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Effect of Potassium Application on Yield-Related Characters and Contents of Starch and Hydrocyanic Acid of Cassava

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ABSTRACT: Higher level of KCl application stimulated both leaf area index and leaf area duration in all cassava varieties, while the leaf and tuber number of the bitter varieties (*high cyanide-level varieties*) decreased in proportion to the level of KCl application. The root/shoot (R/S) ratio and harvest index (HI) were negatively related with the level of KCl application in all cassava varieties. The bitter varieties obtained the lowest R/S ratio at the level of 100 - 150 kg KCl ha^{-1}, while the sweet varieties (*low cyanide-level varieties)* acquired the highest values at the level of 50 - 150 kg KCl ha^{-1}. Also, the sweet varieties showed the lowest HI at the level of 250 kg KCl ha^{-1}, but the bitter varieties at the level of 150 kg KCl ha^{-1}. At 6 - 8 months after planting, the sweet varieties tended to obtain higher starch content of roots (tubers) at the level of 50 - 150 kg KCl ha^{-1}, while the bitter varieties at the level of 150 - 250 kg KCl ha^{-1}. Relatively lower level of 50 - 150 kg KCl ha^{-1} was more appropriate for decreasing hydrocyanic acid (HCN) content of roots (tubers) in the sweet varieties at the harvest time, and the level of 250 kg KCl ha^{-1} was adequate to decrease not only HCN content of leaves but also that of roots (tubers) in the bitter varieties during the growing period. To obtain higher yield and starch content of tubers, and lower HCN content of roots (tubers), it was recommended that the sweet varieties are applied with the level of 50 - 100 kg KCl ha^{-1} and the bitter varieties with the level of 150 - 200 kg KCl ha^{-1}, respectively, in Latosol soils of Bogor areas, West Java.

Keywords: Cassava, potassium chloride, yield-related characters, starch, hydrocyanic acid

Improving tuber production with higher starch content while decreasing hydrocyanic acid (HCN) content for human diet safety in cassava (*Manihot esculenta* Crantz) have been emphasized for a long time in many tropical countries including Indonesia (Bradbury & Warren, 1988; O'Hair, 1995; Hidayat *et al.*, 2000; Hartojo *et al.*, 2001; Wargiono *et al.*, 2001; Jennings & Iglesias, 2002).

Generally, cassava removes large quantities of potassium (K) from soil compared with other macro elements such as nitrogen or phosphorus (Grace, 1977; Ekanayake *et al.*, 1998) and utilizes K more efficiently in the production of dry matter (DM) in contrast to other upland crops including maize (Spear *et al.*, 1978a). Because K determines photosynthetic efficiency (Spear *et al.*, 1978b; Wargiono, 1990), stimulates tuber development in both number and length of tubers (Noor, 1997), affects system and weight of root (Spear *et al.*, 1978a), and accelerates the translocation of assimilates from source to sink (Juo, 1974; Suryatna, 1979; Wargiono, 1979; Cock, 1986), cassava tuber yields are highly affected by the existence of K.

Besides, K promotes the formation of starch (Ekanayake *et al.*, 1998), but reduces HCN content in cassava (Cock, 1986; Suherman *et al.*, 1991; Ekanayake & Bokanga, 1995). According to Howeler (2002), the starch content of cassava roots was increased by K_2O application up to 80-100 kg ha^{-1} and then it was decreased at higher rates. De Bruijn (1971), Duke (1983), Lingga *et al.* (1986), and Ekanayake & Bokanga (1995) observed that HCN content tended to be increased by K deficiency. For those reasons, in cassava, K application is an important factor, which determines both yield and quality of roots. Therefore, determining optimum K application level is being successively emphasized in cassava in order to increase yield and starch content of tuber along with decreasing HCN content of roots (Wargiono, 1990; Ekanayake *et al.*, 1997; Howeler, 2002).

This study was carried out to observe the effect of potassium application on the yield-related major characters and the content of starch and HCN, and to screen their relationships in sweet and bitter varieties of cassava.

MATERIALS AND METHODS

General methods

Two experiments were carried out at two field sites, which had different cultivars with the same treatment in Bogor Education Center, Education Office of Bogor district, West Java, Indonesia. Cultivars for the first experiment were Adira1 (*a low cyanide-level* or *sweet variety*) and Adira4 (*a*

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high cyanide-level or *bitter variety*), while the second experiment was conducted with Valenca (*a low cyanide-level* or *sweet variety*) and Pucuk Biru (*a high cyanide-level* or *bitter variety*).

