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DUAL-PURPOSE ASSESSMENT FOR SWEETPOTATO

Sri Umi Lestari*) and Ricky Indri Hapsari
Faculty of Agriculture University of Tribhuwana Tunggadewi
Jl. Telaga Warna blok C Tlogomas Malang 65144 East Java Indonesia
*) Corresponding author E-mail: sriumi.lestari@yahoo.com

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ABSTRACT

This study aimed to classify the types of sweet potato based on the ratio of total dry matter of roots to vine (R/V) in order to make the option available in integrating the crop-livestock systems. Seventeen sweet potato cultivars were planted in Randomized Complete Block Design with three replications applied at two locations, Malang and Blitar. Each cultivar planted in plot measures 2.5 m x 5 m in Malang and 3.0 m x 5 m in Blitar, and each consists of four rows with a spacing of 25 cm in rows. All cultivars gave a dose of 250 kg NPK fertilizer (15-15-15)/ha twice, one-third of dose given at planting and the remainder in a month after planting. Plants were harvested at four months after planting. Fresh weight and dry weight of storage root, fresh weight and dry weight of vines, harvest index, and the ratio R/V are determined. There was different performance of 17 cultivars planted at two locations. Cultivars planted in Malang were classified into four types, namely forage, which consists of three cultivars among 17 cultivars, low dual-purpose (3 cultivars), high dual-purpose (7 cultivars), and low root production (4 cultivars); while cultivars planted in Blitar turned into the forage type.

Keywords: dual-purpose, root/vine ratio, sweet potato

INTRODUCTION

Sweet potato can produce a large amount of forages to animal feed, but in Indonesia, the use of sweet potato vines for feed source has been limited. According to Peters (2008), sweet potato breeders in CIP-SSA estimated cultivars to produce a large amount of forages in East Africa, reached 35 t - 60 t/ha / season, or 70 t - 120 t/ ha/year. Many cultivars in Indonesia has not been evaluated its vines potential that should be contributed to develop the potential use of sweet potato as an animal feed in this region.

According to Leon-Velarde *et al*., (1997), sweet potato cultivar was classified into five types, namely: (1) forage, (2) low dual-purpose, (3) high dual-purpose, (4) low root production, and (5) high root production. Cultivars belonging to the low or high-dual-purpose types and forage type were appropriate if integrated to crop-livestock systems. In addition, sweet potato vines is suitable for animal feed because the crude protein content is high, ranging between 16-29% based on the dry weight, comparable to forage leguminous (An *et al*., 2003). Similarly, according to Kaya and Yildirim (2011), sweet potato can be used to improve egg yolk color of layers, since the storage root and foliage of sweet potato are rich in β-carotene and xanthophylls respectively, and they are not only important food for human but also for poultry.

According to León-Velarde (CIP Program Report, 1999-2000), a dual-purpose of sweet potato would have a comparative advantage over clones selected only for roots or forage production. It would provide food for human consumption and animal feeds for livestock, would be optimally integrated with livestock management system. The management system could utilize the sweet potato's ability to regenerate by continually or sporadically harvesting the vines throughout the growing season before finally harvesting the roots. Many researchers have studied sweet potato used for dual-purpose, such as Larbi *et al*., (2007), Peters (2008), Etela *et al*., (2008), Claessens *et al.,* (2008), Kaya and Yildirim (2011), Etela and Kalio (2011), and Ahmed *et al*., (2012). Those findings are correlated one another in using sweet potato forage to substitute animal fodder grass in crop-livestock system.

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MATERIALS AND METHODS

Seventeen cultivars were used in this study, consisting of nine released varieties, six improved clones varieties but have not been released (Lestari *et al*., 2012*a*; 2012*b*), and two local varieties namely Kuningan Putih and Kuningan Merah (Lestari and Basuki, 2013). All cultivars were collected at Brawijaya University Research Station, located in Jatikerto, Kromengan, Malang Regency. Sweet potato varieties released included Cangkuang, Ayamurasakhi, Sari, Jago, Papua Solosa, Sawentar, Beta 1, Beta 2 and Beniazuma. Improved clones were D67, 73-6 / 2, BIS OP-4, BIS OP-61, OP-73 5, and 73 OP-8. The experiments were conducted in two locations, respectively in Malang on May to September 2013, and in Blitar on September 2013 to January 2014. Randomized Complete Block Design with three replications were applied in these trials.

