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Yield and Quality of Sweet potato Influenced by Tillage and Nutrient Management in Sandy Loams of Onattukara in Kerala

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ABSTRACT

An experiment was conducted to examine the effect of different tillage practices and nutrient management on yield and quality of sweet potato in the Onattukara sandy plains. The experiment was laid out in split plot design with three main plot treatments, four subplot treatments and four replications. The main plot treatments were reduced tillage (T_1), ridge tillage (T_2) and conventional tillage (T_3). The subplots treatments were 100% RDF (n_1), n_1 + magnesium sulphate @ 0.2% foliar spray @ 30 DAP (n_2), n_1 + borax @ 0.2% foliar spray @ 30 DAP (n_3) and n_2 + borax @ 0.2% foliar spray @ 30 DAP (n_4). The results revealed that, in the *Onattukara* sandy loam soils of Kerala, higher number of tubers per vine, marketable tubers per vine, tuber yield per hectare and vitamin C can be obtained, when sweet potato vines were planted under reduced tillage (only one shallow primary tillage) and supplied with the recommended dose of fertilizers (FYM @ 10 t/ha, N, P_2O5 and K_2O @ 75:50:75 kg/ha) along with one foliar application of magnesium sulphate followed by borax (both @ 0.2%) at 30 days after planting.

Key Words: Borax, Magnesium sulphate, *Onattukara*, Quality, Sweet potato

INTRODUCTION

Sweet Potato [*Ipomea batatus* L. (Lam)] is a herbaceous root crop belonging to the Convolvulaceae family. The crop has a duration of 90 to 130 days depending on the variety. Sweet potato is grown throughout the tropical and subtropical countries for its edible tubers. In India, it is cultivated as an important food crop for humans and also as feed for domestic animals. The tubers of sweet potato are having a number of health benefits as it contains several antioxidants and anti-inflammatory properties. Soil compaction of agricultural soils is a well-recognized global problem. One of the most effective ways to reduce compaction is tillage. Tillage helps to optimize the productivity of crops by reducing the physical, chemical and biological stresses on the soil. Sweet potato being a root crop responds differently to tillage. *Onattukara* region of Alappuzha district has sandy loam soils and is ideally suited for cultivation of sweet potato. Being sandy loam, the soil has high porosity and hence the retention of nutrients in soil is very low. Deficiency of essential nutrients in soil is a major constraint for crop production, especially sweet potato. The response of sweet potato to tillage and nutrient management in the problem zone of Onattukara has not received adequate research attention. Hence, the present study was undertaken with the objective of assessment of different tillage practices and nutrient management on the yield and quality of sweet potato in the Onattukara sandy plains.

MATERIALS AND METHODS

A field experiment entitled 'Tillage and nutrient management for yield and quality of sweet potato in Onattukara Sandy Plains' was conducted in the Instructional Farm attached to Onattukara Regional Agricultural Research Station, Kayamkulam, Kerala during November 2023 to

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March 2024. Onattukara tract is considered as a problem soil region due to the sandy loam nature of the soil and higher water table. The crops cultivated here yield best when the full recommended dose of nutrients were supplied to them. The experiment was laid out in split plot design with three types of tillage as the main plot treatments, four nutrient management measures as subplot treatments and were replicated four times. The main plot treatments were reduced tillage (T_1), ridge tillage (T_2) and conventional tillage (T_3). The subplots treatments were 100% RDF (n_1), n_1 + magnesium sulphate @ 0.2% foliar spray @ 30 DAP (n_2), n_1 + borax @ 0.2% foliar spray @ 30 DAP (n_3) and n_2 + borax @ 0.2% foliar spray @ 30 DAP (n_4).