The first experiment was conducted in the Karadenan field (141 - 163 m above sea level), Bogor, West Java, from March to November 2002, while the second experiment was carried out in the Nanggewer field (140 - 158 m above sea level), Bogor, West Java, from March to November 2003. The soil pH of the Karadenan field ranged between 4.32 and 5.28, while that of the Nanggewer field between 4.32 and 4.51. The dry season ranged from May to October in 2002, while from June to September in 2003 (Committee of Meteorology and Geophysics, 2002, 2003). Split plot design with 3 replications was used in each experimental field. The size and planting density of each plot were 33.6 m^2 and 39 plants $plot^{-1}$, respectively. The factorial components of each experiment were varieties (Adira1 & Adira4 or Valenca & Pucuk Biru) X KCl application levels (0, 50, 150, 250 kg ha^{-1}) = 8, and these components were apportioned to main plot and split plot, respectively. N (urea) of 200 kg ha^{-1} and P (TSP) of 150 kg ha^{-1} were also applied in all experiments.

Fertilizers were applied with twice-split top dressing; the first top dressing was applied with the ratio of N (1/3) + P (All) + K (1/2) at one week after planting, while the second one with the ratio of N (2/3) + P (0) + K (1/2) at 2 months after planting (MAP). After all experiments were finished, data of each experiment were combined together into *sweet varieties* or *bitter varieties* to take the mean values. Cultivation was carried out by modifying the standard cultural practices (MOA, 2000) and other methods recommended (Zuraida, 1993; Ekanayake *et al.*, 1997; George *et al.*, 2001): twice plowing and ridging with a height of 15 - 20 cm before planting; 20 cm long stem-cuttings for planting were taken from the lower 75 cm from the apex of more than 10 month-old plant stems after the distal 20 cm had been discarded; these stem-cuttings were planted vertically by hand in 3 rows per plot with a planting space of 100 cm × 60 cm and a depth of 5 - 10 cm below the soil surface; weeding was done until 6 MAP. The number of nodes per stem-cutting (n=20) prepared for planting was 17.8 in Adira1, 8.9 in Adira4, 13.3 in Valenca, and 13.3 in Pucuk Biru, respectively.

Soil potassium of the field

Total-K (Yoshida *et al.*, 1976) and exchangeable-K (Hidayat, 1978) were determined to investigate the initial condition of soil K in the second experimental field as a sample test before planting and fertilizer application at Indonesian Center for Agricultural Biotechnology and Genetic Resources Research and Development. Total-K varied from 28.5 to 39.5 ppm with a mean value of 33.0 ppm and exchangeable-K from 6.1 to 8.6 ppm with a mean value of 6.9 ppm, respectively.

Yield-related major characters

Leaf number, total leaf area (m^2), tuber number, shoot dry weight (g), and root (tuber) dry weight (g) per plant were investigated with three plants in each treatment and replication harvested every 2 months after planting (MAP). The total leaf area was examined by the length-breadth method using specific leaf area (Wani *et al.*, 2001; Park *et al.*, 2005), while the shoot dry weight and root (tuber) dry weight were measured by the dry method (Hidayat, 1978; Bradbury & Warren, 1988) at Indonesian Center for Agricultural Biotechnology and Genetic Resources Research and Development.

Also, root/shoot (R/S) ratio (g g^{-1}), leaf area index (m^2 m^{-2}, LAI), leaf area duration (m^2 · day, LAD), and harvest index (HI) were determined using the methods described by O'Hair (1995), Sung & Lee (1997), and Ekanayake *et al.* (1998).

Analyses of starch and hydrocyanic acid contents

Starch content (%) of roots (tubers) using the spectrophotometric method (Yoshida *et al.*, 1976; LSC, 1999), and hydrocyanic acid (HCN) content of leaves (mg eq 100 g^{-1} fresh basis) and roots (tubers) (mg eq 100 g^{-1} fresh peeled basis) using the alkaline picrate method (Bradbury *et al.*, 1999; LSC, 1999; Ernesto *et al.*, 2000; Hidayat & Damardjati, 2003) were determined with three plants in each plot every 2 MAP.

