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Effect of Population Density on Yield and Yield Components of *Plukenetia volubilis* L

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Abstract:- The effect of population density on yield and yield components of Sacha inchi (*Plukenetia volubilis* L.) was studied in this experiment. A field experiment with four replications in a completely randomized block design was conducted in Magway 2017-2018 growing season. Planting density 300cm spaced (353 plants ha^{-1})(8 plants t^{-1}) , 150cm spaced (1058plants ha^{-1}))(12 plants t^{-1}) ,105cm spaced (2016 plants ha-^{1}) (16 plants t^{-1}) and 75cm spaced (3527 plants ha-^{1}))(20 plants t^{-1}) was assigned to the main plots. In this study, considering the yield of fruits per plant and the yield of seeds per plant, the 105cm (2016 plants ha-^{1}))(16 plants t^{-1}) plants spacing appeared to be the most recommendable for the cultivation of Sacha inchi (*Plukenetia volubilis* L.)

Keyword:- *Spacing Treatment,300cm,150cm, 105cm, 75cm.*

I. INTRODUCTION

Planting density has important effects on the vegetative and reproductive development of crops (Ciampitti and Vyn, 2011, Dong *et al*., 2012). A high planting density is commonly used to increase crop yields. However, if the planting density is too high, this reduces the availability of resources (i.e, incident radiation, water and nutrients) per plant in the growing season and causes a decline in yield per plant which may not be offset by the increase in planting density (Andrade *et al*, 1999). Although the effects of planting density on crop yield and on various yield components have been studied in many horticultural crops, the results have varied greatly between species.

In many species increased planting densities, up to an optimum level, resulted in increased yields (Brahim *et al*., 1998). In some species, a lower planting densities prolonged the seed-filling period, and thus increased seed size (Rogers and Lomman, 1988). The seed yield per unit area, in response to planting density, depends not only on the species and environmental conditions, but also on the level of applied fertilizer and other agronomic practices (Ciampitti and Vyn, 2011).

The independent effects of planting density on crop yield and yield components have been well documented (Zhang *et al*., 2012; Cai *et al*., 2013), but their interactions have been relatively less well – studied, especially in the field. *Plukenetia volubilis* L. is native to South America and is a promising new oilseed crop in the family Euphorbiaceae. *Plukenetia volubilis* L. is a perennial woody vine that produces seeds with a high oil content. *Plukenetia volubilis* seed oil is one of the richest sources of unsaturated fatty acids and its domestic, industrial, medicinal, and cosmetic industry uses have increased the global value of this crop (Cai *et al*., 2011). *Plukenetia volubilis* plants do not exhibit winter dormancy. They grow continuously in tropical regions and therefore flower and fruit almost continuously throughout the year.

Each fruit is a capsule (4-7 cm in diameter), consisting of four to seven pods, with one seed per pod. *Plukenetia volubilis* seeds number or size are variable and depend on several environmental conditions and agronomic factors (Cal, 2011, Jiao *et al*., 2012). In addition, *P. volubilis* plants have the capacity to develop new reproductive structures in response to an increase in available resources (Cai, 2011; Jiao *et al*., 2012; Cai *et al*., 2012; 2013). There is potential to increase seed yields in *P. volubilis* plants by suitable agronomic management practices.

In the present study, a field experiment was conducted to investigate the effects of planting density on the reproductive structure, total seed and yield components during a single growing season at Magway, a central dry zone of Myanmar. The overall goal was to evaluate the planting density management for this species for increasing seed and oil yields for commercial.

➢ *Aim and Objective*

- To observe the soil and temperature effect on growth of *Plukenetia volubilis* L. (Sacha inchi).
- To investigate the effects of population density on yield and yield components of *Plukenetia volubilis* L. (Sacha inchi).

II. MATERIALS AND METHODS

➢ *Experimental Site*

The field experiment was conducted in the field of Department of Agricultural Research Oil Crops, Research Center in Magway Region from May 2017 to May 2018.

➢ *Soil For Growing of Sacha Inchi*

In the study area, the wild grasses were cut and land was ploughed to clear the root stock and to clean up the land one week before the experimentation.

