INTRODUCTION

Background

Rice is one of the important food crops in the world and is the staple food of nearly half of the world's population. Milled rice consumption increased by 40 percent in the last 30 years, from 61.5 kg per capita to about 85.9 kg per capita (UNCTAD 2010). Demand for rice depends on quality, both physical and chemical qualities. Among various carbohydrate sources, especially in Indonesia, rice plays an important role in the provision of food to support national food security and economic empowerment of farmer households. Most of the rice-producing countries are located in Asia, where rice is not only a major food source but also as a commodity for economic activity that provide employment opportunities for rural households (Adnyana et al. 2008). Thus, future development of rice cultivation has to be focused not only on quantity or increase in productivity, but also on improvement of quality of rice grains in the form of a combination of taste, aroma, and nutritive value to be able to compete in the domestic and international markets.

High yielding varieties as one of component technologies remains a priority to support food security programs. Two major programs in rice improvement, namely increasing yield potential and yield stability. High yield potential improvement programs could be promoted through the establishment of a new plant type of rice (NPT) and hybrid rice (Widiarta et al. 2003). NPTs are designed to have more efficient assimilate distribution to the grain. The desired NPT characteristics: 80 - 100 cm plant height, sturdy stem, 8 - 10 productive tillers, erect leaves, thick, dark green leaves, long panicle, total grain of 200-250/panicle, mature at 100 - 130 days, resistant to pests and major diseases. The heterosis of F1 of hybrid rice can increase the yield potential up to 15 - 20% than inbred varieties (Khush 2000; Fagi et al. 2002). Peng and Khush (2003) however, stated that the yield potential of NPT improved since 1989, were not as high as expected. This may be due to low biomass production and number of filled grain, and also sensitive to major pest and diseases. Therefore, in 1995 new initiation
began to breed the second generation NPT by crossing tropical japonica NPT lines with the elite indica lines to increase the number of tillers (Peng et al. 2008).

New rice varieties, that have better benefits than existing rice varieties, will be more accepted if their characteristics are in accordance to consumer’s preferences (Zen 2007). Therefore, rice breeders should consider about the better quality of new rice varieties in addition to higher yield potential. Consumers will pay more for good quality rice and this implicate better income for farmers (Adnyana et al. 2008). Rice varieties have different productivities and qualities, grain appearance and aroma. Many aromatic rice varieties are produced in Thailand, India, Pakistan, Bangladesh, Nepal, Iran, Afghanistan, Myanmar, and Indonesia. Aromatic rice cultivars that are popular in Thailand are Thai Hom Mali Rice, Jasmine Rice, and Thai Fragrant Rice. In India the famous aromatic rice is Basmati, which has medium texture, with a slender shape and long grain and less chalkiness (Kamath et al. 2008). In Indonesia, the type of aromatic rice that widely cultivated is tender-texture rice. Farmers cultivate local aromatic rice in irrigated land, such as Pandanwangi and Rojolele. However, these local varieties have long maturity (more than 125 days) and susceptible to major pests and diseases.

In the international markets, demands for rice based on quality are very diverse. Aromatic rice having aroma similar to popcorn are numerous in India, Pakistan, and the Middle East. Consumers in Pakistan and India prefer Basmati rice varieties which are aromatic with long grain. Popularity of this type of rice is growing in the United Stated and Europe. European Community imports large quantity of aromatic Basmati rice from India. Italy has also aromatic rice varieties, namely Apollo, Asia, Gange, Giano, and Fragrance which have high productivity and good grain quality (Lupotto et al. 2005).

Aromatic rice is now becoming a good commodity in the international trade. Jasmine rice variety from Thailand is as famous as Basmati from India. United Stated, Australia, and Vietnam have released aromatic rice varieties with high yields (Vanavichit 2007). Demand of Thai rice variety Khaw Dawk Mali (KDML) 105 has continuously increased because of good quality of rice grains (Karim et al. 2007). In general, aromatic rice is more preferred than non-aromatic
Aromatic Basmati rice with a slim grain (length > 6.5 mm) is the most famous variety (Singh 1997). Basmati from India, Pakistan, and Nepal as well as Sadri from Iran has a higher price than common rice, therefore, there is a lot of support for developing aromatic rice varieties with high yield potential (Garris et al. 2004; Dong et al. 2001).

There are 114 compounds that affect the aroma of rice. However, the most common compound found in aromatic rice was 2-acetyl-1-pyrroline (2AP), a compound that also present in pandan leaves (*Pandanus amaryllifolius*). These compounds that cause the smell of popcorn or pandan identified in Basmati, Jasmine and most aromatic rice in Asia (Weber et al. 2000). The presence of 2AP compounds in milled rice can be analyzed using gas chromatography mass spectrometry (GC-MS) (Widjaja et al. 1996). GC-MS methods, PCR, and the KOH test were used by Sarhadi et al. (2009) to distinguish aromatic rice from a non-aromatic.

