The effect of Different Planting Dates on the Growth and Yield of Roselle (*Hibiscus sabdariffa* L.) during the Rainy Season

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Abstract

The experiment was conducted at the vegetables and fruits research and development center (VFRDC), Hlegu Township, Yangon Region ,during the rainy season to evaluate the effect of planting dates on the vegetative growth and reproductive growth of Roselle. The different planting dates are represented as treatments. The experiment was laid out in Randomized Complete Block design (RCBD) with five replications. The soil sample was collected before cultivation. The result of analyzing the soil of VFRDC showed that the nitrogen content was lower but the soil pH was the same as in the reference value. The germination rate of Roselle seeds was 87%. The results of the vegetative growth of Roselle showed that the maximum plant height (44.21cm), petiole length (4.63cm), number of branches (9.35), plant diameter (5.67cm), node length (3.29cm), number of leaves per plant (32.20), leaf length (7.11 cm) leaf width (5.85cm), initial and final single leaf area (32.20cm^2 and 68.56cm^2) were recorded from T_4 Aug (30).The reproductive growth of Roselle, the minimum days to first flowering date (75.0) days, the minimum days to first harvesting date (109) days, the maximum single pod weight (5.05g), single pod length (35.02cm), single pod width (20.96cm), single pod epicalyx number (9.38), single pod calyx weight (2.64 g), single pod calyx length (4.08cm), single pod calyx width (7.11cm), single pod fresh ovary weight (2.82g) , single pod dry ovary weight (1.43g), number of seeds per pod (23.14), pod yield per treatment (137188.80 kg) the maximum was also recorded from T_4 Aug (30).

Keywords: RCBD, Planting dates

Introduction

Roselle is a tropical annual shrub, whose fruit like structures containing eligible pigment belong to the Malvaceae family. Roselle (*Hibiscus sabdariffa* L.) is one of the most important annual medicinal shrubs and it is locally known as “Chin- Baung”. This genus has more than 300 species in this family. It is known as Roselle, Jamaican sorrel, red sorrel, Indian sorrel, Rozelle hemp, natal sorrel and Rosella. It is believed to be native of India and later introduced to Malaysia where it is commonly cultivated and might have been carried at an early date to Africa (Gebremedin and Asfaw, 2017).

The Roselle plant is an important source of vitamins A, B and C, iron phosphorus and proteins, which enables their placement of animal protein. Its calyx is used in jelly, paste, sweets, syrup and wine preparation; its manufacturing residues can also produce vinegar of very good quality. Its seeds contain 17% oil with properties similar to cotton oil. Regarding medicine, the Roselle plant has been considered an anti-septic, aphrodisiac, astringent, digestive, diuretic, emollient, purgative, sedative and tonic; its calyxes have also been used as an anti-hypertensive. Roselle is cultivated for its fleshy fruits, leaves, stems, flowers (calyces), seeds and fiber. The roselle plant has been cultivated and widely used as human and animal food; its fibers also represent a great source for the textile and paper industries (Diovany *et al*., 2014).

Roselle is tolerant of a wide range of environmental conditions, particularly were suited to cultivation in hot, dry regions on a wide range of soils. Some cultivars will also give economic yields in wet, humid areas although optimum rainfall is 18 to 20 inches distributed over 3 to 4 months. Roselle is sensitive to day length, requiring a short day of 12 to 13hours. Depending on the variety it maturesfrom 12 to 16weeks from sowing where diseases and pests

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are rarely serious. Rain or high humidity during the harvest time and drying can downgrade the quality of the calyces and reduce the yield (Futuless *et al*., 2010)

Planting date is an important factor in crop production and productivity as it can positively or negatively affect crop performance and yield. The choice of planting dates could significantly impact on the growth and yields of crops, particularly during the critical development phases where plants require adequate moisture and ideal temperatures at planting, seedling establishment, flowering and fruit formation. Poor planting date selection may subject crops to water and heat stress during dry spells at critical growth stages resulting in reduced yield (Tom, 2014).