Each cultivar planted in each plot measuring 2.5 m x 5 m in Malang and 3.0 m x 5 m in Blitar consisted of four rows with a spacing of 25 cm in rows, so that there were 40 cuttings per plot in Malang and 48 cuttings per plot in Blitar.

Each cultivar was fertilized with 250 kg NPK fertilizer (15-15-15)/ha, twice, one-third dose at planting and the remainder at a month after planting. The plants were harvested at four months after planting. Fresh storage root weight, storage root dry weight, vines fresh weight, vines dry weight, harvest index (HI), and the ratio of total dry matter of roots to vines (R/V) were determined. The mean and the standard error for evaluation of sweet potato characteristics were determined in these trials as presented in Table 1. The ratio of total dry matter of root to vines (R/V) was used to classify sweet potato types: (1) *forage* (R/F 0 – 1), (2) *low dual-purpose* (R/F > 1 – 1.5), (3) *high dual-purpose* (R/F > 1.5 – 2.0), (4) *low root production* (R/F > 2.0 – 3.0), and (5) *high root production* (R/F > 3.0) (Leon-Velarde *et al*., 1997).

RESULTS AND DISCUSSION

Cultivar Classification

Seventeen cultivars evaluated at two locations showed different performances (Tables 1 and 2). Cultivars planted in Malang can be classified into four types, namely (1) forage, consists of three cultivars among 17 cultivars, (2) low dual-purpose (3 cultivars), (3) high dual-purpose (7 cultivars), and (4) low root production (4 cultivars); while cultivars planted in Blitar turned into the type of forage. Among all cultivars evaluated in Malang, none of them was included as a high root production type.

Dual-purpose group consisting of a low dual-purpose and a high dual-purpose, each producing storage root for food and forage for animal feed were balanced. In low dual-purpose group, it had harvest index and ratio R/V ranging between 50-60% (HI) and 1.0-1.50 (R/V) respectively, whereas in high dual-purpose group, it had 60-67% (HI) and 1.50-2.0 (R/V). In these groups, both low- and high dual-purpose groups, they had fresh storage root yield ranged from 7-18 t/ha or 2-6 t/ha on dry weight based, while fresh vines ranged from 6-13 t/ha or 2-3 t/ha on dry weight based (Table 1).

Cultivars belonged to the sweet potato dual-purpose were 10 cultivars among 17 planted cultivars. Thus, there were many selected cultivars to implement in the crop-livestock systems. These cultivars should be able to develop the harvesting technology, the vines, and by periodically they are throughout the growing system without lowering the yield of storage root that can harvest. The use of dual-purpose sweet potato has been evaluated at some areas (Larbi *et al.,* 2007; Peters, 2008; Etelä *et al.,* 2008; Claessens *et al.,* 2008; Kaya and Yildirim, 2011; Etelä and Kalio, 2011; and Ahmed *et al.,* 2012). Those findings can be adapted to sweet potato development for farming systems in Indonesia in line with the agriculture concept of sustainable bio-industry.

Root production type planted in Malang had the value of R/V > 2.0; there were four cultivars among 17 cultivars. They had HI > 68% and storage root yield ranged from 10-13 t/ha or 3-4 t/ha on dry weight basis, while the yield of fresh vines weight ranged from 4-8 t/ha or 1-2 t/ha on weight basis (Table 1). However, different performance of root production types or the others turned into forage types in Blitar (Table 2).

Table 1. Fresh storage roots, dry weight storage roots, fresh vines weight, vines dry weight, harvest index (HI) and the ratio of total dry matter of roots to vines (R/V) of 17 sweet potatoes planted in Malang (Lestari and Hapsari, 2014)

