Adaptation of Some Clones of Sweet Potato (*Ipomoea batatas* L.) in the Lowlands and the Use of Manure

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Abstract
This study aims to determine adaptation of some clones of sweet potato in the lowlands and the best manure application on the growth and yield of sweet potato as well as the interaction between the two factors. Research conducted at the Experimental Field of the Faculty of Agriculture Syiah Kuala University, Banda Aceh, with a height of 4 m above sea level, from March to September 2014. This study used a Randomized Complete Block Design in factorial arrangement (2x8), using a split plot design with three replications. The main plot is a manure treatment (control and manure 20 ton/ha), and the subplot is a treatment of types of sweet potato clones (CIP-LSQ, CIP-1945, CIP-MAN, CIP-153, CIP-CER, CIP-BDG), and local clones (beige and orange). The results showed that the best plant growth was found on CIP-153 clone, while the best crop production was CIP-LSQ clone. Growth and crop production was found best on control treatment. There are interactions between manure and clones on weight of the fresh shoot (ton/ha), fresh weight and dry bulb per plant (g), the weight of large tubers (ton/ha) and tubers yield (ton/ha). The best plant growth and production was found on a combination treatment of CIP-LSQ clones and control (without manure).
Keywords: adaptation, manure, clone

Introduction

Sweet potato (*Ipomoea batatas* L.) is a crop that has great potential to be developed in Indonesia to prevent malnutrition and enhancing food security. Sweet potato is a plant producing carbohydrates is ranks as the world's seventh most important food crop after wheat, rice, maize, potato, barley and cassava and can be used as an alternative of wheat flour. In addition, sweet potato have prospects as a superior agricultural commodity for its easy management, drought resistant and can be grown on a variety of altitude ranging from lowland to highland and able to adapt in areas of less fertile and dry (Eskin, 1989). Sweet potatoes contain vitamins and minerals, and can be used as forage and industry (textiles, adhesives, cosmetics, pharmaceuticals and food) (CIP, 1999; Ofori, 2009). The added value of sweet potato can be obtained by processing fresh sweet potato into flour, butter, chips, noodles, sticks and feed. Sweet potato flour can be processed into dry cakes, ice cream, sweet rolls and juice.

Sweet potato production in Indonesia in 2013-2014 decreased from 2,386 into 2,382 million tons. Likewise, the sweet potato harvest area decreased from 161.85 thousand ha (2013) to 156.67 thousand ha (2015) (BPS, 2015). This low production caused by many factors, among others, for not using superior clones, unproper cultivation techniques and cultivation of the sweet potato only as a byproduct. Efforts to increas the production of sweet potato are being conducted, by using superior clones, by planting clones adaptable to specific environments (Rahayuningsih *et al*., 2002). Opportunities to improve the productivity of sweet potato is still quite large, with the availability of superior clones that have the potential to be released as new varieties. Chance to add or assemble new varieties are quite large with the introduction of foreign varieties. Development varieties of sweet potato clones are aimed at improving yield potential, short lifespan (early maturing), resistant to pests of Cylas, and a high tolerance for intercropping (Balai Penelitian Tanaman Pangan, 2009).

Besides the clones, productivity is also determined by organic matter. Organic materials are a very important role in the soil, to improve the physical, chemical and biological quality of soil. One of the important organic material is manure. Manure has a nutrient component (Tola *et al*., 2007). Fuentes and Chujoy (2009) and Abdissa *et al*. (2012) states that the ideal amount of manure that is given is 15-20 tons/ha to spur the growth and yield of sweet potato. This study is aimed at testing some sweet potato clones of CIP-SEA and local clones with the application of manure is right for the growth and yield of crops in the lowlands. This study also testing the adaptability of some clones of sweet potato and manure on the growth and yield of sweet potato as well as the interaction between the two factors.