➢ *Soil Analysis*

Before growing crop, the soil sample at the depth of 1feet was collected from the study area, The Department of Agricultural Research Oil Crops, Research Center in Magway Region was analyzed in laboratory of Land Use Division, Myanmar Agricultural Service (DOA), Insein Township, Yangon Region

➢ *Experimental Design*

The field experiment was laid out using Randomized Complete Block design (RCBD) with four treatments and four replicates of each treatment as 4 rows per plot. Four different Plant spacing of population density was assigned to the plots; 300 cm x 300 cm; 300 cm x 150 cm; 300 cm x 105cm; 300 cm x 75cm, resulting in population densities of 8, 12, 16, 20 plants respectively. Forty five days old seedlings were transferred the experimental field. Total experimental area was 2700,000cm^2 and total grown plants were 56.

➢ *Cultural Management Practices*

During the growing period of Sacha inchi plants, crop management practice such as watering about 10 liter for each plant twice a week, organic pesticide (Neem) was soil drenched in every week. Weed control were done whenever it was necessary. (Basal fertilization 40g of NPK) was drenched to each plant.

➢ *Data Collection and Statistical Analysis*

The reproductive growth such as the number of flowers, first flowering days,50% flowering days, first fruit setting days, total number of fruit per plant, Dry weight of fruits per plant (g), number of seeds pre fruits, total seed weight of plants (g), dry weight of 100 seeds and total dry matter content were collected in this study. The data are analyzed using IRRISTAT software developed by International Rice Research Institute (IRRI), the Philippines.

III. RESULTS

➢ *Soil Analysis*

Physical and chemical properties of cultivated soil. The result of the analyzed soil from growing area showed loamy sand in soil texture which contained 84.9% sand, silt 9.9% and 3.9% clay. The cultivated soil had low in total nitrogen content (0.12%). The pH of the soil was 6.79% (nearly neutral) and the moisture content was 1.26%. The contents of exchangeable cat-ions, medium content of potassium 0.34% and very high phosphorous content 31.51%. The soil is loamy soil with very low organic carbon content was resulted from analysis (Table 1).

Parameter	Results	Remarks
Moisture (%)	1.26	Nearly Neutral
pH (Soil: Water) 1:2.5	6.79	
Soil Texture		
Sand (%)	84.90	
Silt (%)	9.90	
Clay (%)	3.90	
Total (%)	98.70	Loamy Sand
Organic Carbon (%)	0.82	Very low
Humus (%)	1.42	
Total N_2 (%)	0.12	Low
Exchangeable Cations		
K^+	0.34	Medium
Available Nutrients		
P (ppm) (Olsen)	31.51	Very High
K_2O (mg 100 gm)	15.8	Medium

Table 1:- Physical and Chemical Properties of Soil Samples

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➢ *Weather Condition*

- The maximum temperature (41.7ºC) was obtained on May and the minimum temperature (10.2ºC) in November 2017.
- The maximum temperature (42.4ºC) was obtained on April and the minimum temperature (10.3ºC) in June 2018.
- The maximum rainfall (11.73 inch) was obtained in August and the minimum rainfall (0.08 inch) in December 2017.
- The maximum rainfall (6.42 inch) was obtained in May and the minimum rainfall (zero inch) on Feb, March, April in 2018 (Table 2).
- The average temperature during the cultivation period was 26.7 ºC and the average rainfall was 5.3 inches (Table 2).

➢ *Effect of Population Density on First Fruit Setting Days*

- According to the statistical result, first fruit setting days are highly significant.
- The earliest fruit setting days (173.13) were recorded from 105cm spaced plants.
- The latest fruit setting days (194.88) were recorded from 300 cm spaced plants (Table 4, Figure 4).

