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MORPHOPHYSIOLOGICAL VARIABILITY AND YIELD PERFORMANCE OF SWEETPOTATO GENOTYPES AT PIEDMONT SOIL

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Abstract

Selection of suitable genotypes of sweetpotato for piedmont soil on the basis of morph physiological variability and yield attributes was conducted during November 2015 to April 2016. Nine genotypes viz. Local-1, Local-2, Local-5, Local-8, Exotic-1, Exotic-2, Exotic-3, Exotic-4 and BARI SP-4 were studied under field conditions at Sylhet Agricultural University Farm, Sylhet following Randomized Complete Block Design with three replications. Dry mass production and its partitioning during different growth stages and yields were evaluated. Results revealed that leaf dry weight increased rapidly from 60 to 105 days after planting (DAP), vine dry weight from 60 to 150 DAP and storage roots from 90 to 135 DAP. Initially dry matter partitioning into leaves, vines and fibrous roots were higher. The flows of dry matter translocation to the organizing plant parts continued to 90 DAP and thereafter dry matter translocation flow moved to the storage roots rapidly until 120 DAP. Dry matter content (%) of storage roots increased with plant age. Exotic-4, Exotic-2 had the highest dry matter content. Among the local genotypes, Local-8 had more dry matter content. Local-1, Local-8, Local-2, BARI SP-4 had the greater bulking rate from 105 - 120 DAP while Exotic-2 and Exotic-3 had from 120 - 135 DAP. Local-1 and Local-8 had greater harvest index at 120 DAP while Local-2 at 135 DAP and Exotic-3 at 150 DAP. Therefore life span of sweetpotato from 120 to 135 DAP may be important for breeding works. Harvesting stage of Local-1 and Local-8 may be 135 DAP while Exotic-3 and Local-2 may be 150 DAP. The highest yield was in Local-1 (44.06 t ha^{-1}) followed by Local-8 (38. 82 t ha^{-1}). Exotic-4, Exotic-3 and Local-2 contained higher total soluble solids (Brix %) from 12-14. It can be concluded that Local-1 and Local-8 may be suitable for Khadimnagor soil of Northern and Eastern Piedmont plains for higher yield. In addition Local-2, Exotic-3 showed interest for future investigation.

***Keywords*: Dry matter partitioning, piedmont soil, genotype, harvest index, total soluble solids.**

Introduction

Sweetpotato (*Ipomoea batatas* (L.) Lam.) is an environment friendly and versatile root crop which grows in marginal lands, requiring low amount of fertilizers, other agricultural inputs and less management practices (Kozai *et al*., 2006). Marginal lands such as charlands, homestead areas, saline belts, valley and newly accreted land can be used for its growing. Sweetpotato produces more edible energy ha^{-1} day^{-1} than wheat, rice or cassava (Kitaya *et al*., 2008). Storage roots are rich source of energy, several minerals and micronutrients (Laurie *et al.*, 2012). Leaves are also rich in vitamin B, beta-carotene, iron, calcium, zinc and protein (Islam, 2014). Recently orange fleshed sweetpotato is being used for making innovative complementary food products like food powder with small fish and rice. This food powder is easy to prepare into a smooth porridge, hygienically and safely, and is ideal for 6–9 month old infants (CGIAR, 2014). It is an easily digestible food crops even young children can digest it. According to Bangladesh National Food Policy Report (BNFPR, 2014), even at low yield (6 t ha^{-1}) of sweetpotato, just 12 decimals (500 m^2) of land can generate adequate annual supply of vitamin A for a family of five members. Despite its many benefits, sweetpotato is characterized by low production, yield and root quality in Bangladesh. According to Ministry of Agriculture (MoA, 2016) in the last 20 years yield of sweetpotato remains static, national average yield (t ha^{-1}) is only 10.4.

Bangladesh has a total arable land of 8.56 million hectares of which 2.45% is cultivable waste (BBS, 2015) and about 6.7 million hectares of arable land are acidic. Soil pH of 26% of cultivable land of Sylhet region ranges from 4.5 to 5.7 (SRDI, 2010). Among the cultivated lands of the Sylhet region, 71% of lands are sandy loam to clay loam. About 17.2% of culturable land of Sylhet division remains fallow each year and 58.1 % of cultivable land has no irrigation

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facilities in Rabi season (DAE, 2017). Sweetpotato is a fast growing root crop. It has capable of rapid soil coverage and good rooting characteristics which helps to reduce soil acidity (Essilfie *et al*., 2015) and soil erosion in hilly areas.

