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Full Length Research Paper

Effect of ridge height and planting orientation on *Ipomea batatas* (sweet potato) production

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***Ipomea batatas* (sweet potato) yield vary widely among farmers due to improper ridging and planting orientation. This study was to establish the proper ridging and planting orientation, so as to enhance constant reliable yields among sweet potato producing farmers. The objectives of the study were to compare vine length and to determine root yield, central root diameter and root length among different ridge heights and planting orientations. A 3 x 3 factorial in a completely randomised block design with 3 replications was used. Ridge height had levels; 30, 40 and 50 cm while planting angle had levels; horizontal 180°, inclined 45° and vertical 90°. Vine length was measured at 3, 6, 9 and 12 weeks after planting and root yield, root diameter and root length were measured at harvesting. Data was analysed using M STAT C for variance between treatment means. The results showed interaction effect (p = 0.05) of ridge height and planting angle on the vine length, root diameter, length and yield. Lower ridges produced longer vines than higher ridges. Decreasing inclination of cuttings also increases vine length. Root diameter decreases with increasing ridge height while root length increased as ridge height increased. Medium ridge height (40 cm) with inclined planting angle may be recommended for higher root yields and horizontal planting angle on low ridges can be used to produce rounded swollen roots.**

Key words: Ridge, height, planting orientation, sweet potato, vine, yield.

INTRODUCTION

Sweet potato tolerates a wide range of soils and even on poor acid soils, it gives satisfactory yields (Chipangura and Jackson, 2003). Though grown in areas with relatively high rainfall, it cannot withstand water logging conditions; hence, why they are grown on ridges and mounds (Gomes, 1999). It also has good drought tolerance ability. In Zimbabwe, its production is concentrated in natural regions I, II and III which have high rainfall and good soils (Chipangura and Jackson, 2003). Sweet potato was discovered to be potentially high yielding such that, it can yield up to 50 tonnes per hectare under minimum management (Coertze and Van den Berg, 1995). The area under sweet potato production in Zimbabwe has recently increased; however, most communal farmers have learnt by experience to grow sweet potatoes. Variable planting methods are being used by sweet potato farmers in Zimbabwe. Many farmers believe that, high yields are produced from very high ridges, yet Dhliwayo and Chiunzi (2004) reiterate that, small to medium sized ridges that are easy to make may produce good yields as long as fertility is present. Ridges should also be high enough to prevent water logging (Gomes, 1999). On the planting angle, various authors have diverged. Dhliwayo and Chiunzi (2004) stipulate that, planting at an angle or horizontally produce more yields while Onwuene (1999) recommends vertical orientation. It was the purpose of this study to explore and examine these different lines of thoughts and get the most appropriate recommendation to farmers. This was achieved by determining vine length on different ridge heights under different planting angles and root diameter, length and yield on different planting angles under varying ridge heights. For this study, Brondal variety which takes about 135 days to mature was used. The variety was developed in South Africa and is now popular in Zimbabwean rural areas. Vine cuttings were used as

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Table 1. Factors, factor levels and treatments.

Factor A: Planting angle	Factor B: Ridge height (cm)		
	(1) 30	(2) 40	(3) 50
1. Horizontal (H)	30H (1)	40H (2)	50 H (3)
2. Inclined (I)	30 I (4)	40I (5)	50 I (6)
3. Vertical (V)	30 V (7)	40V (8)	50V (9)

planting material.

MATERIALS AND METHODS

Study site description

The experiment was carried out in Natural Farming Region IIa of Zimbabwe. The region receives high annual rainfall of 700 to 1000 mm with warm summer (18 to 22°C) and cool winter (16 to 18°C). The site is characterised by loam soil type with pH 5.8 ($CaCl_2$ scale) and local vegetation consists of veld grasses and Musasa trees. The area is located 1248 m above sea level. The site is gently sloping and well drained. The plot was previously occupied by organically produced green mealies.

Experimental design

A 3 x 3 factorial experiment in a Randomised Complete Block Design (CRBD) with 3 replicates was used. Slope was the blocking factor.

Land preparation

The trial plot was ploughed to a depth of 30 cm using an ox drawn plough, after which decomposed cattle manure was broadcast at a rate of 20 tonnes per hectare and incorporated into the soil. 27 ridges, each 1.2 m long and 50 cm wide were made. Ridges were spaced 1 m between blocks and 50 cm within blocks. Ridges differed in height among treatments.

Planting

The vine cuttings were cut into 30 cm long and planted with two thirds of their lengths buried into the soil uniformly on all treatments, making sure an equal number of nodes were buried into the soil. Cuttings were spaced 30 cm apart along the 1.2 m long ridges in two rows, leaving 15 cm spaces at both edges. Therefore, a total of 6 cuttings were planted per ridge. A wooden campus was placed on the levelled ridges to obtain a planting angle. The horizontal, vertical and inclined angles were measured 180°, 90° and 45° respectively (Table 1).

