Original Research Article

Evaluation of Non-Irrigated and Irrigated For Grain Corn Cultivation during the Rainfed Season

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Abstract: Rainfed planting is a traditional planting method for crops. Based on our prediction from rainfall pattern, grain corn yield potential under a small experimental plot would exceed 6 t/ha without installing an irrigation system. In Malaysia, high rainfall intensity during the monsoon season is advantageous for the cultivation of grain corn without an irrigation system. Good cultural practice and proper water management system design would allow grain yield to the potential level.

Keywords: rainfed; water management; grain corn; yield

1. Introduction

Malaysia is one of the countries which is situated in the tropical rainforest climate. It lies at an equatorial line that is hot and humid throughout the year and can get rain all year long. The average rainfall in Malaysia is around 2700 mm, and the average temperature is 27 degrees Celsius. The rainfall distribution pattern in the west coast peninsula of Malaysia has two rainy seasons, Jackson (1982) mentioned the two monsoon seasonal happened from January to May for northeast monsoon and from June to September for the southwest monsoon. Recently, another significant difference that delineates this zone from the rest of the west coast region is the relatively high amount of rainfall received during the May–July months (>200 mm/month) and the northeast monsoon from August to November, where the

primary peak during the autumn transitional period in October (Wong *et al*., 2016). There will be a significant dry season from December to Mac, specifically in the Northern region between the two rainy seasons. Wong *et al*. (2016) stated that the primary monthly rainfall peak drops dramatically and reaches the minimum level in January. World Resources Institute (WRI) stated that Malaysia is categorized as low in water stress, therefore, has enough water resources for its agricultural sector.

In Malaysia, rainfed agriculture area proportionally 68.7%, dominated by perennial crops such as palm oil, rubber, cocoa, and pepper, while the cash crop like wild rice, tapioca, etc. involving large and small planting area (Devendra, 2016). The possibility of grain corn cultivated during the rainfed season would advantages for growers to reduce the cost of operation, mainly water, and thus increase the farmers' income (Lee, 1986). During the monsoon season, corn can be cultivated without the irrigation system. The study was conducted to determine the grain corn yield production under rainfed conditions.

2. Materials and Methods

2.1 Study Site and Morphology

Evaluating potential yields of grain corn under non-irrigated and irrigated conditions has been conducted in the study plot at MARDI Seberang Perai. The exact location of the area was at longitudes 100°28'22.72"E and latitudes 5°32'33.56"N with an averagely of 10 m above mean sea level. MARDI Seberang Perai was located at Kepala Batas, Pulau Pinang. Kepala Batas climate is classified as tropical. Kepala Batas is a city with significant rainfall. Even in the driest month, there is much rain. The average annual rainfall is 2110 mm based on the latest rainfall data from 2013–2019 (Figure 1). Precipitation is the lowest in February, with an average of 80 mm. Most of the precipitation here falls in October, averaging 310 mm. Between the driest and wettest months, the difference in precipitation is 230 mm. The average temperature is 27.5°C. The maximum average temperature of 28.1°C occurs in March, the hottest month of the year. Meanwhile, September is the coldest month, with temperatures averaging 27.1°C.
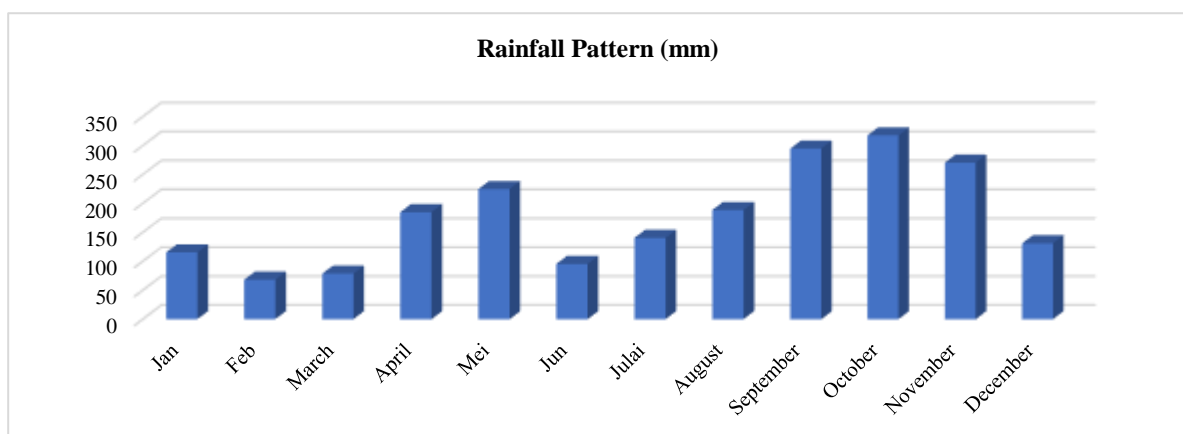