Meteorological Parameters	2017								
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Maximum Temperature (°C)	41.7	37.0	35.5	35.2	36.0	36.0	36.0	31.4	36.1
Minimum Temperature (°C)	18.8	19.0	19.0	19.0	19.5	16.5	10.2	11.5	16.7
Rainfall (inch)	3.39	7.60	6.86	11.73	5.39	8.74	0.20	0.08	5.5

Meteorological Parameters	2018					
	Jan	Feb	Mar	Apr	Mar	Mean
Maximum Temperature (°C)	29.2	37.0	37.6	42.4	41.5	37.5
Minimum Temperature (°C)	10.3	12.5	18.7	20.0	20.7	16.4
Rainfall (inch)	3.62	-	-	-	6.42	5.0

36.8
16.6
5.3

Table 2:- Monthly Meteorological Data of Experimental Area during Growing of Sacha Inchi

➢ *Effect of Population Density on Number of Flowers Per Plant*

- According to the statistical result, number of flowers per plant are highly significant.
- The highest flowers (21.25) were recorded from 105cm spaced plants.
- The lowest flowers (7.88) were recorded from 300 cm spaced plants (Table 3, Figure 3).

Treatment	Number of flowers/Plant
T1(300cm spaced,8 plants t^{-1})	7.88
T2(150cm spaced, 12plants t^{-1})	14.63
T3(105cm spaced, 16 plants t^{-1})	21.25
T4(75cm spaced, 20 plants t^{-1})	9.50

Table 3:- Effect of Population Density on Number of Flowers per Plant

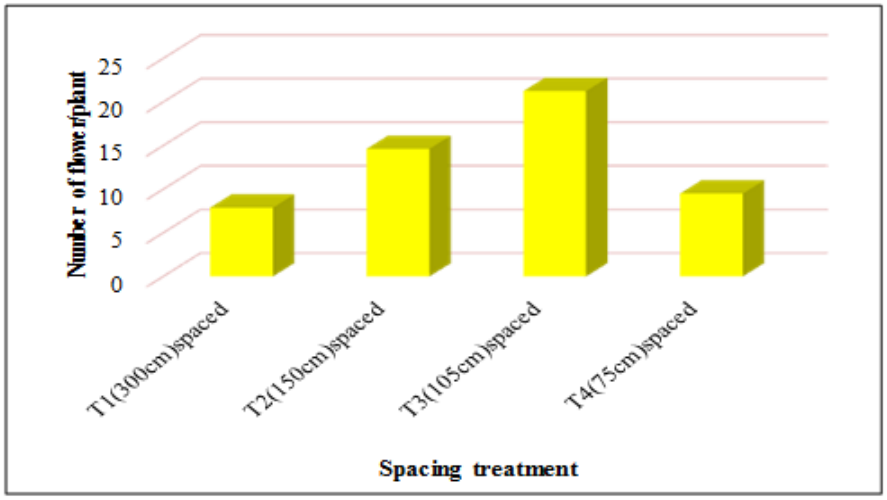

Fig 3:- Effect of Population Density on Number of Flowers of Sacha Inchi

Treatment	First Fruit setting Days
T1(300cm spaced,8 plants t^{-1})	194.88
T2(150cm spaced, 12plants t^{-1})	181.50
T3(105cm spaced, 16 plants t^{-1})	173.13
T4(75cm spaced, 20 plants t^{-1})	193.88
F-test	**
5%LSD	10.49
CV%	3.5

Table 4:- Effect of Population Density on First Fruit Setting Days

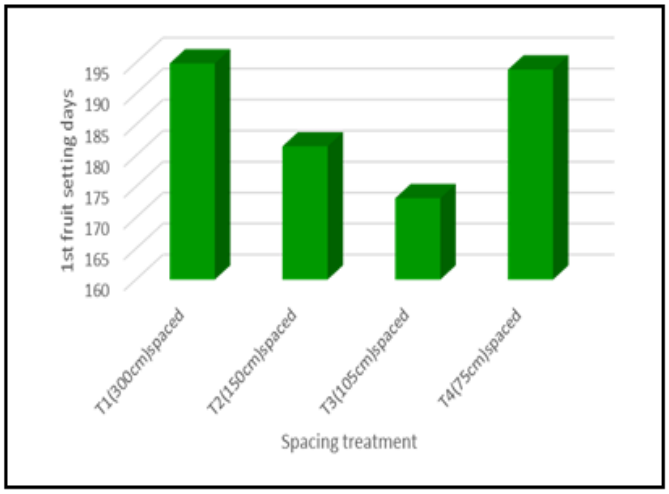

Fig 4:- Effect of Population Density on First Fruit Setting Days

➢ *Effect of Population Density on Total Number of Fruits Per Plant*

- The statistical result showed that the total number of Sacha inchi fruits had highly significant.
- The highest number of fruits (16) were attained also treated with 105 cm spaced plants .
- The lowest number of fruits (6.38) were obtained from 300 cm spaced plants (Table 5, and Figure 5).

