TUBER PRODUCTION OF YAM BEAN (*Pachyrhizus* spp.) DUE TO SINK-REPRODUCTIVE PRUNING

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ABSTRACT

Yam bean (*Pachyrizhus*spp) can be used as new alternative food resource. To increase yam bean production including tuber quality traits, can be acquired troughintraspesific and interspesific crosses between *P. erosus* and *P. ahipa.* Simultaneous sink-reproductive pruning treatment is conducted to increased the tuber production, because the treatment can divert assimilate flow to tuber which consequently change the tuber dimensions. Materials used in this experiment were 9 yam bean genotypes collection of A. Karuniawan (Plant Breeding Laboratory, Padjadjaran University). Nine genotypes consisted of three genotypes of *P. Erosus*, one genotype of *P. Ahipa*, two genotypes of *P. erosus* intraspecific hybrid and three genotypes resulted from interspecific between *P. erosus* and *P. ahipa*. The field trial was conducted at experimental field of Faculty of Agriculture, Padjadjaran University Jatinangor located at an altitude of 753 m above sea level with Inceptisols soil type and type C rainfall according to Schmidt-Fergusson. The experiment was conducted from August 2009 until March 2010. The experiment was arranged in split plot design which was repeated twice. The main plot consisted of two treatments: without sink-reproductive pruning and with sink-reproductive pruning. The main plot was divided into nine subplots based on genotypes. Characters observed were tuber fresh weight (g), tuber dry matter (%), total starch content (% WB), and protein content of tuber (% WB). Pruning affected the increasing of tuber fresh weight. Interspesific hybrid genotype AC 216-139 d x EC 550 produced the highest value for dry matter content. The highest starch and protein content contained on *P. ahipa* genotype AC 216-139 d. There was interaction between pruning and genotype on dry matter content, which the best result shown by AC 216-139 d with pruning treatment. The genotype which was good for food resource material with high starch and protein production was intraspecific crosses genotype x B-56/CJ EC 550.

Keywords: *yield, sink-reproductive pruning, yam bean.*

INTRODUCTION

Yam bean is a plant originated from Mexico, Central America and South America. This plant consists of five species, three of which have been cultivated and two of them are wild species. Cultivated species are *Pachyrhizuserosus, P. ahipa*, and *P. tuberosus*. Meanwhile, for the wild species are *P.panamensis* and *P. ferrugineus*[6]. Until currently, yam bean (*Pachyrhizus*spp) is categorized as one of the neglected and underutilized by the International Plant Genetic Resources Institute (IPGRI). In Indonesia, this plant is a minor crop that has not been a priority for development, meanwhile, it is widely cultivated in Sumatra, Java, Southeast Nusa, Sulawesi, Bali and Kalimantan.

The role of tuberous plant which is also a legume crop such as yam bean (*Pachyrizhus*spp) will be more strategic in food security, including Indonesia. Yam bean is a plant which produces both starch and proteins in quite high level. Thus, yam bean can be used as an alternative source of starch with high protein content [6]. This is related to the efforts in fulfill the alternative sources of protein-rich starch as food. FAO (1979) has given attention to the importance of the use of tuberous legume as well as starch and protein sources, especially in areas experiencing the deficiencies of starch and protein fulfillment.

Average productivity of yam bean tuber in Indonesia remains in low level. In the western part of Indonesia, the average production ranges from 10 ton ha^{-1}-70 ton ha^{-1} and in the eastern parts of Indonesia ranged from 10 ton 10 ton ha^{-1}-36 ton ha^{-1}[3]. While in Mexico, the yam bean productivity can reach 100 ton ha^{-1}-145 ton ha^{-1}. In the Philippines, productivity of yam bean about 80 ton ha^{-1}-90 ton ha^{-1} [3], and in Thailand's average productivity of yam 60 ton ha^{-1}-90 ton ha^{-1}[5]. From the above data, it is shown that Indonesia yam bean productivity is lower compared with other yam bean producer countries.