Materials and Methods

This research was conducted at the Farm land of the Faculty of Agriculture Experimental Syiah Kuala University Darussalam, Banda Aceh, Indonesia. The research was conducted from March to September 2014. The sweet potato clones used comes from the International Potato Center-South East Asia (CIP-SEA) Bogor, namely: CIP-LSQ, CIP-1945, CIP-MAN, CIP-153, CIP-CER, CIP-WHI-5 and 2 Local clone the tuber beige and orange bulbs. The study uses decomposed cow dung as a manure at a dose of 20 tonnes/ha. The tools used in this study is a tool cultivation, calipers, scales and oven.

This study uses a Discrete Random Design (split plot design), the pattern of randomized block design. The main plot is dose of manure treatment (2 level: control (P_0) and manure of 20 ton/ha (P_1)) and sub plot is the treatment of types of clone (8 types: CIP-LSQ (K_1), CIP-1945 (K_2), CIP-MAN (K_3), CIP-153 (K_4), CIP-CER (K_5), CIP-WHI-5 (K_6), Bulbs beige (K_7) and Tuber orange (K_8)). From these two factors obtained 16 units of trial with three replications. Each experimental unit consisted of five plant samples.

At the implementation of this study, land preparation starts with the clearing of weeds, and loaming of soil with a hoe, embeding weeds. Plots were prepared with a 500 cm long, 100 cm wide, 40 cm high, and 60 cm distance between plots. Cutteges of sweet potato (length 25 cm) were planted 1 cuttage/hole with a space of 25 cm x 40 cm plants maintained by replanting bad plants at 2 week after planting (WAP), weed control carried out at 4, 8, 12 and 16 weeks and the reversal of the plant performed at 4, 8 and 12 WAP. Harvesting is done at the time the plant was 18 MST, by pulling the sweet potato plant, then dig beds and tubers are taken and collected. Bulbs are grouped based on observed treatments and put in a plastic container or burlap bags.

The parameters observed in this study were: percentage of growth (3 WAP), growth vigorous (strength grow) of plants (6 WAP) (scale of 1-3, where 1 = whithout vine, 2 = 1-3 vines, and 3 = more than 3 vines), fresh weight biomass per plant (g), dry weight of biomass per plant (oven-dried at 70°C for 48 h) (g), tuber fresh weight per plant (g), tuber air dried weight per plant (air dried for 6 days) (g), larger tuber yield (tons/ha), smaller tuber yield (ton/ha) (Criterion for larger tuber size is greater than 200 g, while the smaller tuber size is less than 100 g), total tuber weight (ton/ha), total biomass fresh weight and general evaluation tubers the time of harvest (a score of 1-3, a value of 1 = good, 2 = moderate and 3 = good).

Results and Discussion

1. Effect of clones on the Growth and Yield of Sweet Potato

Analysis of variance (F test) showed that clones significant by effect the percentage of life, growth vigorous, fresh biomass weight per plant, dry biomass weight per plant, tuber fresh weight per plant, air dried weight of tuber per plant, weight of large tubers per hectare, the weight of small tubers per hectare, total biomass weight per hectare, the total weight of tuber per hectare and general evaluation tubers. Table 1 shows that the best sweet potato plant growth treatment was found in CIP-513 clone (K_4). The clones suspected to have high environmental adaptability for future growth. Types of clones adaptable to the environment is expected to grow better. The best sweet potato crop production was found on clones CIP-LSQ (K_1).

Table 1. Average percentage of growth (PG), growth vigorous (GV), fresh biomass weight per plant (FBW), dry biomass weight per plant (DBW), tuber fresh weight per plant (TFW), air dried weight of tuber per plant (ADWT), the weight of larger tubers (WLT) per hectare, smaller tuber weight per hectare (STW), total fresh biomass weight per hectare (TFBW), total tuber weight per hectare (TTW) and the general evaluation of the tubers (GET)

