Relationship between Characteristics and Germination Ability of Cuttings in Cassava (*Manihot esculenta Crantz*)

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Introduction

Germination ability*** of cassava stem cuttings is one of the important agronomic characters. It depends upon the quality of the cutting itself, growth conditions, and edaphic and climatic factors[1-9,11]. There is a large difference in the germination ability among cassava varieties. Kawano stated that Rayong 1 has a relatively higher germination ability than Rayong 3 under moisture stress, and that the former produced good germination progenies when used as a cross parent (personal communication). Germination rate is lower in the dry season than in the rainy season as observed in major cassava producing areas of Thailand. Onwueme (1978)[10] reported that soil moisture was the most important factor for rooting of cuttings, especially within the first few days after planting when roots were just differentiating from the mass of callus.

In the present study, the main characteristics of cuttings influencing their germination ability were clarified.

Materials and methods

This study was conducted at the Rayong Field Crop Research Center, Department of Agriculture of Thailand, in the dry (March 28–May 23, 1984) and the rainy (September 11–November 6, 1984) seasons. The soil is classified as Gray Podozolic soil of low fertility with a sandy texture. Cassava varieties used were erect Rayong 1 and branching Rayong 3. The cuttings (about 20 cm in length) were taken from the upper, middle and lower parts of the stems (Fig. 1) after the stems were stored for 7 days in the shade of trees. The experimental design involved three parameters; varieties, plant ages, and parts of stems used as cuttings with two replications. The numbers of cuttings used were 65 and 80 per plot in the dry and the rainy seasons, respectively. Cuttings of both varieties were planted at 30×30 cm spacing on March 28 (dry season) and at 40×30 cm on September 11 (rainy season) in 1984. Chemical fertilizers were not applied.

Before planting, the following characteristics of the cuttings were measured; fresh and dry weight, volume, volume density (the ratio of fresh weight to volume), water content, and respiratory rate. The volume was measured by using a measuring cylinder (0.5 or 1.0 *l*). Dry weight was calculated by using dry matter content measured with other 20 cuttings using a drying oven. The respiratory rate was measured with the chamber method using an infra-red gas analyzer (HORIBA Plant Assimilation Analyzer ASSA 1110) immediately after the cuttings were taken from the stems stored under trees.

*** Germination indicates sprouting of cassava cuttings.

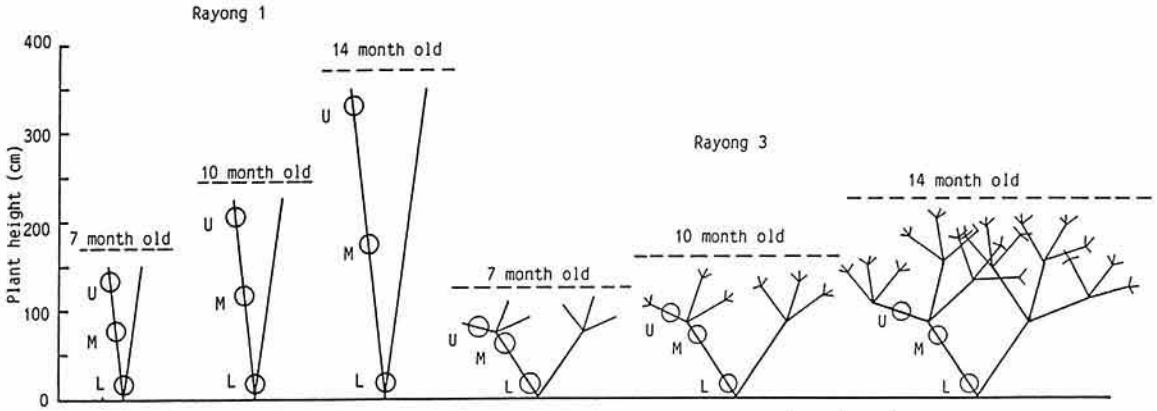

Fig. 1. Parts of the stems used as cuttings and the age of mother plants
Broken line indicates plant height.
Parts of stems: U (upper), M (middle), and L (lower)