The experimental field was previously cropped with rice before raising sweet potato. After the harvest of rice crop, the stubbles were incorporated into the main field by a shallow primary tillage and dolomite @ 1 t/ha was uniformly applied. The whole experimental area was divided as per treatments into reduced tillage, ridge tillage and conventional tillage. One additional tillage to a depth of 30 cm was done, to bring the soil to a fine tilth in conventionally prepared plots. Raised beds were prepared for planting sweet potato vines in reduced tillage and conventional tillage plots. For ridge tillage, ridges were formed at the time of land preparation. Manures and fertilizers were applied as per KAU (2016). As a basal dose, well decomposed FYM @ 10 t/ ha along with half N, full P and full K of the recommended dose of chemical fertilizers (75:50:75 N, P_2O_5, K_2O kg/ha) was given to all the plots. The remaining half N was given as split dose at one month after planting along with foliar application of magnesium sulphate and borax as per the treatments. Vines of sweet potato *var*. Sree Arun was used as planting material for the main field. Sree Arun is a high yielding, early maturing variety with pink skin and cream flesh released from ICAR-CTCRI (Central Tuber Crops Research Institute) Thiruvananthapuram, Kerala. The sweet potato vines were planted at a spacing of 60 cm x 20 cm. Interculture, weeding and earthing up was done at 30 DAP before foliar application of nutrients.

Five observational plants from each plot were tagged for observation. At harvest, the total number of tubers from each observational plants were counted and the average was worked out to find the number of tubers per vine. The total numbers of marketable tubers per plant were worked out by counting the number of marketable tubers from each observational plants and their average was calculated. The tubers with less than 2.5 cm diameter were considered as non-marketable tubers. The tuber yield obtained from the net plot area of all the treatments were measured separately and was expressed in t/ha. The net weight of vines was also calculated and expressed in t/ha. For estimating the quality, starch content, total sugars, vitamin C, carotene content, crude protein and crude fibre was analysed. The starch content of the tubers was estimated by AOAC (1975) on fresh weight basis. The total sugars were estimated as per the method described by Ranganna (1977) and was expressed as percentage on fresh weight basis. Vitamin C content was estimated on fresh weight basis by following the spectrophotometric method and the values were expressed in mg/100 g. The carotene content (mg/100g) on dry weight basis was determined as per the method described by Sadasivam and Manickam (2008). The plant crude protein content at harvest was calculated using Micro-Kjeldahl digestion and distillation method (Simpson *et al*, 1965) and was expressed as percentage. Plant crude fibre was analysed using Weende method (AOAC, 1990) and was expressed in percentage on dry weight basis.

RESULTS AND DISUSION

Effect on Yield and Yield Attributes

The number of tubers per vine was significantly influenced by tillage (Table 1). Reduced tillage (T_1) produced significantly higher number of tubers per vine (3.51) and was found to be on a par with ridge tillage (3.48). Conventional tillage (T_3) could produce only 1.39 tubers per vine. There was an overall increase of 152.2 percent in the number of tubers per vine due to reduced tillage. The presence of stubbles of previous rice crop in reduced tillage might have provided an ideal soil physical condition for the development of sweet potato tubers per vine. Peter

(2008) had earlier reported higher number of cassava tubers per plant under zero tillage followed by ridge tillage. Ahmed *et al* (2012) had also observed increased tuberous roots from reduced tillage and ridge tillage due to the loose top soil in which storage roots were grown. The foliar application of magnesium sulphate followed by foliar application of borax (n_4) had significantly influenced the number of tubers per vine. The treatment n_4, recorded significantly higher number of tubers per vine (3.08 tubers per vine) and is 18.46 percent higher than the control (n_1). Magnesium, a constituent of the ring structure of chlorophyll, along with boron, which helps in the regulation of carbohydrates and translocation of starches, might have contributed to the increased production of photosynthates leading to a higher number of tubers per vine in n_4 treatment. El-Metwaly and Mansour (2019) had earlier reported an increased number of tubers per plant in potato due to application of magnesium sulphate in soil and as foliar spray. Sharaf-Eldin *et al* (2019) had reported an increase in number of tubers per vine in sweet potato due to foliar application of boron @ 50 ppm. No significant difference for interaction was obtained for the number of tubers per vine.

