CHAPTER 1

INTRODUCTION

Introduction

Soybean is one of the most important oil crops of the world and Thailand. The world production area in 2001 was 76,296,988 ha with total yield of 177,324,555 tonnes (OAE, 2002). Thailand production area and total yield in 1999/2000 were 232,000 ha and 319,000 tonnes, respectively (OAE, 2002) and also a large amount of soybean is imported each year.

Germination test is an analytical procedure to evaluate seed viability under standardized (favorable) conditions (ISTA, 1999; AOSA, 2001). The percentage of germination reflects the planting value of the seed lot as well as its storability and is perhaps the single most convincing and accepted index of seed quality (Liu *et al*., 1999). Highly predictive seed germination is necessary for farmers to make economic decisions regarding the cost of seeds, time of planting, quantity of seeds to be planted, and the anticipated uniformity of field stand. However, it has been frequently noted that standard germination does not correspond to the field performance under most planting conditions (Delouche and Baskin, 1973; Makkawi *et al*., 1999; Vieira *et al*., 1999b), particularly under drought and rainy conditions. Drought has the most serious effects on soybean production (Burton, 1997), leading to low field emergence, stand establishment, plant population and yield (Helms *et al*., 1996a, b; Vieira *et al.*, 1992; De Souza *et al.*, 1997). Many crop production areas, including Thailand, are faced with drought (Ouprasitwong, 1994) and flooding condition (Anonymous, 2004), especially during the planting season. Seed vigor comprises those seed properties which determine the potential for rapid, uniform emergence, and development of normal seedlings under a wide range of field conditions (AOSA, 2002), which will be a better determination of seed field stand. Many seed vigor tests have been developed to correspond to the field planting conditions. For instance, cold test has been designed and used for seed emergence evaluation under high soil moisture content and low temperature of early spring planting season of the temperate area for soybean and corn seeds

(AOSA, 2002). Accurate prediction of the germinating performance of seeds under the drought and rainy season conditions is needed for tropical crop production area. Germinating seeds in soil in a basket with limited moisture content and flooding condition has been shown to have a good correlation with field emergence under drought and rainy season planting, respectively, in corn (Sawatdikarn, 2002), sweet corn (Jittham, 2002) and cucumber (Werakul, 2003). The water-limited germination test for evaluating field emergence under drought and wet field conditions was studied to optimize seed used for soybean planting.

Literature review

1. Soybean production in Thailand

Soybean has been cultivated for a century in the upper north of the country and expanded to the lower part of the northern, the north-eastern region and central plains of Thailand. Soybean is planted in three main seasons. The first season crop is planted in the uplands during the early rainy season from May to mid June. The main planting areas are in the lower northern region such as Sukhothai, Uttaradit, Phitsanulok, and Kamphaeng Phet provinces. This planting season accounts for about 25% of the total soybean production area. The second season crop is planted in the late rainy season from August to mid September, mainly in the lower northern region and the central plains such as Sukhothai, Nakhon Sawan, Lop Buri, and Saraburi provinces. The late rainy season planting covers about 25% of the total soybean production area. The third season crop is planted in rice fields during the dry season from mid December to mid January. The crop is sown under irrigated areas in the northern and north-eastern region such as Chiang Mai, Chiang Rai, Lamphun, Tak, Sukhothai, Uttaradit, Phitsanulok, and Khon Kaen provinces. The planting area in the dry season is 45-50% of the total soybean production area (FCRI, 2001; Anonymous, 1999). Rapid changes of global weather have caused more variation in the world climate leading to drought at the planting season (Ouprasitwong, 1994) or heavy rain resulting in flooding or saturation of the soil in the production area (Wuebker *et al*., 2001).

In tropical regions, most soils are sandy soil which have low water holding capacity or water retention (FAO, 1994). In Thailand, soybean has been grown in various soils such as sandy loam, sandy clay loam, silt, clay and clay loam (Arayangkool, 1998; Boonpradab and Kaewmeechai, 2000). The current soybean varieties growing in Thailand are CM 60, SJ 4, SJ 5, ST 1, ST 2, NS 1, CM 2, and KKU 35. Their production characteristics are shown in Table 1A.

2. Seed emergence and stand establishment

Adequate plant population is an important part of soybean production, which is determined by planting rate and field emergence combination. Field emergence is influenced by many important factors including seed quality, seedbed conditions, and planting depth (Egli and TeKrony, 1996).

Seed quality influences field emergence (Tully *et al*., 1986). Planting of high quality seeds both under favorable moisture and temperature conditions and under stress conditions resulted in good emergence (FAO, 1994; AOSA, 2002). The field emergence of high-and medium-vigor soybean seeds was always higher than that of low-vigor seeds, and the advantage was greatest under stressful conditions (Hamman *et al*., 2002). Egli and TeKrony (1995) suggested that planting soybean seeds with standard germination of 95% or higher would ensure adequate performance in many field conditions. The optimum germination conditions for soybean seeds required 8-18 and 102-138 hours after planting to complete seed imbibition and emergence, respectively (Muthiah *et al.*, 1994).

