Modern Environmental Science and Engineering (ISSN 2333-2581)
February 2020, Volume 6, No. 2, pp. 257-263
Doi: 10.15341/mese(2333-2581)/02.06.2020/009
Academic Star Publishing Company, 2020
www.academicstar.us

Effect of Fertilization and Pruning on Inulin Levels of Yam Bean

Mismawarni Srima Ningsih[1], Irfan Suliansyah[2], Aswaldi Anwar[2], and Yusniwati[2]

1. Agricultural Study Program of Andalas University, Indonesia

2. Department of AgroEcotechnologi, Agricultural Faculty of Andalas University, Indonesia

Abstract: Market demand for inulin as functional food tends to increase every year. Tuber of yam bean was one source of inulin, potential to be developed. Research that aims to determine the effect of fertilization and pruning on tuber yam inulin levels has been carried out in Duku, Padang Pariaman, West Sumatra, Indonesia and the Agricultural Product Technology Laboratory of Andalas University from January to July 2019. Using experimental methods, environmental design were Split Plot Design 4×4 with 5 replications. The main plot is pruning: without pruning, shoot pruning, flower pruning, shoot and flowers pruning. The subplots were NPK fertilizer (15:15:15) doses of 100,125,150 and 175 kg ha-1, the levels of inulin were tested by the Cysteine-Carbazole method. Data were processed using Statistics 8, LSD test continued at a level of 5%. The results showed that applying fertilizer with different doses combined with different pruning would produce tubers with different levels of inulin. The tuber inulin content has interval 9.36-24.39% with a degree of polymerization interval of 8.50-28.75. The highest levels of inulin were obtained by combining a 125 kg ha-1 NPK fertilizer dose with shoot pruning.

Key words: tubers, fertilizing, pruning, inulin, functional food

1. Introduction

Yam bean ((*Pachyrhizus erosus* L. Urban) is a plant introduction that can grow well in Indonesia. Tuber is considered as fruit is the main product of yam bean that has been used in everyday life, especially for fresh consumption and food stuffs, potential yam bean developed in the field of pharmacology and industry in the future. Nevertheless, the current popularity of yam bean is still lacking, because it has to compete with other commodities that are considered higher quality, even less the tendency of people to consume imported commodities from abroad, so the IPGRI (*International Plant Genetic resources Institute*) categorizes the Yam Bean as a neglected and unexploited plant [1]. Therefore, it is necessary to study the research to improve the quality of yam bean.

Corresponding author: Mismawarni Srima Ningsih, MSi./S2; research areas/interests: agronomy. E-mail: mismawarnisrima@gmail.com.

Advances in bioscience stated that the diet modulates various bodily functions. Diets can maintain health and reduce the risk of some diseases, so that the concept of functional food develops rapidly. Inulin is one of the functional foodstuffs [2].

Inulin is very widely used in industrial, commercial scale Inulin manufactured from chicory plant, So the last few decades chicory inulin production in Western Europe has risen from 1,000 to 100,000 per year [3].Indonesia has not been able to produce inulin industrily, because chicory does not grow here, so the need for both inulin industry and research 100% is still imported from some countries, such as Belgium, Australia, China and India (Indonesian Institute of Sciences, 2010). Therefore production of inulin from local raw materials very need to be developed.

Nurrohman et al. (2010) [4] says that the sweetness of the yam bean tuber is due to inulin content. Supported by the results of research [5] which obtained

that the extract of yam bean tuber water contains inulin at 24.331%. The levels of inulin yam bean tubers are influenced by various factors, the height of planting, varieties, harvest age and plant growth conditions.

Plant growth conditions are closely related to the availability of nutrients absorbed by plants. Nitrogen (N), Phospor (P) and potassium (K) are essential elements that should always be available. Growth and development of plants. In order to have enough crop needs be given the addition of fertilizer. Zanklan (2003) [6] said that the production of yam bean can also be improved by developing the technique of leaf tip pruning and reproductive pruning (flower and pod pruning). Because pruning can reduce competition between sinks in plants, with pruning is expected to occur photosynthesis to the tuber, so that the tuber results will increase. This research aims to see the influence of fertilization and pruning on the levels of yam beans inulin.

