INVESTIGATION ON CULTIVATION OF FOUR PERENNIAL RICE CULTIVARS IN FIELD UNDER MANDALAY CLIMATE

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Abstract

This study deals with the climatic adaptation of four perennial rice (PR) cultivars (PR 23, PR 25, PR 101, PR 107) for five growing seasons using Single Trial Design, and their growth and yield characters were studied in the Mandalay area, Patheingyi Township. The cultivation was carried out in the field conditions at Let Thit Village, Patheingyi Township, Mandalay Region from 2021 to 2022. The seeds were provided by the Research Center of Perennial Rice Engineering and Technology in Yunnan, School of Agriculture (SOA), Yunnan University (YNU) in China. Plant height and number of tillers were collected every 15-days after transplanting [DAT (Day After Transplanting)] until harvesting. At the harvesting times, number of panicles, panicles lengths, numbers of spikelets, filled-grains weight, filled-grains percentages and 1000 grains weight were collected and measured from ten sampling plants of each plot, and the yield data were collected from the 6.6 x 6.6 ft^2 of two sampling plots. In the growth characters, PR 101 resulted in the tallest plant height during the five growing seasons. The maximum numbers of tillers were found in PR 23. In the yield characters, the maximum numbers of panicles, filled-grains weight, filled-grains percentages and highest yields were found in PR23. The longest panicle lengths were found in PR 107, maximum numbers of spikelets in PR 101, maximum straw dry weight in PR 25 and highest 1000 grains weight in PR107 were obtained respectively. In according of these findings indicated the capability of perennial rice cultivation, well-adaptable growth characters and high yields of perennial rice cultivars over their successive regrowth seasons starting from the first growing seasons until the fifth growing seasons, short duration of life span, low cost of labor and cultural management system in field preparation during rice cultivation. Therefore, the cultivation of PR cultivars would provide many benefits for the efficient food supply and security, and also for the socio-economic development of Mandalay Region.

Keywords: climatic adaptation, perennial rice (PR) cultivar, growth characters, yields

Introduction

Rice (*Oryza sativa* L.) is the primary stable food for more than two billions of people in Asia and about hundred millions of people in Africa and Latin America. Rice is one of the most important cereal crops cultivated in the world. It provides foods for more than half of the world population. Asia is the leader in rice production and accounts for more than 90% of world rice production (Matsnoto *et al.* 2005). Agriculture in Myanmar is also dominated by paddy rice cultivation, which generates a direct or indirect economic livelihood for over 75% of the population. In Myanmar, rice is not only the stable food but also the major export product in the past and future.

With the global population increasing, pressure on the resource base and the impact of climate change, even the marginal lands, which currently support 50% of world population are at risk of degradation under annual cropping, and must be farmed sustainably in future to meet the increasing demand for food and livelihood (Shilai *et al.* 2017). Conversion of annual fields into perennial fields offers many biodiversity friendly benefits. One of those benefits is reduced soil erosion. Annual farming leaves fields fallow at the intervals of growing seasons and offers less root mass through the growth cycle. Perennial plants develop much greater root mass and

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protect the soil year-round. Perennial farming can reduce erosion rates by up to 50% (Pimentel and Huang,1997).

Perennial plants also conserve fresh water better than annual plants. Annual crops lose up to five times more water than perennials (Glover and Regauold, 2010). This means that annual fields require more irrigation which threatens fresh water sources and consequently biodiversity in certain ecosystems. Perennial grain crops hold the promise of stabilizing fragile lands, while contributing grain and grazing in mixed farming systems. Farmers were keen to grow it because of reduced costs and especially savings in labor (Huang *et al*. 2018).

Perennial rice is currently the most advanced of the perennial cereal species, as some cultivated rice strains are already able to have regrowth after harvesting, especially in humid tropical areas. In fact, humid tropical areas could be the first areas to adopt new perennial rice types. In temperate areas, the most important limitations for perennial rice may be drought, cold resistance and longevity (Alessandro 2018).

