.3	9.0	8.7	85.4	99.5	92.5
22	Asgrow AG5332	EPT 5	Monsanto	7.4	7.8	7.6	68.9	91.1	80.0
23	AvDX - E112	EPT 5	Dulaney Seed/Agventure	3.9	8.0	6.0	52.8	91.4	72.1
24	Croplan R2C5081	EPT 5	Croplan Genetics	8.8	8.8	8.8	81.1	98.9	90.0
25	Croplan R2C5371	EPT 5	Croplan Genetics	7.5	9.0	8.2	78.7	97.4	88.0
26	Delta Grow 5175RR2	EPT 5	Delta Grow Seed	8.5	9.0	8.7	80.7	99.4	90.1
27	Dyna-Gro 35RY51	EPT 5	CPS Dyna-Gro Seed	8.3	9.0	8.7	83.5	98.5	91.0
28	Dyna-Gro S53RY23	EPT 5	CPS Dyna-Gro Seed	7.1	9.1	8.1	71.5	99.1	85.1
29	Progeny 5111RY	EPT 5	Progeny AG products	8.0	9.0	8.5	78.4	93.9	86.1
30	Progeny 5210RY	EPT 5	Progeny AG products	8.3	8.8	8.5	64.2	90.2	77.2
31	Progeny 5388RY	EPT 5	Progeny AG products	8.2	8.8	8.5	76.7	96.9	86.8
32	REV®51R53™	EPT 5	Terral Seed	7.0	8.0	7.5	70.1	92.0	81.0
33	REV®52R74™	EPT 5	Terral Seed	6.1	8.7	7.4	77.7	95.5	86.6
34	REV®53R23™	EPT 5	Terral Seed	8.3	9.0	8.6	81.2	97.8	89.5

Appendix 2b. Means of visual scores and percent dead plants of soybean cultivars evaluated in MG V flood test at R1 in Stuttgart, AR in 2012 and 2013 (Cont.).

Ent	Name	ID	Source	SC 1	SC 2	MSC	%DP (SC 1)	%DP (SC 2)	%MDP
35	S08-X6399	EPT 5	University of Missouri	6.7	8.5	7.6	57.4	91.0	74.2
36	S08-X7279	EPT 5	University of Missouri	8.8	9.0	8.9	92.1	97.0	94.5
37	Schillinger 5220.RC	EPT 5	Stratton Seed Company	7.9	9.0	8.4	68.0	92.1	80.1
38	AgBorn S06-X9464	FST 5 Early	AgBorn Inc	5.0	6.0	5.5	54.5	86.2	70.3
39	AGS 554 RR	FST 5 Early	Ag South Genetics	7.9	8.7	8.3	75.2	94.1	84.6
40	Armor 53-R15	FST 5 Early	Armor	4.5	8.3	6.4	64.8	94.4	79.6
41	Armor 55-R22	FST 5 Early	Armor	8.7	9.0	8.8	80.5	98.2	89.4
42	Armor X1217	FST 5 Early	Armor	6.6	8.6	7.3	66.2	97.7	81.9
43	Armor X1313	FST 5 Early	Armor	7.8	8.8	8.3	75.8	99.7	87.7
44	Armor X1314	FST 5 Early	Armor	6.5	9.0	7.7	56.3	99.8	78.0
45	Armor X1315	FST 5 Early	Armor	6.6	8.9	7.7	77.2	97.8	87.4
46	Armor X1316	FST 5 Early	Armor	7.7	9.0	8.3	76.4	96.9	86.6
47	Asgrow AG5233	FST 5 Early	Monsanto	8.4	9.0	8.7	91.7	98.8	95.3
48	Asgrow AG5532	FST 5 Early	Monsanto	7.2	8.8	8.0	66.9	96.7	81.8
49	Asgrow AG5533	FST 5 Early	Monsanto	7.5	9.0	8.2	71.0	97.5	84.2
50	AvDX - E513	FST 5 Early	Dulaney Seed/Agventure	8.2	8.5	8.3	70.0	97.1	83.5
51	AvDX - V411	FST 5 Early	Dulaney Seed/Agventure	7.3	8.8	8.1	79.9	98.0	88.9
52	Croplan R2C5482	FST 5 Early	Croplan Genetics	6.0	8.8	7.4	55.5	98.4	76.9
53	Delta Grow 5475RR2	FST 5 Early	Delta Grow Seed	7.8	9.0	8.4	61.5	99.6	80.6
54	Delta Grow 5535RR2	FST 5 Early	Delta Grow Seed	8.2	9.0	8.6	80.5	99.7	90.1
55	Delta Grow 5556RR1	FST 5 Early	Delta Grow Seed	8.2	8.9	8.5	88.4	98.3	93.2
56	Dyna-Gro 32RY55	FST 5 Early	CPS Dyna-Gro Seed	7.7	8.7	8.2	63.0	93.6	78.3
57	Dyna-Gro 37RY52	FST 5 Early	CPS Dyna-Gro Seed	6.9	8.7	7.8	60.4	89.4	74.9
58	Dyna-Gro S54RY43	FST 5 Early	CPS Dyna-Gro Seed	5.6	9.0	7.3	58.6	99.8	79.2
59	Eagle Seed ES5400	FST 5 Early	Eagle Seed	8.5	8.8	8.7	92.7	99.1	95.9
60	Eagle Seed ES5507	FST 5 Early	Eagle Seed	7.0	8.8	7.9	73.3	97.1	85.2
61	Eagle Seed ES5519	FST 5 Early	Eagle Seed	8.0	8.8	8.4	85.8	97.5	91.7
62	HBK RY5221	FST 5 Early	Bayer/Hornbeck	7.1	8.5	7.8	50.3	89.5	69.9
63	HBK RY5421	FST 5 Early	Bayer/Hornbeck	8.3	8.8	8.6	93.1	100.0	96.6

Appendix 2b. Means of visual scores and percent dead plants of soybean cultivars evaluated in MG V flood test at R1 in Stuttgart, AR in 2012 and 2013 (Cont.).

Ent	Name	ID	Source	SC 1	SC 2	MSC	%DP (SC 1)	%DP (SC 2)	%MDP
64	HBK RY5521	FST 5 Early	Bayer/Hornbeck	8.2	8.8	8.5	86.9	97.8	92.3
65	MorSoy 5429	FST 5 Early	Cache River Valley Seed, LLC	8.0	8.8	8.4	83.6	95.5	89.5
66	MorSoy XTRA 51X52	FST 5 Early	Cache River Valley Seed, LLC	8.5	9.0	8.7	76.0	99.1	87.6
67	MorSoy XTRA 53X82	FST 5 Early	Cache River Valley Seed, LLC	5.7	8.7	7.2	50.5	98.1	74.3
68	MorSoy XTRA 54X41	FST 5 Early	Cache River Valley Seed, LLC	7.4	9.1	8.2	70.6	95.9	83.1
69	NK S51-H9 Brand	FST 5 Early	Syngenta	8.3	8.8	8.5	73.8	97.7	85.7
70	Pioneer 95Y01	FST 5 Early	Pioneer Hi-Bred International, Inc.	6.8	7.8	7.3	61.2	83.3	72.2
71	Pioneer 95Y10	FST 5 Early	Pioneer Hi-Bred International, Inc.	7.4	8.7	8.0	66.5	82.8	74.7
72	Pioneer 95Y50	FST 5 Early	Pioneer Hi-Bred International, Inc.	7.8	9.0	8.4	85.1	98.6	91.8
73	Progeny 5412RY	FST 5 Early	Progeny AG products	8.0	9.0	8.5	74.3	98.3	86.3
74	R04-1268RR	FST 5 Early	University of Arkansas	5.0	8.5	6.7	50.4	95.4	72.9
75	R09-1607RR	FST 5 Early	University of Arkansas	7.6	8.8	8.2	71.8	96.1	84.0
76	REV®54R84™	FST 5 Early	Terral Seed	6.0	8.7	7.3	74.3	90.5	82.4
77	REV®55R53™	FST 5 Early	Terral Seed	5.9	8.3	7.1	63.0	93.6	78.3
78	REV®55R83™	FST 5 Early	Terral Seed	6.5	8.7	7.6	63.8	95.8	79.8
79	Schillinger 557. RC	FST 5 Early	Stratton Seed Company	7.9	9.0	8.5	62.0	95.1	78.6
80	USG 7553nRS	FST 5 Early	UniSouth Genetics, Inc.	8.5	9.0	8.7	93.0	100.0	96.5
81	USG 75B21R	FST 5 Early	UniSouth Genetics, Inc.	8.0	8.7	8.3	80.4	97.0	88.7
82	USG 75Q42R	FST 5 Early	UniSouth Genetics, Inc.	5.9	8.8	7.4	63.9	97.8	80.9
83	USG 75Q52R	FST 5 Early	UniSouth Genetics, Inc.	7.7	8.8	8.2	66.8	98.2	82.5
84	Willcross RR2507NS	FST 5 Early	Willcross Seeds, Inc.	6.8	8.3	7.6	59.7	94.5	77.1
85	Willcross RR2544NS	FST 5 Early	Willcross Seeds, Inc.	8.2	9.0	8.6	81.9	99.1	90.4
86	Willcross RR2547N	FST 5 Early	Willcross Seeds, Inc.	8.8	9.0	8.9	94.7	99.8	97.2
87	AGS 568 RR	FST 5 Late	Ag South Genetics	7.8	9.0	8.4	83.2	99.5	91.3
88	AGS 597 RR	FST 5 Late	Ag South Genetics	7.3	9.0	8.2	62.1	89.2	75.6
89	Asgrow AG5632	FST 5 Late	Monsanto	6.2	8.8	7.5	73.9	97.6	85.8
90	Asgrow AG5633	FST 5 Late	Monsanto	8.5	9.0	8.7	89.3	99.6	94.5
91	Asgrow AG5732	FST 5 Late	Monsanto	8.7	9.0	8.8	92.8	98.8	95.8
92	Delta Grow 5625RR2	FST 5 Late	Delta Grow Seed	8.0	8.7	8.3	79.1	99.4	89.1
93	Dyna-Gro 39RY57	FST 5 Late	CPS Dyna-Gro Seed	7.5	8.8	8.2	86.2	96.9	91.5
94	Eagle Seed ES5650	FST 5 Late	Eagle Seed	7.9	8.2	8.1	72.4	89.8	81.1
95	NK S56-G6 Brand	FST 5 Late	Syngenta	4.6	8.1	6.3	57.8	85.2	71.5
96	Progeny 5610RY	FST 5 Late	Progeny AG products	7.0	8.5	7.7	74.4	92.4	83.4