Table 1. Characteristics of cassava cuttings used for the experiment in the dry season (March—May, 1984)

Plant age, part of stems	Fresh weight (g)	Volume (cm^3)	Dry weight (g)	Volume density* (g/cm^3)	Water content (%)	Respiratory rate (mg CO_2/g dry wt·hr)
			Rayong 1			
7-month-old plants						
Upper	27	34	8	0.77	71	0.69
Middle	45	54	14	0.84	70	0.57
Lower	66	71	20	0.93	70	0.48
10-month-old plants						
Upper	44	52	10	0.85	77	0.56
Middle	88	89	25	0.99	72	0.40
Lower	126	122	41	1.04	67	0.37
14-month-old plants						
Upper	45	47	9	0.94	79	0.62
Middle	109	110	25	1.00	77	0.36
Lower	134	144	43	0.93	68	0.37
			Rayong 3			
7-month-old plants						
Upper	14	19	5	0.72	65	0.97
Middle	29	35	9	0.83	69	0.66
Lower	49	58	17	0.84	66	0.47
10-month-old plants						
Upper	27	35	9	0.76	69	0.82
Middle	65	74	24	0.88	64	0.58
Lower	77	82	29	0.93	62	0.40
14-month-old plants						
Upper	40	46	16	0.85	61	0.46
Middle	66	76	26	0.86	61	0.39
Lower	78	88	33	0.89	59	0.41

*Volume density indicates fresh weight/volume of cuttings.

Table 2. Characteristics of cassava cuttings used for the experiment in the rainy season (September—November 1984)

Plant age, part of stems	Fresh weight (g)	Volume (cm^3)	Dry weight (g)	Volume density* (g/cm^3)	Water content (%)
			Rayong 1		
7-month-old plants					
Upper	32	53	9	0.61	72
Middle	52	71	14	0.74	73
Lower	70	80	22	0.87	68
14-month-old plants					
Upper	53	63	14	0.84	73
Middle	65	68	22	0.96	67
Lower	84	90	27	0.94	68
			Rayong 3		
7-month-old plants					
Upper	11	19	4	0.57	66
Middle	25	35	8	0.72	69
Lower	41	47	15	0.87	64
14-month-old plants					
Upper	32	37	13	0.87	59
Middle	60	68	21	0.88	64
Lower	75	85	26	0.88	66

* Volume density indicates fresh weight/volume of cuttings.

Table 3. Germination rate (%) as related to plant age and part of stems

Plant age, part of stems	Rayong 1				Rayong 3			
	1	2	4	8 wk*	1	2	4	8 wk*
				Dry season				
7-month-old plants								
Upper	15	29	52	72	72	74	44	19
Middle	50	75	92	82	80	86	79	61
Lower	93	95	97	87	100	100	100	89
10-month-old plants								
Upper	75	84	95	90	100	100	98	85
Middle	100	100	100	99	100	100	100	85
Lower	98	100	100	99	100	100	100	99
14-month-old plants								
Upper	94	96	97	97	96	99	95	86
Middle	100	100	100	95	100	100	99	79
Lower	100	100	100	99	94	96	96	76
				Rainy season				
7-month-old plants								
Upper	3	23	58	28	36	52	29	25
Middle	0	38	75	71	33	70	69	61
Lower	0	61	90	86	36	93	94	90
14-month-old plants								
Upper	0	84	99	90	24	94	94	83
Middle	4	81	100	99	81	97	99	93
Lower	46	99	99	98	91	100	99	94

* Values at 8 weeks after planting represent the survival rate, by excluding the number of cuttings with small sprouts.