According to Simatupang (1997), higher production of a clone is caused by the adaptability of the clones to the environment. Therefore, environmental factors such as climate and soil are greatly affect crop production. According to Adiyoga *et al*. (2004), the use of superior sweet potato clones with high yielding and high adaptation capacity to the environment is one way to increase the production of sweet potatoes. In addition to environmental factors, growth capacity of clones are also influenced by genetic factors. According Riani *et al*. (2001), each individual clones growth and results are vary according genetic influences, where genetic influences are inherited by the descendants of each clone. Sadjad (1993) also stated that the growth capacity are difference between the different clones and determined by genetic factors. Manrique and Herman (2002) showed that a very close interaction between clones and the environment in a given location will not be the same at other locations, due to environmental factors that greatly affect the appearance and yield of sweet potato. Growth and yield of sweet potato is highly dependent on the clone and conditions of plant growth.

Parameters	Clones							
	K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8
PG (%)	42.50 (18.58) b	37.50 (17.88) b	74.17 (25.68)d	95.83 (29.42)e	49.17 (20.46)c	3.33 (4.65) a	98.33 (29.82)e	99.17 (29.95)e
GV (score)	2.50 (5.23)c	1.67 (4.45) b	3.00 (5.61) d	3.00 (5.61) d	3.00 (5.61) d	1.17 (3.48)a	3.00 (5.61) d	3.00 (5.61) d
FBW (g)	377.89 (57.89)e	293.00 (46.90)c	385.67 (57.36) e	425.33 (60.54e	376.33 (55.70)de	58.33 (14.06)a	181.00 (39.25)b	284.83 (49.93)cd
DBW (g)	45.26 (20.26)d	28.61 (14.70)b	86.35 (25.67)d	53.83 (21.65)c	59.95 (21.98)c	6.41 (5.83)a	27.98 (15.67)b	56.36 (22.27)c
TFW (g)	384.86 (56.22)f	67.92 (18.14)C	11.67 (5.97)b	203.89 (31.98)d	304.67 (42.47)e	0.00 (2.12)a	403.00 (56.77)f	259.50 (44.62)e
ADWT (g)	332.58 (52.21)f	55.83 (16.87)b	10.00 (5.66)b	159.45 (28.45)c	245.60 (38.43)d	0.00 (2.12)a	357.33 (53.09)e	219.33 (40.77)d
WLT (ton/ha)	5.17 (6.83)d	0.42 (2.63)a	0.00 (2.12)a	1.97 (4.15)b	4.10 (5.84)c	0.00 (2.12)a	5.94 (7.01)d	3.92 (5.67)c
STW (ton/ha)	2.32 (4.76)d	0.58 (2.93)b	0.07 (2.25)a	0.48 (2.89)b	0.48 (2.89)b	0.00 (2.12)a	0.99 (3.63)c	1.94 (4.65)d
TFBW (ton/ha)	24.49 (14.84)d	9.25 (8.84)a	16.68 (12.16)b	23.40 (14.21)cd	19.85 (12.56)b	1.46 (3.68)a	20.38 (13.30)bc	23.74 (13.91)cd
TTW (ton/ha)	7.57 (8.10)f	0.99 (3.44)b	0.07 (2.25)a	2.45 (4.62)c	4.58 (6.12)d	0.00 (2.12)a	6.92 (7.78)ef	5.87 (7.12)e
GET (score)	3.00 (5.61)d	2.00 (4.60)c	0.33 (2.56)a	1.50 (3.87)b	1.67 (4.16)b	0.00 (2.12)a	2.83 (5.47)c	3.00 (5.61)e

Description: Figures followed by the same letter on the same line had no significant difference at 5% level (Duncan Multiple Range Test). Figures in brackets are the data transformation (X + 0.5) ½

2. Effects of Manure on the Growth and Yield of Sweet Potato

Results of analysis of variance (F test) showed that treatment of manure highly significant effect on biomass fresh weight per plant, significantly affect the fresh weight of tuber per plant, weight of large tubers per hectare, biomass fresh weight per hectare, the total weight of tuber per hectare, and not significant on the percentage of growth, growth vigorous, biomass dry weight per plant, air dried weight of tuber per plant, weight of smaller tubers per hectare and a general evaluation of the bulbs.