Appendix 2b. Means of visual scores and percent dead plants of soybean cultivars evaluated in MG V flood test at R1 in Stuttgart, AR in 2012 and 2013 (Cont.).

Ent	Name	ID	Source	SC 1	SC 2	MSC	%DP (SC 1)	%DP (SC 2)	%MDP
97	Progeny 5655RY	FST 5 Late	Progeny AG products	7.8	8.8	8.3	81.4	100.0	90.7
98	Progeny 5711RY	FST 5 Late	Progeny AG products	8.5	8.8	8.7	76.1	96.4	86.2
99	Progeny 5811RY	FST 5 Late	Progeny AG products	6.2	8.2	7.2	63.7	91.1	77.4
100	REV®56R21™	FST 5 Late	Terral Seed	7.0	9.0	8.0	59.2	88.2	73.7
101	REV®56R63™	FST 5 Late	Terral Seed	7.8	9.0	8.4	76.2	99.3	87.7
102	REV®57R21™	FST 5 Late	Terral Seed	6.0	8.3	7.2	63.4	96.1	79.7
103	REV®59R13™	FST 5 Late	Terral Seed	7.8	9.0	8.4	82.2	99.5	90.8
104	USG 75J62R	FST 5 Late	UniSouth Genetics, Inc.	8.7	9.0	8.8	88.4	99.2	93.8
105	USG 75Z98	FST 5 Late	UniSouth Genetics, Inc.	5.6	8.8	7.2	63.6	94.5	79.0
106	AGS 553 LL	NRR 5 Early	Ag South Genetics	7.8	9.0	8.4	80.5	94.6	87.6
107	Armor 50-C3	NRR 5 Early	Armor	8.3	9.0	8.7	82.3	99.7	91.0
108	DB03-8416	NRR 5 Early	USDA-ARS Stoneville, MS	8.7	9.0	8.8	92.4	97.7	95.0
109	DB04-10836	NRR 5 Early	USDA-ARS Stoneville, MS	6.3	8.7	7.5	65.6	98.4	82.0
110	Delta Grow 5461LL	NRR 5 Early	Delta Grow Seed	7.8	8.4	8.1	63.5	86.1	74.8
111	Dyna-Gro 34LL53	NRR 5 Early	CPS Dyna-Gro Seed	5.5	8.2	6.9	48.3	92.0	70.1
112	Eagle Seed LL	NRR 5 Early	Eagle Seed	7.2	9.0	8.1	78.8	96.4	87.6
113	Glenn	NRR 5 Early	Virginia Tech	5.7	8.5	7.1	74.6	96.9	85.7
114	Go Soy 5010 LL	NRR 5 Early	Stratton Seed Company	4.8	8.5	6.6	66.7	96.0	81.3
115	Go Soy 5111 LL	NRR 5 Early	Stratton Seed Company	5.7	8.8	7.2	49.4	98.2	73.8
116	Go Soy 5410 LL	NRR 5 Early	Stratton Seed Company	5.2	8.1	6.6	64.1	84.4	74.2
117	Halo 5:25	NRR 5 Early	US Seeds, Inc.	4.7	8.5	6.6	44.6	90.9	67.7
118	Halo 5:45	NRR 5 Early	US Seeds, Inc.	4.1	7.9	6.0	45.6	90.9	68.3
119	Halo X50	NRR 5 Early	US Seeds, Inc.	4.5	7.2	5.8	54.6	83.6	69.1
120	Halo X51	NRR 5 Early	US Seeds, Inc.	7.7	9.0	8.3	86.4	98.8	92.6
121	Halo X55	NRR 5 Early	US Seeds, Inc.	5.0	7.5	6.2	55.2	95.8	75.5
122	Hutcheson	NRR 5 Early	University of Arkansas	5.6	8.5	7.0	38.2	96.1	67.2
123	JTN-4307	NRR 5 Early	USDA-ARS Jackson, TN	9.0	9.0	9.0	97.9	100.0	98.9
124	JTN-4408	NRR 5 Early	USDA-ARS Jackson, TN	8.0	8.8	8.4	80.5	96.7	88.6
125	JTN-5108	NRR 5 Early	USDA-ARS Jackson, TN	7.5	9.0	8.2	76.1	98.7	87.4
126	JTN-5110	NRR 5 Early	USDA-ARS Jackson, TN	7.7	9.0	8.3	86.4	98.6	92.5
127	JTN-5203	NRR 5 Early	USDA-ARS Jackson, TN	8.3	9.0	8.7	80.7	99.8	90.3
128	Ozark	NRR 5 Early	University of Arkansas	4.6	6.0	5.3	54.6	92.9	73.7
129	Progeny 5160LL	NRR 5 Early	Progeny AG products	5.3	8.7	7.0	45.4	79.6	62.5
130	Progeny 5460LL	NRR 5 Early	Rogeny AG products	8.4	9.0	8.7	78.7	90.9	84.8
131	S08-X17371	NRR 5 Early	University of Missouri	8.0	9.0	8.5	74.6	97.9	86.2

Appendix 3. Soybean cultivars evaluated at different flooding durations at R1 in 2013 at Stuttgart, AR.

Ent	Name	Source	Type
1	Osage	Foundation	FLD-T
2	Ozark	Foundation	FLD-T
3	Walters		FLD-T
4	R10-5450	11PD5	FLD-T
5	RO7-7775	12 ARV-2	FLD-T
6	RO7-2001	12PSF-1	FLD-T
7	PI-471931		FLD-T
8	RM-1639		FLD-T
9	MorSoy XTRA 46 X29		FLD-T
10	Armor DK 4744		FLD-T
11	R10-5569	12PDF-2	FLD-T
12	Pickett 71	O8ARV-3	FLD-T
13	R10-4892	13UP-6	FLD-T
14	Uark 5798	12ARV-1	FLD-T
15	R10-5096	PDF-1	FLD-T
16	Uark 5896	12ARV-1	FLD-S
17	RO3-1250	12ARV-1	FLD-S
18	RO5-3239	Foundation	FLD-S
19	Asgrow AG5233	Monsanto	FLD-S
20	Delta Grow 5461LL	Delta Grow Seed	FLD-S
21	Delta Grow 4990LL	Delta Grow Seed	FLD-S
22	Progeny 5388RY	Progeny AG products	FLD-S
23	S08-X7279	University of Missouri	FLD-S
24	Willcross RR2547N	Willcross Seeds, Inc.	FLD-S
25	Schillinger 5220.RC	Stratton Seed Company	FLD-S
26	Pioneer 95Y01	Pioneer Hi-Bred International, Inc.	FLD-S
27	JTN-4307	USDA-ARS Jackson, TN	FLD-S
28	Halo 4:65	US Seeds, Inc.	FLD-S
29	Willcross RR2477N	Willcross Seeds, Inc.	FLD-S
30	Progeny 4920RY	Progeny AG products	FLD-S

FLD-T= flood tolerant
FLD-S= flood susceptible

Appendix 4. Soybean cultivars evaluated at different flooding durations atV 5 and R1 flood test in 2014 at Stuttgart, AR.