RESULTS AND DISCUSSION

Potassium effect on yield-related major characters

Even though the sweet varieties increased the leaf number in proportion to the KCl application levels and obtained the highest values at the level of 250 kg KCl ha^{-1}, the leaf number of bitter varieties was decreased by higher rates of KCl application showing the lowest leaf number at the level of 250 kg ha^{-1} (Fig. 1). Nevertheless, the LAI of all varieties increased in proportion to the KCl application levels and showed the highest values at the level of 250 kg KCl ha^{-1} (Fig. 1). Therefore, it seemed that higher levels of K fertilizer might promote the development of leaf or leaf area, especially in the sweet varieties. However, it may cause higher competition for assimilates between shoot and root affecting the tuber yield, after the canopy establishment (vegetative) phase. This result supported the observation by Cock (1985), which reported that cassava plant adjusts its top growth in relation to the availability of major nutrients, and higher levels of fertilizer application tend to decrease cassava yields due to maintaining a high nutrient status in

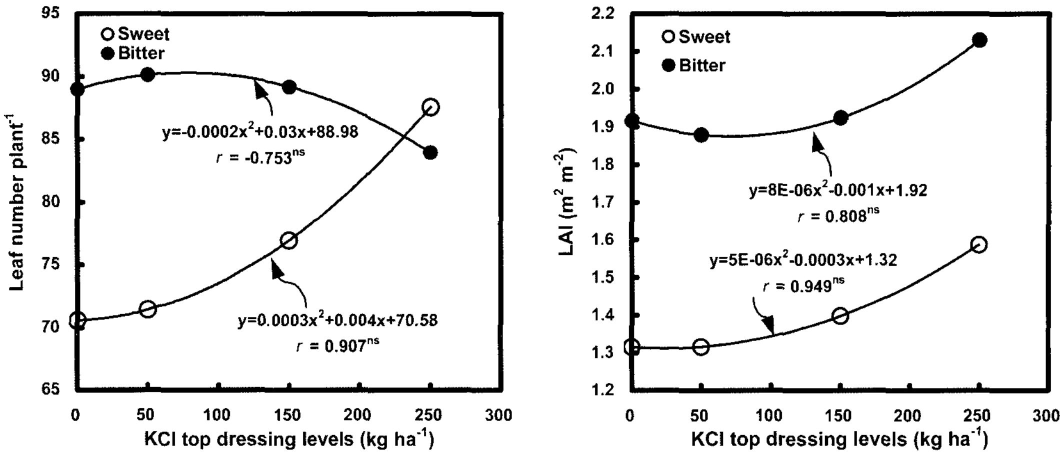

Fig. 1. Effect of KCl top dressing on leaf number (left) and leaf area index (LAI) (right) during growing period in cassava varieties.

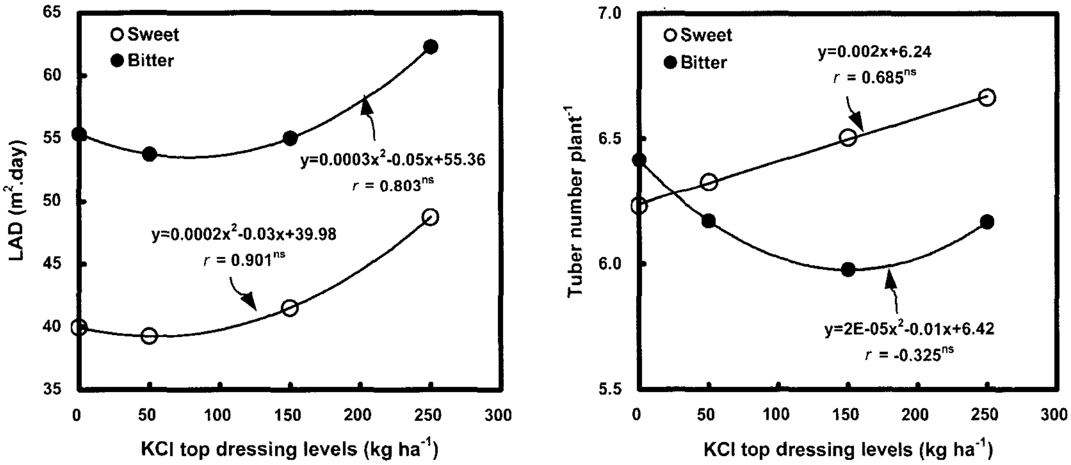

Fig. 2. Effect of KCl top dressing on leaf area duration (LAD) (left) and tuber number (right) during growing period in cassava varieties.