The overall objectives of this research are to determine the appropriate date of planting Roselle for better performance such as vegetative growth and yield, to investigate the optimum planting time for flower and calyx production, to examine the dry mass production and partitioning at different times of planting, to evaluate the planting dates for Roselle during Rainy season.

Materials and Methods

Description of the Study Area

The experiment will be conducted at the farms of the vegetables and fruits research and development center (VFRDC), Hlegu Township, Yangon Region during 2019 - 2020. It is located at 17° 5' North latitude and 96° 15' East longitude and its annual average rainfall is 8.98 inches. The soil of the experimental site is sandy loam in texture.

Planting materials of *Hibiscus sabdariffa* L.

The seeds of *Hibiscus sabdariffa* L. were provided by VFRDC.

Soil Analysis

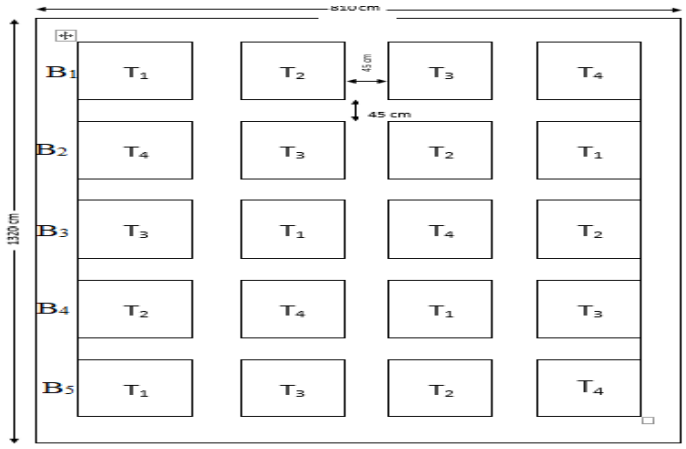
The analysis of soil from the experimental area was dug at a depth of 6 inches and collected soil samples before sowing. The 9 collected sample sites were taken and about 100g was in each site. Then it was mixed all together and 100g was used for analysis. The soil samples were analyzed at the Laboratory of Land Use Division, Department of Land Use, Myanmar Service (MAS), Isein Township, Yangon Division during the experiment.

Soil preparation and field cultivation

Before sowing, the land is thoroughly prepared and brought to a fine tilth.4:1 soil and burnt is incorporated with rice hunk were mixed with 1.5 kg chicken manure of in each plot. After soil preparation the plots (210cm x 145cm) were designed. One plot contained 2 rows. One row had 3 furrows. There were seven holes in each furrow and the holes were 15cm apart. The hole was 2.5cm in depth. The seeding method was applied. One seed was sown in each hole.

Experimental layout: Different sowing dates were the treatments in this experiment

Four sowing date; July (15), July (30); August (15) and August (15) during 2019, respectively were used. The experimental design was a randomized complete block design (RCBD). There were five replications and plot size was 210cm with 165cm pathway between plots and 45cm pathway between replications. The plot consisted of two rows. The total experimental area was 1230 cm × 810 cm. The data collected from the field was from the plants randomly selected in the middle spacing of each plot while the outer ones were left as discards. Watering and weeding were performed whenever necessary. For insects and pests control, shwe-tha-mar 10g/ water10 liter was applied at 28 DAS (day after sowing).



T_1 (July-15),
T_2 (July-30),
T_3 (Aug-15),
T_4 (Aug-30)
Experimental area =1320cm × 810cm
=1069200cm^2

Figure 1. Experimental layout (RCBD)

Data Collection and Analysis

The physical and chemical analysis of soil, single leaf area, the germination rate morphological characters, vegetative characters such as plant height, petiole length, petiole width, number of branches, plant diameter, node length, number of leaves per plant, leaf length, leaf width, initial single leaf area and final single leaf area were collected from this experiment. Besides, reproductive characteristics such as days to first flowering date, days to first harvesting date, single pod weight, single pod length, single pod width, number of seeds per pod, number of pod per plant, pods weight per plant, pod yield per treatment and weather of the study area were recorded throughout the cultivation period. The collected data was analyzed using Crop Stat software 7.2.The treatment means were compared using the least significant difference (LSD) 5%.