Inadequate water for seed germination could result in decreasing germination percentage and speed of germination, and increasing pathogen infestion (Hadas and Russo, 1974). Dry seedbed conditions such as the initial low soil water content and high temperature cause a reduction in soybean seed emergence (Dharmasena, 1986). Low soil moisture at about 7% in coarse-silty soil retarded soybean seed germination (Helms *et al*., 1997) unless the seeds could achieve moisture up to 50% (FAO, 1982). Furthermore, under a relatively dry soil, seed-borne fungi *Phomopsis longicolla* Hobbs, reduces soybean emergence (Gleason and Ferriss, 1985). The interaction of fungal colonization with soil moisture appears to result from the fungus being able to grow at water potentials well below those needed for soybean seed germination. If colonized seeds are planted into soil that is too dry to support germination, but moist enough to allow

Phomopsis longicolla in the seed coat to become active, the fungus has sufficient time to infect the embryo before the seed coat pulls off. In soil that is near optimum moisture for germination, most seeds apparently loose their seed coats rapidly enough to escape embryo infection (Ferriss and Baker, 1990). In addition, compacted soil also impedes seed emergence (Hawle and Caviness, 1988). Fehr *et al.* (1973) reported that planting depth had a major influence on emergence percentage. FAO (1994) recommended that the best planting depth for soybean varied between 2.5 and 5.0 cm. Poor emergence and stand establishment of soybean seeds under dry condition planting in the humid tropics might be due to inadequate water for seed emergence, high temperature and fungal infection.

3. Relationship between seed quality test and field emergence in soybean

Seed germination and vigor are measured to provide an indication of the future performance of the seed lot. In most cases, performance relates to the ability of seeds to germinate and produce seedlings that will emerge from the soil and develop into healthy vigorous plants. Useful measures of seed quality should relate to field emergence (Egli and TeKrony, 1995). However, it has been difficult to establish a direct relationship between soybean seed germination or vigor and field emergence (Egli and TeKrony, 1995). The seed quality test which best predicts soybean emergence can vary with seedbed conditions (Ferriss and Baker, 1990). Many studies have reported the significant correlation between standard germination and vigor tests (such as electrical conductivity test) with field emergence for soybean (Edje and Burris, 1971; TeKrony and Egli, 1977; Johnson and Wax, 1978; Yaklich and Kulik, 1979; Yaklich *et al*., 1979; Kulik and Yaklich, 1982; Vieira *et al*., 1999b), but these relationships were not consistent across experiments and could not be used to well predict field emergence (Egli and TeKrony, 1996; Vieira *et al*., 1999b). The examples of viability and vigor tests for soybean seeds are volatile aldehyde assay, potassium leakage test, conductivity test, and tetrazolium test (Wilson and McDonald, 1986; Hampton and TeKrony, 1995; Dias *et al*., 1996; AOSA, 2002). However, most of them provided results not conforming to field emergence and required considerable testing skill.

4. Germination and vigor test under stress conditions

Seed germination test is the accepted standard for evaluating seed lot quality. However, it is recognized that high laboratory germination percentages do not necessarily predict good field emergence performance. Seed vigor tests have been used to detect the differences in potential of seed lot performance that are not detected by the conventional germination test (Trawatha *et al*., 1990). According to Hampton and TeKrony (1995), there were four requirements of a vigor test : 1) to provide a more sensitive index of seed quality than the germination test, 2) to provide a consistent ranking of seed lots in terms of their potential performance, 3) to be objective, rapid, simple, and economically practical, and 4) to be reproducible and interpretable. Many vigor tests were developed by simulating natural adverse field conditions in the planting areas. The vigor tests based on germination behavior are the cold test, cool germination test, and accelerated aging (Hampton and TeKrony, 1995). The cold test is used to predict field emergence of soybean, maize and sorghum under high soil moisture, low temperatures and soil borne fungi in cold and wet climatic regions (Hampton and TeKrony, 1995). Therefore, vigor tests under stress condition are usually conducted under certain simulated stresses which the seeds may encounter in the field. In these tests, seeds were put to stress condition either prior to imbibition or during germination. However, seed germination remains the criterion for evaluation (AOSA, 2002).

AOSA (2002) reported that when seeds were sown in the field, they were subjected to drought stress which resulted in poor field emergence. Such a drought condition can be simulated in a laboratory test by the use of soil, soil solution and solutions with various osmotica such as sodium chloride, glycerol, sucrose, polyethylene glycol (PEG) or manitol. For evaluating corn and sweet corn seed field performance under drought field condition, the tests were done by planting the seeds in 2,000 g of soil in plastic baskets (26x30x8 cm) and watering at 70% of field capacity once on the planting date with germination evaluated for 5 days (Sawatdikarn, 2002; Jittham, 2002). A similar procedure could be used for cucumber seeds (Werakul, 2003).

The germination in 1,000 g soil in plastic baskets and flooded for 25 and 5 hours showed the same germination percentage as rainy season planting for corn (Sawatdikarn, 2002) and sweet corn seeds (Jittham, 2002), respectively. For cucumber seed field emergence in the rainy season, the germination test should be done under 10-15 hours flooding and evaluated at 6 days after planting (Werakul, 2003).

5. Field emergence index

Field emergence index is an index used to characterize seedbed conditions suitable for planting the seeds. It is calculated by dividing the field emergence by the standard germination of the seeds. A field emergence index of 100 (or above) means ideal conditions for seed field emergence. Conditions become progressively less than ideal as the field emergence index decreases below 100 (Egli and TeKrony, 1995). Egli and TeKrony (1996) proposed that the field emergence index representing ideal field conditions, moderate level of stress, and severe stress of soybean seeds were near 100, 60-80, and lower than 60%, respectively. Field emergence index could also be used as a criterion for monitoring the accuracy of some vigor tests. Vieira *et al*. (1999a) found that under more adverse conditions or lower field emergence index, the electrical conductivity gave a less precise prediction of field performance of a seed lot, while under ideal conditions or higher field emergence index, the test became a good indicator of field performance. The field emergence index can also be used to indicate the ability of the seeds to emerge in the field as compared to its standard germination. Hence, the field emergence of the seeds can be calculated from standard germination if the field emergence index is known.

OBJECTIVES

1. To study soybean seed field emergence under various field conditions.
2. To develop the germination test to evaluate soybean seed field emergence under drought and rainy season conditions.