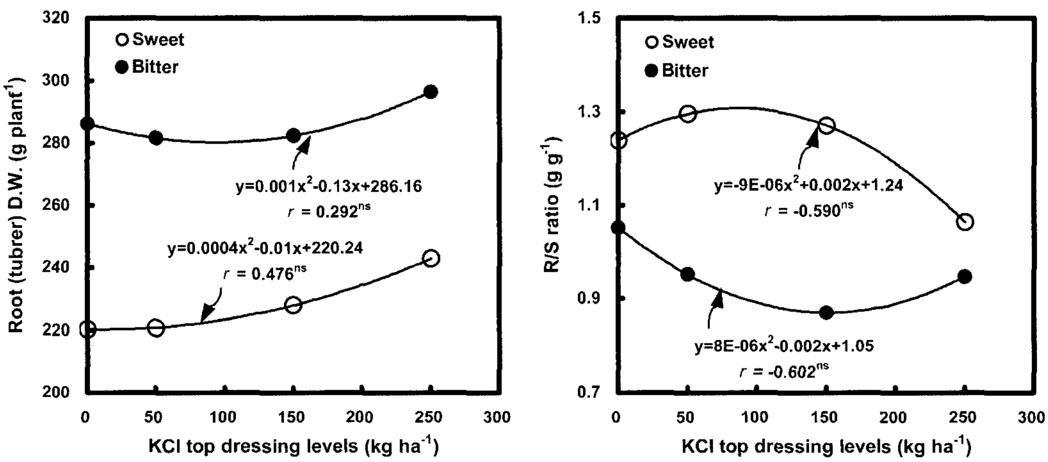

Fig. 3. Effect of KCl top dressing on root (tuber) dry weight (left) and root/shoot (R/S) ratio (right) during growing period in cassava varieties.

the leaves, giving a healthy-looking.

The LAD increased in proportional to the KCl application levels and the level of 250 kg KCl ha^{-1} gave the highest values in all varieties (Fig. 2). However, the tuber number of the bitter varieties decreased in proportion to the KCl application levels and obtained the lowest values at the level of 100 - 150 kg KCl ha^{-1}, even though the sweet varieties showed a linear relationship between the tuber number and the KCl application (Fig. 2). Therefore, too higher levels of K application may bring lower tuber yield, especially in the bitter varieties, even if it has been known that K can stimulate the number, length, and weight of tubers (Noor *et al.*, 1990; Noor, 1997). For that reason, it is important to maintain optimum K levels in soils in order to prevent an excessive development of shoot, which may cause higher competition for assimilates (Howeler, 2002).

The root (tuber) dry weight tended to increase in proportion to the KCl application levels in all varieties but the relationship was not linear (Howeler, 2002). The R/S ratio of all varieties, moreover, was negatively related with the KCl application levels (Fig. 3). Therefore, higher K levels stimulated the accumulation of more DM in shoot than root, especially in the bitter varieties (Fig. 3). Sugito & Guritno (1990) also observed a similar result that K fertilizer tended to increase shoot weight of cassava.

The results described above showed that varietal responses to K application were different in yield-related major characters, mainly in the leaf number, tuber number, and root (tuber) dry weight. As shown in Fig. 3, the bitter varieties obtained the lowest R/S ratio at the level of 100 - 150 kg KCl ha^{-1}, while the sweet varieties showed the highest values at the level of 50 - 150 kg KCl ha^{-1}. For maximum root yield, the appropriate fertilizer level should be below the level required for maximum plant growth or for maximum root yield as opposed to total dry weight, because cassava has relatively low nutrient requirements (Cock, 1985). Therefore, it was generally supposed that the adequate KCl application level is 50 - 100 kg ha^{-1} for the sweet varieties and 150 - 200 kg ha^{-1} for the bitter varieties, respectively.

Potassium effect on the content of starch and hydrocyanic acid

During the growing period, the starch content of roots was not different significantly and it did not show certain patterns of increase or decrease among the levels of KCl application in all varieties (Table 1). The reason that the effect of the KCl application on the starch content of roots was less expressed may because higher initial available-K existed in the experimental field soils or an efficient K absorption by roots was obstructed by the field soils showing strong acid or acid condition (Marschner, 1995; How-

Table 1. Changes of the starch content (%) of roots (tubers) by KCl top dressing levels (PT, kg ha^{-1}) during growing period in cassava varieties.