Treatment	Fruit yield (number)/plant
T1(300cm spaced, 8 plants t^{-1})	6.38
T2(150cm spaced, 12 plants t^{-1})	12.13
T3(105cm spaced, 16 plants t^{-1})	16.00
T4(75cm spaced, 20 plants t^{-1})	6.75
F-test	**
5%LSD	3.99
CV%	24

Table 5:- Effect of Population Density on Total Number of Fruits per Plant

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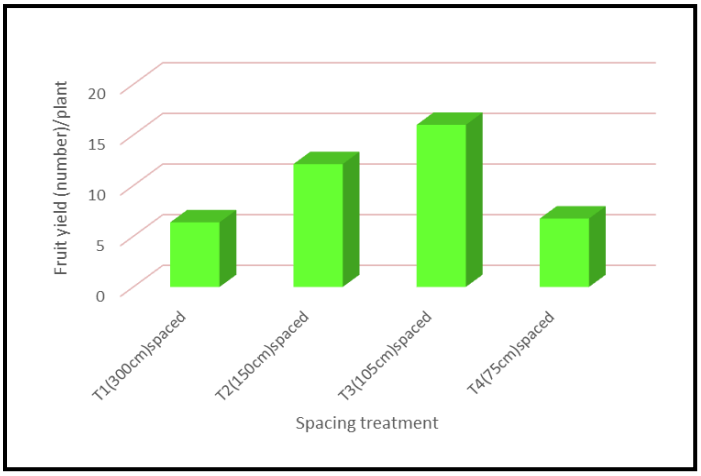

Fig 5:- Effect of Population Density on Total Number of Fruits per Plant

➢ *Effect of Population Density on Dry Weight of Fruits Per Plant*

- The statistical result showed that the maximum dry weight of fruits per plants were found in 105 cm spaced.
- The minimum dry weight of fruits per plants were obtained in 300 cm spaced.
- Total dry weight of fruits plant^{-1} was highly significant (Table 6, Figure 6).

Treatment	Dry weight of fruit /plant (gm)
T1(300cm spaced, 8 plants t^{-1})	44.09
T2(150cm spaced, 12 plants t^{-1})	93.14
T3(105cm spaced, 16 plants t^{-1})	130.58
T4(75cm spaced, 20 plants t^{-1})	51.38
F-test	**
5%LSD	50.87
CV%	21.3

Table 6:- Effect of Population Density on Dry Weight of Fruits per Plant

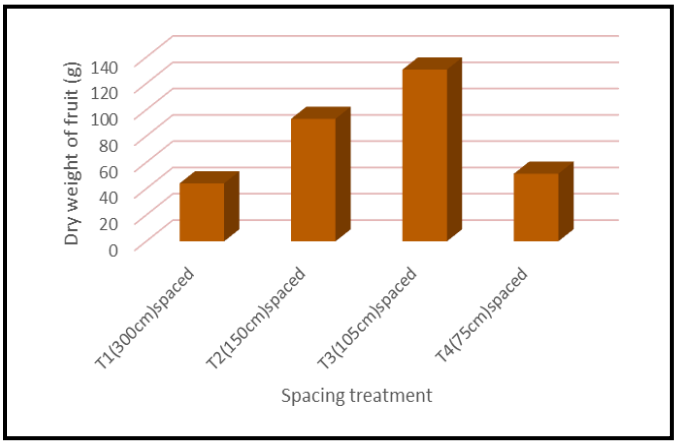

Fig 6:- Effect of Population Density on Dry Weight of Fruits per Plant (Gm)

➢ *Effect of Population Density on Number of Seeds Per Fruit*

Number of seeds per fruit was not significant different among the plant arrangement. In this experiment more or less similar seeds per fruit (Table 7).

