Faculty of Resource Science and Technology

Phenological Development of Sarawak Traditional Rice Landraces; Bario Sederhana and Biris

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DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Malaysia Sarawak. Except where due acknowledgements have been made, the work is that of the author alone. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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ABSTRACT

Phenological development and growth of Sarawak traditional rice landraces, i.e. Bario Sederhana and Biris were quantified from a series of field and incubation experiments. In both landraces, incubation study estimated cardinal temperatures of 10 °C for base, 32 – 33 °C for optimum and 43 °C for maximum seed germination. The thermal time (Tt) requirement for 75% germination in the sub-optimal range for Bario Sederhana was 61 °Cd and 54 °Cd for Biris meanwhile within the supra-optimal range, both landraces required 27 – 29 °Cd. Bario Sederhana had 93% of seed populations germinated at 30 °C while Biris had 100% at 27.5 °C. For phenological pot experiments, both landraces had the highest Tt requirement for third leaf appearance for crops sown in June (358 °Cd for Bario Sederhana and 386 °Cd for Biris) and the lowest for crops sown in December (149 °Cd for Bario Sederhana and 165 °Cd for Biris). The leaf appearance rate (phyllochron) for Bario Sederhana decreased with each successive sowing date from 646 °Cd/leaf for April sown crops to 467 °Cd/leaf for the crops were in late October. In contrast, the phyllochron of Biris was the shortest in late June sowing (495 °Cd/leaf) and the longest (~624 °Cd/leaf) for April and late October sown crops. Irrespective of landraces, thermal time to flag leaf decreased with sowing date from 4051°Cd in April to 2569 °Cd in late October with a total production of nine leaves on the primary stem across all sowing dates. In both landraces, crops took the longest time to reach flowering for April sowing (4790 °Cd for Bario Sederhana and 4315 °Cd for Biris) and the shortest time for October sown crop (2980 °Cd for Bario Sederhana and 2857 °Cd for Biris). Nevertheless, the duration of grain filling was the longest for October sown crops (784 – 818 °Cd, 30-33 calendar days) which resulted in the highest grain weight (48 g/pot for Bario Sederhana and 22 g/pot for Biris). For field experiment conducted at Pusat Penyelidikan Tumbuhan (PPT), UNIMAS, both landraces took almost similar calendar days to flower (151 days). Bario Sederhana and Biris rice had almost similar yield components when planted in the field.

Keywords: Development of rice, growing degree days, linear model, *Oryza sativa*, paddy