Varieties (V)	PT (K)	Month after planting (MAP)			
		2	4	6	8
Sweet[1)]	0	19.10	53.39	61.48	66.88
	50	18.15	52.10	63.42	64.37
	150	14.93	54.70	62.72	67.18
	250	17.27	52.62	62.47	65.68
Bitter[2)]	0	16.11	51.63	61.56	63.03
	50	19.18	46.70	57.70	58.69
	150	17.47	43.65	63.56	64.32
	250	15.61	51.36	65.91	62.62
F-value	V	0.04^{ns}	38.31*	0.03^{ns}	8.51^{ns}
	K	1.54^{ns}	1.01^{ns}	1.42^{ns}	3.33^{ns}
	V×K	1.86^{ns}	1.74^{ns}	2.01^{ns}	0.41^{ns}
LSD 0.05	V	6.11	3.38	8.71	5.69
	K	2.84	5.28	4.20	3.09
	V_1K_1-V_1K_2	4.01	7.47	5.94	4.37
	V_1K_1-V_2K_1	6.66	7.12	9.57	6.46

[1)]Mean value of Adira1 (planted in 2002) and Valenca (planted in 2003).
[2)]Mean value of Adira4 (planted in 2002) and Pucuk Biru (planted in 2003).
*Significant at P=0.05 (LSD), **Significant at P=0.01 (LSD), ^{ns}Not significant.

eler, 2002).

However, at 6 - 8 MAP, the sweet varieties tended to obtain higher starch content of roots at the level of 50 - 150 kg KCl ha^{-1} and the bitter varieties at the level of 150 - 250 kg KCl ha^{-1}, respectively (Table 1). It has been generally known that K accelerates the translocation of assimilates from leaves to tubers (Marschner, 1995), promotes the production of starch (Grace, 1977; Suherman *et al.*, 1991), and affects the root quality in cassava (Ekanayake *et al.*, 1997).

Even though the HCN content of leaves did not show any significant differences among the KCl application levels until 6 MAP in all varieties, the sweet varieties tended to obtain the lowest HCN content of leaves at the level of 250 kg KCl ha^{-1} of 2 - 4 MAP. Also, these varieties obtained significantly lowest HCN content of leaves at the level of 150 kg KCl ha^{-1} of 8 MAP but the rate of 50 kg KCl ha^{-1} seemed to increase the HCN content of leaves during the growing period, particularly at 8 MAP (Table 2). On the other hand,

Table 2. Changes of the HCN content (mg 100 g^{-1} f.w.) of leaves and roots by KCl top dressing levels (PT, kg ha^{-1}) during growing period in cassava varieties.

Plant part	Varieties (V)	PT (K)	Month after planting (MAP)			
			2	4	6	8
Leaf	Sweet[1)]	0	77.98	67.96	59.68	68.21
		50	87.91	79.75	66.60	89.32
		150	82.41	77.83	71.12	64.64
		250	65.53	61.03	71.50	74.50
	Bitter[2)]	0	89.64	92.41	71.38	90.67
		50	86.59	87.54	86.19	91.13
		150	87.54	100.32	76.13	81.43
		250	83.68	76.15	71.02	80.93
	F-value	V	1.84^{ns}	4.08^{ns}	27.91*	10.86^{ns}
		K	1.20^{ns}	2.98^{ns}	0.91^{ns}	4.04*
		V×K	0.68^{ns}	0.57^{ns}	0.80^{ns}	1.70^{ns}
	LSD 0.05	V	26.64	37.21	7.29	15.50
		K	15.65	15.48	14.88	11.14
		V_1K_1-V_1K_2	22.13	21.89	21.05	15.76
		V_1K_1-V_2K_1	31.01	39.68	19.31	19.56
Root	Sweet[1)]	0	16.94	15.29	16.02	18.90
		50	18.55	18.51	20.32	18.38
		150	14.39	14.09	34.35	18.93
		250	13.03	12.67	17.36	35.59
	Bitter[2)]	0	18.72	43.45	36.36	35.89
		50	21.14	38.82	28.18	35.11
		150	13.45	28.22	40.36	38.17
		250	17.76	38.92	33.75	35.77
	F-value	V	1.73^{ns}	27.36*	34.47*	2.14^{ns}
		K	1.71^{ns}	2.17^{ns}	11.01**	0.62^{ns}
		V×K	0.34^{ns}	1.57^{ns}	3.49*	0.17^{ns}
	LSD 0.05	V	6.68	18.27	9.27	39.11
		K	6.17	7.80	5.63	16.14
		V_1K_1-V_1K_2	8.73	11.03	7.97	22.83
		V_1K_1-V_2K_1	9.63	19.58	10.92	41.65

[1)]Mean value of Adira1 (planted in 2002) and Valenca (planted in 2003).
[2)]Mean value of Adira4 (planted in 2002) and Pucuk Biru (planted in 2003).
*Significant at P=0.05 (LSD), ** Significant at P=0.01 (LSD), ^{ns}Not significant.

the bitter varieties were able to obtain the lowest HCN content of leaves at the level of 250 kg KCl ha^{-1} during the growing period, and the level of 150 kg KCl ha^{-1} followed it at 8 MAP. Nevertheless, the HCN content of leaves tended to be somewhat higher at the level of 50 kg KCl ha^{-1} from 6 MAP like in the sweet varieties (Table 2).