Yam bean has been recommended as an alternative flour production material[1]. In Indonesia yam bean has potential to be further developed as an alternative source of starch and high protein. This can be seen from the analysis of 100 g of fresh yam bean which has starch content at 2.1 g - 10.7 g and 1 g - 2.2 g protein. The lowest water content contained in *P. tuberosus* which is 70% -74%, followed by *P. ahipa* that is equal to 74% -76%, then *P. erosus* by 78% -94% [6].

Based on the assumption that the average results of 35 t ha-1, dry weight ranges from 6% - 22% per 100 g of fresh yam bean tuber, the starch content of 50% and protein 10% dry matter, the content of starch and protein produced by yam bean per hectare is 1.05 ton – 3.85 ton starch and 0.21 ton – 0.77 ton protein [4]. It makes yam bean as a potential source of starch and protein.

One disadvantage of starch yam bean tuber use is the high water content, so that although the tuber has great size but the starch and protein levels possibly will be low due to the low dry matter content. To broaden genetic diversity and increase the amount of dry matter, Plant Breeding Laboratory, Padjadjaran University in Bandung did intraspecific and interspecific hybridization between *P. erosus* and *P. ahipa*. All *Pachyrhizus* spp. species are diploid plants with chromosome number n = 11. The same chromosome number makes compatible crosses (no obstacle in the process of pollination).

Besides plant breeding, the potential of yam can be improved by developing appropriate cultivation techniques. One of the frequent cultivation techniques are sink-reproductive pruning [6]. Sink-reproductive pruning is the cutting of reproductive parts of plants, which is beginning at the first flower bud appearance. Sink-reproductive pruning aimed to reduce competition of photosynthates distribution between the sink-reproductive and tuber. Therefore, sink-reproductive pruning will shift assimilate to tuber. Flower bud pruning on the yam bean can increase 30%-70% of tuber fresh weight [4].

This study aimed to test the simultaneous effect of sink-reproductive pruning on tuber production, also study on starch and protein content of yam bean tuber. Further, expectantly there will be new genotypes with better tuber productions with high starch and protein contents.

MATERIAL AND METHODE

Materials used in this experiment were 9 yam bean genotypes collection of A. Karuniawan (Plant Breeding Laboratory, Padjadjaran University). Nine genotypes consisted of three genotypes of *P. Erosus*, one genotype of *P. Ahipa*, two genotypes of *P. erosus* intraspecific hybrid and three genotypes resulted from interspecific between *P. erosus* and *P. ahipa*.

The method used was experiment method. The field trial was conducted at experimental field of Faculty of Agriculture, Padjadjaran University Jatinangor located at an altitude of 753 m above sea level with Inceptisols soil type and type C rainfall according to Schmidt-Fergusson. The experiment was conducted from August 2009 until March 2010.

The experiment was arranged in split plot design which was repeated twice. The main plot consisted of two treatments: without sink-reproductive pruning and with sink-reproductive pruning. The main plot was divided into nine subplots based on genotypes. Each subplot size was 2 m x 3 m with spacing 50 cm x 50 cm between plants and 100 cm between subplots. Fertilizer recommendations are given referring to the sweet potato cultivation in dry land.

Sink-reproductive application treatment was carried out after 50% of plants per plot had entered the flowering phase (R5) [6], it was done once a week until the harvest time. Harvesting of tuber was approximately 180 days (six months) after planting.

Characters observed were weight of tubers (g), tuber dry matter content (%), total starch content (% WB), and total protein content (%WB). Yam bean tuber starch content was analyzed using Luff Schoorl method and protein content was analyzed using Micro-Kjeldahl Method. Quality traits test was conducted at Yield Physiology Laboratory, Vegetable Research Institute, Lembang West Bandung.

Data were analyzed using statistical analysis of variance (anova). Comparison of the mean value was done using the least significant difference test (LSD) on the real level 5%.