2. Research Methode

2.1 Planting

Yam Bean is planted in Duku's community field, Padang Pariaman Regency, West Sumatera. Laboratory observation was conducted at Laboratory of agricultural technology, Andalas University from January to July 2019.Using experimental methods and Environmental design Split Plot 4×4 with 10 repeats. The main plot is the NPK (15:15:15) brand of Ponska (100, 125, 150 and 175 kg ha^{-1}). Half the dose gave when the plant is 15 days old and another half the dose when the plant is 60 days. Plot is pruning treatment that is without trimming, crop the tip (at the age of 45 days), crop the flower (when the plant begins to bloom), crop the tip and flowers (flowers cropped when the plant begins to bloom and the tip cropped when the plant aged 105 days).

2.2 Observation

2.2.1 Measurement of Wet Weight Tuber

Tuber is harvested when the plant is 135 days. The tuber is separated from the stem and the root ends, then washed clean, wind drying and weighed in the wet weight.

2.2.2 Testing Inulin Levels with the Method of Cysteine Karbazol [7]

(1) Inulin Flour Extraction

The extraction of inulin flour was done based on a method done by Susdiana (1997). Weighing first before processing done. Then cleaned from the dirt attached to the skin and then shredded using a grater machine. The result is added to the water by comparing water and the grater result 2:1. The mixture is then heated to a temperature of 80-90°C for 30 minutes. The results are cooled and filtered to be taken the filtrate. The volume of Filtrate measured and added absolute ethanol as much as 40% filtrate. The solution is stored in a freezer temperature -18°C for 18 hours until the deposits are obtained. Deposits are dried with an oven to a constant weight. The obtained result is mashed into inulin flour.

(2) Testing Inulin Levels

0.1 grams of inulin flour was dissolved in 10 ml aquades. 1 ml samples added 0.2 ml cysteine 1.5%, then added 6 ml H_2SO_4 70% and shaken. The mixture was then added 0.2 ml of the 0.12% of carbazol in ethanol solution. Then heated at 60°C for 10 minutes, then cooled and measured the inverse rate using a spectrophotometer with a wavelength of 560 nm. Standard curves made using standard Inulin (Inulin cichory) with a range of 20, 40, 60, and 80 ppm.

2.2.3 Total Sugar Testing of the Phenol Method [8]

For a standard curve as much as 2 ml of standard fructose solution which each was pipetted and inserted into the test tube, then added 0.5 ml of phenol solution 5%, then shaken. Added 2.5 ml H_2SO_4 concentrated. The absorbance was measured with a spectrophotometer at a wavelength of 490 nm. The total measurement of sample sugar must be clear liquid. Samples were diluted with distilled water. The sample determination was done like on a standard curve

creation, then prescribed total carbohydrate or total sugar samples.

2.2.4 Testing of the Reducing Sugar content of DNS method [9]

Samples were diluted until scalable at a range of 0.2 to 0.9 absorbance at a wavelength of 550 nm. A total of 1 ml of the sample was inserted into the test tube, then add 3 ml of the DNS reagent. Heated in boiling water for 5 minutes, allowed to cool in room temperature. And read its absorption. the form used is distilled water. The standard curve is made using a standard fructose solution, a range of 0-300 mg/L.

2.2.5 Degree of polymerization [8]

The value of polymerization degree was obtained by dividing the total value of sugar on the value of reducing sugar.

2.3 Data Analysis

To see the effect of treatment, data was processed with Program statistics 8. If there is a difference in treatment of the outcome, the LSD 5% level advance test then done.

3. Results and Discussion

Fertilization is the provision of additional nutrients on the soil either directly or indirectly that aims to improve soil conditions, improve soil fertility, provide nutrients to plants, and improve the quality and quantity of crop yield. NPK Fertilizer (15:15:15) Phonska is one of the compound fertilizer subsidized by the Government so that the price is cheaper and affordable by farmers. Consists of several macro nutrients, namely nitrogen (N), phosphor (P), potassium (K). The advantage of using this fertilizer is the same nutrient content as single fertilizer, the use of compound fertilizer is very practical, low transport costs and save storage space.

NPK Fertilizer is important for plant growth and development and crop yields. *N* nutrients absorbed by plants in the form of ammonium ions (NH^{4+}) or nitric ions (NO^{3-}), are the building materials of amino acids/proteins, enzymes, nucleic acids, nucleoproteins, and alkaloids. *N* deficiency will limit cell cleavage and magnification.