Therefore, the HCN content of leaves of all varieties could be reduced by higher rate of 150 - 250 kg KCl ha^{-1}, particularly at the early growth phase, while lower level of 50 kg KCl ha^{-1} was less effective and rather increased the HCN content of leaves during the growing period (Table 2). These results generally agreed with other observations (De Bruijn, 1971; Wargiono, 1990; Ekanayake & Bokanga, 1995) reporting that lower level of K may increase the HCN of cassava. It was also considered that because of their genetic characteristic, *i.e.*, high cyanide-level genotype, the bitter varieties require much higher level of K than the sweet varieties to obtain lower level of HCN.

The HCN content of roots of the sweet varieties tended to be decreased by the level of 150 - 250 kg KCl ha^{-1} until 4 MAP (Table 2) but these application levels seemed to increase the HCN content of roots again after 4 MAP. As a result, these varieties obtained the highest HCN content of roots at the level of 150 kg KCl ha^{-1} of 6 MAP and at the level of 250 kg KCl ha^{-1} of 8 MAP, respectively. On the contrary, the level of 50 kg KCl ha^{-1} was able to give the lowest HCN content of roots at 8 MAP in the sweet varieties, even if it was not significant. In the bitter varieties, the rate of 150 kg KCl ha^{-1} seemed to give the lowest HCN content of roots until 4 MAP and then tended to increase the HCN content of roots again, showing the highest values at 8 MAP. However, the level of 50 kg KCl ha^{-1} gave the lowest HCN content of roots from 6 MAP and it was followed by the level of 250 kg KCl ha^{-1} (Table 2). Also, there was a significant interaction effect of variety × KCl application on the HCN content of roots at 6 MAP, and it seemed that the bitter varieties were more responsive to the KCl application than the sweet varieties.

After all, even though higher level of KCl application tended to decrease the HCN content of roots at the early developmental phase, lower rate of KCl application was more effective at the harvest time (Table 2). It was considered that although optimum level of K suppresses the biosynthesis of cyanogenic glucosides from its precursors, *i.e.*, *valine* and *isoleucine*, in the cell membrane of cassava tissues (De Bruijn, 1971; UGT, 1972), more than optimum level of K application may cause an adverse effect on the control function, especially in the sweet varieties. Also, because the enzyme linamarase is synthesized from leaves and then transported to roots (Wargiono, 1990; Santana *et al.*, 2002), higher level of K application promoting the development of leaf and leaf area (Fig. 1) may have increased the formation and translocation of this enzyme, particularly in the sweet varieties. Nevertheless, the reason the bitter varieties were more responsive to higher level of K than the sweet varieties may be due to their genetic characteristic of high cyanide-level genotype.

In summary, even though higher level of 250 kg KCl ha^{-1} seemed to be more effective on reducing both HCN content of leaves and that of roots in the sweet varieties at the early developmental phase, the level of 50 - 150 kg KCl ha^{-1} was supposed to be more appropriate for decreasing the HCN content of roots at the harvest time. On the contrary, in the bitter varieties, the rate of 250 kg KCl ha^{-1} was considered to be good enough to decrease both HCN content of leaves and that of roots during the growing period, and lower level of

Table 3. Simple correlation between major chemical constituents and KCl top dressing during growing period in cassava varieties†.

Chemicals	Varieties	Month after planting (MAP)				Mean
		2	4	6	8	
HCN of leaves	Total[1)]	-0.778	-0.512	0.268	-0.476	-0.574
	Sweet[2)]	-0.684	-0.453	0.887	-0.163	-0.308
	Bitter[3)]	-0.859	-0.486	-0.339	-0.917	-0.816
HCN of roots	Total	-0.697	-0.609	0.224	0.891	0.788
	Sweet	-0.889	-0.732	0.215	0.831	0.761
	Bitter	-0.450	-0.421	0.178	0.266	-0.475
Starch of roots	Total	-0.738	-0.004	0.903	0.220	0.331
	Sweet	-0.587	0.065	0.229	0.008	-0.576
	Bitter	-0.396	-0.023	0.790	0.327	0.499

†Correlation coefficients are not significant at P=0.05 (t-test).
1)Examined with the mean value of the 4 test varieties.
2)Examined with the mean value of Adira1 (planted in 2002) and Valenca (planted in 2003).
3)Examined with the mean value of Adira4 (planted in 2002) and Pucuk Biru (planted in 2003).