Entry	Name	Source	Type
1	Walters	13ARV-1-16	FLD-T
2	R10-2346	13DTF-1-28	FLD-T
3	R11-2965	13DTF-1-14	FLD-T
4	R11-3373	13DTF-2-12	FLD-T
5	R11-3115	13DTF-2-27	FLD-T
6	R11-11G	13FLF-1	FLD-T
7	R11-432G	13FLF-2	FLD-T
8	R11-3625	13FLF-9	FLD-T
9	R11-3598	13FLF-14	FLD-T
10	R11-6870	13PDF-1-1	FLD-T
11	R10-4892	13PDF-1-6	FLD-T
12	R11-9513	13RRF-2-8	FLD-T
13	R07-6669	13RU-31	FLD-T
14	R09-5088	13RU-29	FLD-T
15	R10-197 RY	13RU-23	FLD-T
16	R10-130 RY	13RU-24	FLD-T
17	Osage	13ARV-1-7	FLD-T
18	R07-2001	13ARV-3-20	FLD-T
19	Ozark	13ARV-1-8	FLD-T
20	RM-1639	13ARV-3-16	FLD-T
21	Desha	13ARV-1-2	FLD-S
22	Lee	13ARV-1-4	FLD-S
23	Lonoke	13ARV-1-5	FLD-S
24	UA 4913C(R05-3239)	13ARV-1-31	FLD-S
25	RM-22590	13ARV-3-18	FLD-S
26	R07-129	13ARV-4-24	FLD-S
27	R09-4095	13ARV-4-22	FLD-S
28	R11-2964	13DTF-1-13	FLD-S
29	R11-2577	13DTF-1-22	FLD-S
30	R11-3283	13DTF-2-3	FLD-S
31	R11-7700	13PDF-2-20	FLD-S
32	R11-7636	13PDF-2-16	FLD-S
33	R10-6606RR	13RRF-1-3	FLD-S
34	R09-1827RR	13RRF-1-27	FLD-S
35	R11-9428	13RRF-2-2	FLD-S
36	R09-1831RR	13RRF-1-26	FLD-S
37	R06-4433	13ARV-1-29	FLD-S
38	R08-3119	13ARV-3-3	FLD-S
39	R01-2731F	13ARV-3-1	FLD-S
40	R99-1613F	13ARV-3-4	FLD-S

FLD-T= flood tolerant
FLD-S= flood susceptible

Appendix 5. Means of visual scores and percent dead plants of soybean cultivars evaluated at different flooding durations at V 5 and R1 flood test in 2014 at Stuttgart, AR.

Cultivars	Stage	Duration	SC 1	SC 2	SC 3	SC 4	MSC	%DP (SC 1)	%DP (SC 2)	%DP (SC 3)	%DP (SC 4)	%MDP
Walters	R1	3	1.0	1.3	1.3	1.3	1.3	0.6	3.3	5.4	7.6	4.3
R10-2346	R1	3	1.0	1.3	1.3	1.7	1.4	7.5	12.8	14.4	21.8	14.1
R11-2965	R1	3	1.0	1.7	2.0	2.0	1.7	6.8	11.1	14.9	18.8	12.9
R11-3373	R1	3	1.3	1.7	2.0	2.0	1.8	8.4	10.6	12.7	13.8	11.4
R11-3115	R1	3	1.0	1.0	1.0	1.0	1.0	3.5	3.5	5.7	9.0	5.5
R11-11G	R1	3	1.0	1.0	1.0	1.3	1.1	5.9	8.7	9.2	13.2	9.2
R11-432G	R1	3	1.3	1.3	2.0	2.0	1.7	12.0	16.1	19.6	23.8	17.9
R11-3625	R1	3	2.0	2.3	2.7	3.3	2.6	24.1	30.7	33.5	43.9	33.1
R11-3598	R1	3	1.0	1.7	1.7	1.7	1.5	7.4	10.4	10.4	12.5	10.2
R11-6870	R1	3	1.3	1.3	1.3	1.3	1.3	4.4	6.8	8.8	8.8	7.2
R10-4892	R1	3	1.3	1.3	1.7	2.0	1.6	8.9	17.8	20.1	29.8	19.2
R11-9513	R1	3	1.0	1.0	1.3	1.7	1.3	2.2	3.2	12.0	20.5	9.5
R07-6669	R1	3	1.0	1.0	1.0	1.3	1.1	0.7	0.7	2.6	5.0	2.2
R09-5088	R1	3	1.0	1.0	1.0	1.0	1.0	4.0	5.0	5.0	8.4	5.6
R10-197 RY	R1	3	1.0	1.3	1.3	1.7	1.4	2.4	7.7	11.7	22.5	11.0
R10-130 RY	R1	3	1.0	1.0	1.0	1.3	1.1	3.0	3.0	7.6	13.5	6.8
Osage	R1	3	1.3	1.7	2.0	2.7	1.9	6.0	10.6	17.1	24.5	14.5
R07-2001	R1	3	1.0	1.0	1.3	2.0	1.4	1.6	2.2	6.5	15.2	6.4
Ozark	R1	3	1.0	1.0	1.3	1.3	1.2	0.8	2.2	5.8	9.0	4.5
RM-1639	R1	3	1.3	1.3	1.7	2.0	1.6	2.8	3.6	5.9	12.2	6.1
Desha	R1	3	1.0	1.0	1.3	1.3	1.2	1.7	1.7	5.0	7.3	3.9
Lee	R1	3	1.0	1.3	1.3	1.7	1.4	2.2	6.0	9.1	15.5	8.2
Lonoke	R1	3	1.0	1.0	1.0	1.0	1.0	0.7	1.1	2.9	5.1	2.4
UA 4913C	R1	3	1.3	1.7	2.0	2.0	1.8	12.1	17.6	20.6	22.3	18.2
RM-22590	R1	3	1.0	2.0	2.0	2.7	2.0	4.9	11.7	16.8	30.6	16.0
R07-129	R1	3	3.0	3.3	3.3	3.3	3.3	28.2	35.4	35.4	37.8	34.2
R09-4095	R1	3	2.7	3.0	3.3	3.3	3.1	19.5	29.1	33.7	33.7	29.0
R11-2964	R1	3	2.0	2.0	2.3	3.0	2.4	12.5	22.7	29.4	37.2	25.4
R11-2577	R1	3	1.0	1.3	2.0	2.3	1.7	2.9	9.2	15.9	22.2	12.6
R11-3283	R1	3	1.7	2.0	2.0	2.7	2.1	12.4	15.3	19.5	30.6	19.5
R11-7700	R1	3	1.0	1.0	2.0	2.0	1.5	5.9	5.9	15.1	19.6	11.6

Appendix 5. Means of visual scores and percent dead plants of soybean cultivars evaluated at different flooding durations at V 5 and R1 flood test in 2014 at Stuttgart, AR. (Cont.).

Cultivars	Stage	Duration	SC 1	SC 2	SC 3	SC 4	MSC	%DP (SC 1)	%DP (SC 2)	%DP (SC 3)	%DP (SC 4)	%MDP
R11-7636	R1	3	1.3	1.3	1.7	2.0	1.6	4.8	10.0	12.2	20.3	11.9
R10-6606RR	R1	3	1.3	2.0	2.3	2.7	2.1	11.5	19.3	28.7	31.2	22.6
R09-1827RR	R1	3	1.0	1.0	1.7	2.0	1.4	2.2	6.0	11.6	18.5	9.5
R11-9428	R1	3	1.0	1.0	1.3	1.3	1.2	7.7	11.7	11.7	15.5	11.6
R09-1831RR	R1	3	1.3	1.3	2.3	2.3	1.8	11.8	12.4	24.8	27.1	19.0
R06-4433	R1	3	1.0	1.0	1.3	1.3	1.2	2.1	2.1	8.0	13.8	6.5
R08-3119	R1	3	2.0	2.0	2.3	2.7	2.3	11.9	13.2	14.9	18.6	14.6
R01-2731F	R1	3	1.0	1.3	2.0	2.0	1.6	7.2	11.8	19.5	21.7	15.0
R99-1613F	R1	3	3.0	3.0	3.3	3.3	3.2	32.2	34.8	38.2	39.3	36.1
Walters	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
R10-2346	V5	3	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1
R11-2965	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
R11-3373	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
R11-3115	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
R11-11G	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
R11-432G	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
R11-3625	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
R11-3598	V5	3	1.0	1.0	1.3	1.3	1.2	0.0	0.0	2.9	2.9	1.4
R11-6870	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
R10-4892	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
R11-9513	V5	3	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1
R07-6669	V5	3	1.0	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9
R09-5088	V5	3	1.3	1.3	1.3	1.3	1.3	3.4	3.4	3.4	3.4	3.4
R10-197 RY	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
R10-130 RY	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
Osage	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
R07-2001	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
Ozark	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
RM-1639	V5	3	1.0	1.0	1.0	1.0	1.0	0.9	0.9	0.9	1.4	1.1
Desha	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
Lee	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0

Appendix 5. Means of visual scores and percent dead plants of soybean cultivars evaluated at different flooding durations at V 5 and R1 flood test in 2014 at Stuttgart, AR. (Cont.).