The aim and objectives of this study was to study the effects of growth characters on four perennial rice cultivars, under field conditions for five growing seasons. The objectives were to study the growth characters of four perennial rice (PR) cultivars for five growing seasons under field conditions and to monitor the yield characters of those PR cultivars for five growing seasons after the cultivation in field.

Materials and Methods

The field experiments were conducted in field located at Let Thit village, Patheingyi Township, Mandalay Region from July 2021 to December 2022.

The seeds of four perennial rice cultivars, namely PR 23, PR 25, PR 101 and PR 107 were used. All the seeds were provided by the Research Center of Perennial Rice Engineering and Technology in Yunnan, School of Agriculture (SOA), Yunnan University (YNU) from China (Figure 1).

Soil Samples Collection and Soil Analysis

The soil samples were randomly collected from the experimental field at the depth of 20 cm. The collected soil samples were analyzed before cultivation at Laboratory of Land Use Department, Department of Agriculture (DOA), Chan Mya Thar Si Township in Mandalay.

Meteorological Determination

During the rice cultivation, the meteorological data of monthly temperature, rainfall and relative humidity (RH) were obtained from the Department of Meteorology and Hydrology Station, Patheingyi Township in Mandalay.

Preparation of Seed Beds

Seeds were soaked into the water for 24 hours and germinated with wrapping wet clothes for 36 hours. The germinated seeds were soaked in water again for 10-15 minutes before sowing to the nursery seed beds. Some water was sprayed 2 times per week during germinating.

Each nursery seed bed was laid out 120 cm long, 90 cm wide and 15 cm height. The 165 g of seeds weight for each cultivar was sown in each seed bed. Then, the 28-day old-seedlings were transplanted into the paddy fields.

Figure 1. Seeds of four perennial rice (PR) cultivars

A. PR 23 B. PR 25 C. PR 101 D. PR 107

Field Preparation and Cultivation

For the field preparation, one stroke of ploughing and two strokes of harrowing, irrigation and soil preparation were carried out for two weeks before transplanting. Transplanting was carried out after three or four leaves were emerged from the seedlings at 28 days after sowing (DAS). The healthy seedlings were selected and transplanted into the designated plots in field conditions.

Irrigation was 2 - 5 times per month according to the available water contents of soil. The compound fertilizers, N: P: K (15: 15:15) were treated three times. The compound fertilizer, 100 kg ha^{-1}, was applied at the transplanting time. For the second time, the combination of compound fertilizer 100 kg ha^{-1} and urea 25 kg ha^{-1} was applied on the paddy fields during the growing stage of tilling. For the third time, the combination of compound fertilizer 100 kg ha^{-1} and urea 50 kg ha^{-1} was applied at the time of flowering (anthesis). Those methods for the fertilizer treatments were recommended by Department of Agriculture. There are two times fertilizer applications for every growing season. First time applications were made within 5 days after the harvesting times and the second time application were made during the initial heading stage. 15 cm length of stem cutting was left after harvest to be regrowth of stems for the next growing season.

Experimental Layout and Design

Field experiments were carried out in field from first to fifth growing seasons. The single trial experimental design was laid out for each cultivar. The plot area for each cultivar was 510 cm × 3750 cm. Each plot included 15 rows and each of which contained 125 plants. The row-to-row spacing and plant-to-plant spacing were 30 cm each other (Figure 3.4).

Data Collection

Data were collected at every 15-days after transplanting (DAT) until harvesting. Ten plants from each plot were randomly collected and measured for the growth, yield components and yields parameters. The 6.6 × 6.6 ft^2 of two plots data were randomly collected for the plot yields at harvest. Filled-grains weight per panicle, filled-grains percentages, 1000 grains weight, grain yields and plot yields were recorded at the harvesting times.