Vegetable production is very limited in Sylhet region. People of this region depend on the supply of vegetables from other parts of the country. Thus price of vegetables is relatively high. About 87.8% of households own a homestead in the country. Thus growing of suitable sweetpotato genotypes in these areas can meet the demand of vegetable.

Sweetpotato varieties having dry matter content of 30-32 % are preferable as a bread substitute for breakfast (CIP, 2011). Orange-fleshed clones have moist texture compared to clones with other flesh colors. Moist texture and low dry matter content storage roots are not getting preferences to the sweetpotato consumers in Asia and the Pacific. Hence it is necessary to take positive steps to increase the dry matter content in orange-fleshed sweetpotato with preferred dry texture.

There are many indigenous sweetpotato genotypes are available in Sylhet region, but their dry mass production, partitioning pattern, physiological growth and yield performance are unknown. On the other hand, sweetpotato export countries like Japan has developed many high yielding, nutritious varieties. Therefore, there is a need to determine how these genotypes/varieties can be made available to the farmers.

Sweetpotato cultivars with a high total dry mass diverted more dry matter to storage roots compared to those with a lower total dry mass (Yen, 1974). Therefore the main objectives of the field trials on the production and partitioning of dry matter were to characterize the growth and yield of nine genotypes of sweetpotato by (a) determining the dry mass of the leaves, vines, fibrous roots and storage roots; (b) determining the dry matter partitioning of assimilates to the storage roots of the local and exotic genotypes over check variety and (c) yield contributing characters and yield of the genotypes.

Material and Methods

The experiment was carried out at Sylhet Agricultural University Farm, Bangladesh during November 2015 to March 2016. Soil samples were collected from the field, analyzed and fertilizer rate was calculated following procedure of FRG (2012) (Table 1 and 2). Local-1, Local-2, Local-5, Local-8, Exotic-1, Exotic-2, Exotic-3, Exotic-4 and BARI SP-4 were used as planting materials. Research field was prepared by following 4 consecutives ploughing and cross ploughing. Soil reaction was corrected out by dolomite application (4 kg decimal^{-1}) prior to 15 days of planting and fertilizer recommendation was made as per soil test value (FRG, 2012). Cowdung, Urea, TSP, MoP, Gypsum, Zinc sulphate (Hepta), Solubor and Magnesium sulphate ha^{-1} were 5000 kg, 224 kg, 186 kg, 200 kg, 70 kg, 10 kg, 3 kg, and 85 kg, respectively. All of cowdung, TSP, Gypsum, Zinc sulfate, magnesium sulfate and solubor; half of urea and MoP were applied as basal during final land preparation. Remaining Urea and MoP was applied as side dressing at 30-35 days after planting during earthing up operation. Vine cuttings were planted on raised beds following Randomized Complete Block Design (RCBD). Weeding, irrigation, earthing-up, vine lifting and other intercultural operations were done as and when necessary.

The observations on storage roots initiation was started at 45 DAP and continued till to 150 DAP with an interval of 15 days. In each harvest 4 plants plot^{-1} were harvested. Harvested plants were poured into the polybag and brought them in the laboratory carefully with proper tagging. Then the plant was washed with running tap water and left it sometimes to drip out excess water. Leaves, vines, fibrous roots and storage roots were separated and fresh weights were taken using electrical balance. Storage roots were sliced with the sharpen knife. 100g of leaves, roots, vines and sliced storage roots were packed separately into labeled brown paper and was kept them into the oven at 60°C until constant dry weight achieved. Dry weights were measured separately with an electrical balance.

At final harvest rest of the plants were harvested and storage roots of each plot were counted and weighed. Fresh clean storage roots were acerated and total soluble solids (Brix %) was estimated by TSS instrument. Length of storage roots and girth were measured with a measuring tape. Finally, diameter was calculated using the formula: Girth = 2πr, where, 2r = diameter of storage roots. Storage roots bulking rate (BR) and harvest index (HI) were calculated as follows:

(a) Bulking rate (BR) = $\frac{\text{Weight of fresh storage roots (g/plant)}}{\text{Period of storage root growth (days)}}$

(b) Harvest index (%) $= \frac{\text{Storage roots fresh weight (g/plant)}}{\text{Total plant fresh weight (g/plant)}} \times 100$

Table 1. Land and Soil characteristics of the experiments site

Physical parameter	Characteristics
Location	Sylhet Agricultural University Farm, Tilagorh, Sylhet
Geographic location	24°54′37″ to 24°54′38.10″ North latitude and 91°54′ 00.7″ to 91°54′01.8″ East longitude
Agro-ecological zone	Northern and Eastern Piedmont Plains (22)
Physiography	Piedmont soils
Parent materials	Tertiary rock of Dupitila formation (UNDP and FAO. 1988)
Land type	High land
Soil series/group	Khadimnagor
Soil texture (0-15 cm)	Sandy loam