Germination Rate

The germination rate was calculated using the following formula developed by Soupe (2009).

$$\text{Germination rate (\%)} = \frac{\text{No. of germinated seeds}}{\text{Total sown seeds}} \times 100 \text{ (Soupe, 2009)}$$

Single leaf area

According to the method of grid paper, the surface area of a leaf was calculated by using 1cm grid paper. The required materials were grid paper and pencil. The leaf blades were placed on a sheet of grid paper. The outline of the leaf blades was traced with a pencil and the area of the leaf was counted from the grid paper.

Results

The Physical and Chemical Analysis of Soil

The pre-planting soil analysis showed that the soil was sandy loam with its attendant pH of 5.99, very low 0.07% of nitrogen, potassium 0.28 (meq/100gm), phosphorous 233.96 ppm, potassium oxide 31.73 (mg/100gm), organic Carbon 0.72 and moisture 0.39% were contained in the soil medium (Table1).

Table 1. Physical and chemical characteristics of soil in experimental area

Parameters	Results	Rating
pH (soil : water, 1:2.5)	5.99	Moderately acid
Total N %	0.07	Very Low
Exchangeable K (meq/100 gm)	0.28	Medium
Available Nutrients, P, ppm (Olsen)	233.96	High
Available Nutrients, K_2O (mg/100gm)	31.73	High
Organic Carbon	0.72	Very Low
Moisture (%)	0.39	_
Texture	Sandy Loam	-
Soil Type	Healthy	-
Sand (%)	54.40	-
Silt (%)	32.00	-
Clay (%)	13.60	-

Measurement of Temperature, Rainfall and Humidity

The recorded weather data of the experimental filed from July to December, 2019 showed that the mean temperature during the cultivation period was from 27.33°C to 27.49°C, the mean rainfall from 23.92mm to 27.07mm and mean humidity from 94.76% to 95.01% (Table 2).

Table 2. Measurement of temperature, relative humidity (%) and rainfall for each growing season

Treatments	Mean Temperature (°C)	Mean Rainfall (millimeter)	Mean Humidity (%)
T_1 (July-15)	27.33	27.07	95.01
T_2 (July-30)	27.38	28.73	94.95
T_3 (Aug-15)	27.45	24.41	94.84
T_4 (July-30)	27.49	23.92	94.76

Germination Test

The mixture of sand and burnt rice husk (1:1) was used as the medium for germination of *Hibiscus sabdariffa* L. In this medium, four plots were designed and 100 seeds were sown in each plot. On day two, no seeds germinated. On day three, 88 seeds were germinated, four 147 seeds and five 113 seeds were again germinated. There were no more germination seeds until 7 days. Therefore, the germination percentage of Roselle was 87% in this experiment (Table 3), and the seeds in this experiment were certified and expected for better growth and yield.

Table 3. Germination rate of *Hibiscus sabdariffa* L.

Plot	Number of sown seeds	Germinated seedlings					Germinated Rate (%)
		Day 3	Day 4	Day 5	Day 6	Day 7	
1	100	20	59	85	85	85	85
2	100	30	53	87	87	87	87
3	100	23	57	86	86	86	86
4	100	15	66	90	90	90	90
Total	400	88	235	348	348	348	87

Vegetative Growth

The summarized results of vegetative plant growth expressed that T_4 (Aug-30) possessed the highest growth values in the plant height,petiole length , number of branches per plant, plant diameter, node length, number of leaves per plant, leaf length, leaf width, initial single leaf area and final single leaf area except petiole.

The results of T_1 (July-15) had the smallest in the plant height, petiole length, number of leaves per plant, leaf width, initial single leaf area and final single leaf area. Then T_2 (July-30) observed the least number of branches per plant, plant diameter, node length and leaf length respectively (Table 4).