The *P* nutrient is taken plants from within the soil in the form of H_2PO_4 ions, serving as important structural components such as ADP, ATP, NAD, NADPH, and components of the genetic information system, namely DNA and RNA. The nutrients *K* is absorbed by plants from the soil in the form of K+ ions, functioning as activators of 46 kinds of enzymes, plays a role in the process of photosynthesis, improvement of LAI (leaf area index), and increase photosynthesis of translocation from source to recipient. Potassium also acts as a balancing water balance in cells, cell Turgor, responsible for the production and transportation of sugar, increasing crop tolerance to drought or cold stress as well as pest and disease attacks. And will improve the harvest from both aspects of color, taste and the power of the bait.

To nurture crops, pruning is a stage that can't be missed. Pruning is the act of eliminating unwanted plant parts in existence. In the cultivation of yam bean tuber producer is usually done reproductive pruning that removes reproductive organs such as flowers and pods.The pruning tips aim to limit the length of the stem and eliminate the apical dominancy so as to stimulate the lateral growth.From the treatment of pruning and fertilization given, the photosynthesis results can accumulate maximum on the tuber.

Table 1 is seen that the interaction of fertilizer and pruning has a value of P = 0.9489, greater than at 0.05 (95% confidence interval). It means the treatment of dose of fertilizers combined with different pruning gives a no different effect to the wet weight of the tuber. But the treatment of different doses of fertilizer or pruning in a single, has a value of P respectively 0.0002 and 0.0000, meaning that the treatment of fertilizer dose or different pruning treatment by a single gives a different effect to the wet weight of the Yam Bean tuber.

Table 1 Effect of NPK fertilizer dose and pruning to wet-heavy tuber Yam Bean (%).

Fertilizer Dose (kg ha^{-1})	Pruning									
	TP		PP		PB		PPPB		Average	
100	82.79	f	**84.29**	**f**	193.69	cdef	292.49	bcd	163.32	C
125	182.39	cdef	153.79	ef	265.39	bcde	308.06	bc	227.41	BC
150	159.59	ef	166.39	def	305.19	bcd	305.19	bc	231.17	B
175	194.99	cdef	242.79	bcde	368.06	ab	**459.49**	**a**	**316.39**	**A**
Rata-rata	154.94	B	161.82	B	280.22	A	**341.31**	**A**		

Value P: Fertilizer Dose = 0.0002; Pruning = 0.0000; Fertilizer Dose * Pruning = 0.9489

Description: The numbers in the columns and lines followed by the same lower case indicate the effect of interactions with the dose of fertilizer and pruning which do not differ in the LSD test with a 95% confidence interval. The numbers in the column/row followed by the same capitalization indicate the single influence of the dose of fertilizer or pruning which do not differ in the LSD test with a 95% confidence interval. TP = No Pruning, PP = Tips pruning, PB = Flower Pruning, PPPB = Tips Pruning and flower, P = Significance Value, * = interaction.

The combination of treatment of dose of fertilizer and different pruning obtained the tuber that has wet weight with a range of 82.79-459.49 gram. The effect of optimum interaction to increase the wet weight of the tuber is at a dose of 175 kg ha^{-1} fertilizer combined with the treatment of crop and flower trimming. The optimal fertilizer dose generally applies to increase the wet weight of the tuber is 175 kg ha^{-1}. And the generally prevailing optimum pruning treatment is the pruning of the tips and flowers.

Increase the dose of fertilizer is directly proportional to the increase of wet weight of the tuber, where the greater the dose of fertiliser given, then the greater the fresh weight of tuber. It means NPK fertilizer 175 kgha^{-1} is a proper dose to increase the fresh weight of the tuber.