Table 2. Fertility status of the soils of the experimental site

Elements	Critical limit	Initial soil		Post-harvest soil	
		STV	Status	STV	Status
pH	>5.5	5.0	Strongly acidic	5.6	Slightly acidic
Total N (%)	0.10	0.08	Low	0.10	Low
P (µg g^{-1})	7	6.0	Low	27	Very high
K (meq100 g^{-1})	0.08	0.07	Low	0.09	Low
S (µg g^{-1})	8	9.0	Low	20	Optimum
Zn (µg g^{-1})	0.50	0.37	Very low	0.40	Low
B (µg g^{-1})	0.16	0.23	Low	0.26	Medium
Mg (meq 100 g^{-1})	0.50	0.37	Very low	0.69	Low
Ca (meq 100 g^{-1})	2.00	1.50	Very low	1.80	Low
OM (%)	C:N= 10:1	1.20	Low	1.30	Low

STV = Soil test value

Results and Discussion

Dry weight of leaves (g $plant^{-1}$)

Leaf dry weight increased upto 135 DAP in all of the genotypes except Exotic-3 and then declined (Fig. 1). The rates of dry weight increment upto 60 DAP were slow and thereafter dramatically increased to peak at 135 DAP, and finally the rates dropped. The highest leaf dry weight was found in Local-1 (49.16 g) followed by Local-5 (41.10 g), and the lowest was in Exotic-3 (25.86 g) at peak period (135 DAP). After final harvest, the highest leaf dry weight was in Local-1 (47.55 g) followed by the rest of the local genotypes and the lowest was in check variety BARI SP-4 (27.03 g).

Dry weight of vines (g $plant^{-1}$)

Increment of vine dry weight upto 60 DAP was slow (Fig. 2). Then it soared upto 150 DAP except Local-5, Exotic-3 and check variety BARI SP-4. Vine dry weight of Local-5 declined at 135 DAP, whereas vine dry weights of Exotic-3 and BARI SP-4 increased gradually upto 150 DAP. The highest vine dry weight was in Local-1 (64.8 g) followed by Local-2 and the lowest was in Exotic-3 (22.48 g).

Dry weight of fibrous roots (g $plant^{-1}$)

Fibrous roots dry weight increased rapidly upto 105 DAP and thereafter slowed down except Local-1 (Fig. 3). The highest fibrous roots dry weight was in Local-1 (1.80 g) followed by Local-2 (1.67 g), and the lowest was in check variety BARI SP-4 and Exotic-2 (0.42 g).

Dry weight of storage roots (g $plant^{-1}$)

At the initial stage (upto 75 DAP), storage roots dry weight increased very slowly and then increased gradually upto 90 DAP (Fig. 4). Storage roots dry weight increased very rapidly from 90 to 135 DAP. At final harvest, the highest weight (196.10 g) was in Local-8 and Local-1 (190.20 g) followed by Local-2 (147.10 g), and the lowest was in check variety BARI SP-4 (64.81 g).

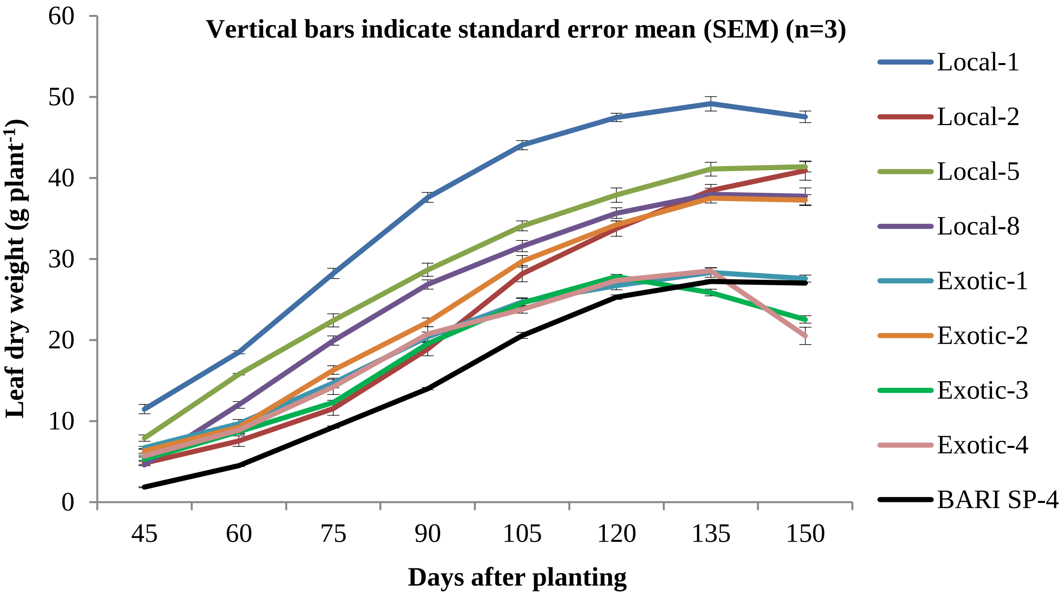

Fig. 1. Leaf dry weight at different days after planting (DAP).