Statistical Analysis

The data were analyzed by using the CROPSTAT, Version 7.0. The treatment means were compared by LSD (Least Significant Differences) at 5% level of significance (IRRI 1997).

Harvesting and Threshing

Harvesting was carried out at maturity stage when 85% of grains were changed into golden color. All plants were harvested and threshed manually. The grains of each plot were allowed separately for sun drying until the well-dried.

Determination of Growth and Yield Characters

The data of plant height, numbers of tillers per plant, numbers of panicles plant^{-1} and numbers of spikelets per panicle were collected from ten sample plants of each plot at every 15-days after transplanting (DAT) and from the 6.6 × 6.6 ft^2 size of two sampling plots at harvest.

Yield per plant (g) was calculated with the following formula (IRRI 2013).

$$\text{Yield plant}^{-1}\text{ (g)} = \frac{\text{1000 grain weight} \times \text{Filled grain \%} \times \text{Effective tillers} \times \text{Total Spikeletes}}{1000 \times 100}$$

Results and Discussion

Plant Height

The plant heights of all PR cultivars were measured through first to fifth growing seasons. PR 101 showed the tallest plant height in all growing seasons. The plant heights of all PR cultivars were shorter the second growing season than the first growing season. The plant height was gradually tallest in third growing season, and it was found that the plant height of all rice cultivars was gradually shortest from third to fifth growing seasons. In those findings, the PR 101 showed the rapid their growth in all growing seasons, however, it did not obtain the highest yields. (Table 1 and Figure 2-7).

Table 1. Means plant height of four PR cultivars from first to fifth growing seasons

PR Cultivars	Plant height (cm plant^{-1})				
	First growing season	Second growing season	Third growing season	Fourth growing season	Fifth growing season
PR 23	86.90	77.40	104.50	93.10	80.00
PR 25	92.40	79.00	102.00	93.30	81.70
PR 101	139.40	92.00	112.20	100.00	95.70
PR 107	101.80	65.30	82.10	88.50	84.70

Number of Tillers

The number of tillers was collected at the time of harvesting time for all growing seasons. The maximum number of tillers was found in the second growing season and the minimum number in the first growing season. Among all PR cultivars, PR 23 showed the maximum numbers of tillers and the minimum number of tillers was observed in PR 101 (Table 2).

Table 2. Means numbers of tillers of four PR cultivars from first to fifth growing seasons

PR Cultivars	Number of Tillers (plant^{-1})				
	First growing season	Second growing season	Third growing season	Fourth growing season	Fifth growing season
PR 23	18.20	40.50	27.20	35.50	27.60
PR 25	18.00	37.20	26.20	34.00	24.20
PR 101	15.60	36.10	25.10	23.50	30.50
PR 107	19.20	31.10	28.50	20.40	26.80

Number of Panicles

The number of panicles per plant was collected at the harvesting time for all growing seasons. The maximum number of panicles was found in PR 23 and minimum number in PR 107. It was found that if the number of tillers was increase, the number of panicles was also increase, and if the number of tillers was decreased, the number of panicles also decreased, which demonstrated the positive correlation between number of tillers and number of panicles. Therefore, these findings were agreed with Hossain *et al.* (2008), they reported that the number of panicles depends on the number of tillers and proportion of effective tillers (Table 3).

Table 3. Means numbers of panicles of four PR cultivars from first to fifth growing seasons

PR Cultivars	Number of Panicles (plant^{-1})				
	First growing season	Second growing season	Third growing season	Fourth growing season	Fifth growing season
PR 23	15.70	14.20	12.90	14.20	20.80
PR 25	17.60	16.50	14.40	16.50	17.00
PR 101	13.20	13.10	16.80	16.00	15.80
PR 107	14.20	13.60	13.90	13.70	12.50

Panicle Length

The panicle length (cm) was measured at the time of harvesting. The maximum panicle length was found in PR 107 in the first growing season and the minimum length was found in PR 23 in the fifth growing season (Table 4).