Table 4. Summarized table of vegetative growth of *Hibiscus sabdariffa* L.

Treatments	T_1 July-15	T_2 July-30	T_3 Aug-15	T_4 Aug-30
Plant height (cm)	24.58	27.68	31.19	44.21
Petiole length (cm)	3.16	3.47	3.64	4.63
No. of branches	5.58	5.03	6.56	9.35
Plant diameter (mm)	4.44	4.03	4.66	5.67
Node length(cm)	5.58	5.03	6.56	9.35
No. of leaves per plant	18.01	24.52	26.63	32.20
Leaf Length(cm)	5.92	5.80	6.08	7.11
Leaf width (mm)	4.48	4.56	4.73	5.85
Initial single leaf area ($cm^{2)}$	18.03	24.52	26.63	32.20
Final single leaf area ($cm^{2)}$	39.64	40.44	54.6	68.56

Figure 2. Measurement of vegetative growth

Reproductive Growth of *Hibiscus sabdariffa* L.

Days to first flowering date and first harvesting pod date

Roselle planted in T_4 (Aug-30) was the earliest to produce flowers at 75 days after planting (DAP), followed by 78 DAP in T_3 (Aug-15), 93DAP in T_2 (July-30). T_1 (July-15) had the latest number of days to first flower production at 103 (DAP).Individual mean days of experiments are different in numbers when compared but the statistical results of these are highly significant (Table 5).

Roselle planted in T_4 (Aug-30) were earliest to first harvest pod date at 109 days after planting DAP, followed by 123DAP in T_1 (July-15), 126DAP in T_2 (July-30). T_3 (Aug-15)was the latest number of days to the first harvest pod at 132 (DAP).Individual mean days of experiments are different in numbers when compared but the statistical results of these were non- significant in table 5.

Table 5. Effect of different planting dates on first flowering date and first harvesting pod date

Treatments	First flowering date	First harvesting pod date
T_1 (July-15)	103	123
T_2 (July-30)	93	126
T_3 (Aug-15)	78	132
T_4 (Aug-30)	75	109
F-test	**	ns
5% LSD	1.41	41.47
cv%	1.20	25.10

CV% = coefficient variation (%), LSD = least significant difference

** = highly significant, ns = non-significant

Summarized reproductive growth of *Hibiscus sabdariffa* L.

The summarized results of reproductive growth expressed that of T_4 (Aug-30) possessed the highest reproductive growth values in days to first flowering date, days to first harvesting date, single pod weight, single pod length, single pod width, single pod epicalyx

number, single pod calyx weight, single pod calyx length, single pod calyx width, single pod fresh ovary weight, single pod ovary dry weight, number of seeds per pod and pod yield per treatment period. (Table 6)

Table 6. Summary table of the reproductive growth of *Hibiscus sabdariffa* L.

Treatments	T_1 July-15	T_2 July-30	T_3 Aug-15	T_4 Aug-30
Single pod weight (g)	4.55	4.44	4.52	5.05
Single pod length (cm)	32.85	32.51	33.70	35.02
Single pod width (cm)	19.82	19.14	19.56	20.96
Single pod epicalyx number	8.84	8.80	8.80	9.38
Single pod calyx weight (g)	2.27	2.26	2.08	2.64
Single Pod calyx length (cm)	3.89	3.5	3.88	4.08
Single pod calyx width (cm)	6.46	6.03	6.33	7.11
Single pod fresh ovary weight (g)	2.48	2.46	2.47	2.82
Single pod ovary dry weight (g)	0.95	1.14	1.22	1.43
No. of seeds per pod	20.70	18.66	20.18	23.14
Pods yield (kg) per treatment	104672.40	100615.20	77691.60	137188.80

Figure 3. Measurement of reproductive growth

Discussion and Conclusion

In this research, the seed germination was first conducted and the results showed that the complete germinate was obtained at day 7 and the germination rate was 87%.The germination of above 55% of flex seed types is regarded as certified seeds meaning that the seeds are of good quality (Furtas, 2018).