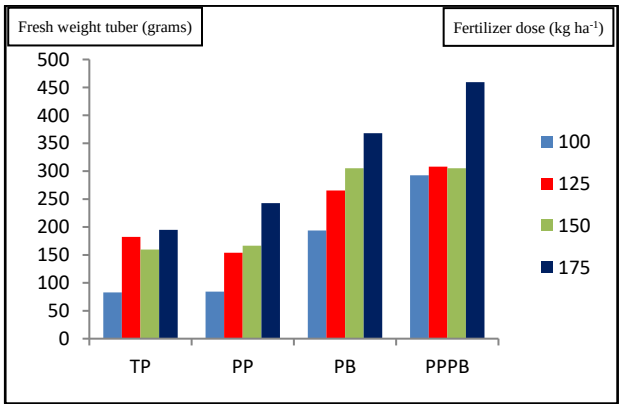

Fig. 1 Graph influence of Dose NPK fertilizer and pruning on wet weight of Yam Beans tuber.

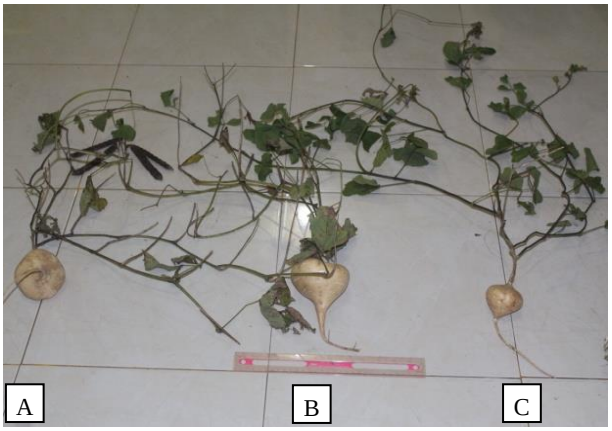

Fig. 2 Yam beans fresh harvest:A = PP, B = PPPB, C = TP.

Inulin is a group of natural polysaccharides found in yam bean tuber, which are used as energy reserves and regulate crop resistance. Inulin is composed of fructose units and usually has a glucose terminal that joins the β Glycoprint bonds (21).

Table 2 seen that the interaction between the dose of fertilizer and pruning has a value of P = 0.0003, meaning that the interaction between the fertilizer dose and different pruning gives different effects to inulin levels in the 95% confidence interval. Similarly, with a single giving, the treatment fertilizer dose or pruning has a value of P respectively 0.0000 and 0.0135, meaning that the treatment fertilizer dose or different pruning treatment gives different influence on the level of inulin yam bean tuber.

Table 2 Effect of NPK fertilizer dose and pruning on Yam bean tuber Inulin levels (%).

Fertilizer dose	Pruning									
(kg ha^{-1})	TP		PP		PB		PPPB		Average	
100	16.86	bcde	12.42	efghi	15.54	defg	20.49	abc	16.33	B
125	15.72	cdefg	24.39	a	14.69	efgh	21.09	ab	18.97	A
150	9.36	i	19.90	abcd	16.37	bcdef	13.66	efghi	14.82	B
175	11.26	ghi	11.89	fghi	11.83	fghi	10.13	hi	11.28	C
average	**13.30**	**C**	**17.15**	**A**	**14.61**	**BC**	16.34	AB		

The value of P fertilizer dose = 0.0000; Pruning = 0.0135; Fertilizer * Pruning = 0.0003

Description: The numbers in the columns and lines followed by the same lower case indicate the effect of interactions with the dose of fertilizer and pruning which do not differ in the LSD test with a 95% confidence interval. The numbers in the column/row followed by the same capitalization indicate the single influence of the dose of fertilizer or prunig which do not differ in the LSD test with a 95% confidence interval. TP = no pruning, PP = Tip Pruning, PB = Flower pruning, PPPB = Tip Pruning and flower, P = significance value, * = interaction

From the interaction of the dose of fertilizer and pruning treatment, the tuber is obtained with inulin levels of 9.36-24.39%. The effect of interaction of fertilizer dose and optimum pruning to increase the level of inulin yam bean tuber is a combination of fertilizer dose of 125 kg ha^{-1} and the pruning of tips. The optimum fertilizer dose on the treatment without pruning is 100, in kg ha^{-1} tip pruning treatment is 125 kg ha^{-1}, on the treatment of flower pruning is 150 kg ha^{-1} while the treatment of tips and flowers pruning is 125 kg ha^{-1}.

In single, optimum NPK fertilizer dose generally to increase inulin levels is 125 kg ha^{-1}. While the treatment of optimum pruning is the effect of tips pruning.

