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Effects of cutting speeds, moisture contents and sweet potato varieties on tractor fuel consumption.

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Abstract

A study was conducted to test the effects of three mower cutting speeds (2300, 2500 and 2700 rpm), three varieties of sweet potato (VitAto, Orange and Stone) at three different moisture contents of the plant (22.4, 30.39 and 41.06 %), wet base (wb %) on tractor fuel consumption (ml/m). The results showed that all the treatments were significant at p ‹ 0.01 significance level for fuel consumption (ml/m). The best fuel consumption of 1.49 ml/m was achieved when using the Stone variety of sweet potato at 22.4 % moisture content and 2300 rpm mower speed. Data were analyzed statistically using ANOVA and the least significant difference LSD calculated at 1 % to estimate the differences between the averages.

Keywords: fuel consumption, moisture content, mower, speed, sweet potato, varieties.

INTRODUCTION

The results of data analysis by Hoseinzadeh et al. (2009) showed that the shearing stress of wheat stems decreased as the moisture content decreased, in a study for shearing stress of wheat stalk measured for four moisture content levels (15, 25, 35 and 45 % w.b), three cutting heights (100, 200 and 300 mm), two types of cutting blades, smooth and serrated edge and three blade oblique angles (0, 15° and 30°). The results further indicated that the shearing stress of wheat stems decreased as the moisture content decreased (Hoseinzadeh et al., 2009).Nazari et al. (2008) conducted experiments at moisture contents of 10 %, 20 %, 40 % and 80 % w.b. The bending stress decreased as the moisture content increased.

The best cutting of unrestrained material depends on impact between blade and stalk and relies upon the inertia of the 'target', in practice (Atkins, 2005). Kanafojski and Karwowski (1976) reported that the power requirement has proved to be twice lower as compared with the flail mower (At identical operational speeds). According to the results from Khar and Ahuja (2007), the power demand for pineapple fields shredding increases with the feeding speed and the cutting apparatus angular velocities.

Most of the literature studied by O'Dogherty (1984) indicated that very high blade cutting speed is required and ranged between 60 - 84 m/s. McRandal and McNulty (1978) revealed from laboratory tests that energy consumption in cutting groups of grass and oat straw stems decreased by approximately 25 % as blade velocity increased from 20 to 60 m/s. Johnson et al. (2012) and Taghijarah et al. (2011) reported that specific shear energy increased as the loading rate increased and recommended a lower speed for harvesting operations for sugarcane. Prasad and Gupta (1975) reported that, for maize stems, at

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highercutting speeds the cutting energy increased. It appears that more energy is transferred to the stem at higher speeds which might be absorbed in impact, vibration, and deflection.

Hoseinzadeh et al. (2009) reported that variety, blade bevel angle, moisture content and cutting speed are the main factors affecting shearing strength and energy of the wheat stem.

Paneque (1992) also supported the elimination of foliage at least 24 hours before harvesting, and the presence of foliage or inadequate soil preparation can make this type of harvesting more difficult. In harvest systems where the vines would tangle in the harvester, vines are cut before harvest. Potato harvesters are sometimes used to harvest sweet potatoes but damage is usually unacceptably high (Sue, 2013). This paper discusses the effects of cutting speed, moisture content and sweet potato variety on tractor fuel consumption during harvesting.

MATERIALS AND METHODS

The study was conducted at the Malaysian Agricultural Research and Development Institute, MARDI, Serdang, Selangor, Malaysia, to investigate the effects of three cutting speeds of the mower (2300, 2500 and 2700 rpm) on three varieties of sweet potato (VitAto, Orange and Stone) at three different moisture contents of the plant (22.4, 30.39 and 41.06 %), wet base (wb %) on fuel consumption. Fuel consumption was measured using Graduated Cylinder Method.

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

RESULTS AND DISCUSSION

Harvesting With the New Designed Blade in One Pass for the Tractor

The results indicate that all the treatments were significant at $p < 0.01$ significance level for fuel consumption millilitre/meter (Table 1).

Table 1. Analysis of variance (ANOVA) for the fuel consumption (ml/m).

Source of variation (S.O.V)	Degree of freedom	M.S of Fuel consumption
Replications	2	2.156377
Moisture content (m)	2	759.8846**
Varieties of plant (v)	2	237.8942**
Speeds of mower (s)	2	61.8057**
Interactions between (m× v)	4	60.83812**
Interactions between (m × s)	4	7.580934**
Interactions between (v × s)	4	5.197051**
Interactions between(m× v ×s)	8	10.37179**
Error	52	0.732386
Total	80	
		L.S.D1%=1.67002

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

1. Effects of Plant Moisture Content

The best result was obtained at the plant moisture content of 22.4 % with average value of 5.78 ml/m for fuel consumption. The highest value of 16.18 ml/m was at 41.06 % (wet base, wb %) moisture content of the plant (Tables 1 and 2).

Table 2. Factors influencing fuel consumption (ml/m).

