ADAPTATION OF WHEAT TO A TROPICAL ENVIRONMENT

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ABSTRACT

Wheat consumption in Indonesia is continuously increasing. Indonesia imports considerable amounts of wheat for domestic consumption and processing and this has increased with economic development. Therefore to lower the high import of wheat grains, Indonesia should have domestic production. Even though Indonesia straddles the equator, the high altitudes in many parts of Indonesia means that wheat could potentially be grown during the dry season as it is more drought tolerant than rice. However, improved adaptation of wheat to tropical environments is needed to achieve this goal.

Lombok Island (8.5°S 116°E) is suggested to be one of the potential areas of wheat growing. The average maximum temperature at the capital city, Mataram (low altitude) is 30-32°C during day time and minimum at 20-23°C at night but this is moderated by elevation in the centre of the island. The lowest temperature during the year is between June and August which also is the dry season. Lombok's current farming system consists of two rice plantings during the rainy season and a non-rice planting during the dry season. May to September is proposed to be the wheat growing period on Lombok to have the plant flowering during the time of lowest temperatures and coincidently with no or limited rainfall during grain development to avoid grain sprouting in the field before harvested.

In order to investigate the adaptation of wheat on Lombok Island Indonesia, a series of growth chamber and field experiments was conducted. The initial controlled environment experiments at Adelaide University that examined patterns of apical development and seedling growth were done at a continuously high temperature (32/23°C) day/night to imitate temperatures at lowland sites of Lombok Island while in later experiments in which development, growth and yield were studied, the temperature treatments were expanded to 3 temperature regime, 32/23°C, 28/20°C to imitate lowland and highland temperatures of Lombok Island and 25/15°C to represent a temperature more

typical of a wheat producing area in a temperate environment. Field experiments were done in two consecutive years 2010 and 2011 at 3 different elevation sites on Lombok Island-Indonesia: Sembalun (1000masl), Narmada (200 masl) and Gunung Sari (10masl) in 2010, and Sembalun, Senaru (500masl) and Lekok (10masl) in 2011. Seeds were sown at 6 sowing times in 2010 and 3 sowing times in 2011. A range of Australian varieties with different maturities were grown and later two Indonesian varieties were included.

Plant development was rapid under continuously high temperature environment both under controlled environment experiments and in field experiments with double ridge occurring 15-30 days after sowing and flowering occurring 40-70 days after sowing in most varieties. There was good correlation in the rates of development under controlled environment and field conditions. The differences in flowering time were related to photoperiod sensitivity and intrinsic earliness among varieties. The results suggested that early maturing varieties (eg. Axe) developed very rapidly which may limit their yield potential.

In the field trials on Lombok, wheat productivity was influenced by elevation and sowing date. At lowland sites yields were about 1 t/ha or less, whereas when grown at 500 masl elevation or above yields were substantially higher and ranged from 2.2-3.2 t/ha. The change in yields with elevations was associated with changes in mean temperature: the change in yield with increasing temperature was -55 g/m^2/°C. The optimum sowing time at higher elevation on Lombok was from mid-May to early June which allowed plants to flower in the cooler and drier time of the year, and this also allow wheat to fit in with the current cropping systems. Mid-season varieties that flowered after 65 days were generally higher yielding than earlier flowering or later flowering varieties. Yield was most strongly related to grains/m^2 which emphasised the importance of the timing of the phase of ear and floret development for sink development in this short season environment.

Growing wheat at 32/23°C greatly reduced wheat yields compared to 28/20°C and 25/15°C due to much more rapid development, lower net photosynthesis rates and lower accumulation of water soluble carbohydrates (WSC). This resulted in reduction in both grain number and kernel weight with yield being relatively more affected by changes in grain number. There was some evidence of genetic variability to heat stress. The differences in yield among varieties was related to differences in photosynthetic rate, stomatal conductance as well as the amount and remobilisation of WSC. Two Indonesian varieties were more tolerant to high temperature than Australian varieties.

The results of this work suggested that it is feasible to grow wheat on Lombok Island at elevations above 500 m. Mid-season varieties that flower after 60-70 days appear to be the most promising pattern of development. There appears to be significant genetic variation in yield to allow further development of improved varieties. Future work should consider adapting wheat into broader potential areas of Indonesia, developing appropriate cropping practices for different altitude and yield potential areas, and introducing or breeding new heat stress tolerant varieties.