Cultivars	Stage	Duration	SC 1	SC 2	SC 3	SC 4	MSC	%DP (SC 1)	%DP (SC 2)	%DP (SC 3)	%DP (SC 4)	%MDP
Lonoke	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
UA 4913C(R05-3239)	V5	3	1.3	1.3	1.3	1.3	1.3	7.7	7.7	7.7	7.7	7.7
RM-22590?	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
R07-129	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
R09-4095	V5	3	1.3	1.3	1.3	1.3	1.3	3.3	3.3	3.3	3.3	3.3
R11-2964	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
R11-2577	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
R11-3283	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
R11-7700	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
R11-7636	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
R10-6606RR	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
R09-1827RR	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
R11-9428	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
R09-1831RR	V5	3	1.0	1.0	1.3	1.3	1.2	0.0	0.0	1.8	1.8	0.9
R06-4433	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
R08-3119	V5	3	1.3	1.3	1.3	1.3	1.3	2.8	2.8	2.8	2.8	2.8
R01-2731F	V5	3	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
R99-1613F	V5	3	1.0	1.0	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.2
Walters	R1	6	1.7	4.3	6.0	6.0	4.5	9.3	51.3	72.2	72.2	51.2
R10-2346	R1	6	1.0	4.0	5.0	5.3	3.9	1.0	38.1	52.8	54.4	36.6
R11-2965	R1	6	1.3	3.0	4.0	4.3	3.2	6.4	29.5	38.2	44.0	29.5
R11-3373	R1	6	2.0	5.3	6.7	6.7	5.2	14.2	52.2	59.7	63.4	47.3
R11-3115	R1	6	1.0	3.3	4.3	4.7	3.4	4.4	27.0	32.0	41.0	26.1
R11-11G	R1	6	1.0	3.0	4.0	4.3	3.1	1.8	28.4	43.7	48.1	30.5
R11-432G	R1	6	1.3	3.7	4.0	4.7	3.4	2.9	28.7	49.3	53.2	33.5
R11-3625	R1	6	1.7	2.7	3.7	3.7	2.9	6.3	17.7	30.9	56.7	27.9
R11-3598	R1	6	2.7	5.0	6.0	6.0	4.9	19.6	53.8	61.9	64.0	49.8
R11-6870	R1	6	1.0	1.7	3.3	3.7	2.4	1.2	9.5	5.2	9.5	6.4
R10-4892	R1	6	1.0	2.3	3.7	4.3	2.9	2.0	16.5	29.7	34.7	20.7
R11-9513	R1	6	1.3	3.3	4.3	4.3	3.3	9.5	29.7	36.1	37.6	28.3
R07-6669	R1	6	1.3	4.0	4.7	4.7	3.7	3.7	48.2	53.6	55.3	40.2

Appendix 5. Means of visual scores and percent dead plants of soybean cultivars evaluated at different flooding durations at V 5 and R1 flood test in 2014 at Stuttgart, AR. (Cont.).

Cultivars	Stage	Duration	SC 1	SC 2	SC 3	SC 4	MSC	%DP (SC 1)	%DP (SC 2)	%DP (SC 3)	%DP (SC 4)	%MDP
R09-5088	R1	6	1.3	4.7	4.7	6.0	4.2	4.6	49.3	54.8	63.3	43.0
R10-197 RY	R1	6	1.3	4.3	4.7	5.3	4.0	6.4	42.3	51.7	56.5	39.2
R10-130 RY	R1	6	2.0	5.0	5.7	6.7	4.9	12.2	57.5	60.5	69.4	49.9
Osage	R1	6	1.0	5.0	6.3	6.3	4.7	3.5	57.6	71.7	73.7	51.6
R07-2001	R1	6	2.0	5.3	6.3	6.3	5.0	10.9	55.5	70.4	73.9	52.7
Ozark	R1	6	1.3	2.7	3.3	3.3	2.7	9.4	20.3	29.6	33.1	23.1
RM-1639	R1	6	1.3	2.3	3.3	3.3	2.6	2.1	25.3	5.0	8.3	10.2
Desha	R1	6	1.0	5.0	5.0	5.7	4.2	0.4	54.3	54.8	62.3	42.9
Lee	R1	6	1.7	5.3	6.0	6.0	4.8	-0.7	50.9	57.7	59.7	41.9
Lonoke	R1	6	2.3	5.7	6.3	6.7	5.3	12.4	66.3	72.7	77.4	57.2
UA 4913C(R05-3239)	R1	6	2.0	7.0	7.7	8.3	6.3	11.5	83.1	87.2	91.3	68.3
RM-22590	R1	6	3.3	4.7	5.3	5.7	4.8	33.9	53.3	61.0	64.9	53.3
R07-129	R1	6	1.3	2.7	3.7	4.0	2.9	8.4	16.7	23.3	30.3	19.7
R09-4095	R1	6	2.3	6.3	8.0	8.0	6.2	16.7	63.8	73.4	75.5	57.4
R11-2964	R1	6	2.0	7.7	8.3	9.0	6.8	15.9	88.2	92.3	95.6	73.0
R11-2577	R1	6	2.7	8.7	8.7	9.0	7.3	20.1	95.9	96.4	98.2	77.7
R11-3283	R1	6	2.3	8.0	8.7	9.0	7.0	16.3	89.4	93.3	97.7	74.2
R11-7700	R1	6	1.3	4.0	5.0	5.0	3.9	5.4	42.5	53.7	54.9	39.1
R11-7636	R1	6	2.3	6.0	7.0	7.3	5.7	16.1	63.3	74.4	78.4	58.1
R10-6606RR	R1	6	2.0	7.3	8.0	8.3	6.4	8.8	80.6	86.3	90.2	66.5
R09-1827RR	R1	6	1.7	5.0	6.3	7.0	5.0	8.4	62.9	69.9	76.4	54.4
R11-9428	R1	6	1.3	5.0	6.3	7.0	4.9	4.7	52.8	67.0	78.1	50.6
R09-1831RR	R1	6	1.3	5.0	6.3	7.0	4.9	3.4	61.0	73.2	80.6	54.5
R06-4433	R1	6	1.3	5.7	6.3	7.3	5.2	3.3	67.7	71.6	80.8	55.8
R08-3119	R1	6	1.3	7.3	7.7	8.7	6.3	3.5	85.5	87.2	93.2	67.4
R01-2731F	R1	6	2.0	6.0	6.7	7.7	5.6	13.3	75.3	80.5	86.9	64.0
R99-1613F	R1	6	3.0	7.0	8.0	8.0	6.5	31.9	78.4	84.7	86.4	70.4
Walters	V5	6	1.7	3.3	3.7	4.7	3.3	15.2	34.5	40.2	50.3	35.1
R10-2346	V5	6	2.0	3.3	3.3	3.7	3.1	14.3	33.2	35.0	41.3	31.0
R11-2965	V5	6	1.0	1.7	1.7	2.0	1.6	0.0	8.4	9.3	13.9	7.9
R11-3373	V5	6	1.0	1.7	1.7	2.7	1.8	0.6	12.7	13.3	28.0	13.7

Appendix 5. Means of visual scores and percent dead plants of soybean cultivars evaluated at different flooding durations at V 5 and R1 flood test in 2014 at Stuttgart, AR. (Cont.).

Cultivars	Stage	Duration	SC 1	SC 2	SC 3	SC 4	MSC	%DP (SC 1)	%DP (SC 2)	%DP (SC 3)	%DP (SC 4)	%MDP
R11-3115	V5	6	1.0	2.7	2.7	3.0	2.4	3.5	26.4	27.6	31.9	22.4
R11-11G	V5	6	1.0	1.3	1.3	1.7	1.3	0.0	3.2	3.2	13.7	5.1
R11-432G	V5	6	1.3	2.7	3.0	3.3	2.6	9.2	19.3	26.9	41.5	24.2
R11-3625	V5	6	1.0	3.7	3.7	4.3	3.2	3.9	33.8	35.6	43.9	29.3
R11-3598	V5	6	2.0	3.7	4.0	4.3	3.5	17.2	38.7	46.7	48.5	37.8
R11-6870	V5	6	1.3	2.0	2.0	2.3	1.9	2.4	15.5	15.5	20.2	13.4
R10-4892	V5	6	1.0	2.7	2.7	4.0	2.6	3.5	22.5	23.8	39.3	22.3
R11-9513	V5	6	1.7	2.0	2.0	2.3	2.0	9.6	14.8	15.8	20.1	15.1
R07-6669	V5	6	1.3	2.3	2.7	3.0	2.4	7.2	21.2	29.6	34.7	23.2
R09-5088	V5	6	1.3	3.7	3.7	4.3	3.3	2.3	34.2	36.2	45.8	29.6
R10-197 RY	V5	6	1.3	2.3	2.3	2.7	2.2	4.4	17.2	20.7	28.1	17.6
R10-130 RY	V5	6	1.0	2.3	2.3	3.3	2.3	2.0	18.0	20.8	30.0	17.7
Osage	V5	6	1.0	2.3	2.7	3.7	2.4	5.1	18.5	19.0	40.0	20.6
R07-2001	V5	6	1.0	2.0	2.0	2.3	1.9	0.0	14.0	14.4	23.2	12.9
Ozark	V5	6	1.0	2.7	2.7	3.3	2.4	2.1	25.4	29.5	40.3	24.3
RM-1639	V5	6	1.3	2.7	2.7	3.3	2.5	5.0	21.6	22.7	33.4	20.7
Desha	V5	6	1.0	1.3	1.3	2.0	1.4	0.0	6.4	7.1	17.7	7.8
Lee	V5	6	2.3	3.3	3.3	4.3	3.4	15.4	37.3	37.8	47.6	34.5
Lonoke	V5	6	1.0	2.7	2.7	3.3	2.4	1.8	16.1	19.7	30.6	17.1
UA 4913C(R05-3239)	V5	6	1.7	4.0	4.0	5.0	3.7	15.6	36.2	39.9	54.8	36.6
RM-22590	V5	6	1.7	3.3	3.3	3.7	3.0	12.9	31.6	31.9	39.1	28.9
R07-129	V5	6	1.7	3.7	3.7	4.3	3.4	7.0	35.7	37.4	45.3	31.3
R09-4095	V5	6	3.0	5.3	6.3	7.0	5.5	28.9	44.8	66.7	73.0	53.3
R11-2964	V5	6	3.7	5.3	5.3	6.3	5.2	32.8	55.6	57.7	68.7	53.7
R11-2577	V5	6	1.0	2.7	2.7	4.7	2.8	1.2	29.6	30.5	51.5	28.2
R11-3283	V5	6	3.7	5.0	5.0	6.3	5.0	27.0	48.6	56.6	67.6	49.9
R11-7700	V5	6	2.0	4.7	5.0	6.0	4.4	14.2	51.1	56.5	66.6	47.1
R11-7636	V5	6	2.0	4.3	4.3	5.0	4.0	11.6	46.0	47.9	65.0	42.6
R10-6606RR	V5	6	4.0	5.7	6.3	7.0	5.8	40.0	56.8	68.6	75.6	60.3
R09-1827RR	V5	6	2.7	5.7	5.0	7.0	5.1	29.2	52.7	58.0	75.3	53.8
R11-9428	V5	6	1.0	2.7	2.7	3.3	2.5	0.0	19.9	23.8	32.1	19.0