Pembangunan Fenologi Padi Tradisi di Sarawak; Bario Sederhana dan Biris

ABSTRAK

Satu siri eksperimen lapangan dan inkubasi bertujuan untuk mengukur perkembangan pertumbuhan dan fenologi landraces padi tradisional Sarawak, iaitu Bario Sederhana dan Biris. Suhu kardinal (asas, optimum dan maksimum) telah dikira dan kedua-dua landraces mempunyai T_{base} 10 °C, T_{opt} antara 32 – 33 °C, dan T_{max} 43 °C. Keperluan masa terma (Tt) untuk 75% percambahan dalam julat sub-optimum untuk Bario Sederhana ialah 62 °Cd dan 53 °Cd untuk Biris manakala dalam julat supra-optimum, kedua-dua landraces memerlukan 27-29 °Cd. Bario Sederhana mempunyai 93% populasi benih bercambah pada suhu 30 °C manakala Biris 100% pada suhu 27.5 °C. Untuk fenologi eksperimen dalam bekas, bagi kedua-dua landrace, keperluan Tt untuk penampilan daun ketiga adalah yang tertinggi untuk semaian pada bulan Jun (358 °Cd untuk Bario Sederhana dan 386 °Cd untuk Biris) dan yang paling rendah untuk semaian pada bulan Disember (149 °Cd untuk Bario Sederhana dan 165 °Cd untuk Biris). Kadar penampilan daun (phyllochron) untuk Bario Sederhana menurun dengan setiap tarikh penanaman berturut daripada 646 °Cd/daun untuk semaian pada bulan April kepada 467 °Cd/daun untuk semaian pada akhir bulan Oktober. Sebaliknya, phyllochron Biris adalah yang paling singkat pada akhir bulan Jun (495 °Cd/daun) dan yang paling lama (~624 °Cd/daun) untuk semaian pada bulan April dan akhir Oktober. Tanpa mengira landrace, keperluan masa terma untuk penampilan daun bendera berkurangan dengan tempoh penyemaian daripada 4051 °Cd pada bulan April kepada 2569 °Cd pada akhir bulan Oktober dengan jumlah pengeluaran sebanyak sembilan helai daun pada batang utama merentasi semua tarikh semaian. Kedua-dua landraces memerlukan masa yang tertinggi untuk berbunga bagi semaian pada bulan April (4790 °Cd *untuk Bario Sederhana dan 4315 °Cd untuk Biris) dan yang paling rendah bagi semaian pada bulan Oktober (2980 °Cd untuk Bario Sederhana dan 2857 °Cd untuk Biris). Namun begitu, tempoh pengisian bijirin adalah paling lama untuk semaian pada bulan Oktober (784 – 818 °Cd, 30-33 hari) yang menghasilkan berat bijirin tertinggi (48 g/pasu untuk Bario Sederhana dan 22 g/pasu untuk Biris). Bagi ujikaji lapangan yang dijalankan di Pusat Penyelidikan Tumbuhan (PPT), UNIMAS, kedua-dua landrace mengambil masa hampir sama hari kalendar untuk berbunga (151 hari). Padi Bario Sederhana dan Biris mempunyai komponen hasil yang hampir serupa apabila ditanam di lapangan.*

Kata kunci: *Pembangunan padi, hari peningkatan darjah, model linear, Oryza sativa, padi*

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PPT	Pusat Penyelidikan Tumbuhan
UNIMAS	Universiti Malaysia Sarawak
Tt	Thermal Time

CHAPTER 1

INTRODUCTION

1.1 Study Background

In rural regions of Sarawak, East Malaysia, traditional rice remains a popular choice among rice growers because it is pest resistance, requires a minimum farm input and resilient to unploughed land environments. Thus, cultivation of traditional rice is prevalent in Sarawak with estimation of at least 300 rice varieties identified (Khazanah Research Institute, 2018). Many of these varieties are said to possess exceptional quality in terms of taste (Wong et al., 2009), texture (Huei Ying, 2016), aroma (Libin et al., 2012) and nutritional properties (Ronie et al., 2022). These varieties are sold as specialty rice and they fetch a premium price between MYR 8.00 – 19.50 per kilogram in the retail market (Lai et al., 2017). Coupled with high consumer demand for specialty rice, the emphasis on production of specialty, premium rice products could increase the farmers' profits and improve rural development. In fact, some varieties have a specific locational origin and qualities derived from its origin and were registered as Malaysia Geographical Indication. Such varieties are Bario and Biris rice.

Bario rice originates from the Kelabit Highland in Bario, Sarawak. The varieties of Bario rice are renowned for its finest grain qualities such as aromatic, soft texture, tasty, palatable, and nutritious (Wong et al., 2009; Thomas et al., 2013; Nicholas et al., 2014; Ronie et al., 2022). Its moderate glycemic index suggests that Bario rice has a potential to control blood glucose level and thus can be marketed as health food (Nicholas et al., 2014). Specifically, a commercially grown variety 'Bario Sederhana' is classified as medium grain rice with high protein and low fat content, low gelatinization temperature and high gel consistency which indicates a soft texture of cooked grain (Huei Ying, 2016). This variety is suitable for health conscious consumers who at the same time prefer food with excellent taste.