50 kg KCl ha^{-1} also effectively reduced the HCN content of roots at the harvest time (Table 2).

On average, the HCN content of leaves was negatively correlated with the KCl application levels in all varieties (Table 3). In particular, the bitter varieties continued to show higher negative correlations with the KCl application levels until 8 MAP, while the sweet varieties showed gradually lower correlations. The HCN content of roots was also negatively correlated with the KCl application rates at 2 - 4 MAP in all varieties (Table 3), but, after 4 MAP, their correlations became positive in proportion to the KCl application levels. However, the HCN content of roots of the sweet varieties showed much higher negative correlations at 2 - 4 MAP compared with those of the bitter varieties. Therefore, even if higher level of K may reduce both the HCN content of leaves and that of roots at 2 - 4 MAP in all varieties, the HCN content of roots seemed to be more affected by lower level of K at 6 - 8 MAP, particularly in the sweet varieties.

The starch content of roots was also negatively correlated with the KCl application levels at 2 - 4 MAP (Table 3). However, the correlations became positive from 6 MAP, even though these tended to be lower gradually. Also, on average, the sweet varieties showed relatively higher negative correlation with the KCl application levels. Consequently, these results indicated that higher level of K application might disturb the formation of starch (Marschner, 1995) at the early growth phase and also it might reduce both the HCN content of leaves or roots and the starch content of roots at the storage roots bulking phase, particularly in the sweet varieties.

The relationship between the HI and the KCl application levels was negative in all varieties (Fig. 4), indicating that higher level of K application decreases the ratio of tuber dry weight over total dry weight of the plants. In particular, the level of 250 kg KCl ha^{-1} and 150 kg KCl ha^{-1} gave the lowest HI in the sweet and bitter varieties, respectively, and the reduction of HI was much steeper in the bitter varieties than the sweet varieties. As shown in Fig. 1 & 2, canopy-related major characters were much more stimulated by the KCl application in the bitter varieties than the sweet varieties, while the tuber number and R/S ratio of the bitter varieties steeply decreased in proportion to the level of KCl application compared with the sweet varieties (Fig. 2 & 3). As a result, these indicated that the response of the bitter varieties to K application is much higher enough to develop a larger canopy, and, at the same time, these varieties accelerated the accumulation of more DM in shoot than root under higher level of K application (Maulianna *et al.*, 1977) compared with the sweet varieties. These results supported the observation reported by Marschner (1995) describing that yield response curve are strongly modulated by interactions between mineral nutrients and other growth factors, and that higher levels of fertilizer may cause sink limitation.

The starch content of roots also decreased in proportion to the rate of KCl application in all varieties (Fig. 4). Unlike the sweet varieties, which showed a slow reduction, the starch content of roots of the bitter varieties decreased steeply until the level of 100 kg KCl ha^{-1} and then began to increase again, showing the highest values at the level of 250 kg KCl ha^{-1}. These results were a bit different with Howeler (2002) reporting that the root starch content of cassava was increased by higher K_2O application rate up to 80 - 100 kg ha^{-1} and then decreased at higher rates of K application. This seemed to be mainly due to the varietal difference of responsiveness to K. As a result, both yield potential and starch content of roots may decrease when K is applied with higher rates, especially in the sweet varieties. The bitter varieties, however, seemed to