Marketable Tubers

The data on number of marketable tubers are given in Table 1 and Table 2. The number of marketable tubers per vine followed a similar trend as that of number of tubers per vine. Significantly higher number of marketable tubers per vine (3.35) was observed for ridge tillage and was found to be on a par with reduced tillage (T_1 - 3.31). This might be due to the reduced soil compaction and better aeration in reduced and ridge tillage compared to the conventional tillage. Plants in conventional tillage could produce only 1.28 number of marketable tubers per vine. Similar results of increased number of marketable tubers per vine was observed by Anikwe *et al* (2007) in cocoyams that were raised in ridge seed beds. Foliar application of magnesium sulphate and borax (n_4) had significant influence on the number of marketable tubers per vine (2.92). There was an overall increase of 19.18 percent in the number of marketable tubers per vine compared to n_1 (100%RDF). The application of magnesium sulphate along with boron had significantly increased the number of tubers per vine and this was reflected in the production of significantly higher number of marketable tubers per vine. Foliar application of magnesium sulphate might have increased the production of photosynthates which led to an increase in number of marketable tubers per vine. In addition to magnesium sulphate, foliar application of boron might have helped in translocation of more starches to the tuber. In the Onattukara region of Alappuzha district, Kerala, cracking of sweet potato tubers due to deficiency of boron is a serious problem faced by farmers. This affects the marketability of tubers in the area. The tubers obtained in the treatment n_4 was free from tuber cracking. Similar results of increased total marketable yield in sweet potato was also reported by Sharaf-Eldin *et al* (2019), when boron (@ 50 ppm) was sprayed as foliar at 60 and 90 DAP. Findings by Singh *et al* (2024) also suggested that spraying of $MgSO_4$and $CaNO_3$@ 2% increased the marketable yield of potato. The interaction effects were found to be significant for the number of marketable tubers per vine (Table 2). The treatment combination T_2n_4 was found to produce significantly higher number of marketable tubers per vine (3.70) and this was found to be at par with the treatment T_1n_4 (3.60). Thus, for obtaining increased number of marketable tubers per vine, sweet potato vines should either be raised in ridges or under reduced tillage and should be supplied with the full recommended dose of fertilizers along with one foliar application of magnesium sulphate (@ 0.2 %) and borax (@ 0.2 %) at 30 days after planting. Regardless of the nutrient management, conventional tillage produced lower number of marketable tubers per vine. There was an increase of 208.33 percent of number of marketable tubers per vine in T_2n_4over T_3n_1.

Tuber Yield

Among tillage, significantly higher tuber yield per hectare (20.28 t/ha) was recorded for reduced tillage (T_1) (Table 1). The yield attributes of sweet potato *viz*. number of tubers per vine and number of marketable tubers per vine were observed to be significantly higher for reduced

Table 1. Effect of tillage and nutrient management on yield and yield attributes of sweet potato

Treatments	Number of tubers per vine	Number of marketable tubers per vine	Tuber yield (t/ha)
Tillage			
T_1 – reduced tillage	3.51	3.31	20.28
T_2 – ridge tillage	3.48	3.35	17.41
T_3 – Conventional tillage	1.39	1.28	5.99
SEm (±)	0.09	0.09	0.12
CD (0.05)	0.294	0.313	0.404
Nutrient management			
n_1 – 100% RDF	2.60	2.45	13.59
n_2 – n_1 + MgSO4 @ 0.2% foliar spray	272	2.53	14.27
n_3 – n_1 + borax @ 0.2% foliar spray	2.77	2.68	14.77
n_4 – n_2 + borax @ 0.2% foliar spray	3.08	2.92	15.62
SEm (±)	0.05	0.05	0.24
CD (0.05)	0.145	0.313	0.696