Yam bean has a semideterminate type of growth, which is a type of plant whose vegetative growth continues even though it has entered the generative phase (flowering), a new vegetative yam bean growth will stop after the formation of flag leaves (aged 100-105 days of planting).

Yam bean generative growth phases along with the formation phase of the tuber (tuberization), at this time there is photosintat scramble. In research obtained, the small dose of fertilizer will extend the time of filling tuber, so that the maturity of tuber is also slow. While the higher the dose of fertilizer gave accompanied by pruning, it will accelerate the process of maturation of the tuber (visible with the start of yellow and dried leaves).

So the higher the dose of fertilizer will minimize levels of tuber inulin. Rutherford et al. (1971) in Doorell et al. (1977) says that invertase activity increases during tuber replenishment and decreases at the end of tuber maturation, followed by increased hydrolase activity. This can result in inulin degradation and the occurrence of a lower molecular weight (polymerization degree) of Polyfruthane.

The degree of polymerization is derived from the total percentage distribution of sugar with reducing sugar. In Table 3, it appears that the interaction treatment of fertilizer dose and pruning has a value P = 0,0000, smaller than 0.05 (confidence Interval 95%). This means that the interaction between different doses of fertilizer and pruning will give different effects to the degree of polymerization. In single, the treatment of different fertilizer dose has a value of P = 0.0005, which means that the dose of different fertilizers give different influence to the degree of polymerization of yam bean tuber. The pruning treatment which has a value of P = 0.1266 means different pruning treatments do not give a different effect to the degree of polymerization of yam bean tuber.

The interaction of fertilizer dose and pruning, obtained yam bean tuber has a degree of polymerization ranged 8.50-28.75. Based on the

opinion of Roberfroid (1999) [2] which says that the degree of polymerization of inulin molecules is 2-60 +. It means fertilization treatment and pruning affects the degree of polymerisation of yam bean tuber. Effect of interaction of fertilizer dose and optimum pruning to increase the degree of polymerization of yam bean tuber is a combination of fertilizer doses of 125 kg ha^{-1} and without pruning. The optimum fertilizer dose on the treatment without pruning is 175 kg ha^{-1}, in the treatment of tip pruning, flower pruning as well as the pruning of tips and flowers is 125 kg ha^{-1}.

Table 3 Effect of NPK fertilizer dose and pruning on the degree of polymerization of Yam bean tuber.

	Pruning									
Fertilizer dose (kg/ha)	TP		PP		PB		PPPB		Average	
100	19,750	bcd	16,250	cdefg	16,250	cdefg	19,000	bcde	16,328	B
125	13,000	fghi	10,500	hi	28,750	a	22,000	b	18,973	A
150	14,750	defgh	12,750	fghi	12,750	fghi	13,500	efghi	14,821	B
175	20,750	bc	8,500	i	8,500	i	13,000	fghi	11,277	C
Average	17,063	A	16,563	AB	16,563	AB	16,875	B		

The value of P fertilizer dose = 0.0005; Pruning = 0.1266; Fertilizer * Pruning = 0.0000

Description: The numbers in the columns and lines followed by the same lower case indicate the effect of interactions with the dose of fertilizer and pruning which do not differ in the LSD test with a 95% confidence interval. The numbers in the column/row followed by the same capitalization indicate the single influence of the dose of fertilizer or pruning which do not differ in the LSD test with a 95% confidence interval. TP = no pruning, PP = tip pruning, PB = Flower pruning, PPPB = tip and flower pruning, P = significance value, * = interaction

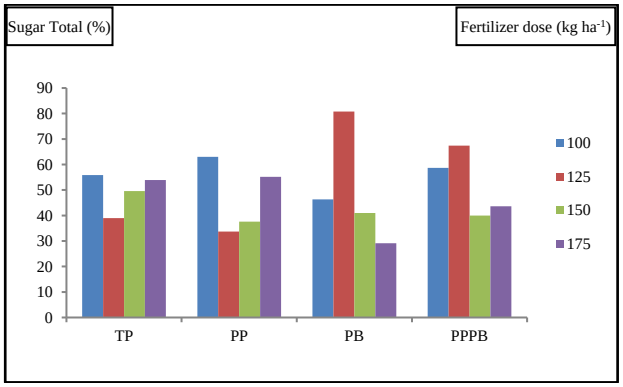

Fig. 3 Graph of fertilization influence and pruning on Total percentage of sugar yam bean tuber.