Appendix 5. Means of visual scores and percent dead plants of soybean cultivars evaluated at different flooding durations at V 5 and R1 flood test in 2014 at Stuttgart, AR. (Cont.).

Cultivars	Stage	Duration	SC 1	SC 2	SC 3	SC 4	MSC	%DP (SC 1)	%DP (SC 2)	%DP (SC 3)	%DP (SC 4)	%MDP
R09-1831RR	V5	6	1.7	4.0	4.0	6.3	4.0	9.5	45.1	47.3	79.1	45.3
R06-4433	V5	6	1.3	3.0	3.0	4.3	2.9	8.2	23.4	27.3	46.8	26.4
R08-3119	V5	6	4.0	5.3	5.3	6.3	5.3	42.6	58.9	60.5	70.6	58.2
R01-2731F	V5	6	3.3	6.3	7.0	7.3	6.0	33.1	70.4	79.9	80.8	66.0
R99-1613F	V5	6	2.3	5.0	5.7	6.0	4.8	14.2	51.1	66.7	69.6	50.4
Walters	R1	9	7.0	8.0	8.7	9.0	8.2	81.4	91.8	96.5	99.1	92.2
R10-2346	R1	9	6.7	8.0	8.3	9.0	8.0	74.6	90.2	94.7	99.1	89.6
R11-2965	R1	9	6.0	7.3	7.0	8.0	7.1	71.1	82.6	84.8	93.3	82.9
R11-3373	R1	9	7.7	8.7	9.0	9.0	8.6	80.4	93.7	99.4	100.0	93.4
R11-3115	R1	9	5.0	7.0	7.7	8.7	7.1	50.2	77.5	86.7	94.8	77.3
R11-11G	R1	9	4.0	6.0	7.0	8.3	6.4	45.0	71.6	83.1	93.2	73.2
R11-432G	R1	9	5.7	7.0	7.0	8.0	6.9	69.5	83.7	85.8	93.2	83.1
R11-3625	R1	9	6.0	7.3	7.3	8.0	7.2	67.3	80.5	83.2	91.1	80.5
R11-3598	R1	9	7.0	8.3	8.3	8.7	8.1	77.7	91.6	93.9	97.0	90.1
R11-6870	R1	9	4.0	5.7	6.7	7.3	5.9	29.9	61.9	71.0	79.3	60.5
R10-4892	R1	9	7.0	8.0	9.0	9.0	8.3	76.6	87.5	100.0	100.0	91.0
R11-9513	R1	9	6.7	7.7	8.3	9.0	7.9	71.6	86.1	92.0	96.9	86.6
R07-6669	R1	9	6.0	7.3	8.7	9.0	7.8	72.8	81.6	96.9	100.0	87.8
R09-5088	R1	9	6.7	7.7	8.3	9.0	7.9	78.2	88.6	96.1	99.1	90.5
R10-197 RY	R1	9	6.0	7.7	8.7	9.0	7.9	73.8	88.4	96.7	99.0	89.5
R10-130 RY	R1	9	6.0	7.3	8.3	8.7	7.6	61.4	78.8	90.4	95.4	81.5
Osage	R1	9	4.3	6.0	7.0	7.7	6.3	52.2	71.3	79.5	86.8	72.4
R07-2001	R1	9	5.7	7.0	8.0	8.7	7.4	69.8	84.3	91.0	96.4	85.4
Ozark	R1	9	5.0	6.7	7.7	8.3	7.0	62.7	82.2	90.9	95.0	82.7
RM-1639	R1	9	5.7	7.3	7.3	8.0	7.1	63.7	81.5	82.4	90.4	79.5
Desha	R1	9	4.7	6.7	7.7	8.3	6.9	56.6	77.9	89.2	94.6	79.6
Lee	R1	9	6.3	7.7	8.0	8.7	7.7	71.1	86.9	91.7	96.9	86.6
Lonoke	R1	9	5.3	7.3	8.0	8.7	7.4	63.2	82.2	91.4	96.1	83.2
UA 4913C(R05-3239)	R1	9	5.3	6.7	8.0	9.0	7.3	68.4	82.6	92.4	99.2	85.7
RM-22590	R1	9	7.7	8.3	9.0	9.0	8.5	86.4	93.6	99.6	100.0	94.9
R07-129	R1	9	6.0	7.3	7.3	8.3	7.3	71.1	83.6	86.6	95.4	84.2

Appendix 5. Means of visual scores and percent dead plants of soybean cultivars evaluated at different flooding durations at V 5 and R1 flood test in 2014 at Stuttgart, AR. (Cont.).

Cultivars	Stage	Duration	SC 1	SC 2	SC 3	SC 4	MSC	%DP (SC 1)	%DP (SC 2)	%DP (SC 3)	%DP (SC 4)	%MDP
R09-4095	R1	9	6.3	7.7	8.3	8.7	7.8	38.0	66.3	82.5	90.5	69.3
R11-2964	R1	9	5.7	7.0	8.0	8.3	7.3	53.7	76.7	88.7	93.8	78.2
R11-2577	R1	9	5.7	7.7	8.3	8.7	7.6	66.0	85.4	93.5	97.9	85.7
R11-3283	R1	9	7.7	8.3	8.7	9.0	8.4	83.8	91.0	96.1	99.5	92.6
R11-7700	R1	9	6.3	7.7	7.7	8.7	7.6	70.5	86.6	87.6	95.9	85.1
R11-7636	R1	9	6.3	7.3	8.3	8.3	7.6	67.5	83.3	90.0	95.0	84.0
R10-6606RR	R1	9	8.0	9.0	8.7	9.0	8.7	89.2	96.4	98.1	99.5	95.8
R09-1827RR	R1	9	6.3	7.7	8.3	9.0	7.9	71.7	87.2	90.6	96.9	86.5
R11-9428	R1	9	5.7	7.3	8.3	9.0	7.6	65.4	84.4	93.9	98.0	85.4
R09-1831RR	R1	9	7.3	8.3	9.0	9.0	8.5	82.6	93.0	99.5	100.0	93.8
R06-4433	R1	9	5.3	6.7	8.3	9.0	7.3	60.8	78.6	94.7	98.6	83.2
R08-3119	R1	9	5.7	7.0	7.3	8.3	7.1	71.3	84.4	88.2	94.3	84.6
R01-2731F	R1	9	5.3	7.0	7.3	8.3	7.0	61.0	81.4	85.2	94.1	80.4
R99-1613F	R1	9	5.0	7.0	7.0	8.0	6.8	57.9	78.5	81.2	91.1	77.2
Walters	V5	9	3.3	4.3	4.7	6.0	4.6	32.7	47.3	55.1	69.6	51.2
R10-2346	V5	9	4.3	5.7	6.3	7.3	5.9	52.2	69.5	76.1	82.9	70.2
R11-2965	V5	9	2.0	2.3	3.0	4.7	3.0	11.6	21.4	32.1	52.0	29.2
R11-3373	V5	9	3.3	5.0	5.0	6.7	5.0	30.0	54.9	56.2	73.5	53.6
R11-3115	V5	9	2.0	2.3	3.3	4.7	3.1	12.7	20.6	29.4	53.9	29.2
R11-11G	V5	9	1.7	2.3	2.7	4.3	2.8	7.3	20.5	21.4	47.4	24.2
R11-432G	V5	9	2.7	3.3	3.3	4.7	3.5	16.7	33.6	39.9	60.3	37.6
R11-3625	V5	9	4.0	4.3	5.0	6.3	5.0	44.0	49.8	58.2	74.3	56.6
R11-3598	V5	9	5.7	6.7	7.0	8.0	6.9	59.9	76.2	80.7	87.4	76.1
R11-6870	V5	9	2.7	3.3	3.3	4.7	3.5	24.4	37.3	42.1	55.6	39.9
R10-4892	V5	9	3.7	4.7	5.7	7.3	5.4	39.7	60.7	68.5	83.3	63.1
R11-9513	V5	9	3.0	3.7	3.7	4.0	3.6	29.9	36.9	42.0	43.8	38.1
R07-6669	V5	9	4.0	5.3	6.0	6.7	5.5	41.6	58.0	65.7	76.4	60.4
R09-5088	V5	9	5.3	6.3	6.3	7.7	6.4	59.6	71.8	76.0	87.2	73.7
R10-197 RY	V5	9	2.7	4.3	5.0	6.0	4.5	24.1	46.7	51.5	70.4	48.2
R10-130 RY	V5	9	2.0	3.0	4.0	6.0	3.8	18.3	32.1	42.0	69.1	40.4
Osage	V5	9	2.3	2.7	3.0	5.0	3.3	10.1	21.7	24.3	58.7	28.7

