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Effects of Cutting Speeds, Moisture Contents and Sweet Potato Varieties on Percentage of Vine Pulverization

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Abstract – *A study was conducted to investigate the effects of three varieties of sweet potato (VitAto, Orange and Stone) by three cutting speeds of the mower (2300, 2500 and 2700 rpm) at three different moisture content for the plant (22.4, 30.39 and 41.06 %), wet base (wb %). The results indicate that all the treatments were significant at p ‹ 0.01 significance level for percentage of sweet potato vine pulverized passing through the sieve (< 28 mm). The best result was by the Stone type of sweet potato at 22.4 % moisture content of the plant and 2300 rpm speed of the mower with 89.16 % of the pulverized vine. Data were analyzed statistically using ANOVA and the least significant difference LSD calculated at 1 % to estimate the differences between the averages.*

Keywords: Blade, Moisture content, Mower, Pulverization, Speed, Sweet Potato, Varieties, Vine

1.0 INTRODUCTION

1.1 Effects of the Plant Moisture Content

O'Dogherty [1], based on several studies, showed that there was a good linear correlation between density and moisture content and, as would be expected, the density increased as the chop length was reduced. For grass, the mean density at 80 % moisture content was 0.12 t/m^3 at a chop length of 50 mm, but at a 5 mm chop length it was found to be 0.26 t/m^3. And a range of dry matter density from 0.16 to 0.25 t/m^3 and a maximum between 40 % and 60 % moisture content.

In another study by Mani et al. [2] on barley straw, corn stover and switch grass, it was found that the compressive force, particle size and moisture content significantly affected the pellet density. Nazari et al. [3] conducted experiments at a moisture content of 10 %, 20 %, 40 % and 80 % w.b. The bending stress decreased as the moisture content increased.

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1.2 Effects of Speeds of Mower

Research by O'Dogherty [1] shows that blades used in forage chopping should have cutting at speeds up to 30 m/s. The optimum radius of the cutting edge is approximately 0.05 mm.

O'Dogherty and Gale [4] reported that the stubble length showed a rapid reduction with increasing cutting speed up to speeds of 20 - 25 m/s, above which it was relatively constant. The minimum stubble lengths were observed for the polystyrene tube and were about 41 mm. For grass and straw, when using the sharp blade, the minima were about 42 mm. For the blunt blades, however, minimum values were higher for grass and straw, in a range of about 46 - 48 mm, although for grass at the highest speed ($\geq$ 30 m/s) they were about 43 mm.

In general, for a constant bevel angle, the critical cutting speed is fairly insensitive to blade rake angle [5]. It was found that low blade velocities are satisfactory for thick-stemmed plants but higher velocities are required for light-stemmed plants such as grass. Thus disc and drum type rotary mowers typically employ blade velocities of 71 - 84 m/s.

Jorge et al. [6] which indicated that the results for harvesting efficiency, throughput capacity and height of cut were 96.12 %, 5.87 t/h and 6.32 cm respectively. Three speeds selected for field study were; 950 rpm (26.86 m/s), 1150 rpm (32.51 m/s) and 1424 rpm (40.26 m/s).

1.3 Combined Harvester

No references were found for fully combined potato harvester or single pass for the tractor (two operations at the same time, pulverizing and digging). All the harvesting operations were done in two steps at different time, at least 2 to 5 days between the two operations because of the difficulty of digging, and the most of the top growth are required to be removed or it will become entwined in the digging machine and can damage the roots. Akhir [7] recommended a new machine that can complete all the operations in a single pass, for example slashing, digging, lifting and collecting. Vines must be eliminated prior to digging the potatoes. They need to be removed by hand or slashed mechanically with a flail type pulveriser or rotary slasher at least 24 hours before digging.

Before harvesting, the majority of the top growth needs to be removed or it will become entwined in the digging machine. Vine removal is best done with a swinging pulveriser where the flails are shaped to the contour of the bed. This will chop the vine into pieces and leaves the hills bare. A standard slasher or pulveriser can be used, but will not remove material between the rows. Chopping into the top of the hill should be avoided at all costs as this may damage the roots. Following this, any remaining vines can be cut on both sides of the hill with large, sharp coulters mounted on a tool bar. This vine removal should be done a week before digging to toughen the skin of the roots [8]. This paper focuses on the effects of cutting speeds, moisture contents and sweet potato varieties on percentage of vine pulverization during harvesting.