Figure 1. MARDI Seberang Perai Rainfall pattern 2013-2018 (MET 2019)

Soil nutrient analysis was carried out to determine the status of soil and its original mean for the essential nutrient like pH (5.2), nitrate (N) (0.17%), Phosphorus (P) (22.8 µg/g), and Kalium (K) (4.5 ppm) at the study site. The random sampling method was used for the processes of soil surveying. Three sampling points were specified at each research plot. The samples were taken at depths between 0 to 20 cm. In addition, detailed soil survey information such as conductivity (30.9 uS/cm), coarse sand (19.6%), fined sand (39.9%), silt (28.1%), and clay (11.9%) were obtained from the MARDI's archive. This report found that the dominant land series for the area selected for this grain corn project is from the Holyrood soil series and in sandy loam type.

The project was carried out using a split-plot design with three replications; non-irrigation (P0) and irrigation (P1) were the main plots, while a different time stage was the sub-plot. The main factors are divided into two types: non-irrigated and irrigated. For the non-irrigated factor, the water needs of the crop are only from the rainfed. During the monsoon seasons, it was estimated that the rainfall would supply enough water to meet the crop water requirement. For the fully irrigated factor, the entire plot was installed with an irrigation system to supply the water during the short period of drought.
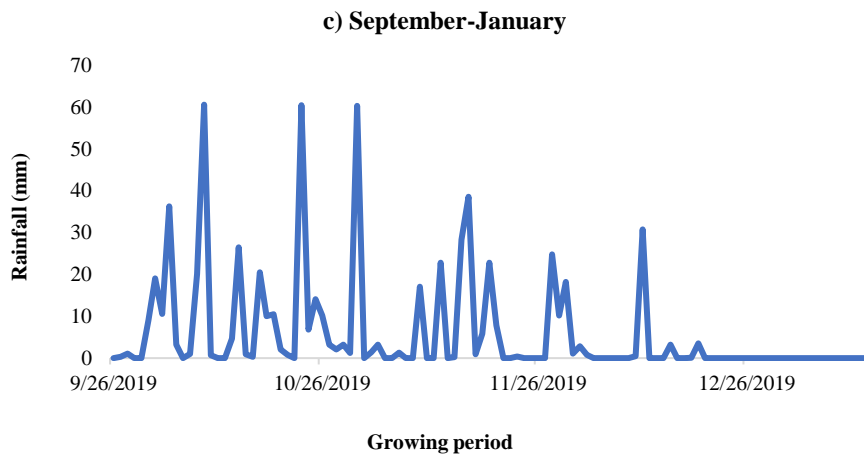
a) July-Nov