Table 4. Means panicle lengths of four PR cultivars from first to fifth growing seasons

PR Cultivars	Panicle Length (cm plant^{-1})				
	First growing season	Second growing season	Third growing season	Fourth growing season	Fifth growing season
PR 23	25.51	23.20	25.10	23.10	16.90
PR 25	25.20	21.80	23.40	25.70	25.70
PR 101	31.40	28.00	29.80	24.40	20.80
PR 107	31.50	27.40	26.50	25.20	20.60

Number of Spikelets

The number of spiklelets per panicle was measured at the time of harvesting. The maximum number of spikelets was found in PR 101 (Table 5).

Table 5. Means numbers of spikelets of four PR cultivars from first to fifth growing seasons

PR Cultivars	Number of Spikelets (panicle^{-1})				
	First growing season	Second growing season	Third growing season	Fourth growing season	Fifth growing season
PR 23	8.09	7.97	6.90	8.08	8.37
PR 25	7.52	7.43	6.85	7.76	7.03
PR 101	9.31	8.06	6.65	8.59	7.25
PR 107	6.29	6.52	6.34	6.54	6.26

Filled-Grains Weight

Filled grain weights of all PR cultivars were measured after harvesting. The maximum numbers of filled-grains weight were found in the first growing seasons. However, the numbers of filled-grains weight were gradually reduced from second to fifth growing seasons (Table 6).

Table 6. Means filled-grains weight of four PR cultivars from first to fifth growing seasons

PR Cultivars	Filled-grains weight (g plant^{-1})				
	First growing season	Second growing season	Third growing season	Fourth growing season	Fifth growing season
PR 23	28.88	3.57	4.62	1.41	4.52
PR 25	28.35	4.25	5.39	2.31	4.24
PR 101	27.87	8.07	9.82	9.95	6.35
PR 107	22.43	4.74	6.63	7.52	3.63

Filled-Grain Percentages

The maximum filled-grain percentage was found in the first growing seasons for all PR cultivars. Filled-grains percentages were gradually reduced from second to fifth growing season (Table 7).

Table 7. Means filled-grains percentages for four PR cultivars from first to fifth growing seasons

PR Cultivars	Filled grain percentage (% plant^{-1})				
	First growing season	Second growing season	Third growing season	Fourth growing season	Fifth growing season
PR 23	94.61	73.81	69.93	47.27	78.86
PR 25	95.53	78.51	71.36	65.10	75.64
PR 101	96.19	87.92	89.91	88.47	83.00
PR 107	84.88	77.03	81.94	84.61	75.61

1000 Grains Weight

The maximum 1000 grains weights of all PR cultivars were found in the first growing seasons and gradually lower in season by season and the lowest grains weights were observed in the fifth growing seasons for all PR cultivars (Table 8).

Table 8. Means 1000 grains weights of four PR cultivars from first to fifth growing seasons

PR Cultivars	1000 grains weight (g plant^{-1})				
	First growing season	Second growing season	Third growing season	Fourth growing season	Fifth growing season
PR 23	27.26	20.64	20.65	19.47	19.51
PR 25	27.86	20.55	22.39	19.50	19.59
PR 101	26.36	18.14	17.94	18.05	18.17
PR 107	33.26	22.50	25.96	20.90	18.53

Straw Dry Weights

The straw dry weights of all PR cultivars were also measured after harvesting. The lowest straw dry weight was observed in PR 23 and PR 25 in their first growing seasons, and PR 101 and PR 107 in their fourth growing seasons (Table 9).