2.0 METHODOLOGY

The study was conducted at the Malaysian Agricultural Research and Development Institute, MARDI, Serdang, Selangor, Malaysia, to investigate the effects of three varieties of sweet potato (VitAto, Orange and Stone) by three cutting speeds of the mower (2300, 2500 and 2700 rpm) at three different moisture content for the plant (22.4, 30.39 and 41.06 %), wet base (wb %). The

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results indicate that all the treatments were significant at p ‹ 0.01 significance level for percentage of sweet potato vine pulverized passing through the sieve (< 28 mm).

Data were analyzed statistically using ANOVA and the least significant difference LSD calculated at 1 % to estimate the differences between the averages.

3.0 RESULTS AND DISCUSSION

The results indicate that all the treatments were significant at p ‹ 0.01 significance level for percentage of sweet potato vine pulverized passing through the sieve (< 28 mm) (Table 1).

Table 1: Analysis of variance (ANOVA) for the sweet potato vine pulverization.

Source of variation (S.O.V)	Degree of freedom (d.f)	M.S of pulverized vine
Replications	2	26.16063
Moisture content (m)	2	2668.289**
Varieties of plant (v)	2	4001.144**
Speeds of mower (s)	2	141.6309**
Interactions between (m× v)	4	202.5338**
Interactions between (m × s)	4	596.1091**
Interactions between (v × s)	4	160.1058**
Interactions between(m× v ×s)	8	128.8687**
Error	52	2.141858
Total	80	
		L.S.D1%= 2.85593

**significant at level 1 %, M.S= mean square.

The effects of the treatment on the vine pulverization were:

3.1 One Factor Influence on the Studied Traits

3.1.1 Effects of Plant Moisture Content

The best result obtained was for the moisture content of the plant at 22.4 % with average value of 73.93 % for the percentage of sweet potato vine pulverized passing through the sieve (< 28 mm). The lowest percentage vine pulverization of 54.26 % was at 41.06 % (wet base, wb %) moisture content of the plant (Tables 1 and 2).

Table 2: Factors influencing the pulverized vine %.

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Mean of moisture of the plant (m)	Pulverized vine %
m1	73.93
m2	66.59
m3	54.26

m= moisture content of plant (%).

3.1.2 Effects of Varieties of the Sweet Potato

Meanwhile, the Tables 1 and 3 shows that the best result obtained was for the Stone type of sweet potato with average value 77.04 % for the percentage of sweet potato vine pulverized passing through the sieve (< 28 mm). The lowest vine pulverization of 52.69 % was for the VitAto type sweet potato.

Table 3: Factors influencing the pulverized vine %.

Mean of varieties of sweet potato (V)	Pulverized vine %
VitAto (v1)	52.69
Orange (v2)	65.06
Stone (v3)	77.04

v= variety of sweet potato.

3.1.3 Effects of Speeds of the Mower

Tables 1 and 4 indicate the best result obtained was for the mower speed at 2300 rpm with average value of 67.30 % for the percentage of sweet potato vine pulverized passing through the sieve (< 28 mm), meanwhile, the 27000 rpm of mower speed gave the lowest value at 62.73 %.

Table 4: Factors influencing the pulverized vine %.

Mean of speeds of mower(s) (rpm)	Pulverized vine %
2300 (s1)	67.30
2500 (s2)	64.76
2700 (s3)	62.73

s= speed of mower (rpm).

3.2 Two Factors Influence on the Studied Traits (Interaction BetweenTwo Factors)

3.2.1 Effects of the Interaction between Moisture Content and Varieties of Sweet Potato

Tables 1 and 5 indicate that on interaction effects, the best result was for the Stone type sweet potato at 30.39 % moisture content of the plant at 81.84 % of the percentage of sweet potato vine pulverized passing through the sieve (< 28 mm). Meanwhile, the lowest vine pulverization of 43.68 % was for the VitAto type at 41.06 % moisture content of the plant.