No.	**Cultivar**	**Fresh storage root weight (t/Ha)**	**Storage root dry weight (t/Ha)**	**Fresh vines weight (t/Ha)**	**Vines dry weight (t/Ha)**	**Harvest Index (HI, %)**	**R/V**	**Criteria**
1.	Cangkuang	4.83 ± 0.16	1.82 ± 0.08	12.39 ± 1.89	3.18 ± 0.54	38.56 ± 2.83	0.57	*Forage*
2.	BIS OP-61	8.04 ± 0.34	2.18 ± 0.07	14.64 ± 2.08	2.95 ± 0.31	43.32 ± 2.57	0.74	*Forage*
3.	Beniazuma Papua	5.48 ± 0.48	2.06 ± 0.16	10.18 ± 0.64	2.38 ± 0.13	46.16 ± 0.88	0.87	*Forage*
4.	Solossa	8.52 ± 0.81	2.97 ± 0.23	11.28 ± 1.74	2.60 ± 0.47	55.01 ± 6.71	1.14	*Low Dual Purpose*
5.	BIS OP-4	11.20 ± 1.82	3.55 ± 0.63	13.07 ± 1.24	2.98 ± 0.16	51.75 ± 4.13	1.19	*Low Dual Purpose*
6.	Beta 1	11.79 ± 0.68	4.17 ± 0.39	12.30 ± 1.22	2.84 ± 0.28	59.45 ± 0.53	1.46	*Low Dual Purpose*
7.	D67	6.63 ± 0.68	2.20 ± 0.24	5.95 ± 0.56	1.45 ± 0.15	60.26 ± 0.28	1.52	*High Dual Purpose*
8.	Ayamurasakhi Kuningan	8.63 ± 0.38	3.38 ± 0.19	6.25 ± 0.47	1.96 ± 0.12	63.35 ± 0.27	1.72	*High Dual Purpose*
9.	Merah	12.78 ± 0.36	3.37 ± 0.10	9.78 ± 0.37	1.90 ± 0.11	64.02 ± 1.88	1.77	*High Dual Purpose*
10.	Sawentar	12.04 ± 0.70	4.66 ± 0.29	12.21 ± 0.94	2.61 ± 0.24	64.19 ± 2.03	1.78	*High Dual Purpose*
11.	Jago	10.79 ± 0.28	3.62 ± 0.19	8.28 ± 0.06	1.94 ± 0.09	64.99 ± 0.64	1.86	*High Dual Purpose*
12.	Beta 2	13.76 ± 0.53	4.41 ± 0.44	9.05 ± 0.63	2.30 ± 0.29	66.10 ± 1.09	1.91	*High Dual Purpose*
13.	73 OP-5 Kuningan	18.22 ± 0.53	5.61 ± 0.22	12.38 ± 0.97	2.79 ± 0.16	66.72 ± 2.16	2.01	*High Dual Purpose*
14.	Putih	13.17 ± 1.13	4.46 ± 0.37	8.42 ± 0.50	2.13 ± 0.25	68.16 ± 0.87	2.09	*Low Root Production*
15.	Sari	12.27 ± 0.78	3.88 ± 0.24	6.78 ± 0.63	1.82 ± 0.16	68.34 ± 0.70	2.13	*Low Root Production*
16.	73 OP-8	13.00 ± 0.72	4.43 ± 0.29	8.22 ± 0.38	1.63 ± 0.06	72.75 ± 1.52	2.71	*Low Root Production*
17.	73-6/2	10.63 ± 0.43	3.55 ± 0.16	4.98 ± 1.89	1.26 ± 0.05	73.67 ± 2.83	2.81	*Low Root Production*

Remarks: Ratio R/V 0 – 1.0 (forage); 1.0 – 1.5 (*Low dual purpose*); 1.5 – 2.0 (*High dual purpose*); 2.0 – 3.0 (*Low root production*); > 3.0 (*High root production*)

Table 2. Fresh storage roots, dry weight storage roots, fresh vines weight, vines dry weight, harvest index (HI) and the ratio of total dry matter of roots to vines (R/V) of 17 sweet potatoes planted in Blitar