Results

1) Characteristics of cuttings

Characteristics of cuttings in the dry season are shown in Table 1. The values of quantitative characteristics; fresh weight, volume and dry weight, were larger in Rayong 1 than in Rayong 3 at any plant age and part of stems, although in both varieties the older and the lower the cuttings, the larger these values were. Volume density was higher in Rayong 1 than in Rayong 3, and it was higher in older and lower cuttings except middle and lower cuttings of 14-month-old Rayong 3. It is interesting to note that the volume density exceeded 1.0 g/cm^3 in lower cuttings of 10-month-old plants of Rayong 1. Water content was apparently higher in Rayong 1 than in Rayong 3, and tended to be high in upper cuttings. On the other hand, the respiratory rate was higher in Rayong 3, and it was high in younger and upper cuttings in both varieties.

Characteristics of cuttings in the rainy season are shown in Table 2. The values for fresh weight, volume, dry weight, volume density, and water content showed the same tendency as observed in the dry season. All these values in the rainy season were generally lower than those in the dry season.

2) Variation in germination rate and survival rate

After measuring the characteristics of cuttings, the cuttings were planted in the field, and germination rate was examined for 8 weeks after planting in both seasons. The results are presented in Table 3. The germination rate observed at the end of 8 weeks represents the survival rate by excluding the number of cuttings with small sprouts.

In Rayong 1, the survival rate was very high, especially in all cuttings taken from 10 and 14-month-old plants. Rayong 3 generally showed the lower survival rate than Rayong 1, and the rate decreased in the middle and lower cuttings from 14-month-old plants. Significant differences in the survival rate between varieties, plant ages and parts of the stems at 1% level were recognized by the analysis of variance.

In the rainy season, the germination rate of Rayong 1 was remarkably lower in the first two weeks than that of Rayong 3, but afterwards it surpassed that of Rayong 3 as clearly shown by cuttings of 7-month-old plants in the dry season. It may be considered that the cuttings of Rayong 3 can easily germinate immediately after planting as compared with those of Rayong 1, because small axillary buds are already prepared before taking the cuttings[9]. On the other hand, no significant difference of the survival rate was observed between both varieties in the rainy season, though the survival rate of Rayong 1 was little higher than that of Rayong 3.

3) Relationship between the characteristics of cuttings and their survival rate

Simple correlation coefficients between the characteristics of cuttings and their survival rate in the dry and the rainy seasons were calculated. The survival rate showed significant positive correlations at 1 or 5% level with all characteristics of cuttings except water content in both seasons. The respiratory rate of cuttings had a significant negative correlation with the survival rate ($r=-0.747^{**}$).

Tables 4 and 5 give the results of the multiple regression analysis conducted to elucidate the main factors determining the survival rate in both seasons. Table 4 lists the result after the independent variables were eliminated one by one until all T-values of variables showed significant correlations at 5% level with the survival rate in the dry season. Consequently, fresh weight (X1), volume (X2), and volume density (X4) remained important variables for the survival rate. The multiple regression of these three variables (X1, X2 and X4) determining the survival rate had a higher F-value than that of all variables (X1–X6) (Table 5). The residual variables,

Table 4. Coefficients and T-values of independent variables for survival rate obtained by multiple regression analysis in the dry season

Variables	Coefficients	Standard error	T-values
Fresh weight	−2.66	1.13	2.36*
Volume	2.47	1.04	2.37*
Volume density	305.70	84.65	3.61**
Constant	−189.20		

Multiple regression coefficient (R) is 0.825**.
*,** Significant at 5 and 1% levels, respectively.