*RDF – Recommended dose of fertilizers

tillage. These increased yield attributes had led to the production of significantly higher tuber yield per hectare due to reduced tillage in sweet potato. The incorporation of biomass like stubbles of previous crop of rice, might have also improved the soil environment, creating higher moisture retention in soil thereby, increasing the yield of sweet potato from reduced tillage. There was an overall yield increase of 233.22 percent in reduced tillage compared to conventional tillage. Conventional tillage could produce only 5.99 tonnes of tubers per hectare which might be due to soil compaction that restricted the root growth and reduced its access to nutrients. Gopika (2024) had also reported significantly higher tuber yield (16.20 t/ha) in Chinese potato with reduce tillage along with surface retention of cowpea. Nutrient management had significantly influenced the tuber yield per hectare in sweet potato. Among the treatments, n_4 produced significantly higher tuber yield of 15.62 t/ha. Magnesium, being a part of chlorophyll helps in photosynthesis and aids in the formation and development of sink organs such as seeds and roots (Ceylan *et al*, 2016). During photosynthesis, light energy is converted to chemical energy for producing sugar which needs to be transported to the sink (roots). This distribution of sugars is facilitated by boron. Hence, the treatment n_4 which involved the foliar application of magnesium and boron, might have helped in the production of significantly higher tuber yield per hectare. Among the treatment combinations, T_1n_4 and T_1n_3 produced significantly higher tuber yield with 21.81 t/ha and 21.07 t/ha respectively (Table 2). The tuber yield was found to increase by 280.63 percent in T_1n_4 compared to T_3n_1 asserting the dominance of reduced tillage and foliar nutrition to conventional tillage and recommended dose of nutrition.

Effect on Quality Attributes

Tuber quality of sweet potato was assessed in terms of starch, total sugars, vitamin C, carotene, crude protein and crude fibre. No significant effects were obtained in any of the treatments for starch percentage and total sugars

Table 2. Interaction effect of tillage and nutrient management on yield and yield attributes of sweet potato

Treatments	Number of tubers per vine	Number of marketable tubers per vine	Tuber yield (t/ha)
T_1n_1	3.45	3.20	18.60
T_1n_2	3.35	3.05	19.66
T_1n_3	3.50	3.40	21.07
T_1n_4	3.75	3.60	21.81
T_2n_1	3.10	2.95	16.46
T_2n_2	3.50	3.35	17.05
T_2n_3	3.45	3.40	17.30
T_2n_4	3.85	3.70	18.83
T_3n_1	1.25	1.20	5.73
T_3n_2	1.30	1.20	6.10
T_3n_3	1.35	1.25	5.93
T_3n_4	1.65	1.45	6.21
SE (m) A/B (±)	0.09	0.09	0.42
SE (m) B/A (±)	0.11	0.12	0.38
CD (0.05) A/B	NS	0.263	1.205
CD (0.05) B/A	NS	0.386	1.117

*NS – Not significant
* A/B – Factor (B) at same levels of Factor A
* B/A – Factor (A) at same levels of Factor B

(Table 3). Significantly higher vitamin C content was observed for reduced tillage (T_1- 20.60 mg/100g) and was found to be on a par with conventional tillage (T_3 - 19.99 mg /100g). Similar reports of significantly higher vitamin C was also reported in sweet potato raised in flat beds under irrigated conditions by Saqib *et al* (2017). No significant effects were observed for nutrient management and interaction. Significantly higher carotene content was observed for the treatment T_2 (ridge tillage) with 0.60 mg /100g (Table 5). There was significant difference in nutrient management for carotene content in sweet potato. Magnesium is crucial for photosynthesis and it also plays a role in synthesizing carotene. Boron is also attributed to increasing concentration of carotene and was confirmed by the study conducted by Younis *et al* (2024) who reported higher carotene content in sweet potato tubers when borax was sprayed. There was significance for interaction effects. Significantly higher carotene content was observed for the treatment T_2n_4 with 0.89 mg/100g. Crude fibre and crude protein were not significantly influenced by any of the treatments.

CONCLUSION

In *Onattukara* sandy loam soils of Kerala, higher number of tubers per vine, marketable tubers per vine, tuber yield per hectare and vitamin C can be obtained from sweet potato, when the vines are planted under reduced tillage (only one shallow primary tillage) and supplied with the recommended dose of fertilizers (FYM @ 10 t/ ha, N, P_2O5 and K_2O @ 75:50:75 kg/ ha) along with one foliar application of magnesium sulphate followed by borax (both @ 0.2%) at 30 days after planting.