No.	Cultivar	Fresh storage root weight (t/Ha)	Storage root dry weight (t/Ha)	Fresh vines weight (t/Ha)	Vines dry weight (t/Ha)	Harvest Index (HI, %)	R/V	Criteria
1.	Cangkuang	0.63 ± 0.28	0.21 ± 0.09	43.06 ± 4.27	6.64 ± 0.74	2.74 ± 0.94	0.03	forage
2.	BIS OP-61	0.39 ± 0.57	0.12 ± 0.23	44.17 ± 6.28	5.24 ± 0.58	28.00 ± 8.63	0.02	forage
3.	Beniazuma	0.57 ± 1.60	0.23 ± 0.49	33.06 ± 5.63	4.35 ± 0.85	22.12 ± 7.92	0.05	forage
4.	Papua Solossa	1.28 ± 0.25	0.49 ± 0.08	50.97 ± 3.50	5.72 ± 0.45	9.08 ± 1.75	0.09	forage
5.	BIS OP-4	1.89 ± 0.53	0.59 ± 0.20	43.33 ± 2.50	4.25 ± 0.44	16.84 ± 3.43	0.14	forage
6.	Beta 1	0.25 ± 0.12	0.10 ± 0.05	56.67 ± 1.58	5.97 ± 0.22	1.56 ± 0.72	0.02	forage
7.	D67	1.72 ± 0.29	0.63 ± 0.12	18.33 ± 3.31	2.83 ± 0.33	5.85 ± 3.07	0.22	forage
8.	Ayamurasakhi	2.67 ± 1.04	1.02 ± 0.26	32.36 ± 1.68	3.28 ± 0.32	25.53 ± 1.91	0.31	forage
9.	Kuningan Merah	0.13 ± 1.33	0.05 ± 0.47	43.47 ± 3.73	5.05 ± 0.52	40.25 ± 13.97	0.01	forage
10.	Sawentar	2.94 ± 0.13	1.14 ± 0.04	58.33 ± 1.21	6.98 ± 0.15	2.36 ± 0.79	0.16	forage
11.	Jago	0.37 ± 0.13	0.14 ± 0.05	41.53 ± 2.86	5.27 ± 0.56	3.31 ± 1.48	0.03	forage
12.	Beta 2	4.03 ± 0.24	1.21 ± 0.06	41.81 ± 1.47	4.32 ± 0.13	12.20 ± 0.95	0.28	forage
13.	73 OP-5	4.78 ± 0.71	1.47 ± 0.27	40.83 ± 2.32	4.05 ± 0.33	14.14 ± 3.47	0.36	forage
14.	Kuningan Putih	1.72 ± 0.04	0.53 ± 0.01	43.61 ± 4.45	5.60 ± 0.56	0.91 ± 0.29	0.10	forage
15.	Sari	4.44 ± 0.23	1.41 ± 0.08	35.97 ± 3.19	5.36 ± 0.22	7.72 ± 1.03	0.26	forage
16.	73 OP-8	4.92 ± 0.31	1.64 ± 0.09	47.78 ± 2.86	4.13 ± 0.31	21.96 ± 1.10	0.40	forage
17.	73-6/2	3.98 ± 0.99	1.39 ± 0.31	16.25 ± 1.40	2.16 ± 0.12	27.39 ± 3.99	0.64	forage

Remarks: Ratio R/V 0 – 1.0 (forage); 1.0 – 1.5 (*Low dual purpose*); 1.5 – 2.0 (*High dual purpose*); 2.0 – 3.0 (*Low root production*); > 3.0 (*High root production*)

Type Change of Sweet Potato Performance

Planting 17 cultivars in Malang and Blitar took at different periods of the season. The research in Malang was conducted in dry season, while in Blitar in rainy season. The difference was characterized by rainfall. Rainfall volume in Malang was different from Blitar (Table 3)

Table 3. Rainfall distribution during the trials in Malang and Blitar

Location	Month	Rainfall Distribution (mm/month
Malang	May 2013	31
	June 2013	203
	July 2013	24
	August 2013	0
	Sept 2013	0
Total Rainfall		258
Blitar	Sept 2013	0
	Oct 2013	39
	Nov 2013	190
	Des 2013	806
	Jan 2014	497
Total Rainfall		1532

Remarks: Karangploso Climatology Station, Malang (2014)

All cultivars planted in Blitar were classified to forage type (Table 2), whereas in Malang on the same cultivars showed four types, respectively forage, a low dual-purpose, a high dual-purpose and a low root production (Table 1). This suggests a change of an environmental condition, specifically on changes in the volume of excessive rainfall in the last 2 months affected the growth of sweet potato in Blitar, and as a result, vegetative growth was dominant compared to storage root formation. Fresh storage root yield of all cultivars only ranged between 0.13 - 4.92 t/ha or 0.02 - 1.64 t/ha on dry weight, whereas fresh vines reached 16-51t/ha or 2-7 t/ha on dry weight. Based on harvest index, they ranged between the lowest 2% and the highest 40% (Table 2). Thus, the sweet potato growth was strongly influenced by the changes of environmental conditions, especially by rainfall. Hartemink *et al*. (2000) showed that the rainfall has positive correlation (r = 0.866) with vines yield and negative correlation (r = - 0.601) with marketable storage roots yield and non-marketable storage roots yield (r = - 0.814). as the trial conducted at Hobu PNG with altitude 405 m above the sea and with average rainfall 1897 mm. As Nedunchezhiyan *et al*., (2012) stated that sweet potato requires a moderately warm climate (21 – 26^{0}C) with soil pH 5.5 – 6.5. Heavy rainfall, high temperature and excess cloudiness encourage vegetative growth.