Table 2 shows that the treatment without manure (P_0) gives the best growth and yield of sweet potato compared to the treatment of manure (P_1). This is apparently due to the condition of the land used that has been able to provide nutrients necesserily to support plant growth of sweet potato. The expected productivity of plant is achieved when the amount and types of nutrients in the soil for plant growth are concidered sufficient, balanced, and is available according to the needs of the plant.

Parameters	Manure	
	P_0	P_1
PG (%)	62.29 (22.00)	62.71 (22.11)
GV (skor)	2.70 (5.22)	2.48 (5.08)
BFW (g)	361.54 (52.64) b	234.06 (42.76) a
BDW (g)	58.16 (20.61)	33.03 (16.40)
TFW (g)	282.03 (39.14) b	126.84 (25.43) a
ADWT (g)	237.80 (35.82)	107.23 (23.51)
WLT (ton/ha)	4.04 (5.55) b	1.34 (3.55) a
STW (ton/ha)	1.07 (3.49)	0.65 (3.04)
TFBW (ton/ha)	22.31 (13.29) b	12.50 (10.09) a
TTW (ton/ha)	5.13 (6.23) b	1.98 (4.15) a
GET (skor)	1.43 (4.30)	1.40 (4.19)

Description: Figures followed by the same letter on the same line had no significant difference at 5% level (Duncan Multiple Range Test). Figures in brackets are the data transformation (X + 0.5) ½

Table 2. Average percentage of growth (PG), growth vigorous (GV), biomass fresh weight per plant (BFW), biomass dry weight per plant (BDW), tuber fresh weight per plant (TFW), air dried weight of tuber per plant (ADWT), the weight of larger tubers (WLT) per hectare, smaller tuber weight per hectare (STW), total biomass fresh weight per hectare (TFBW), total tuber weight per hectare (TTW) and the general evaluation of the tubers (GET)

3. Effect of interaction between clones and Manure

Results of analysis of variance (F test) showed that the interaction between clones and manure has a highly significant effect on the percentage of growth, growth vigorous, the weight of large tubers per hectare, significantly affect the fresh weight of tubers per plant, air dried weight of tubers per plant, total biomass fresh weight, total tuber weight per hectare, and the effect was not significant on biomass fresh weight per plant, biomass dry weight per plant and weight of small tubers per hectare. Table 3 shows that, in general, the best interaction between clones and the treatment of manure was found on the combination of CIP-LSQ clones (K_1) and treatment.

Table 3. Average percentage of growth (PG), growth vigorous (GV), tuber fresh weight per plant (TFW), air dried weight of tuber per plant (ADWT), the weight of larger tubers (WLT) per hectare, total biomass fresh weight per hectare (TFBW) and total tuber weight per hectare (TTW)