Treatment	Number of Seeds /Fruit
T1 (300cm spaced, 8 plants t^{-1})	4
T2 (150cm spaced, 12 plants t^{-1})	4
T3 (105cm spaced, 16 plants t^{-1})	4
T4 (75cm spaced, 20 plants t^{-1})	4
F-test	ns
5%LSD	0
CV%	0

Table 7:- Effect of Population Density on Number of Seeds per Fruit

➢ *Effect of Population Density on Total Dry Weight of Seeds (Yield) Per Plant*

- The difference in dry weight of seeds (yield) per plant was highly significant among the population density.
- The result showed that the dry weight of seeds (yield) per plant increased in both of the treatments of 150 cm spaced plants and 105 cm spaced plants .
- It declined at lowest population density 300 cm, spaced plants and also in 75 cm spaced plants (Table 8, Figure 7).

Treatment	Seeds dry weight/plant (g)
T1 (300cm spaced, 8 plants t^{-1})	25.42
T2 (150cm spaced, 12 plants t^{-1})	50.97
T3 (105cm spaced, 16 plants t^{-1})	73.27
T4 (75cm spaced, 20 plants t^{-1})	26.93
F-test	**
5%LSD	21.34
CV%	30.2

Table 8:- Effect of Population Density on Total Dry Weight of Seeds (Yield) Per Plant

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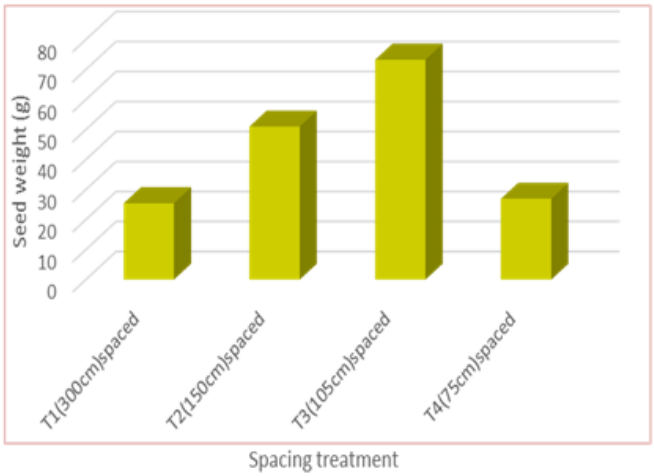

Fig 8:- Effect of Population Density on Total Dry Weight of Seeds (Yield) Per Plant

➢ *Effect of Population Density on Dry Weight of 100 Seeds*

- The difference in dry weight of 100 seeds was not significant in among treatments.
- It was found that T1 (300 cm spaced) plants had 100.5 g while T2 (150 cm spaced) plants had 101.75 g. T3 (105 cm spaced) plants 104 g and T4 (75 cm spaced) plants had 100.88g respectively (Table 9, Figure 8).

Treatment	100 seeds weight (g)
T1 (300cm spaced, 8 plants t^{-1})	100.50
T2 (150cm spaced, 12 plants t^{-1})	101.75
T3 (105cm spaced, 16 plants t^{-1})	104.00
T4 (75cm spaced, 20 plants t^{-1})	100.88
F-test	ns
5%LSD	3.09
CV%	1.9

Table 9:- Effect of Population Density on Dry Weight of 100 Seeds (G)

Fig 9:- Effect of Population Density on Dry Weight of 100 Seeds (Gm)

➢ *Effect of Population Density on Biomass Dry Weight (G)*

- Among the population density, the difference on total dry weight (TDM) (g $plant^{-1}$) was not statistically significant.
- It was observed that optimum dry weight at T3 (105 cm, spaced).
- T1 (300cm, spaced), T2 (150 cm spaced) and T4 (75 cm, spaced) were more or less the same (Table 10, Figure 9).