Mean of moisture of the plant	Fuel consumption (ml/m)
m1	5.78
m2	9.13
m3	16.18

m= moisture content of plant (%).

2. Effects of Varieties of the Sweet Potato

The Stone type of the sweet potato gave the best result for the fuel consumption of 7.29 ml/m. The highest value was for the VitAto type of 13.21 ml/m (Tables 1 and 3).

Table 3. Factors influencing fuel consumption (ml/m).

Mean of varieties of the sweet potato	Fuel consumption (ml/m)
VitAto (v1)	13.21
Orange (v2)	10.60
Stone (v3)	7.29

v= varietyof sweet potato.

3. Effects of Speeds of the Mower

The best result was obtained at a mower speed of 2300 rpm for the fuel consumption of 8.95 ml/m. The highest value of 11.96ml/m was achieved at the speed of 2700 rpm (Tables 1 and 4).

Table 4. Factors influencing fuel consumption (ml/m).

Mean of speeds of mower (rpm)	Fuel consumption (ml/m)
2300 (s1)	8.95
2500 (s2)	10.19
2700 (s3)	11.96

s= speed of mower (rpm).

4. Effects of the interaction between moisture content and varieties of sweet potato.

The best result was for the Stone type sweet potato at 22.4 % moisture content of the plant giving 2.04 ml/m of the fuel consumption. Meanwhile, the highest fuel consumption of 18.49 ml/m was for the VitAto type at 41.06 % moisture content of the plant (Tables 1 and 5).

Table 5. Factors influencing fuel consumption (ml/m).

Interaction between (m × v)	Fuel consumption (ml/m)
m1v1	11.23
m1v2	4.08
m1v3	2.04
m2v1	9.90
m2v2	9.25
m2v3	8.25
m3v1	18.49
m3v2	18.48
m3v3	11.56

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

5. Effects of interaction between moisture contents of plant and mower speeds.

For the interaction effects on the fuel consumption, the best result was for the 2300 rpm mower speed at 22.4 % moisture content of the plant giving 3.41 ml/m of the fuel consumption. Meanwhile, the highest fuel consumption of 17.24 ml/m was for the 2700 rpm mower speed at 41.06 % moisture content of the plant (Tables 1 and 6).

Table 6. Factors influencing fuel consumption (ml/m).

Interaction between (m × s)	Fuel consumption (ml/m)
m1s1	3.41
m1s2	5.43
m1s3	8.52

m2s1	8.20
m2s2	9.09
m2s3	10.12
m3s1	15.23
m3s2	16.06
m3s3	17.24

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

6. Effects of interaction between sweet potato varieties and mower speeds.

For the interaction effects on the fuel consumption, the best result was for the 2300 rpm mower speed with the Stone type of the sweet potato having 6.27 ml/m of the fuel consumption. Meanwhile, the highest fuel consumption of 15.56 ml/m was for the 2700 rpm mower speed with the VitAto type of the sweet potato (Tables 1 and 7).

Table 7. Factors influencing fuel consumption (ml/m).

Interaction between (v × s)	Fuel consumption (ml/m).
v1s1	10.85
v1s2	13.22
v1s3	15.56
v2s1	9.72
v2s2	10.43
v2s3	11.66
v3s1	6.27
v3s2	6.92
v3s3	8.66

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

7. Effects of the Interaction between Plant Moisture Contents, Varieties and Mower Speeds.

Tables 1 and 8 indicate that all the treatments had significant effects on the fuel consumption.

Table 8. Factors influencing the fuel consumption (ml/m).

Interaction between	Fuel consumption (ml/m)		
(m × v × s)	s1	s2	s3
m1v1	5.51	11.11	17.06
m1v2	3.24	3.50	5.51
m1v3	1.49	1.66	2.97
m2v1	8.84	10.28	10.59
m2v2	8.23	9.19	10.32
m2v3	7.52	7.79	9.45
m3v1	18.20	18.26	19.02
m3v2	17.70	18.61	19.13
m3v3	9.80	11.32	13.56

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

For the interaction effects on the fuel consumption, 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 lowest fuel consumption of 1.49 ml/m. Meanwhile the highest value was for the interference between the Stone type of the sweet potato with 2500 rpm mower speed at 41.06 % moisture content of the sweet potato plant (m3v2s3) giving 19.13 ml/m (Tables 1 and 8).

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. This value is in reasonable agreement with Chattopadhyay and Pandey, (1999), who reported that the total specific energy requirement increased when the cutting speed was increased, over the range of 62 – 83 % moisture content. The drier forage required up to 30 % less energy and the cutting speed and cutting angle should be optimized to minimize the energy requirement for flail forage harvesting.

CONCLUSIONS

The following conclusions can be drawn from the study:

- The study indicated that all the treatments were significant at $p < 0.01$ significance level for fuel consumption.
- The best result was shown by the Stone type of sweet potato at 22.4 % moisture content of the plant and at a mower speed of 2300 rpm.

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