Table 9. Means straw dry weight for four PR lines from first to fifth growing seasons

PR Cultivars	Straw dry weight (g plant^{-1})				
	First growing season	Second growing season	Third growing season	Fourth growing season	Fifth growing season
PR 23	27.60	36.44	36.06	28.80	30.88
PR 25	29.10	38.15	41.65	29.76	32.23
PR 101	54.72	40.58	40.19	33.00	34.43
PR 107	38.88	19.22	16.81	13.21	15.69

Yields

The maximum yield was obtained in the first growing season for all PR cultivars. The yield of all PR cultivars was decreased in their fifth growing season compared with their first growing seasons. The highest yield was found in PR 25 in the first growing season (Table 10).

Table 10. Means yield for four PR lines from first to fifth growing seasons

PR Cultivars	Yield (g plant^{-1})				
	First growing season	Second growing season	Third growing season	Fourth growing season	Fifth growing season
PR 23	12.60	1.72	1.28	1.05	2.72
PR 25	12.42	1.97	1.55	1.64	1.76
PR 101	10.27	1.58	1.77	2.30	1.70
PR 107	11.12	1.54	1.81	1.57	1.15

Physical and Chemical Properties of Cultivated Soil

Composite soil sample was collected from the experimental sites before starting the experiment and was analyzed for various physiochemical properties at Laboratory of Land Use Laboratory, Department of Agriculture (DOA), Chan Mya Thar Si Township, Mandalay. Physicochemical properties of the soil were measured by the standard methods of soil chemical analysis. The analysis for respective years of experimentation revealed that the soil had 1.44% organic carbon, 2.49% humus, 0.27% available nitrogen, 9.00 ppm available phosphorus, 30.42% available potassium and Na, K, Ca and Mg 1.10, 0.64, 28.29 and 5.47 mg kg/soil respectively, 1.36% moisture content of the soil, 0.14 mg/kg EC soil with pH 8.3 (Table 11).

According to the result of soil analysis data, it was found that the indigenous nitrogen content was low in the experimental soil. Therefore, the compound fertilizers containing nitrogen were treated to all PR cultivars. Remarkably, it was found that all PR cultivars were growth in all growing season.

The soil type of experimental area was clay soil and Fugen *et al.* (2016) reported that clay soil was suitable for cultivation of rice and the grain yield in clay soil was 46% higher than in sandy soil. Clay soil has more fine particles that can hold water and nutrients, thus it can retain more water and nutrients needed by water-loving rice plant.

The soil samples of experimental site were analyzed and these result show that pH of the sample soil was 7.85 and it is moderately alkaline. The suitable soil pH for rice cultivation is at pH 6 (Harrell & Saichuk 2011) and most of the plants can absorb nutrients well between pH 6.0 - 7.5 (Yoshida 1972). According to the recommendation of Land Use Laboratory, Department of Agriculture, rice prefers the pH 5.5 - 7.5, therefore PR can grow very well in these designated field plots.

Table 11. Physical and chemical properties of cultivated soil of PR cultivars

Physical and Chemical Properties	Results				
		Na^+	K^+	Ca^{++}	Mg^{++}
Total N (%)	0.27	-	-	-	-
Available P_2O_5 (ppm)	9.00	-	-	-	-
Available K_2O (mg/ 100 g)	30.42	-	-	-	-
Exchangeable Cations	-	1.10	0.64	28.29	5.47
Moisture (%)	1.36	-	-	-	-
pH (1: 2.5)	8.3	-	-	-	-
EC ms / cm	0.14	-	-	-	-
Organic Carbon (%)	1.44	-	-	-	-
Humus (%)	2.49	-	-	-	-

Source: Laboratory of Land Use Laboratory, Department of Agriculture (DOA), Chan Mya Thar Si Township, Mandalay.

Meteorological Data during PR Cultivation

The meteorological report was obtained from Department of Meteorology and Hydrology Station, Patheingyi Township, Mandalay (Table 12).

Monthly meteorological data were also recorded and concerning with the meteorological data, the mean temperature for cultivated land was 29.07°C. This temperature was not agreed with Yoshida (1981).