Treatment	Biomass dry weight(g)
T1 (300cm spaced, 8 plants t^{-1})	143.88
T2 (150cm spaced, 12 plants t^{-1})	133.13
T3 (105cm spaced, 16 plants t^{-1})	171.50
T4 (75cm spaced, 20 plants t^{-1})	157.25
F-test	ns
5%LSD	51.67
CV%	21.3

Table 10:- Effect of Population Density on Biomass Dry Weight (G)

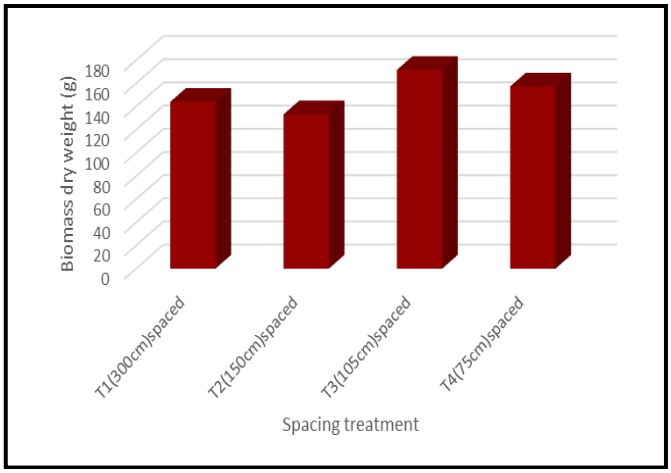

Fig 10:- Effect of Population Density on Biomass Dry Weight (G)

IV. DISCUSSION AND CONCLUSION

The average temperature during the cultivation period was 26.7ºC and the average rainfall was 5.3 inches. Magway, the experimental area is located 60 m above sea level. Sacha inchi plant adapted well to a wide range of temperature, from 26ºC. Higher than 36ºC cause drop-off flowers and immature fruit while temperatures below the optimum slow growth and flowering. It can also grow from 109.3-2186.7 m above sea level (http//www.tandf online.com.).

The temperature of the experimental area was favorable temperature for the growth of Sacha Inchi but the sea level is lower than its preferable range. The result of population density showed that the earliest first fruit setting (173.13) days were obtained from 105 cm spaced. The latest first fruit setting days were obtained from 300 cm, 75 cm. Among treatments effect of population density, maximum number of fruits per plant (16) was observed from 105 cm spaced.

The lowest numbers (6.38), (6.75) from 300 cm spaced. The dry weight of fruit per plant showed that the maximum dry weight was found in 105 cm spaced and the

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minimum dry weight of fruits per plant was obtained in 300 cm spaced plants. Regarding to the seeds per fruit, most of the fruits contained similar number of seeds. The total dry weight of seeds per plant, the highest dry weight was observed (73.27 g) from 105cm spaced. The lowest dry weight was obtained from (25.42 g) from 75 cm spaced.

The result of the dry weight of 100 seeds weight revealed that seeds weight among treatments were not significantly different each other but the maximum 100 seeds weight (104 g) was obtained from 105 cm spacing treatment. Biomass yield was also not significantly different in statistical analysis but the maximum biomass dry weight (171.5 g) was obtained from 105 cm spacing treatment. Simmod and Willian (1989) reported that the wider spacing lost more water from soil through evaporation and the seasonal transpiration was also strongly influenced by population density.

At higher population density the growth and yield was decreased because of the competition for light, water, and nutrients among the plants. Sacha inchi plant prefer that elevation - 900-1700 m. Rainfall - 850-1000 m; best if evenly distributed over 12 months. Soil types - wide range, but prefers medium-texture soil (sandy or clay loams). Soil pH should be between 5.5 and 7.8. Temperature range - 0-36 °C higher than 36 °C cause drop-off of flowers and immature fruit while temperature below the optimum slow growth and flowering. Light - prefers full sun; though it grows with other plants in forests. Spacing of 250-300 cm between rows, narrower spacing of 150 × 150 cm, as this was shown to be optimal in a study in China (2017 ECHO Inc.). In this study, 250-300 cm between rows, plant spacing of 300 × 105 cm, as this was shown to be optimal in Magway Region.

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