Data collection

Vine measurements (in centimetres) were taken at a three week interval from week 3 after planting up to week 12. Total vine length per ridge was obtained and average length recorded. At 16 weeks post planting, the yield from each ridge was weighed in kilograms and converted into tonnes per hectare. Mean root length and mean central root diameter were also calculated and recorded in cm.

Data analysis

A computer package M STAT C was used to analyse the variance between treatment means at 95% significance level using the F-test. The means were separated using the least significant difference ($LSD_{0.05}$) test at 5% to determine difference between the treatment means.

RESULTS

The effect of ridge height and cutting planting angle on vine length

Vine length was determined by the interaction ($p = 0.05$) of ridge height and planting angle as from 3 to 12 weeks after planting (Table 2). At 3 weeks after planting, treatments 40H and 40I had the highest mean vine lengths while 50H had the least. At 6, 9 and 12 weeks after planting, treatment 30H had the highest mean vine length while 50V had the least (Table 2).

The effect of ridge height and planting angle on root diameter, root length and yield

Central root diameter at harvesting was determined by both the ridge height and planting angle ($p = 0.05$) (Table 3). The thickest roots were recorded from 30H (6.3 cm) while the thinnest roots were recorded from 50I and 50V (4.4 cm). Ridge height had a significant effect ($p = 0.05$) on root length at harvesting (Table 3). The longest roots were obtained from 50 cm ridges while the shortest roots were obtained from 30 cm ridges. There was interaction effects of ridge height and planting angle on final root yield ($p = 0.05$). The highest mean yield recorded was from 40I treatments (14.08 t/ha) while the lowest mean yield recorded was from 50V treatments with 9.73 t/ha (Table 3).

Table 2. Mean vine lengths in cm at 3, 6, 9 and 12 weeks after planting.

Treatment combinations	3 weeks	6 weeks	9 weeks	12 weeks
1. Horizontal + 30 cm	24.10^{c}	96.33^{a}	216.3^{a}	341.0^{a}
2. Horizontal + 40 cm	25.33^{a}	80.67^{e}	201.0^{c}	330.3^{d}
3. Horizontal + 50 cm	24.00^{c}	72.33^{g}	191.7^{d}	310.3^{fg}
4. Inclined + 30 cm	24.77^{b}	90.33^{b}	209.7^{b}	336.0^{b}
5. Inclined + 40 cm	25.33^{a}	86.00^{c}	207.7^{b}	332.7^{c}
6. Inclined + 50 cm	24.47^{bc}	67.00^{h}	190.0^{d}	308.7^{g}
7. Vertical + 30 cm	24.27^{bc}	83.33^{d}	207.3^{b}	326.7^{e}
8. Vertical + 40 cm	24.17^{c}	75.00^{f}	192.0^{d}	312.3^{f}
9. Vertical + 50 cm	24.23^{bc}	65.00^{i}	189.3^{d}	304.3^{h}
Coefficient of variation	1.27%	1.19%	0.90%	0.40%
$LSD_{0.05}$	0.5391	1.645	3.134	2.250
Grand mean	24.52	79.56	200.6	322.5
P Values: Planting angle	0.0020	<0.001	<0.001	<0.001
Ridge height	<0.001	<0.001	<0.001	0.0004
Interaction	0.0083	<0.001	<0.001	<0.001

Means with same letter(s) are statistically insignificant at p = 0.05.

Table 3. Mean root diameter (cm), mean root length (cm) and mean root yield (t/ha) at harvesting.

Treatment combinations	Root diameter	Root length	Root yield
1. Horizontal + 30 cm	6.3^{a}	11.6^{c}	12.64^{c}
2. Horizontal + 40 cm	5.4^{c}	12.7^{b}	13.50^{b}
3. Horizontal + 50 cm	4.8^{d}	16.2^{a}	10.66^{f}
4. Inclined + 30 cm	6.1^{ab}	11.6^{c}	11.85^{d}
5. Inclined + 40 cm	5.8^{b}	12.4^{b}	14.08^{a}
6. Inclined + 50 cm	4.4^{e}	16.2^{a}	11.05^{e}
7. Vertical + 30 cm	6.2^{a}	11.3^{c}	11.01^{e}
8. Vertical + 40 cm	5.2^{c}	12.7^{b}	13.53^{b}
9. Vertical + 50 cm	4.4^{e}	16.1^{a}	9.73^{g}
Coefficient of variation	3.61%	2.09%	0.95%
$LSD_{0.05}$	0.3374	0.4865	0.1974
Grand mean	5.381	13.422	12.007
P Values: Planting angle	0.0471		<0.001
Ridge height	<0.001	<0.001	<0.001
Interaction	0.0178		<0.001

Means with same letter(s) are statistically insignificant at p = 0.05

DISCUSSION

Effect of ridge height and planting angle on mean vine length

The vine length was determined by the interaction of ridge height and planting angle. Too high (50 cm) or low (30 cm) resulted into shorter vines, as compared to the intermediary ridge height (40 cm). This could be that plant available water and organic matter rich top soil were at a thicker depth of the planting zone on the 40 cm ridges which is necessary for rapid early vine growth. Whilst on the highest and lowest ridges, these could have been inadequate to support a vigorous increase in length. This tallies well with Edmond (2001) who noted that, ridge height and planting angle affect vine length of sweet potatoes at all growth stages.