The range of storage roots of dual-purpose sweet potato types between 7-18 t/ha (Table 1). The yield was still relatively low compared to its potential yield (Saleh and Hartojo, 2003), since the potential yield of sweet potato ranged from 30 to 40 t/ha. The low yields of storage root was caused by availability of nutrients in the location as presented in Table 4.

One of the soil types in Malang is Alfisol which has a pH of acid, very low C-org and N, and also K and Ca, although the P-content of the soil is high (Table 4). For sweet potato, the availability of K is very low that is to say it can be a limiting factor in the formation of storage root, and it was caused by disturbed photosynthate translocation from source to zink. According to George *et al.,* (2002), potassium is very much important in sweet potato production as it influences cell division, tuberous root initiation and thickening, photosynthesis – formation of carbohydrates and translocation of sugar.

The process of formation and enlargement of storage root sweet potato required nutrients in sufficient kalium quantities (Endah *et al*., 2006). Potassium fertilizer application up to a dose of 120 kg K2O/ha for Narutokintoki varieties in paddy soil produced a large amount to 16.32 t/ha, and without fertilizer of potassium only produced 5.77 t/ha (Putra and Permadi, 2011). Similarly, the study of Paulus (2011), for a dose of 108 kg K2O/ha in which sweet potato was cultivated in an intercropping system with maize, produced 16.83 t/ha storage root yield. Thus, in these trials, in Malang and Blitar, with a dose of 250 kg NPK (15-15-15), it only provided potassium as much as 37.5 kg K2O/ha. It was estimated to be the cause of the low yields of sweet potato. In Hubei Province, low soil fertility – especially low availability of K, is presently restricting yield of sweet potato. The optimal K rate in this area varies from 150 to 300 kg K_2O/ha, but on an average storage root weight and starch content increased with K rate up to an optimum of 225 K_2O/ha, reached 25.8 t/ha flesh yield and 6.59 t/ha starch yield respectively (Lu *et al*., 2001).

Table 4. Soil analysis of location in Malang and Blitar

Location	Soil Type	pH 1:1		C-org (%)	N-total (%)	P (mg/kg)		K	Ca
		H_2O	KCl 1N			Bray1	Olsen	NH_4OAC 1 N pH 7 me/100 g	
Malang	Alfisol	5.4	4.5	0,59	0.05	12.65	-	0.09	0.06
Criteria*)		Acid		Very low	Very low	High		Very low	Very low
Blitar	Vertisol	6.6	5.6	1.35	0.11	-	17.98	0.22	22.24
Criteria *)		Netral		Low	Low		High	Low	Very high

Remarks: *) Balittanah (2005)

Ten cultivars of sweet potato dual-purpose group produced fresh vines weight ranged from 6-13 t/ha and HI ranged between 51-67% (Table 1). It was expected that if it did not happen in a limiting factor of a low availability of potassium (Table 4), the potential of fresh vines yield could also be increasing, so that the availability of fodder source can be higher.

Table 1 shows that there is a type of a low root production, but none of them can be classified in the group of a high root production. Kuningan Putih and Sari cultivars, as well as, 73 OP-8 and 73-6/2 clones were included into the sweet potato of a low root production type. The four cultivars are more appropriate to cultivate for food, because the vines yield is only ± 30% of biomass total or its HI ranged from 68 to 74% (Table 1).

Thus, the 17 cultivars planted and evaluated their storage root weight, vines weight, and harvest index, used the ratio of R/V are able to distinguish between cultivars suitable for forage, dual purpose or root production. Cultivar type in different groups was combined with each other to meet the crop-livestock systems in order to be appropriate to agricultural concept of sustainable bio-industry.

CONCLUSIONS

The results showed that there were 10 cultivars of dual-purpose types among 17 of sweet potato cultivars evaluated in Malang, however all cultivars were turned into forage type in Blitar. The change of rainfall and nutrient availability decreases the dual-purpose of sweet potato's ability to produce the storage roots for food and increasing to produce the vines for feed source of livestock.

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