Biris rice originates from the rice farms of Simunjan, Kota Samarahan, Sarawak. This variety produced an average grain yield of 2.2 tonnes per hectare with stem height of 0.81 m (Nori et al., 2009). Biris rice is popular for its strong aroma and the grain is classified as very long and slender with low percentage of chalkiness (Huei Ying, 2016). Similar with Bario varieties, the cooked grains of Biris have a soft texture and high in protein content. In addition, extracts from seedlings of Biris rice were reported to contain antioxidant properties that may have a potential to complement anti-cancer drug, i.e., doxorubicin (Yeo et al., 2019).

Typically, traditional rice in Sarawak is grown as rainfed lowland and upland rice due to a lack of infrastructures for irrigation. To achieve the maximum potential of rice, it is pertinent to understand the crop's phenology and growth processes in relation to seasonal changes in environmental factors in a year. In particular, variation in temperature over a year at the location of planting can alter timing of crop phenology and the duration of each phenophase (Oteros et al., 2015) as well as the crop growth performance which determine its grain yield (Tao et al., 2006). Therefore, knowing the timing and variability of phenological events can facilitate farmers in planning, decision making and timely execution of farm management that require advanced information on the dates of specific stages of crop development (Selvaraju, 2012). Given the seasonal variation of temperature and climate change, estimation of crop phenology can be quantified using growing heat units or thermal time.

On account of crop phenology and growth, decision on sowing time at the location of planting plays a significant role in ensuring early crop establishment and subsequent vegetative phase occurs during a period of favourable temperatures and optimum amount of rainfall (Cerioli et al., 2021). For example, Ali et al. (2006) and Shimono et al. (2007) reported a threshold temperature of 12 °C was critical for seed germination and for the following 30 days to ensure optimum number of seedling emergence. Moreover, suitable sowing time ensures crop flowering during optimum temperatures which increases spikelets' fertility rate thus maximises number of filled grains, leading to high grain yield (Cerioli et al., 2021). Several studies reported that different time of sowing resulted in different grain yield due to modification in crop vegetative and reproductive phenophases (Shah et al., 2006; Fazily, 2021). For example, sowing earlier than the optimal date was reported to extend the duration of crop growth and delay grain maturity; resulting in a longer period of pesticide and weed control, increased water consumption, higher straw yield but reduced in grain yield (Slaton, 2001). In contrast, the author reported that delayed sowing produced immature panicles due to shorter growth duration thus leading to reduction in grain yield.

1.2 Problem Statement

Given the seasonal fluctuations in the environment and the impact of climate change, there has been a growing recognition of the changing timing of crop phenology and the duration of their phenophases. The knowledge of crop phenology time is important because it determines crop management decisions such as the best time to apply fertiliser, pesticides, and herbicides for optimum grain production. For example, basal fertiliser is applied to rice plant at the appearance of third leaf and top dressings are given at active tillering, heading and grain filling (Alias et al., 2002). Typically, farmers accomplished these agricultural activities through visual evaluation. However, the risk lies in the possibility that farmers might miss the chronological events, making the execution of these activities unattainable. The primary approach for predicting plant phenology is typically based on calendar days. However, due to weather fluctuations across different locations and years, calendar-based predictions often prove to be unreliable. As a result, an alternative method of measuring chronological events in crops is by employing thermal time or growing degree days. When plant phenology is evaluated in terms of thermal time, using degree days as the unit of measurement, the required amount of thermal time remains consistent for a plant to reach a specific developmental stage. The thermal time approach offers a standardised measurement of plant phenology that can be universally applied across various climatic conditions. Accordingly, time of sowing which correlates with environmental variation plays a significant role in the crop growth performance and its subsequent yield through the modification of crop phenology.

1.3 Hypotheses

The hypotheses of this study were as below:

H_0: Time of planting did not affect the growth and development of Bario Sederhana and Biris rice landraces.

H_a: Time of planting affected the growth and development of Bario Sederhana and Biris rice landraces.