Para meters	Manure	Clones							
		K_1	**K_2**	**K_3**	**K_4**	**K_5**	**K_6**	**K_7**	**K_8**
PG (%)	P_0	63.33 (7.97) Bc	30.00 (5.18) Ab	83.33 (9.13) Bd	91.67 (9.60) Ade	28.33 (5.27) Ab	3.33 (1.55) Aa	100.00 (10.02) Ae	98.33 (9.94) Ade
	P_1	21.67 (4.41) Ab	45.00 (6.74) Bc	65.00 (7.99) Ad	100.00 (10.02) Ae	70.00 (8.37) Bd	3.33 (1.55) Aa	96.67 (9.85) Ae	100.00 (10.02) Ae
GV (Score)	P_0	3.00 (1.87) Bc	1.33 (1.27) Aa	3.00 (1.87) Ac	3.00 (1.87) Ac	3.00 (1.87) Ac	2.00 (1.44) Bb	3.00 (1.87) Ac	3.00 (1.87) Ac
	P_1	2.00 (1.62) Ab	2.00 (1.70) Bb	3.00 (1.87) Ac	3.00 (1.87) Ac	3.00 (1.87)Ac	0.33 (0.88) Aa	3.00 (1.87) Ac	3.00 (1.87) Ac
TFW (g)	P_0	496.67 (21.98) Bde	62.50 (5.04) Abc	0.00 (0.71) Aa	94.44 (7.70) Ac	524.67 (22.52) Bde	0.00 (0.71) Aab	649.33 (25.44) Be	428.67 (20.27) Bd
	P_1	273.05 (15.50) Ae	73.33 (7.05) Abc	23.33 (3.27) Aab	313.33 (13.62) Bde	84.67 (5.79) Abc	0.00 (0.71) Aa	156.67 (12.41) Ade	90.33 (9.47) Acd
ADWT (g)	P_0	422.67 (20.14) Bc	45.00 (4.35) Aab	0.00 (0.71) Aa	65.56 (6.60) Ab	421.87 (20.33) Bc	0.00 (0.71) Aa	582.67 (24.08) Bd	364.67 (18.59) Bc
	P_1	242.50 (14.67) Ae	66.67 (6.69) Abc	20.00 (3.06) Aab	253.33 (12.37) Bde	69.33 (5.28) Abc	0.00 (0.71) Aa	132.00 (11.31) Ade	74.00 (8.59) Acd
WLT (g)	P_0	6.08 (2.49) Bc	0.83 (1.05) Aab	0.00 (0.71) Aa	1.25 (1.16) Ab	6.67 (2.67) Bc	0.00 (0.71) Aa	10.28 (3.27) Bd	7.22 (2.75) Bc
	P_1	4.25 (2.07) Ad	0.00 (0.71) Aa	0.00 (0.71) Aa	2.69 (1.61) Bcd	1.53 (1.22) Abc	0.00 (0.71) Aab	1.60 (1.40) Abc	0.63 (1.03) Aab
TFBW (ton)	P_0	27.28 (5.24) Acd	7.56 (2.77) Ab	19.96 (4.48) Bc	24.85 (4.90) Acd	31.61 (5.58) Bde	0.76 (1.03) Aa	28.75 (5.33) Bde	37.72 (6.11) Be
	P_1	21.71 (4.66) Ad	10.94 (3.13) Abc	13.40 (3.63) Acd	21.94 (4.57) Ad	8.08 (2.80) Ab	2.15 (1.43) Aa	12.01 (3.53) Abc	9.75 (3.16) Abc
TTW (ton)	P_0	9.50 (3.11) Bcd	1.60 (1.37) Bb	0.00 (0.71) Aa	1.93 (1.40) Bb	7.39 (2.81) Bc	0.00 (0.71) Aa	10.97 (3.37) Bd	9.65 (3.16) Bcd
	P_1	5.64 (2.29) Af	0.39 (0.92) Abc	0.14 (0.79) Aab	2.97 (1.68) Ade	1.76 (1.27) Acd	0.00 (0.71) Aa	2.88 (1.82) Aef	2.08 (1.59) Ade

Description: Figures followed by the same letter on the same line (capital letter vertical and small letter horizontal) had no significant difference at 5% level (Duncan Multiple Range Test). Figures in brackets are the data transformation (X + 0.5) ½ without manure (P_0).

This is suspected that the clones CIP-LSQ (K_1) has the absorptive capacity of nutrient contained in the soil. This is in confirmed with Purwo (2007) that a plant requires the type, dose, and the optimum concentration that could trigger a maximum of productivity and growth. Sarwono (2005) states that the amount of nutrients needed to form different parts of plants is different for each type of plant and even for the same type of plant.

Conclusions

1. The best growth of sweet potato was found on CIP-153 clone, while the best yield was found on CIP-LSQ clone.
2. The best growth and yield was found on treatment without manure.

3. The best growth and yield was on found in the combination treatment of CIP-LSQ clone and without manure.

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