Table 3. Effect of tillage and nutrient management on quality attributes of sweet potato

Treatments	Starch (%)	Total sugars (%)	Vitamin C (mg/100g)
Tillage			
T_1 – reduced tillage	21.01	4.86	20.60
T_2 – ridge tillage	20.51	4.90	18.54
T_3 – Conventional tillage	20.36	4.82	19.99
SEm (±)	0.22	0.07	0.21
CD (0.05)	NS	NS	0.722
Nutrient management			
n_1 – 100% RDF	20.55	4.90	20.13
n_2 – n_1 + MgSO4 @ 0.2% foliar spray	21.09	4.98	19.82
n_3 – n_1 + borax @ 0.2% foliar spray	20.49	4.80	19.60
n_4 – n_2 + borax @ 0.2% foliar spray	20.38	4.75	19.28
SEm (±)	0.16	0.65	0.66
CD (0.05)	NS	NS	NS

*RDF – Recommended dose of fertilizers
*NS – Not significant

Table 4. Interaction effect of tillage and nutrient management on quality attributes of sweet potato

Treatments	Starch (%)	Total sugars (%)	Vitamin C (mg/100g)
T_1n_1	20.74	4.95	20.42
T_1n_2	21.60	4.84	20.35
T_1n_3	20.94	4.69	20.42
T_1n_4	20.76	4.95	21.20
T_2n_1	20.26	4.96	19.55
T_2n_2	21.50	4.81	20.35
T_2n_3	20.66	4.86	17.97
T_2n_4	19.63	4.79	16.30
T_3n_1	20.65	5.03	20.42
T_3n_2	20.18	4.76	18.75
T_3n_3	19.88	4.70	20.42
T_3n_4	20.75	4.95	20.35
SE (m) A/B (±)	0.34	0.16	1.15
SE (m) B/A (±)	0.37	0.14	1.02
CD (0.05) A/B	NS	NS	NS
CD (0.05) B/A	NS	NS	NS

*NS – Not significant
* A/B – Factor (B) at same levels of Factor A
* B/A – Factor (A) at same levels of Factor B

Table 5. Effect of tillage and nutrient management on quality attributes of sweet potato (continued)

Treatments	Carotene (mg/100 g)	Crude fibre (%)	Crude protein (%)
Tillage			
T_1 – reduced tillage	0.48	2.15	5.51
T_2 – ridge tillage	0.60	2.19	5.47
T_3 – Conventional tillage	0.42	2.22	5.61
SEm (±)	0.02	0.05	0.10
CD (0.05)	0.057	NS	NS
Nutrient management			
n_1 – 100% RDF	0.39	2.16	5.50
n_2 – n_1 + MgSO4 @ 0.2% foliar spray	0.48	2.17	5.46
n_3 – n_1 + borax @ 0.2% foliar spray	0.47	2.16	5.51
n_4 – n_2 + borax @ 0.2% foliar spray	0.65	2.26	5.65
SEm (±)	0.03	0.05	0.16
CD (0.05)	0.098	NS	NS

*RDF – Recommended dose of fertilizers
*NS – Not significant

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Table 6. Interaction effect of tillage and nutrient management on quality attributes of sweet potato (continued)

Treatments	Carotene (mg/100g)	Crude fibre (%)	Crude protein (%)
T_1n_1	0.30	2.10	5.52
T_1n_2	0.56	2.19	5.51
T_1n_3	0.46	2.13	5.42
T_1n_4	0.49	2.17	5.60
T_2n_1	0.49	2.15	5.55
T_2n_2	0.45	2.12	5.16
T_2n_3	0.58	2.12	5.52
T_2n_4	0.89	2.33	5.64
T_3n_1	0.39	2.23	5.42
T_3n_2	0.44	2.21	5.71
T_3n_3	0.37	2.16	5.60
T_3n_4	0.48	2.28	5.71
SE (m) A/B (±)	0.05	0.08	0.27
SE (m) B/A (±)	0.046	0.08	0.26
CD (0.05) A/B	0.142	NS	NS
CD (0.05) B/A	0.135	NS	NS

*NS – Not significant
* A/B – Factor (B) at same levels of Factor A
* B/A – Factor (A) at same levels of Factor B

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