INTRODUCTION

Background

Chili pepper (*Capsicum annuum* L.) is one of Indonesia’s important vegetable that has a high economic value. Indonesia Vegetable Crop Research Center categorizes chili pepper as one of the leading vegetable commodities (Soetiarso et al., 2011). Most Indonesian consumes it fresh, while some consumes it in dry or processed form. The average household in Java consumes chili pepper as much as 2.20 kg/capita/year (Bank of Indonesia, 2007).

In addition, many types of chili pepper are used for food and medicine materials. Among those industries that use it as raw materials are noodles, bread, soy sauce, food seasoning and other modern or traditional food industries. The demand for chili pepper tends to increase from year to year. This is in accordance with the rising demand that comes from industrial and household needs.

Chili pepper production and productivity in Indonesia fluctuates each year. According to the Central Bureau of Statistic (2012), chili pepper production in 2009 was 1,378,727 tons and then decreases to 1,328,864 tons. In 2011, chili pepper production rises to 1,440,214 tons. Productivity also fluctuates from 5.89 tons/ha in 2009, to 5.6 tons/ha in 2010 and 6.07 tons/ha in 2011.

Suharsono et al. (2009) stated that at certain times, chili pepper demand in the community grows so high that the national production is unable to meet the increasing demand. It affects the country's economy directly and indirectly in ways such as the occurrence of inflation as well as an increase in the imports of chili pepper.

Various efforts in increasing chili pepper productivity should be done to meet the increasing demand. One of the ways to increase productivity is through releasing new and improved variety. These varieties are then expected to have superior characteristic and can be grown in various regions in Indonesia.

Plant breeding is a systematic process in releasing new superior variety. There are three main activities, which are (1) creating basic population that has a diverse genetic diversity for character improvement; (2) creating breeding lines as a selection unit from the basic population; and (3) evaluating the breeding line
selection. Yield evaluation needs to be done to understand the characteristic of the new breeding lines.

This yield evaluation research was done to evaluate and select potential new chili pepper lines created by the Plant Breeding Program in the Department of Agronomy and Horticulture of Bogor Agricultural University. If a line has satisfactory result, then it can be recommended for further research. Those lines are then expected to be developed and become a new chili pepper variety.

Objectives

The objectives of this research were to evaluate the variability and yield of new chili pepper lines compared to three commercial varieties, and estimate character heritability values.

Hypothesis

1. There were chili pepper lines that have a higher or equal yield compared to the commercial varieties.
2. There were characters that have a high heritability value.
LITERATURE REVIEW

Chili Peppers (*Capsicum annuum* L.)

**Botany**

Chili pepper is native to tropical and subtropical region in America. Spanish and Portuguese traders play a role in the spreading of chili peppers all around the world. It is a part of the Plantae kingdom, Solanales order, Solanaceae family, Capsicum genus with scientific name *Capsicum annuum*. *Capsicum annuum* is the most widely cultivated species. It includes sweet and spicy fruits with various shapes and sizes. Some of the most know varieties are var. *minima*, var. *acuminatum*, var. *longum*, var. *abbreviatum*, var. *cerasiformae* dan var. *grosium* (Williams *et al*., 1991).

Chili pepper is a tropical herbaceous perennial plant that is usually grown as an annual plant. It grows upright with heigth ranging from 0.5 - 1.5 m, has many branches and has a fully developed strong taproot. It has smooth surface leaves with various shapes (Rubatzky, 1998). The color of the corolla varies from white to purple. The fruit color varies and can change colors to red, orange or yellow as it matures. The shape also varies from linear, conical and round.

**Cultivation**

Red chili pepper can be cultivated in upland or lowland regions. However it is best to cultivate in 500-1,200 m above sea level. The average rainfall that is suitable for chili pepper cultivation is around 600-1,250 mm. It is most suitable to plant chili pepper in clay soil that has good drainage system (Poulos, 1994). Soil acidity (pH) for cultivation should range from 6.5-7 (Williams *et al*., 1991).

According to Williams *et al*. (1991), the ideal temperature for chili pepper growth is 20-25°C in daytime and under 20°C at night. Meanwhile the optimum temperature for pollination is 20-25°C. However, Amati *et al*. (2002) stated that the optimum temperature for chili pepper growth is around 20-30°C with difference of 5°C between night and day. The minimum temperature for chili pepper growth is 16°C and the maximum temperature is 35°C.
Plant spacing varies within each cultivar, but it is often used 25,000 until 30,000 plants in each hectare. The common plant spacing is 40-50 cm inside the row and 70 cm between the rows. Narrow plant spacing can reduce the size of the fruit but can prevent the fruit from sunburn (Rubatzky, 1998). Chili pepper is often cultivated in a small scale in Asia. The planting areas that are used are about 0.1-0.5 hectares for agriculture cultivation (Poulos, 1994).

Chili pepper plant is responsive to fertilization. Additional nitrogen fertilizers are usually added before planting and during the first flowering (Williams et al., 1991). Soil ameliorant recommendations for this plant are 10-20 tons extra organic materials, 130 kg of N/ha, 80 kg of P/ha and 110 kg of K/ha (Poulos, 1994). The amount of fertilizers given for chili pepper plant that is cultivated using drip irrigation and mulch can be up to a dose of 453 kg of N/ha, 207 kg of P₂O₅/ha and 360 kg of K₂O/ha (Alviana and Susila, 2009).