Appendix 5. Means of visual scores and percent dead plants of soybean cultivars evaluated at different flooding durations at V 5 and R1 flood test in 2014 at Stuttgart, AR. (Cont.).

Cultivars	Stage	Duration	SC 1	SC 2	SC 3	SC 4	MSC	%DP (SC 1)	%DP (SC 2)	%DP (SC 3)	%DP (SC 4)	%MDP
R07-2001	V5	9	1.7	2.7	3.3	5.0	3.2	11.7	20.0	33.6	61.8	31.8
Ozark	V5	9	3.0	4.3	5.3	6.7	4.9	29.9	41.7	55.8	72.3	49.9
RM-1639	V5	9	3.0	3.7	3.7	3.7	3.5	33.8	41.5	43.0	43.6	40.5
Desha	V5	9	2.3	3.0	3.7	6.3	3.9	19.4	31.1	41.6	70.4	40.6
Lee	V5	9	3.3	4.3	4.7	6.3	4.7	30.0	44.9	54.9	76.0	51.4
Lonoke	V5	9	3.3	5.0	6.0	8.3	5.7	28.1	54.4	66.9	94.3	60.9
UA 4913C(R05-3239)	V5	9	3.3	4.3	4.7	6.0	4.6	31.4	45.8	49.8	68.7	48.9
RM-22590?	V5	9	3.7	6.0	6.0	6.0	5.4	43.3	70.2	72.0	74.9	65.1
R07-129	V5	9	4.0	5.7	5.7	6.7	5.5	41.9	62.4	70.2	86.4	65.2
R09-4095	V5	9	7.7	8.3	9.0	9.0	8.5	79.8	93.1	96.5	96.5	91.5
R11-2964	V5	9	5.0	6.7	7.3	8.3	6.9	54.7	78.2	84.0	93.3	77.6
R11-2577	V5	9	3.0	4.3	5.3	7.0	5.0	27.6	51.2	63.4	86.1	57.1
R11-3283	V5	9	8.0	8.7	8.7	9.0	8.6	89.1	93.5	95.1	97.8	93.9
R11-7700	V5	9	4.0	5.0	5.7	6.3	5.3	40.5	62.4	65.8	72.8	60.4
R11-7636	V5	9	4.7	5.7	5.7	6.0	5.5	55.9	65.3	67.8	71.8	65.2
R10-6606RR	V5	9	8.3	9.0	9.0	9.0	8.8	90.8	97.5	97.5	99.5	96.3
R09-1827RR	V5	9	3.7	4.7	5.3	6.3	5.0	38.3	52.1	60.2	73.7	56.1
R11-9428	V5	9	3.3	4.3	4.7	6.0	4.6	30.8	46.2	49.8	74.6	50.4
R09-1831RR	V5	9	4.0	6.0	7.0	8.7	6.4	43.5	72.6	82.2	97.4	73.9
R06-4433	V5	9	3.3	5.7	8.0	8.7	6.5	29.2	63.2	87.6	94.2	68.6
R08-3119	V5	9	5.7	7.0	7.3	8.7	7.2	64.4	80.5	81.8	96.2	80.7
R01-2731F	V5	9	6.7	8.0	8.0	8.7	7.8	77.7	90.0	91.0	94.8	88.4
R99-1613F	V5	9	6.7	7.3	7.7	8.3	7.5	72.5	85.0	86.2	92.9	84.1
Walters	R1	12	8.0	9.0	9.0	9.0	8.8	89.8	96.3	99.0	99.0	96.0
R10-2346	R1	12	8.0	9.0	9.0	9.0	8.8	91.2	97.5	99.0	99.5	96.8
R11-2965	R1	12	7.7	8.7	9.0	9.0	8.6	89.9	95.4	97.7	98.7	95.5
R11-3373	R1	12	8.7	9.0	9.0	9.0	8.9	96.0	98.9	100.0	100.0	98.7
R11-3115	R1	12	9.0	9.0	9.0	9.0	9.0	97.4	99.3	100.0	100.0	99.2
R11-11G	R1	12	7.0	8.0	8.3	8.3	8.0	76.6	89.3	93.5	94.1	88.4
R11-432G	R1	12	7.7	8.3	8.7	8.7	8.4	88.7	93.8	96.7	96.7	94.0
R11-3625	R1	12	7.7	8.7	9.0	9.0	8.6	83.1	91.7	98.5	98.5	92.9

Appendix 5. Means of visual scores and percent dead plants of soybean cultivars evaluated at different flooding durations at V 5 and R1 flood test in 2014 at Stuttgart, AR. (Cont.).

Cultivars	Stage	Duration	SC 1	SC 2	SC 3	SC 4	MSC	%DP (SC 1)	%DP (SC 2)	%DP (SC 3)	%DP (SC 4)	%MDP
R11-3598	R1	12	8.7	8.7	8.7	8.7	8.7	95.2	98.2	96.4	96.4	96.5
R11-6870	R1	12	9.0	9.0	9.0	9.0	9.0	96.3	100.0	100.0	100.0	99.1
R10-4892	R1	12	8.0	8.7	8.7	8.7	8.5	89.0	96.9	95.3	95.8	94.2
R11-9513	R1	12	7.3	8.0	8.0	8.0	7.9	82.1	87.2	87.7	87.7	86.2
R07-6669	R1	12	7.7	8.3	8.7	9.0	8.5	90.0	94.1	95.4	97.3	94.1
R09-5088	R1	12	8.7	9.0	9.0	9.0	8.9	95.9	99.1	100.0	100.0	98.7
R10-197 RY	R1	12	8.7	9.0	9.0	9.0	8.9	95.2	99.0	99.5	99.5	98.3
R10-130 RY	R1	12	9.0	9.0	9.0	9.0	9.0	95.3	100.0	100.0	100.0	98.9
Osage	R1	12	8.3	8.7	8.7	9.0	8.7	92.2	96.0	97.0	98.0	95.8
R07-2001	R1	12	8.3	8.7	9.0	9.0	8.8	94.5	97.5	99.2	99.2	97.6
Ozark	R1	12	8.3	9.0	9.0	9.0	8.9	93.1	97.4	99.6	100.0	97.5
RM-1639	R1	12	8.3	8.7	9.0	9.0	8.8	91.8	95.4	99.5	99.5	96.6
Desha	R1	12	7.7	8.7	9.0	9.0	8.6	87.5	95.7	98.4	98.4	95.0
Lee	R1	12	8.3	9.0	9.0	9.0	8.9	93.2	97.4	100.0	100.0	97.7
Lonoke	R1	12	8.0	8.7	8.7	8.7	8.5	90.9	95.5	97.1	97.1	95.1
UA 4913C(R05-3239)	R1	12	8.7	9.0	9.0	9.0	8.9	94.7	97.6	98.6	98.6	97.4
RM-22590	R1	12	9.0	9.0	9.0	9.0	9.0	98.8	97.7	98.3	98.3	98.2
R07-129	R1	12	7.7	8.7	9.0	9.0	8.6	86.6	93.8	98.0	98.5	94.3
R09-4095	R1	12	9.0	9.0	9.0	9.0	9.0	97.2	100.0	100.0	100.0	99.3
R11-2964	R1	12	9.0	9.0	9.0	9.0	9.0	97.5	98.3	100.0	100.0	99.0
R11-2577	R1	12	8.0	9.0	9.0	9.0	8.8	90.4	98.5	97.5	97.5	95.9
R11-3283	R1	12	8.7	9.0	9.0	9.0	8.9	95.8	98.2	98.7	98.7	97.9
R11-7700	R1	12	8.3	9.0	9.0	9.0	8.9	93.0	98.5	98.5	98.5	97.1
R11-7636	R1	12	7.3	8.0	8.0	8.0	7.9	85.3	90.9	92.4	92.4	90.2
R10-6606RR	R1	12	7.7	8.7	9.0	9.0	8.6	85.3	94.5	100.0	100.0	94.9
R09-1827RR	R1	12	8.0	8.7	8.7	8.7	8.5	90.7	96.9	96.9	96.4	95.3
R11-9428	R1	12	8.7	9.0	9.0	9.0	8.9	94.1	99.4	99.3	99.3	98.0
R09-1831RR	R1	12	8.3	9.0	9.0	9.0	8.9	95.2	98.1	99.5	99.5	98.1
R06-4433	R1	12	7.3	8.7	8.7	9.0	8.4	86.7	94.8	94.8	98.3	93.6
R08-3119	R1	12	8.3	8.7	9.0	9.0	8.8	91.4	95.9	98.5	99.0	96.2
R01-2731F	R1	12	7.7	8.7	9.0	9.0	8.6	88.7	97.0	99.5	99.5	96.2