However, Gomes (1999) denoted that sweet potato early vine growth does not differ significantly but only at its mid and late stages. He argued that this difference at later stages after planting might be due to the different adaptive growth rates as the cuttings established differently on the various treatments. Since cuttings roots were well established at 6 after planting, longer vines on 30 cm ridges might be justified as the cuttings roots could easily tap capillary water and nutrients over a short distance as compared to higher ridges, where cutting roots were far from capillary water. The increased root growth to reach capillary water levels might have compensated reduced vine growth on 40 and 50 cm ridges.

These results concur with Dhliwayo and Chiunzi (2004) but contradicts with Gomes (1999) who postulated that, vine growth tends to be higher on high ridges where there is increased root penetration and ample soil from which nutrients are extracted.

On all ridge heights, horizontally planted cuttings had the highest mean vine lengths, followed by inclined cuttings and lastly vertical cuttings. This could be due to root orientation; as sweet potato roots grow downwards following positive geotropism rather than growing laterally (Bose et al., 2003). This might have resulted in roots of horizontally planted cuttings being evenly spaced and having a larger area from which to tap water and nutrients towards vine growth. On the other hand, roots of vertically planted cuttings grew closer together; having a limited area from which water and nutrients could be tapped for photosynthesis, hence reduced vine growth. These results are also consistent with Gomes (1999).

Effect of ridge height and planting angle on root diameter at harvesting

Root thickness was proportional to ridge height. The lower the ridge height, the thicker the roots such that, the 30 cm ridges had the thickest roots, followed by 40 cm ridges while 50 cm ridges had the thinnest roots. The thicker roots on lower ridges as compared to higher ridges might be due to the fact that, tuberous roots form after adventitious roots hit hard soil and thickens upwards; so 30 cm ridges' roots hit hard soil earlier than the 40 and 50 cm ridges' roots, resulting in more time for tuber swelling on 30 cm ridges than on 50 cm ridges. This is supported by Dhliwayo and Chiunzi (2004) and Gomes (1999).

The thicker roots on horizontally planted cuttings as compared to vertically planted cuttings, might be due to positive geotropism of roots which resulted in horizontally planted cuttings, having ample space for free swelling, as compared to vertically planted cuttings where roots grew closer together with limited space for expansion (Gomes, 1999).

Effect of ridge height and planting angle on root length at harvesting

The significant difference on mean root length ($p = 0.05$) due to ridge height where higher ridge produced longer roots, could be as a result of increased root penetration through the soil on higher ridges before hitting hard soil, to initiate tuber formation, resulting in thin elongated roots unlike on low ridges where adventitious roots quickly hit hard soil to initiate root thickening. These results are consistent with Gomes (1999).

Effect of ridge height and planting angle on root yield at harvesting

Ridge height and planting angle determined the final root yield where the 40 cm ridges had the highest yield. This could be due to the fact that, at this ridge height all the necessary conditions for an ideal tuber formation were satisfied. At this ridge height, both the root diameter and length were optimal and so resulted to highest yield. This is in agreement with Chipangura and Jackson (2003) who noted that, neither too high nor low ridge heights results to high tuber yield.

CONCLUSION AND RECOMMENDATIONS

Planting sweet potato at a horizontal angle on 30 cm ridge height resulted to longer vines than at vertical angles with high ridges (50 cm). Lower ridges therefore produce longer vines than higher ridges. Decreasing inclination of cuttings also increases vine length. Inclined planting angle on 40 cm ridge heights had higher root yield. Root diameter decreased with increasing ridge height while root length increased as ridge height increased. From the results it can also be concluded that, increasing inclination of cuttings reduces root diameter while root length increases as cutting inclination increases.

Since the results were based on one season, it is recommended for the research to be repeated for the next two or more seasons, ideally in multiple sites of different climate and soil type to increase the scope of validity of findings. Medium ridge height (40 cm) with inclined planting angle may be recommended for higher root yields. To produce rounded swollen roots, horizontally planted cuttings on low ridges (30 cm) may be recommended. Farmers can establish nurseries and fodder sweet potato on low ridges with horizontally planted cuttings to obtain maximum vine yields.

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