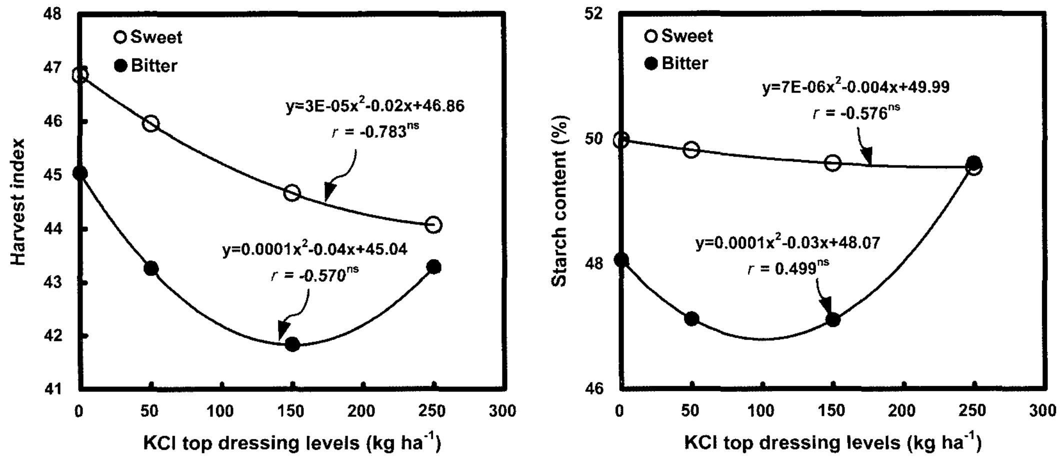

Fig. 4. Effect of KCl top dressing on harvest index (HI) (left) and the starch content of roots (tubers) (right) during growing period in cassava varieties.

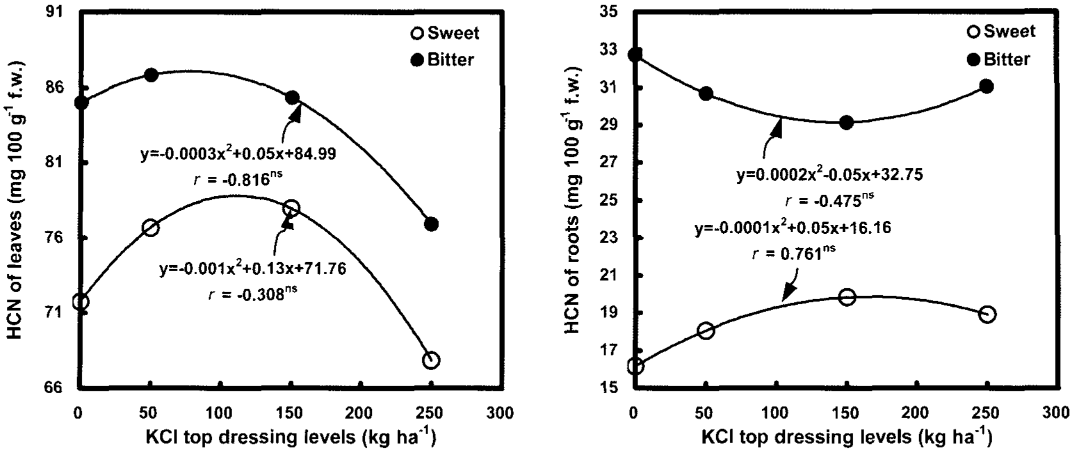

Fig. 5. Effect of KCl top dressing on the HCN content of leaves (left) and roots (right) during growing period in cassava varieties.

require somewhat higher levels of more than 150 kg KCl ha^{-1} for higher starch content of roots (Fig. 4).

The HCN content of leaves of all varieties showed a negative relationship with the level of KCl application and the bitter varieties showed a higher correlation coefficient than the sweet varieties (Fig. 5). However, the HCN content of leaves of all varieties was increased by higher rate of K application up to 100 - 120 kg KCl ha^{-1} and then began to decrease, showing the lowest values at the level of 250 kg KCl ha^{-1}. On the other hand, the HCN content of roots of the bitter varieties decreased in proportion to the level of KCl application, while the sweet varieties showed a positive relationship with a relatively higher correlation coefficient (Fig. 5). Therefore, the bitter varieties obtained the lowest HCN content of roots at higher level of KCl application up to 150 - 200 kg ha^{-1} but the sweet varieties acquired the highest values at the same level of KCl application. As a result, it was considered that the level of 50 - 100 kg KCl ha^{-1} is more appropriate for the sweet varieties, while the level of 150 - 200 kg KCl ha^{-1} for the bitter varieties, respectively, for reducing the HCN content of leaves and roots.

In conclusion, in order to obtain higher yield and starch content of tuber, and lower HCN content of roots (tubers), it was recommended that the sweet varieties are applied with the level of 50 - 100 kg KCl ha^{-1} and the bitter varieties with the level of 150 - 200 kg KCl ha^{-1}, respectively, in Latosol soils of Bogor areas, West Java. However, it seemed that more than 200 kg KCl ha^{-1} may excessively stimulate the growth and development of shoot, causing higher competition for assimilates, after early establishment (vegetative) phase and it also may decrease both yield potential and quality of cassava roots (tubers), particularly in the sweet varieties, even though these higher levels of K are good to reduce the HCN content of leaves of all varieties.

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