RESULTS AND DISSCUSSION

1. Result

TABLE 1

ANALYSIS OF VARIANCE RESULT FOR TUBER FRESH WEIGHT, TUBER DRY MASS, TOTAL STARCH CONTENT AND TOTAL PROTEIN CONTENT OF NINE GENOTYPES YAM BEAN

Variable	F		
	Pruning	Genotype	Interaction PxG
Tuber fresh weight (g)	2742.35*	1.20	0.73
Tuber dry mass (%)	1.12	3.90*	9.43**
Total starch content (%)	0.12	17.02**	2.60
Total protein content (%)	128.27	3.99*	0.77

Explanation : * significant on alpha 0,05 Ftable F(0,05) F(0,01)

** significant on alpha 0,01 Pruning : 161 4062

Genotypes : 2.77 4.30

Interaction PxG : 2.77 4.30

Based on analysis of variance (Table 1), main factor, pruning treatment gave significant different. Genotypes as the subplot factor, gave significant different on all tuber quality traits observed. There was at least one genotype which gave different value on tuber dry mass and total starch content characters, in fact, total protein content showed highly significant result. Sink-reproductive pruning and genotypes interacted on tuber dry mass in highly significant difference.

TABLE 2

PRUNING EFFECT ON YAM BEAN TUBER FRESH WEIGHT.

Treatments	Tuber fresh weight g
Non pruning	122.48 a
Pruning	348.04 b

Exp: Numbers followed by the same letters are not significantly different on alpha 0.05 LSD test

Tabel 2 shows least significant difference (LSD) test on tuber fresh weight. It proved that sink-reproductive pruning had higher value. Non pruning treatment only resulted 122.48 g,whereas, sink-reproductive pruning 348.04 g.The ratio for this result was more than two times.

TABLE 3.

EFFECT OF GENOTYPES ON YAM BEAN TUBER DRY MASS, TOTAL STARCH CONTENT, TOTAL PROTEIN CONTENT

Genotip	Dry mass content	Total starch content	Total protein content
	---%---		
EC 550	6.11 ab	1.07 A	0.94 a
EC 033	5.36 a	0.71 A	1.17 a
B-56 / CJ	7.33 cd	1.63 Ab	1.21 a
AC 216-139 d	8.86 fg	6.73 E	1.89 d
EC 550 x AC 216-139 d	7.50 de	0.87 A	1.01 a
EC 033 x B-56 / CJ	8.82 f	1.69 D	1.80 cd
AC 216-139 d x B-56 / CJ	6.60 bc	1.51 Bc	1.51 ab
EC 550 x B-56 / CJ	8.35 ef	1.74 Cd	1.56 b
EC 550 x AC 208-72h	10.27 g	2.66 De	1.72 bc

Exp: Numbers followed by the same letters are not significantly different on alpha 0.05 LSD test

Table 3 defines LSD test for effect of genotypes for dry mass content, total starch content and total protein content. Interspesific hybrid genotype between *P. erosus* and *P. ahipa* (EC 550 x AC 208-72h) had the highest value on dry mass content. On total starch content character, the best result was showed by *P. ahipa* species, AC 216-139 d genotype, then followed by EC 550 x AC 208-72h genotype which had the highest on dry mass content character. Almost the whole hybrids intraspesific and interspesific genotypes were higher than Indonesian native yam bean, B-56 / CJ also another *P. erosus* genotypes EC 550 and EC 033 on total protein content.

TABLE 4

INTERACTION BETWEEN GENOTYPES x SINK-REPRODUCTIVE PRUNING ON TUBER DRY MASS CONTENT

Genotypes	Tuber dry mass	
	Non-pruning	Pruning
EC 550	8.51 B	3.71 a
	B	A
EC 033	6.04 ab	4.68 ab
	B	A
B-56 / CJ	7.65 B	7.01 de
	B	A
AC 216-139 d	1.38 A	16.34 h
	A	B
EC 550 x AC 216-139 d	8.78 B	6.22 c
	B	A
EC 033 x B-56 / CJ	10.42 B	7.23 e

	B	A
AC 216-139 d x B-56 / CJ	9.70 B	3.50 a
	B	A
EC 550 x B-56 / CJ	8.34 B	8.37 f
	A	A
EC 550 x AC 208-72h	11.71 B	8.84 g
	B	A

Exp: Numbers followed by the same letters are not significantly different on alpha 0.05 LSD test

There was interaction between genotypes x sink-reproductive pruning on tuber dry mass content, it is shown on Table 4. On non pruning treatment, only *P. ahipa*AC 216-139 d which gave smallest mean value for tuber dry mass character. While, contrast result was shown on sink-reproductive pruning, AC 216-139 d genotype had the highest value than other genotypes, then followed by interspesific hybrid genotype EC 550 x AC 208-72h.