Table 5. Analysis of variance for survival rate in the dry and the rainy seasons

Variations	DF	SS	MS	F
..... Dry season				
Regression (X1—X6)	6	4680.77	780.13	5.20**
X1, X2 and X4	3	4309.08	1436.36	9.56**
X3, X5 and X6	3	371.69	123.90	0.83
Error	11	1651.77	150.16	
Total	17	6332.54		
..... Rainy season				
Regression (X1—X5)	5	7040.79	1408.16	30.57**
X4	1	6964.94	6964.94	151.18**
X1—X3 and X5	4	75.85	18.96	0.41
Error	6	276.40	46.07	
Total	11	7317.19		

Independent variables: X1: fresh weight, X2: volume,
X3: dry weight, X4: volume density,
X5: water content, X6: respiratory rate.

dry weight (X3), water content (X5) and respiratory rate (X6), may be ineffective. It can be considered that the respiratory rate which showed a high significant correlation coefficient with the survival rate was eliminated in the selecting process of effective independent variables by the multiple regression analysis, due to the fact that the respiratory rate had high correlation coefficients with fresh weight ($r=-0.979^{**}$), volume (-0.805^{**}) and volume density (-0.811^{**}). These results clearly indicate that the volume density is the most important characteristic of cassava cuttings determing the survival rate in the dry season (Table 4) and is the only main determinant of the survival rate in the rainy season (Table 5). The other characteristics were not effective factors, though they showed significant simple correlation coefficients with the survival rate.

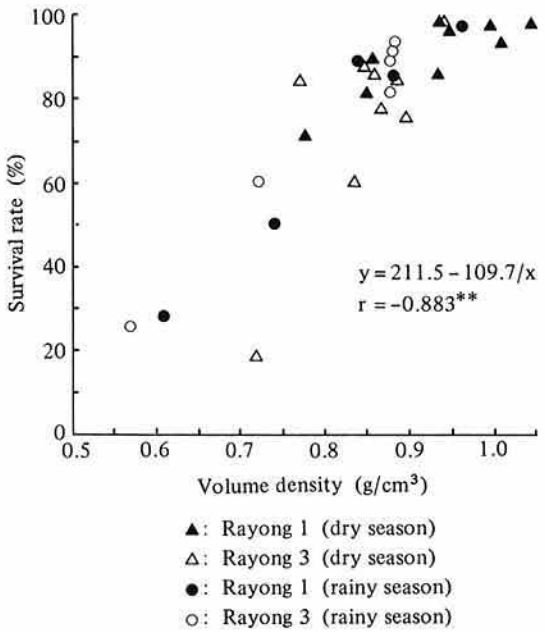

Fig. 2. Relationship between the volume density and survival rate in the dry and the rainy seasons

Conclusion

Of many characteristics examined, volume density, volume, and fresh weight of cuttings were found to be the main factors determining the germination ability of the cuttings planted. The values of these characteristics of Rayong 1 were higher than those of Rayong 3, and the former showed higher germination ability (as expressed by the survival rate) than that of the latter. Although these values tended to be higher in the dry season than in the rainy season, the better germination was observed in the rainy season with the climate favorable for the germination.

In selecting cuttings, emphasis must be placed on the volume density, because the volume density of 0.8 g/cm^3 corresponded nearly to the survival rate as high as 80% both in dry and rainy seasons (Fig. 2). In

practice, it can be recommended that cassava planting materials should be taken from middle and lower parts of the stems of the mother plants showing high volume density, especially in Rayong 3. Thus, volume density of cuttings can be used as an indicator of germination ability.

Summary

The relationship of fresh weight, dry weight, volume, volume density (fresh weight per volume), respiratory rate, and water content of cassava cuttings taken from upper, middle, and lower parts of stems of the mother plants at different ages to the germination ability of the cuttings planted was examined, using two varieties of different plant type, both in dry and rainy seasons.

The germination ability as expressed by the survival rate of the cuttings was positively correlated with the volume density, volume, and fresh weight. The respiratory rate showed a negative correlation, and the water content no correlation.

Multiple regression analysis showed that the leading factors determining the survival rate were the volume density, fresh weight and volume of cuttings in the dry season and the volume density in the rainy season. Thus, the volume density was the main determinant of the germination ability in both seasons. It can be recommended that cassava planting materials should be taken from the middle and lower parts of the stems showing the volume density of more than 0.8 g/cm^3, which approximately corresponded to the survival rate of 80% in both seasons.

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