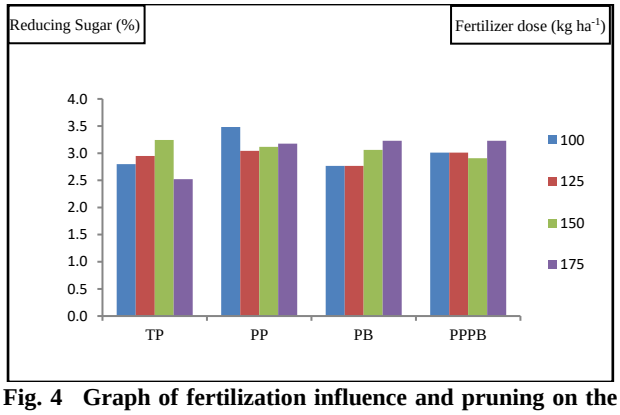

Fig. 4 Graph of fertilization influence and pruning on the percentage of reducing sugar yam bean tuber.

The optimum NPK fertilizer Dose (15:15:15) generally available to increase the degree of polymerization is 125 kg ha^{-1}. While the optimal pruning treatment is generally common is the treatment without pruning.

4. Conclusion

The experiments and analyses that have been conducted can be concluded as follows:

1) The interaction of fertilization and pruning does not affect the fresh weight of yam bean. The best NPK (15:15:15) fertilizer dose to increase wet tuber weight is 175 kg ha-1 combined with tips pruning and flowers.
2) The percentage of inulin levels obtained because of the treatment of fertilization dose and different pruning is 9.36-24.39%. Highest Inulin rate obtained from the treatment NPK fertilizer dose 125 kg ha^{-1} combined with thepruning of tips.
3) The treatment fertilization dose and different prunning produces tuber inulin with a

polymerisation degree of 8.50-28.75. The highest degree of polymerisation is obtained by combining fertilizing treatment 125 kg ha^{-1} with the pruning of tips.

Acknowledgement

Thanks to Dirjen DIKTI (*Directorate General of Higher Education)*who has given the opportunity to continue the study to S3 postgraduate of Andalas University by domestic education scholarship.

References

[1] M. Sorensen, Yam Bean Pachyrizus DC, International Plant Genetic Resources Institute, Italy, 1996.

[2] M. B. Roberfroid, Nutritional and health benefits of inulin and oligofructose. concepts in fungtional foods: The case of inulin and oligofructose, *J. Nutr*. 129 (1999) 1398S-1401S.

[3] A. V. Laere and V. D. Ende, Inulin metabolism in Dicots: Cichory as a model system, *Plant Cell & amp. Environment* 25(2002) (6).

[4] A. Nurrochman, F. Leviana, C. G. Wulancarsari and E. Lukitaningsih, Phytoestrogens of *P. erosus* prevent bone loss in an ovariectomized rat models of osteoporosis, *International Journal of Phytomedicine* 2 (2010) 363-372.

[5] M. Wimala, Y. Retnaningtyas and L. Wulandari, Penetapan kadar inulin dalam ekstrak air umbi bengkuang (*Pachyrhizus erosus* L.) dari Gresik Jawa Timur dengan Metode KLT, *e-Journal Pustaka Kesehatan* 3 (2015) (1) 61-65.

[6] A. S. Zanklan, Agronomic performance and genetic diversity of the root crop yam bean (Pachyrhizus spp.) under West African conditions, doctoral dissertation, Georg-August University Gottingen, Germany, 2003.

[7] M. P. J. Kierstan, *Biotechnology and Bioengineerig*, New York (USA): John Wiley & Sons, 1978, pp. 447-450.

[8] A. Apriyantono, D. Fardiaz, N. Puspitsari, L. Sedarnawati and S. Budiyanto, *Analisis Pangan*, Bogor (ID): IPB Press, 1989.

[9] G. L. Miller, Use of dinitrosalicylic acid reagent for determination of reducing sugar, *Anal Chem*. 31(1959) (3) 426-428, doi:10.1021/ ac60147a030.