TABLE 5

YAM BEAN TUBER, DRY MATTER, STARCH AND PROTEIN PRODUCTION

Genotypes-pruning	Tuber	Dry matter	Starch (WB)	Protein (WB)
	----ton/ha---			
EC 550	73.43	2.72	0.46	0.41
EC 033	72.26	3.38	0.07	0.68
B-56 / CJ	88.70	6.21	1.53	0.78
AC 216-139 d	19.38	3.17	1.23	0.28
EC 550 x AC 216-139 d	61.86	3.85	0.93	0.59
EC 033 x B-56 / CJ	40.36	2.92	0.72	0.50
AC 216-139 d x B-56 / CJ	103.44	3.62	1.19	0.86
EC 550 x B-56 / CJ	97.53	8.16	2.45	1.36
EC 550 x AC 208-72h	69.53	6.14	2.01	0.96

WB = Wet Basic

Table 5 contains production of yam bean tuber for dry matter, starch and protein. To select the best yam bean genotype for industry material is based on yam bean production. These values were got from yield character on 200.000 plants density for one hectare area as mentioned in methodology.

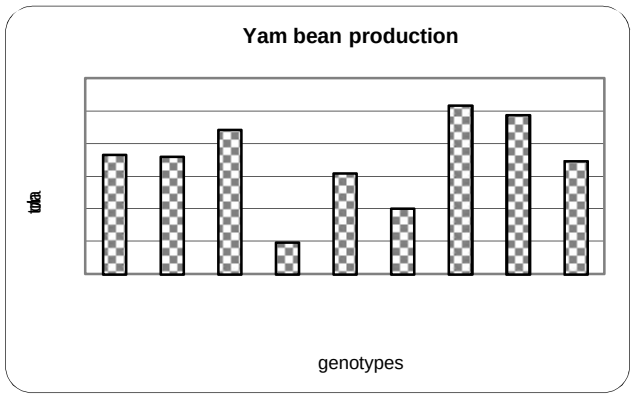

Fig. 1. Yam bean production on nine genotypes

In figure 1, the highest yam bean production was shown by interspesific hybrid genotype AC 216 d x B-56/CJ, then followed by intraspesifc hybrid genotype EC 550 x B-56/CJ. The smallest value was shown by *P. ahipa* genotype AC 216-139 d.

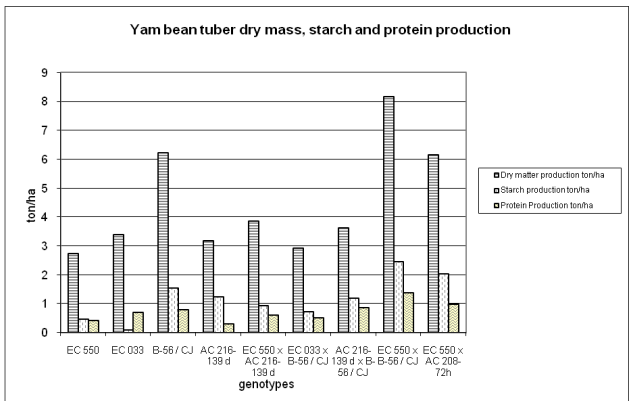

Fig. 2 Yam bean tuber dry mass, starch and protein content

On Figure 2, tuber production based on tuber quality aspects such dry matter, starch and protein production. The value was taken fom the value characters multiplied by yam bean production per hectare. Therefore, the higest value was gained byintraspesifc hybrid genotype EC 550 x B-56/CJ, then followed by interspesific hybrid genotype AC 216 d x B-56/CJ. The smallest value was shown by *P. erosus*genotype EC 550 for dry matter production, EC 033 for starch production, and *P.ahipa* genotype AC 216-139 d for protein production.