Some aromatic rice varieties have been released in 2001, including Sintanur and Batang Gadis with high yield potential (7 - 7.5 t.ha⁻¹), growth duration are 110 - 125 days, and are resistant to brown planthoppers biotype 1 and 2 (Suprihatno et al. 2006). The upland rice Situ Patenggang, was released in 2002.

Aromatic upland rice with good grain quality have been developed since 2000 from crossing between varieties Mentik Wangi (aromatic rice) with Danau Tempe and Poso (high yielding upland rice, drought tolerant, hard-texture of cooked rice) (Haryanto et al. 2008). Results of multi location trials, showed four lines that can be proposed as new aromatic upland rice varieties, are: G10 with the yield of 4.5 t.ha⁻¹, G19 (4 t.ha⁻¹), G39 (4.18 t.ha⁻¹), and G136 (4.11 t.ha⁻¹) (Haryanto 2008).

High quality rice, uniform shape of grains, whiteness and translucency are major factors of market value (Fitzgerald et al. 2008). NPT promising line developed by the Indonesian Center for Rice Research (ICRR) is BP360E-MR-79-PN-3 having a good grain quality, high percentage of head rice and a strong aroma, which will soon be released as a new plant type of high yielding varieties (HYNPT). In addition there are several other lines with good quality but still in the stage of observation, preliminary and advanced yield trials. (Widiarta et al. 2003).
Appearance of a plant called phenotype is the expression of plant genotype in a particular environment and its interactions (Allard 1960). Phenotype of a plant is influenced by genotype, the environment, and genotype environment interaction (G x E). The environment is one of components that can affect the quality of grain and rice productivity and production. Environmental components that affect the quality of grain of rice, among others are: altitude, air temperature, humidity, and biotic factors like pests and diseases, abiotic factors such as drought, floods, irrigation, soil type, or rain. Study on the aromatic rice that was exposed to cold weather from the early stages to 4 weeks after flowering (afternoon 25°C per night 30°C) have high concentrations of 2AP. The 2AP concentrations decreases 20 - 40% if the harvest is delayed (8 weeks after flowering) and in high temperature conditions (afternoon 35°C per night 30°C) (Itani et al. 2004).

Interaction of G x E must be considered by plant breeders. To develop high yielding varieties, plant breeders dealing with the G x E interaction, which means responses of rice varieties or breeding lines are not necessarily suitable to every environment. Macro-environment that affects the physical plant adaptation including: soil type, altitude, and temperature, location in latitude, climate, and seasons. G x E interactions greatly affect the phenotype of a variety, so the stability analysis is required to characterize the performance of varieties in different environmental conditions, it help breeders in selecting location specific varieties. Instability is the result adaptability of cultivars to different environmental conditions which usually indicates a high interaction between genetic and the environmental factors (Lone et al. 2009; Jusuf et al. 2008).

Information regarding G × E interaction is important for countries such as Indonesia with wide variability of geographic characteristics. Breeders can take advantage in determining the policy implementation of a regional distribution of a new variety. In this case there are two alternatives, namely: (1) release a new variety with high yield potential for broad range environments (wide adaptability), (2) release of new varieties with high yield potential in a specific growing region (specific adaptability) (Baihaki and Wicaksana 2005).
Rationales

The existence of interaction between genotype with the environment must be considered in the development of superior plant varieties. Some genotypes show specific reaction to a particular environment. G × E may occur if the phenotype changes at different environments due to the genotype responses. Based on the results of analysis of variation the presence or absence of G × E will be known.

Genotype ability to adapt to the environment can be measured by the interaction of G x E. Instability is the result of a cultivar adaptation to different environments which usually indicates a high interaction between genetic and environmental factors. Based on the response of genotype to the environment, varieties of plants could be grouped into: (1) Varieties that are adaptable to the broad environments, in which the interaction between genotype and environment is relatively small; and (2) Varieties that are adaptable to the particular environment; this entry shows large interaction with the environments.

The development of rice breeding lines having aromatic character still continues. In this effort, Bogor Agricultural University (BAU) has used aromatic upland rice from South Sulawesi as parental source of the aroma gene. These local rices are Pulu Mandoti, Pinjan, Pare Bau, Lambau, besides Sintanur varieties. Indonesian Center of Rice Research (ICRR) has currently developed breeding lines for aromatic NPT with gene source from Gilirang. Aromatic advanced lines have been obtained. However, the yield stability of the aromatic rice parents from different sources in different environments is still unknown. Yield stability of these lines is necessary to be examined across different locations and seasons.

Objectives

1. To study the yield components, yields, and response of NPT lines to different environment condition.
2. To study the stability of yields and aromatic character of NPT lines in different environmental condition.
3. To evaluate the level of aromatic improved breeding lines for development of aromatic rice.