The results of soil analysis revealed that the nitrogen content of soil was 0.07% (very low), phosphorus was 233.96 ppm (high), potassium was 0.28meq (high) and the soil pH was 5.99 (moderately acid). The soil was sandy loam soil with less nitrogen content and the soil pH was moderated acid. These results were in accordance with the reference value of Futuless and Clement (2010) who reported that the Roselle prefers a sandy loamy soil with a pH value ranging from 4.5 to 8.0. The present investigation used chicken manure and rice husk char for the soil amended. Chicken manure acts as a good soil amendment that mainly provides N, P and K to the soil and can also increase the soil and leaf nutrient content (Oagile and Namasiku,2010)

Regarding to the climatic condition of experiments site, the average temperature was 27.33°C, the average rainfall 27.07 mm and mean humidity 95.01 %, throughout the T_1, the planting date of July-15and its growing period.InT_2,theplanting date of July-30 and its growing period, the average temperature was 27.38°C, the average rainfall was 28.73 mm and the mean humidity was 94.95 %. InT_3, the planting date of Aug-15 and its growing period, the average temperature was 27.45° C, the average rainfall was 24.41 mm and the mean humidity was 94.84 %. InT_4, the planting date of Aug-30 and its growing period, the average temperature was 27.49° C, the average rainfall was 23.92 mm and the mean humidity 94.76 %.

Throughout the growing periods of this experiment, the temperature was not significantly different among planting dates but the average temperature of T_4 was a little higher and had the lowest rainfall.

Juhi Agarwal and Ela Dedhia observed that the optimum temperature for favorable roselle is between 25 C and 35 C. In this experiment, the planting date of late-August gave the maximum calyx yield and also the seed yield. Indabawa and Sani (2015) mentioned that the planting date of late-August had effect on the total calyx yield and seed density.According to Apeyuan *et al*. (2017), planting in the late-August has an effect on the total calyx yield, seed density and planting date, highest total calyx/ha was recorded.In this experiment, one seed was sown in a hole. Indabawa and Sani (2015) reported that more seeds were observed using one plant growing a hole gave the optimum growth.

The vegetative growth such as plant height, petiole length, number of branches, plant diameter, node length, leaves per plant, leaf length and leaf width were the maximum in T_4 (Aug-30)in this experiment (Table 4). Moreover, the reproductive growth such as days to first flowering date, days to first harvesting date, number of pods per plant, single pod weight, single pod length, single pod width, single pod epicalyx number, single pod calyx weight single pod calyx length, single pod calyx width, single pod fresh ovary weight, single pod ovary dry weight, number of seeds per pod and pod yield per treatment were also the highest in T_4 (Aug-30) (Table 6).Crops sown in late August recorded a longer number of days to 50% flowering. The plant at the planting date of July 15 showed the least vegetative growth but the second highest reproductive growth was observed in this experiment. Futuless and Clement (2010) setup an experiment with different planting date such as 15th July 2009, 22nd July 2009, 29th July 2009 and 4th August 2009.The results revealed that the superior vegetative growth of Roselle and days to 50% flowering were recorded by (29^{th} July). They concluded that it was probably due to a high cumulative rainfall amount prevalent at the planting date.

According to Twin *et al*. (2002), the relative earliness of July sown Roselle has the strength for early flowering especially in short day lengths. They reported that the plant may not flower when the day length exceeds 11 hours. Based on the result of this research; the highest pod yield (weight per treatment) of 137188.80kg was recorded on the August 30 planting date. It is therefore concluded that the August 30 planting date appears to be optimum for growth and yield.

Acknowledgements

Firstly, I would like to thank Dr. Thida Oo, Professor and Head of Botany Department, Yangon University, for her encouragement and invaluable permission to carry out the research. I am also grateful to Dr. Ko Tin, Professor and Head, Department of Botany, West Yangon University, for his ideas, kindness and suggestion.

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