2. Discussion

In this study, sink-reproductive pruning gave higher tuber fresh weight trait for whole genotypes. Sink-reproductive pruning of flower bud removal diverts assimilate distribution into tuber storage sinks (Ho, 1988). The increased flow of assimilate to the tuber, consequential on the change in dimensions. In addition, the increased of assimilate flow also affect tuber fresh weight.

Interspesific hybrid genotype between *P. erosus* and *P. ahipa* (EC 550 x AC 208-72h) had the highest value on dry mass content. On total starch content character, the utmost result was showed by *P. ahipa* species, AC 216-139 d genotype, then followed by EC 550 x AC 208-72h genotype which had the highest on dry mass content character. Almost the whole hybrids intraspesific and interspesific genotypes were higher than Indonesian native yam bean, B-56 / CJ also another *P. erosus* genotypes EC 550 and EC 033 on total protein content.

In this study, pruning did not affect the qualitative character of the percentage of dry matter, starch and protein content. Yam bean production increased as a result of pruning, this practice did not affect the percentage of soluble sugar content and dry matter percentage. But there are variations of these traits on genotypes were evaluated caused by genetic factors [7]. This variation can be seen in the character of dry matter, starch and protein content in this study.

P.ahipa has a dry matter contained 24% -26% dry matter, while *P. erosus* contained 6%-22% dry matter depend on environment [6]. In this study, *P. ahipa* genotype AC 216-139 d got a second on dry matter, the highest dry matter occupied by interspesific hybrid genotype EC 550 x AC 208-72h, 10.27% dry matter content, and contrary with the elder EC 550 which had only 6.11% of dry matter. Therefore, the cross was succeed to improve the dry matter character.

P.erosus contains 2.1% -10.7% starch [6]. Starch content of *P. ahipa* generally higher than *P. erosus*[2]. In the present study showed that the highest starch content contained in *P. ahipa* genotype AC 216-139 d is 6.73%, followed by hybrid genotype interspesific AC 216-139d x EC 550, 2.66%. Whereas other genotypes had starch content started from 0.71% - 1.69%. This also showed that the crossing able to alter the character of starch.

*P. erosus*contained higher protein than *P.ahipa,* both of which were planted in Benin[2]. In this study, the protein content of hybridization genotypes generally was higher than that of yam genotypes of *P. erosus* but not to *P. Ahipa*. This was likely influenced by different planting conditions, so that gene expression on protein characters was different with statement above [2]. The highest protein content was gained by *P. ahipa,* then followed by EC 033 x B-56 / CJ and AC 216-139d x EC 550. The smallest value was attained by EC 550.

P. erosus is the most stable species in production, also it produces the prime number for yield [2]. *P. ahipa* is known as species with higher dry matter and starch content but not for protein content. Therefore, hybridization using those species is expected to gain the new genotype in high production amount with better quality. This study noted that intraspesific and interpesific crosses produced a new genotype with higher production amount with better quality character for dry matter, starch and protein than the elders.

CONCLUSION

Pruning affected on tuber fresh weight for all genotypes observed. Interspesific hybrid genotype AC 216-139 d x EC 550 produced the highest value for dry matter content. The highest starch and protein content contained on *P. ahipa* genotype AC 216-139 d. There was interaction between pruning and genotype on dry matter content, which the best result shown by AC 216-139 d with pruning treatment.

The main material used food resource is starch with high protein content. Therefore, characters which become the basis of determining best genotype must be balanced between the yield and qualitative character. Thus, although the genotype AC 216-139 d has the highest starch and protein content, but not it was supported by yield character.

The genotype which was good for a alternative foodstuffs had to have high starch and protein suppoted by high tuber production. Therefore, it can be concluded that the genotype of yam bean EC 550 x B-56/CJ which get sink -

reproductive pruning treatment is the best genotypes as new food alternatives resources.

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