Chili pepper fruit harvesting is affected by genetic factor and environment factors. One of the genetic factors is days to flowering. According to Sujiprihati et al. (2010), faster days to flowering can result in a faster harvest time. Environment factors that affect difference of harvest time are climate and cultivation technique.

Harvest interval of chili pepper is once every 2-3 days or depending on the market demand. For yield evaluation, chili pepper fruits should be harvested every week when the fruit’s color turns red (Berke and Gniffke, 2006).

Pest and disease are factors that cause low productivity. Chili pepper diseases are caused by fungi, nematodes and virus. The most common disease in chili pepper producing countries is anthracnose that is caused by Colletotrichum sp. (Syukur et al., 2010). Virus and plant damage can be caused by pest such as aphids, mite, thrips and fleas. In addition, physiology factors such as blossom end rot, salinity and sun overexposure can also cause damage to the plant. Excess of pesticide also can cause damage to chili pepper plant (Black et al., 1991).

Types of Chili Pepper

Big chili pepper is one of common leading red chili pepper variety. It has a high market demand, especially the superior variety. The big chili pepper standard
according to the National Standardization Agency of Indonesia (1998) is fruits that have blunt or pointed fruit tip, thick fruit skin, smooth surface and spicy taste. Fruit length ranges from 9-14 cm and fruit diameter is up to 17 mm.

Big red chili peppers that are suitable with the producers and the consumer’s preference are surveyed by Syukur et al. (2010) in Bekasi Cibitung Market, Jakarta Kramat Jati Main Market and in the farmers. Consumers want big red chili pepper with spicy taste, smooth surface and thick fruit skin. The shape resembles Prembun, Tit Super or Hot Beauty variety. The desired length is 10-11 cm with a diameter of 13-15 mm. It has a better yield and faster harvest time than Jatilaba and Hot Beauty variety.

Curly chili pepper is one of the red chili pepper varieties. A good curly chili pepper fruit quality according to the National Standardization Agency of Indonesia (1998) is fruits that have pointed fruit tip, wavy fruit surface, thin fruit skin and spicy taste. Fruit length ranges from 10-17 cm and fruit diameter is up to 17 mm.

Curly chili peppers that are suitable with the producer and the consumer’s preference are also surveyed by Syukur et al. (2010) in Bekasi Cibitung Market, Jakarta Kramat Jati Main Market and in the farmers. Consumers want curly chili that has spicy taste and a dark red color. The yield is better than LV-3044 or LV-3188. The harvest time is shorter than LV-3044. The fruit have a slender shape with length around 11-15 cm and a diameter of 8-10 mm.

Breeding of Chili Pepper (*Capsicum annuum* L.)

Chili pepper breeding is needed to develop superior variety seeds. It is expected that the new variety has a high yield and resistant to pest and diseases. According to Greenleaf (1986), objectives in chili pepper breeding are to generate superior horticultural character, yield improvement and resistance to pest and diseases. Some of the horticultural characters stated are the days to anthesis or flowering, shape and size of fruits, fruit quality, taste, pungency and fruit’s color. However according to Welsh (1981), the main objective of every breeding program is yield evaluation.
Yield evaluation and horticultural characteristic of chili pepper are done according to the consumer’s desire. Information regarding the need of consumers can be used as a reference to decide on the breeding target. Williams et al. (1991) stated that in the tropical countries, chili pepper is often selected based on aroma than appearance.

Stages in chili pepper plant breeding are collecting germ-plasm and characterizing, selecting or choosing the suitable breeding lines, breeding line purification, crossing and evaluating yield. The steps to cross chili pepper flowers are preparation, castration or removing unused parts, emasculation or removing the male genitals on the female parents, pollination, isolation and labeling (Syukur et al., 2012).

Department of Agronomy and Horticulture in Bogor Agricultural University (IPB) has been generating chili pepper variety since 2003. Some prospective breeding lines had been evaluated, such as the crossing between IPB C110 and IPB C5 that resulted in a shorter days to flowering and harvest time (Ferdiansyah, 2010). The selection process also resulted in a higher yield breeding line such as breeding line 5 in the crossing between IPB C120 with IPB C5 (Hermawati, 2010). Some lines such as IPB 120005, IPB 009019 and IPB 002046 are also in the first quality category for fruit length variable after being evaluated in three different locations (Mastaufan, 2011).

**Yield Evaluation**

Yield evaluation is one of the ways to test genetic material of the population in further generation. Selected breeding lines need to be evaluated to see if it correlates with the breeding objective. The chosen lines are then put through a yield evaluation to test the growth and productivity (Suhartina, 2005). Field testing is an important part to be conducted by breeders who want to evaluate breeding lines with commercial variety (Greenleaf, 1986).

Preliminary and further yield evaluations are done in the last stage of plant breeding process. The number of breeding lines in the preliminary evaluation are much more than the ones in the further evaluation. Evaluation can be done in
one or multiple locations and seasons. Both evaluations are targeted to evaluate the plant’s response to uncontrolled environment factors (Yudiwanti, 2008). If one breeding line has a satisfactory yield evaluation result, then the line can be recommended for further research to become a new high yielding variety.