b) August- December

c) September-January
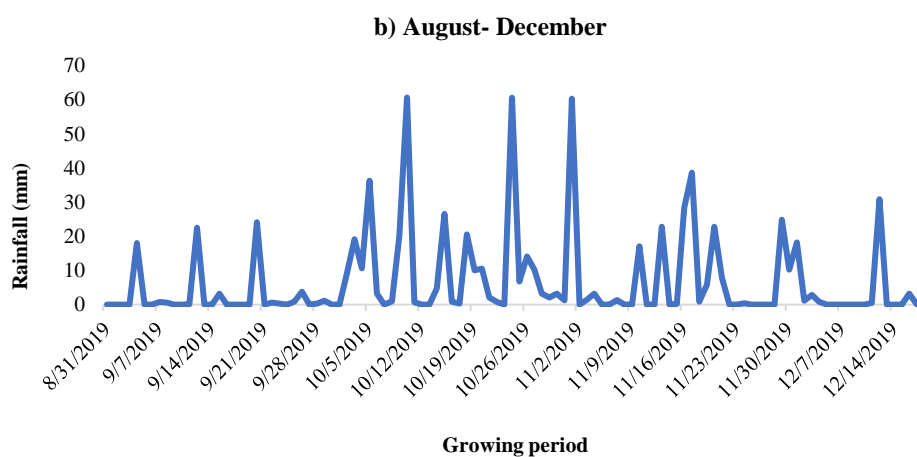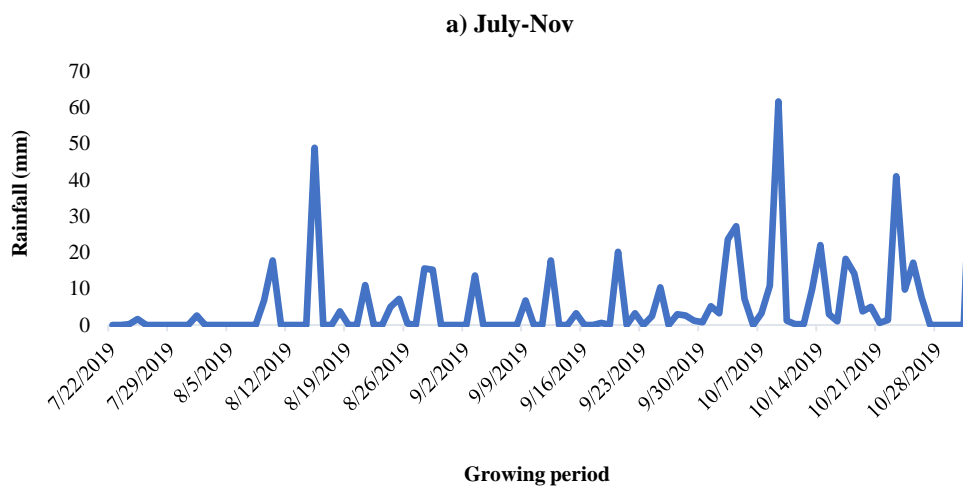
Figure 2. Rainfall data collected during the a) First planting stage, b) Second planting stage, and c) Third planting stage of Northeast monsoon season 2019

During the crop growing period, rainfall events occur observed to predict the crop water requirement. From the graph above, the rain trend is seen evenly from the beginning of the planting season to the harvest. The drought period is almost absent in the diagram. All stages get adequate rainfall from these three stages during the age of 45 days to 65 days, where the reproductive period started to bloom. Zaharah (1992) reported on the physiology of corn planting from 40 days after planting to 50 days after planting needed to be irrigated sufficiently for healthy crop growth.

For maintaining the irrigated crop water supply, an Overhead sprinkler was used to irrigate based on the soil moisture meter data and the daily rainfall (Leong *et al*., 1991). The irrigation rate applied was 3 mm/day to 7 mm/day depend on the crop stages. For the vegetative period was applied 3 mm daily and for the reproductive period was 7 mm daily. Udom and Kamalu (2019) recorded that the highest crop water requirement for grain corn during the vegetative period started from 44 days after planting, tasseling stage at 68 days after planting, and cob setting at 87 days after planting, which amount of water is 4.98 mm to 5.03 mm daily. Soil moisture was sampling to estimate the water stress based on New Mexico State University's study, for the sandy loam field capacity is in-between range 10% to 20%. In this study, the mean soil moisture meter is 14.2%.