Table 12. Meteorological data during the cultivation of PR cultivars (2021-2022)

Month	Rainfall (mm)		Temperature (°C)		Mean Relative Humidity (%)	
	2021	2022	2021	2022	2021	2022
January	0.00	0.00	23.91	22.46	65.44	68.71
February	0.00	0.00	25.74	23.01	49.00	57.13
March	0.00	0.03	30.14	30.64	40.18	46.58
April	0.07	0.11	32.28	32.01	50.92	55.77
May	0.17	0.22	32.93	30.17	57.34	70.45
June	0.02	0.02	32.35	31.42	59.00	63.90
July	0.26	0.12	31.19	35.08	68.03	66.18
August	0.50	0.17	28.86	34.69	73.17	70.27
September	0.27	0.14	29.69	31.11	79.14	70.55
October	0.21	0.23	30.11	30.17	74.79	72.42
November	0.06	0.00	27.10	27.23	75.45	65.08
December	0.00	0.00	23.91	25.22	71.92	67.40
Mean	0.13	0.09	29.02	29.48	63.70	64.54

Source: Department of Meteorology and Hydrology Station, Patheingyi Township, Mandalay.

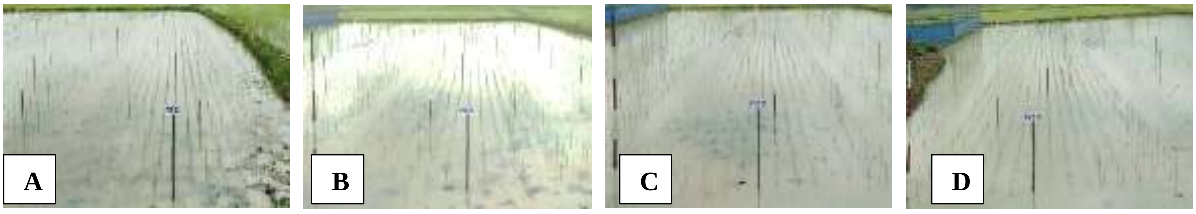

Figure 2. First growing seasons of perennial rice (PR) cultivars in field
A. PR 23 B. PR 25 C. PR 101 D. PR 107

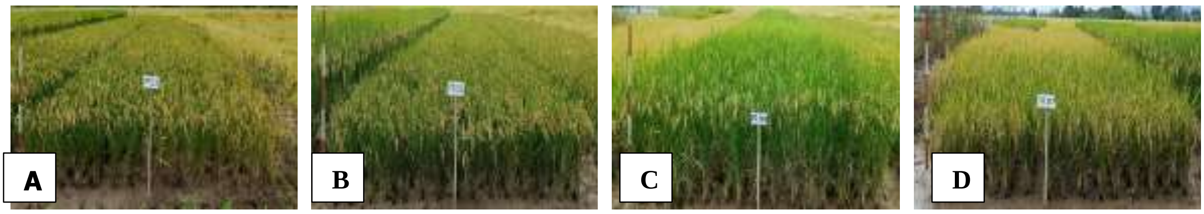

Figure 3. First growing seasons of perennial rice (PR) cultivars in field
A. PR 23 B. PR 25 C. PR 101 D. PR 107

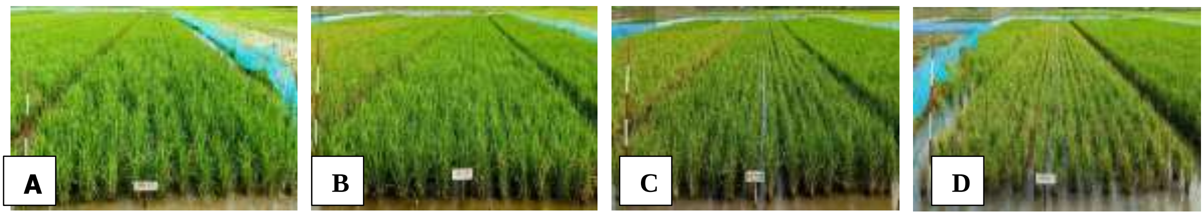

Figure 4. Second regrowth seasons of perennial rice (PR) cultivars in field
A. PR 23 B. PR 25 C. PR 101 D. PR 107