Appendix 5. Means of visual scores and percent dead plants of soybean cultivars evaluated at different flooding durations at V 5 and R1 flood test in 2014 at Stuttgart, AR. (Cont.).

Cultivars	Stage	Duration	SC 1	SC 2	SC 3	SC 4	MSC	%DP (SC 1)	%DP (SC 2)	%DP (SC 3)	%DP (SC 4)	%MDP
R99-1613F	R1	12	8.0	8.7	9.0	9.0	8.7	88.1	95.5	99.4	99.4	95.6
Walters	V5	12	1.3	2.0	3.7	3.7	2.7	3.5	15.1	37.9	39.7	24.1
R10-2346	V5	12	3.3	5.0	7.3	7.0	5.7	30.3	51.0	81.9	84.0	61.8
R11-2965	V5	12	3.0	4.3	7.7	8.0	5.8	28.3	47.6	89.0	91.8	64.2
R11-3373	V5	12	3.0	4.0	6.7	6.7	5.1	28.4	43.7	69.6	71.8	53.3
R11-3115	V5	12	2.3	3.7	6.3	7.0	4.9	13.9	29.3	66.3	73.4	45.7
R11-11G	V5	12	2.7	3.7	7.0	7.7	5.3	18.4	35.3	78.3	84.5	54.1
R11-432G	V5	12	2.0	3.0	6.0	7.0	4.5	18.5	34.8	68.7	78.5	50.1
R11-3625	V5	12	3.0	4.0	6.7	7.0	5.2	22.6	39.2	71.4	74.9	52.1
R11-3598	V5	12	3.7	5.3	7.7	8.0	6.2	23.7	46.1	82.7	86.9	59.8
R11-6870	V5	12	2.3	3.3	6.3	6.3	4.6	14.4	32.6	62.9	68.6	44.6
R10-4892	V5	12	3.7	4.7	8.0	8.3	6.2	47.9	59.5	90.7	92.7	72.7
R11-9513	V5	12	2.7	3.3	5.7	6.0	4.4	21.0	34.0	64.8	67.9	47.0
R07-6669	V5	12	4.0	5.3	8.7	9.0	6.8	46.0	67.4	94.4	96.8	76.1
R09-5088	V5	12	3.3	4.0	7.7	8.0	5.8	28.5	47.7	86.6	89.4	63.0
R10-197 RY	V5	12	2.7	4.0	7.7	8.3	5.7	17.6	37.8	87.2	91.6	58.5
R10-130 RY	V5	12	2.7	4.0	7.7	8.0	5.6	24.0	46.6	79.1	84.6	58.6
Osage	V5	12	2.7	4.0	7.3	7.7	5.4	15.3	41.8	85.0	86.6	57.2
R07-2001	V5	12	4.7	5.3	8.3	8.7	6.8	51.8	63.4	90.2	94.3	74.9
Ozark	V5	12	2.0	4.0	7.0	7.3	5.1	13.0	38.1	80.8	84.8	54.2
RM-1639	V5	12	1.3	3.0	5.3	5.7	3.9	8.5	34.1	51.8	57.0	37.8
Desha	V5	12	2.7	3.7	7.3	8.0	5.4	22.0	44.5	84.4	88.4	59.9
Lee	V5	12	3.3	5.3	8.3	8.7	6.4	21.0	49.0	92.0	94.5	64.1
Lonoke	V5	12	4.7	5.7	8.7	8.3	6.9	50.7	63.8	96.8	97.2	77.1
UA 4913C(R05-3239)	V5	12	4.7	6.7	9.0	9.0	7.3	53.7	75.7	98.4	99.0	81.7
RM-22590	V5	12	4.0	5.3	8.7	8.7	6.7	36.8	70.3	93.9	94.5	73.9
R07-129	V5	12	3.0	3.7	7.3	8.0	5.5	14.5	36.4	80.9	86.9	54.6
R09-4095	V5	12	5.3	7.7	9.0	9.0	7.8	41.0	79.8	100.0	100.0	80.2
R11-2964	V5	12	5.7	7.3	8.3	9.0	7.6	59.2	79.9	97.3	97.3	83.4
R11-2577	V5	12	5.3	6.0	8.7	8.7	7.2	60.1	70.6	94.9	95.3	80.2
R11-3283	V5	12	7.7	8.7	9.0	9.0	8.6	84.0	92.6	95.4	100.0	93.0

Appendix 5. Means of visual scores and percent dead plants of soybean cultivars evaluated at different flooding durations at V 5 and R1 flood test in 2014 at Stuttgart, AR. (Cont.).

Cultivars	Stage	Duration	SC 1	SC 2	SC 3	SC 4	MSC	%DP (SC 1)	%DP (SC 2)	%DP (SC 3)	%DP (SC 4)	%MDP
R11-7700	V5	12	2.3	4.0	7.0	7.3	5.2	14.5	46.1	81.5	83.7	56.5
R11-7636	V5	12	2.3	4.3	7.0	7.0	5.2	16.1	42.0	76.8	77.0	53.0
R10-6606RR	V5	12	5.7	7.7	8.7	9.0	7.8	64.1	82.0	98.1	98.1	85.6
R09-1827RR	V5	12	3.0	4.0	7.0	7.3	5.4	21.7	43.2	79.0	80.5	56.1
R11-9428	V5	12	3.7	4.3	8.0	8.0	6.0	24.4	39.8	87.9	90.5	60.7
R09-1831RR	V5	12	4.3	5.7	9.0	9.0	7.0	51.5	68.8	98.6	98.6	79.3
R06-4433	V5	12	4.3	6.7	8.7	9.0	7.2	53.8	78.7	97.2	98.2	82.0
R08-3119	V5	12	5.7	8.0	9.0	9.0	7.9	72.6	89.6	100.0	100.0	90.5
R01-2731F	V5	12	3.0	4.7	7.7	7.7	5.8	15.5	56.7	88.2	89.1	62.3
R99-1613F	V5	12	4.0	5.3	8.7	9.0	6.8	40.5	57.4	96.4	97.6	73.0
Walters	R1	15	8.7	9.0	9.0	9.0	8.9	94.5	95.2	96.1	97.4	95.8
R10-2346	R1	15	8.3	8.7	8.7	9.0	8.7	92.1	94.1	95.3	98.3	95.0
R11-2965	R1	15	7.3	8.7	8.7	8.7	8.4	83.0	92.6	94.1	97.6	91.8
R11-3373	R1	15	8.7	9.0	9.0	9.0	8.9	90.8	92.7	95.9	97.7	94.3
R11-3115	R1	15	8.7	9.0	9.0	9.0	8.9	91.7	94.0	95.1	98.0	94.7
R11-11G	R1	15	6.3	7.0	7.0	7.0	6.8	70.8	82.0	83.8	85.1	80.4
R11-432G	R1	15	7.3	8.0	8.0	8.3	8.0	82.6	89.1	90.0	92.9	88.6
R11-3625	R1	15	7.7	8.3	9.0	9.0	8.5	79.1	89.4	93.5	96.2	89.6
R11-3598	R1	15	8.3	8.7	8.7	9.0	8.7	85.2	88.7	93.0	98.3	91.3
R11-6870	R1	15	7.7	8.7	8.7	9.0	8.5	82.6	91.2	93.9	96.4	91.0
R10-4892	R1	15	7.7	8.7	8.7	8.7	8.4	82.8	93.3	94.7	96.3	91.8
R11-9513	R1	15	6.7	7.7	8.0	8.3	7.7	66.7	84.6	87.0	90.8	82.3
R07-6669	R1	15	7.7	8.3	8.3	8.7	8.3	85.4	91.2	92.5	94.9	91.0
R09-5088	R1	15	8.0	8.7	8.7	9.0	8.6	90.7	94.7	95.1	97.4	94.5
R10-197 RY	R1	15	7.7	8.7	8.7	8.7	8.5	82.9	91.4	92.7	94.6	90.4
R10-130 RY	R1	15	8.3	9.0	9.0	9.0	8.9	88.3	94.0	96.1	97.3	94.0
Osage	R1	15	7.0	7.7	8.0	8.7	7.8	76.8	86.6	89.6	92.8	86.4
R07-2001	R1	15	8.7	9.0	9.0	9.0	8.9	93.5	97.6	100.0	100.0	97.8
Ozark	R1	15	7.0	7.7	8.0	8.0	7.7	80.8	87.4	90.4	91.6	87.5
RM-1639	R1	15	7.7	8.3	8.3	8.7	8.3	81.0	89.9	91.5	95.7	89.5

Appendix 5. Means of visual scores and percent dead plants of soybean cultivars evaluated at different flooding durations at V 5 and R1 flood test in 2014 at Stuttgart, AR. (Cont.).