Table 5: Factors influencing the pulverized vine %.

Interaction between (m × v)	Pulverized vine %
m1v1	65.39
m1v2	74.78
m1v3	81.63
m2v1	49.00
m2v2	68.93
m2v3	81.84
m3v1	43.68
m3v2	51.47
m3v3	67.63

m= moisture content of plant (%), v= sweet potato variety

3.2.2 Effects of Interaction Between the Moisture Content of Plant and Speeds of Mower.

Tables 1 and 6 indicate that on interaction effects, the best result was by the 2500 rpm mower speed at 22.4 % of moisture content of the plant giving 78.17 % of the percentage of sweet potato vine pulverized passing through the sieve (< 28 mm). Meanwhile the lowest value was for the 2700 rpm mower speed at 41.07 % of moisture content of the plant giving 44.43 % of the Percentage of sweet potato vine pulverized passing through the sieve (< 28 mm).

Table 6: Factors influencing the pulverized vine %.

Interaction between (m × s)	Pulverized vine %
m1s1	73.71
m1s2	78.17
m1s3	69.92
m2s1	65.26
m2s2	60.68
m2s3	73.84
m3s1	62.93
m3s2	55.42
m3s3	44.43

m= moisture content of plant (%), s= speed of mower

3.2.3 Effects of Interaction between Sweet Potato Varieties and Mower Speeds.

Tables 1 and 7 indicate that on interaction effects, the best result was for the 2300 rpm speed of mower with Stone type of the sweet potato having 81.29 % of the percentage of sweet potato vine pulverized passing through the sieve (< 28 mm). Meanwhile the lowest value was for the mower speed at 2500 rpm with VitAto type of sweet potato having 51.42 % of the percentage of sweet potato vine pulverized passing through the sieve (< 28 mm).

Table 7: Factors influencing the pulverized vine %.

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Interaction between (v × s)	Pulverized vine %
v1s1	53.31
v1s2	51.42
v1s3	53.34
v2s1	67.30
v2s2	62.42
v2s3	65.45
v3s1	81.29
v3s2	80.43
v3s3	69.39

v= sweet potato variety, s= speed of mower (rpm).

3.3 Three Factors Influence on the Studied Traits (Interaction between Three Factors)

3.3.1 Effects of the Interaction between Plant Moisture Content, Varieties and Speeds of Mower

Tables 1 and 8 indicate that on interaction effects on the percentage of sweet potato vine pulverized passing through the sieve (< 28 mm), the best result was by the Stone type of sweet potato at 22.4 % moisture content of the plant and 2300 rpm speed of the mower (m1v3s1) with 89.16 % of sweet potato vine pulverized passing through the sieve (< 28 mm). Meanwhile the lowest value was for the interference between the VitA to type of the sweet potato with 2700 rpm mower speed at 41.06 % moisture content of the sweet potato plant (m3v1s3) with 39.21 %.

Table 8: Factors influencing the pulverized vine %.

Interaction between (m × v × s)	Pulverized vine %		
	s1	s2	s3
m1v1	55.72	73.22	67.25
m1v2	76.27	77.84	70.23
m1v3	89.16	83.45	72.27
m2v1	52.36	41.05	53.58
m2v2	65.47	59.93	81.39
m2v3	77.94	81.06	86.54
m3v1	51.84	39.99	39.21
m3v2	60.17	49.50	44.74
m3v3	76.76	76.79	49.35

m= moisture content of plant (%), v= variety and s= speed of mower (rpm)

The results indicated that the best performance was obtained at high mower speed with low moisture content, since at higher moisture content the stems became entangled with the mower blades. Also, Stone type potato was found to have the best value of cutting, and there was significant difference in all the studied characters. This value is in reasonable agreement with Chattopadhyay and Pandey [5].

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4.0 CONCLUSSION

The study indicated that all the treatments were significant at $p < 0.01$ significance level for percentage of sweet potato vine pulverized passing through the sieve (< 28 mm). The best result was by the Stone type of sweet potato at 22.4 % moisture content of the plant and 2300 rpm speed of the mower.

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