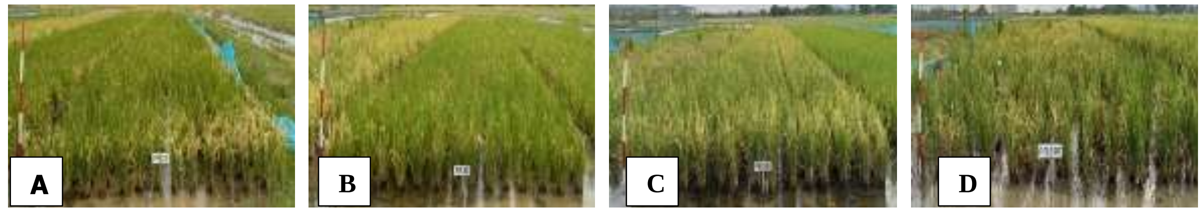

Figure 5. Third regrowth seasons of perennial rice (PR) cultivars in field
A. PR 23 B. PR 25 C. PR 101 D. PR 107

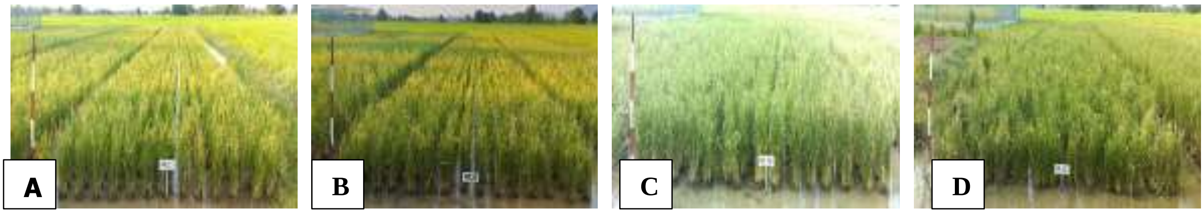

Figure 6. Fourth regrowth seasons of perennial rice (PR) cultivars in field
A. PR 23 B. PR 25 C. PR 101 D. PR 107

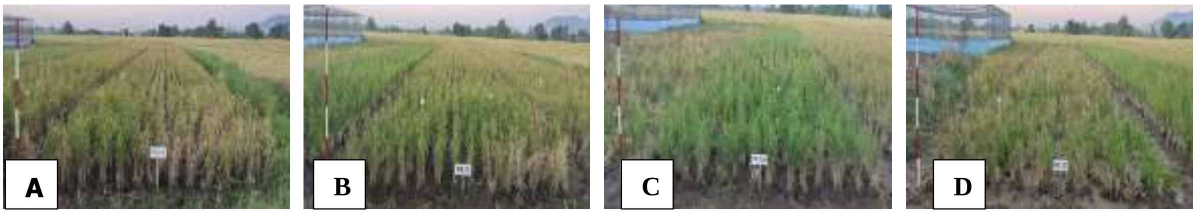

Figure 7. Fifth regrowth seasons of perennial rice (PR) cultivars in field
A. PR 23 B. PR 25 C. PR 101 D. PR 107

Conclusions

This study demonstrated the well-adaptable growth characters of four PR cultivars in the experimental field in Mandalay Region, particularly in Patheingyi Township and the high production yields in four PR cultivars over all of five growing seasons. Besides, the PR cultivars obviously performed early flowering, early harvesting maturities, and continuously growing. Moreover, the time and costs of field preparation, cultural management system would be reduced significantly during their cultivation and also found as the well adaptability under the Mandalay climate. Therefore, it was believed that the cultivation of PR cultivars would provide many benefits for the efficient food security and socio-economic development, especially in Mandalay Region.

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