Stages planted the sub-plot: the first planting stage was in July–November, the second planting was in August–December, and the third planting stage was in September–January. The corn variety chosen was P 4546 from DuPont Pioneer, which was tested and suggested by MARDI due to the stability of yield and suitability to be planted in Malaysian climate conditions. This is in line with the objective of the experiment, which was to see the ability of a hybrid corn crop to grow solely under rainfed conditions.

2.2 Agricultural practice for grain corn

During land preparation, plowing, harrowing and rotovating were applied using field machinery. Grain corn seeds were planted manually at a planting density of 66,667 plants per hectare. The planting distance was 75 cm between rows and 20 cm between plants in a plot size of 6 m × 7 m, where the two rows of 1.5 m length for both sides were used as the gut row to avoid border effects from neighboring plots. Pre-emergence were applied just after the planting. To ensure optimum growth of the plants, regular maintenance was carried out during the growth stage. Observation of pest infestation was carried out daily in between 0 to 20 days after sowing. Thinning of excess plants was done seven days after sowing (DAS) while fertilizer was applied on 10 DAS and at a total rate of 140 kg N/ha, 100 kg P/ha, and 120 kg K/ha. NPK green fertilizer (15N:15P2O5:15K2O), NPK blue fertilizer (12N:12P2O5:17 K2O), and top dressing with urea at 60 kg N/ha have applied 30 DAS for one-time application within the planting period. Each plant cob sample was harvested manually. The following data were taken at the harvesting stage after 110 DAS using the standard ruler and weighing machine: plant height, cob height, number of plants, number of cobs within the crop cutting test (CCT) area, which is 5 m × 3 m (15 m²) per plot. Grain yield was converted to 14 percent of grain moisture content. Moisture content is measured using the Agratronix MT-16 grain moisture tester.

3. Results

Crop growth analysis was determined by crop cutting test (CCT), which was carried out around 110 days after planting. Data were concluded in the following tables.

Table 1. Performance of grain corn growth

	Plants numbers	Cob numbers	Cob weight (g)	Plant height (cm)	Cob height (cm)	Grain moisture content (%)	Gross yield (t ha⁻¹)	Yield (t ha⁻¹)
Planting Stages								
July-November	83.67b	81.33b	16.00a	202.33b	103.50b	26.82a	8.48a	7.21a
August-December	88.00ab	83.00b	15.00a	221.67a	110.00ab	24.94a	7.90a	6.88a
September-January	102.33a	99.17a	16.33a	230.67a	118.00a	24.72a	8.67a	7.59a
Water source								
Non-irrigated	88.00a	85.89a	15.00a	216.11a	110.22a	25.64a	7.92a	6.83a
Irrigated	94.67a	89.78a	16.56a	220.33a	110.78a	25.34a	8.78a	7.62a
Planting Stages	*	*	ns	**	*	ns	ns	ns
Water sourcePlanting Stages	ns*	ns*	nsns	ns**	ns*	nsns	nsns	nsns
Planting stage vs. water	nsns	nsns	nsns	nsns	nsns	nsns	nsns	nsns

	Plants numbers	Cob numbers	Cob weight (g)	Plant height (cm)	Cob height (cm)	Grain moisture content (%)	Gross yield (t ha⁻¹)	Yield (t ha⁻¹)
sourceWater source Planting stage vs. water source	ns	ns	ns	ns	ns	ns	ns	ns

Note: **Significant at 1% probability level, *Significant at 5% probability level, ns: Not significant. Means in each column with the different letters within each factor indicate significant differences at $p \leq 0.05\%$ level according to LSD (Mean ± S.E; n=3)

Results showed no significant interactions ($p<0.05$) between the main factors, planting stages, and water source for all parameters collected. No significant effect ($p<0.05$) was recorded in all the main factor water source parameters. The main factor planting stages significantly affects several plants ($p<0.05$), plant height ($p<0.01$), cob number ($p<0.05$), and cob height ($p<0.05$), while the rest parameters were not significantly affected.