Cultivars	Stage	Duration	SC 1	SC 2	SC 3	SC 4	MSC	%DP (SC 1)	%DP (SC 2)	%DP (SC 3)	%DP (SC 4)	%MDP
Desha	R1	15	7.3	8.3	8.7	9.0	8.3	81.5	91.0	93.5	97.5	90.9
Lee	R1	15	8.3	9.0	9.0	9.0	8.9	90.3	95.5	96.4	98.7	95.2
Lonoke	R1	15	8.0	8.3	8.7	9.0	8.5	90.0	92.5	94.5	96.2	93.3
UA 4913C(R05-3239)	R1	15	7.7	8.7	9.0	9.0	8.6	89.1	95.7	96.9	97.7	94.8
RM-22590	R1	15	9.0	9.0	9.0	9.0	9.0	96.9	97.8	98.2	99.1	98.0
R07-129	R1	15	8.7	8.7	9.0	9.0	8.8	93.8	95.4	97.4	98.9	96.4
R09-4095	R1	15	9.0	9.0	9.0	9.0	9.0	91.3	91.3	94.7	97.6	93.7
R11-2964	R1	15	8.3	9.0	9.0	9.0	8.9	90.3	93.3	96.1	97.7	94.3
R11-2577	R1	15	7.7	8.7	8.7	9.0	8.5	86.6	92.8	94.7	97.6	92.9
R11-3283	R1	15	8.7	9.0	9.0	9.0	8.9	91.5	95.0	96.7	99.4	95.7
R11-7700	R1	15	8.3	8.3	9.0	9.0	8.7	89.5	92.1	94.8	96.3	93.2
R11-7636	R1	15	6.3	8.0	8.0	8.3	7.7	74.4	85.3	89.0	91.9	85.2
R10-6606RR	R1	15	8.7	8.7	8.7	9.0	8.8	94.9	96.8	97.3	98.7	96.9
R09-1827RR	R1	15	8.3	8.3	9.0	9.0	8.7	90.5	93.1	95.4	97.3	94.0
R11-9428	R1	15	7.7	8.7	8.7	9.0	8.5	82.9	91.0	92.2	95.4	90.4
R09-1831RR	R1	15	9.0	9.0	9.0	9.0	9.0	96.2	97.5	98.8	100.0	98.1
R06-4433	R1	15	7.0	7.0	7.0	7.7	7.2	78.9	82.2	83.1	87.2	82.8
R08-3119	R1	15	7.7	8.3	8.7	9.0	8.4	89.9	92.4	95.1	98.0	93.9
R01-2731F	R1	15	6.7	8.0	8.0	8.0	7.7	81.6	90.1	90.5	93.0	88.8
R99-1613F	R1	15	8.7	9.0	9.0	9.0	8.9	90.1	94.5	96.3	98.7	94.9
Walters	V5	15	6.5	7.0	7.5	7.5	7.2	82.6	84.5	85.7	85.7	84.7
R10-2346	V5	15	8.0	8.0	8.0	8.0	8.0	89.5	90.7	91.6	92.0	90.9
R11-2965	V5	15	7.0	7.3	7.3	7.3	7.3	81.4	83.0	83.8	84.3	83.1
R11-3373	V5	15	8.0	8.0	7.7	7.7	7.8	86.9	87.6	88.2	89.4	88.0
R11-3115	V5	15	5.0	5.3	5.3	5.3	5.3	58.3	62.0	63.1	64.2	61.9
R11-11G	V5	15	6.0	6.3	6.3	6.7	6.4	69.6	77.0	77.0	80.1	75.9
R11-432G	V5	15	6.7	7.0	7.0	7.0	6.9	75.8	79.5	82.2	83.0	80.1
R11-3625	V5	15	7.3	7.3	7.3	7.3	7.3	83.2	84.2	87.0	87.4	85.4
R11-3598	V5	15	8.3	8.7	8.7	8.7	8.6	94.0	94.6	96.0	96.5	95.3

Appendix 5. Means of visual scores and percent dead plants of soybean cultivars evaluated at different flooding durations at V 5 and R1 flood test in 2014 at Stuttgart, AR. (Cont.).

Cultivars	Stage	Duration	SC 1	SC 2	SC 3	SC 4	MSC	%DP (SC 1)	%DP (SC 2)	%DP (SC 3)	%DP (SC 4)	%MDP
R11-6870	V5	15	7.0	7.0	7.0	7.0	7.0	77.2	78.9	81.3	81.8	79.8
R10-4892	V5	15	7.7	7.7	8.3	8.3	8.0	87.9	88.8	91.8	92.3	90.2
R11-9513	V5	15	4.0	4.0	4.3	4.3	4.2	51.3	52.4	52.4	52.4	52.2
R07-6669	V5	15	8.0	8.0	7.7	8.0	7.9	88.1	88.9	88.9	89.4	88.8
R09-5088	V5	15	5.0	5.3	6.0	6.0	5.6	68.5	72.3	73.9	74.7	72.4
R10-197 RY	V5	15	5.7	5.7	5.7	5.7	5.7	63.2	64.1	66.1	67.1	65.1
R10-130 RY	V5	15	6.7	6.7	7.0	7.0	6.8	74.0	75.2	77.0	77.6	76.0
Osage	V5	15	5.0	5.0	5.3	5.7	5.3	57.6	58.8	68.1	70.6	63.8
R07-2001	V5	15	7.7	7.7	8.0	8.0	7.8	86.6	88.4	90.7	90.7	89.1
Ozark	V5	15	6.7	6.7	7.3	7.3	7.0	77.4	78.3	82.6	83.1	80.4
RM-1639	V5	15	6.3	6.3	6.3	6.3	6.3	69.1	70.8	72.5	72.5	71.2
Desha	V5	15	5.7	5.7	6.0	6.0	5.8	75.9	77.0	77.5	77.5	77.0
Lee	V5	15	8.0	8.3	8.3	8.3	8.3	88.9	91.8	91.8	92.3	91.2
Lonoke	V5	15	6.7	6.7	6.7	6.7	6.7	76.8	78.5	78.5	78.5	78.1
UA 4913C(R05-3239)	V5	15	7.0	7.3	7.3	7.3	7.3	83.4	87.1	87.1	87.1	86.2
RM-22590	V5	15	6.3	6.3	6.3	6.3	6.3	76.7	78.7	79.1	79.6	78.5
R07-129	V5	15	8.0	8.0	8.3	8.3	8.2	90.7	91.8	91.8	92.3	91.6
R09-4095	V5	15	8.0	8.3	8.3	8.3	8.3	81.6	85.9	87.5	87.5	85.6
R11-2964	V5	15	8.0	8.3	8.3	8.3	8.3	88.6	91.1	91.1	91.1	90.5
R11-2577	V5	15	6.3	6.7	6.7	7.0	6.7	74.4	80.9	83.8	84.3	80.9
R11-3283	V5	15	9.0	9.0	9.0	9.0	9.0	98.5	98.5	98.5	98.5	98.5
R11-7700	V5	15	7.7	7.7	7.7	7.7	7.7	85.2	85.7	86.7	89.3	86.7
R11-7636	V5	15	7.7	7.7	7.7	7.7	7.7	86.5	87.1	87.1	87.1	86.9
R10-6606RR	V5	15	9.0	9.0	9.0	9.0	9.0	96.9	97.4	98.5	98.5	97.8
R09-1827RR	V5	15	8.0	8.0	8.0	8.3	8.1	90.8	91.3	91.3	93.6	91.7
R11-9428	V5	15	7.3	7.3	7.7	7.7	7.5	83.1	84.2	85.2	85.2	84.5
R09-1831RR	V5	15	8.0	8.0	8.3	8.3	8.2	85.1	85.7	88.3	89.6	87.2
R06-4433	V5	15	7.7	7.7	7.7	8.3	7.9	89.6	89.6	89.6	90.9	89.9
R08-3119	V5	15	9.0	9.0	9.0	9.0	9.0	98.3	98.7	98.7	98.7	98.6
R01-2731F	V5	15	7.0	7.0	7.0	7.3	7.1	82.4	83.6	83.6	87.3	84.2
R99-1613F	V5	15	9.0	9.0	9.0	9.0	9.0	97.6	98.2	98.8	99.5	98.5