3.1 Analysis Between Difference Stage of Planting T1(July–November), T2(August–December), and T3(September–January) for Non-Irrigated and Irrigated

In analyzing Stages differences during the northeast monsoon season, plants planted during September–January had significantly higher plant numbers, plant height, cob number, and cob height compared to plants planted during July–November. When compared between August–December and September–January, all parameters were ranked the same except for cob number, where September–January had a significantly higher cob number than August–December. However, the results of yield in all stages are still insignificant.

3.2 Yield Analysis Between Non-Irrigated and Irrigated

The comparison between those without irrigated and irrigated during the monsoon season does not show much difference. Grain corn yields on irrigation factor slightly more than the yield at blocks without irrigation. From this data, the yield of corn is not significant. The mean yield is 6.83 t/ha for non-irrigation and 7.62 t/ha for irrigation from the chart below.
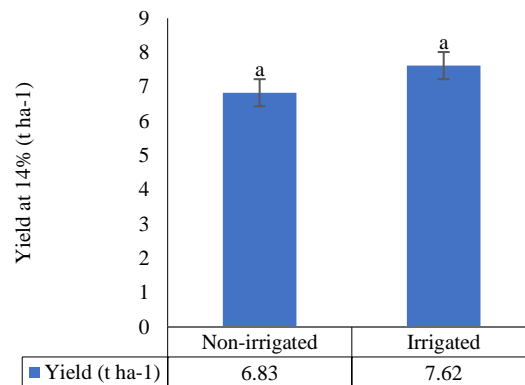
Table 3. Grain corn yield at MARDI Seberang Perai (Non-irrigated x irrigated)

4. Discussion

The results showed that grain corn cultivating at Seberang Perai was not significantly affected between the blocks without irrigation systems and those installed. Grain corn yield of 6.83 ha on the non-irrigated block and 7.62 t/ha on the irrigated block was observed. Differences of 10% yield from the irrigation block are more significant than the non-irrigation. Rainfed grain corn yield differs substantially between regions reported by Wani et al. (2009). Latin America, including the Caribbean, exceeds 3 t/ha, while in South Asia, it is around 2 t/ha. In sub-Saharan Africa, it only just exceeds 1 t/ha. Compared to tropical regions, utilizing the rainfall season should be one factor in cultivating grain corn. Pasuquin et al. (2014) studied range yield for rainfed and irrigated in the Southeast Asia region was around 4 t/ha to 8 t/ha in several areas. Regular rainfall during crop growth gives the advantage of non-irrigated blocks to match the yield of irrigation blocks. This proves that the cultivation of grain corn during the monsoon season can provide returns even when the irrigation system is not installed. Taking into account planting time and weather factors can reduce losses to farmers. The planting season does not show a significant difference in yield; therefore, farmers can plant corn from July and harvest in November, grow in August, and harvest in December and in September and January. From the weather data (Figure 1), the appropriate planting season is from July to January. Stockholm International Water Institute (SIWI) reported that the potential of rainfed agriculture towards a cost-effective and sustainable increase in productivity. The public sector must lead large-scale programmed to improve rainfed agriculture, supported by the international development sector and, where feasible, the private sector.

For the irrigated factor, potentially to secured the yield is undoubted. The yield recorded above the grain corn yield was 5 t/ha based on a report by CGIAR. In this study, the Installation of an irrigation system can achieve the grain corn potential yield depend on the variety. The farmer will also reduce the cost of irrigation operation due to less irrigation scheduled. Planted during the rainfed season, growers weather planting in non-irrigated or irrigated to gain more income and sustainable yield production.

5. Conclusions

This study did not show any significant differences in yield of corn variety P4546 (DuPont Pioneer) between non-irrigated and irrigated cultivation methods. Therefore, this study suggests that corn cultivation could be done without an irrigation system during the monsoon season, where frequent rainfall occurs. The finding of this study can be used by stakeholders as a guideline to evaluate the economic impact and potential improvement of corn cultivation methods. To implement planting corn in the rainy season, farmers need to look at rainfall data in specific areas of cornfields. It would appear that ensuring adequate crop water requirements is critical to obtaining and sustaining high yields in Malaysia's environment.

Conflict Interest: The author declares no competing interest.

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