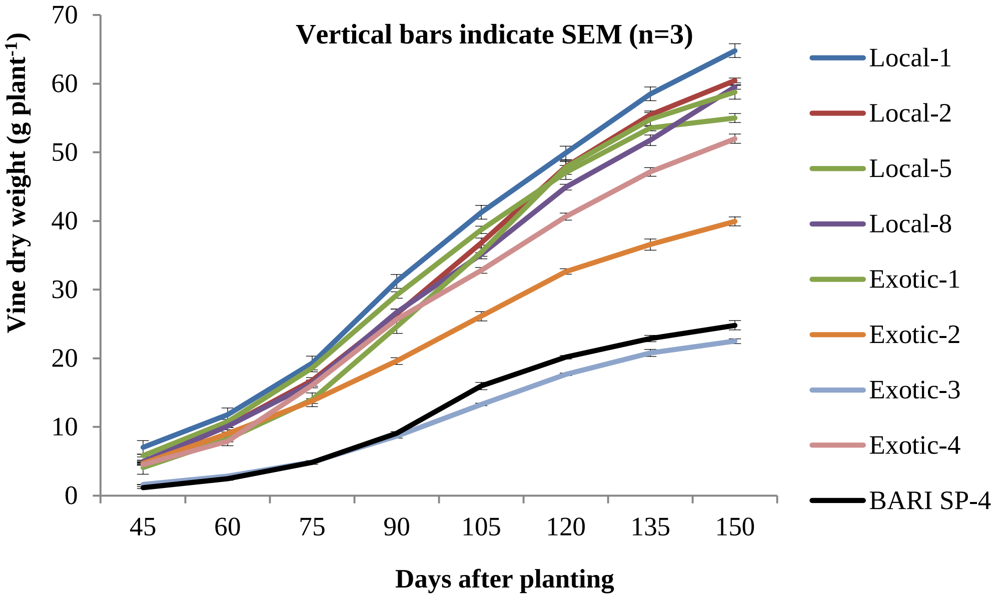

Fig. 2. Vine dry weight at different days after planting (DAP)

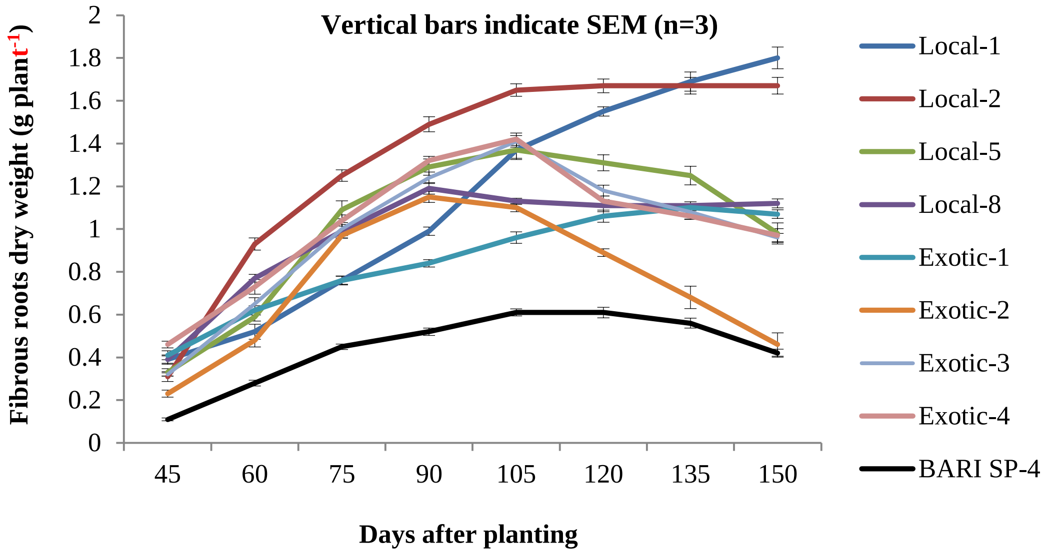

Fig. 3. Fibrous roots dry weight at different days after planting (DAP)

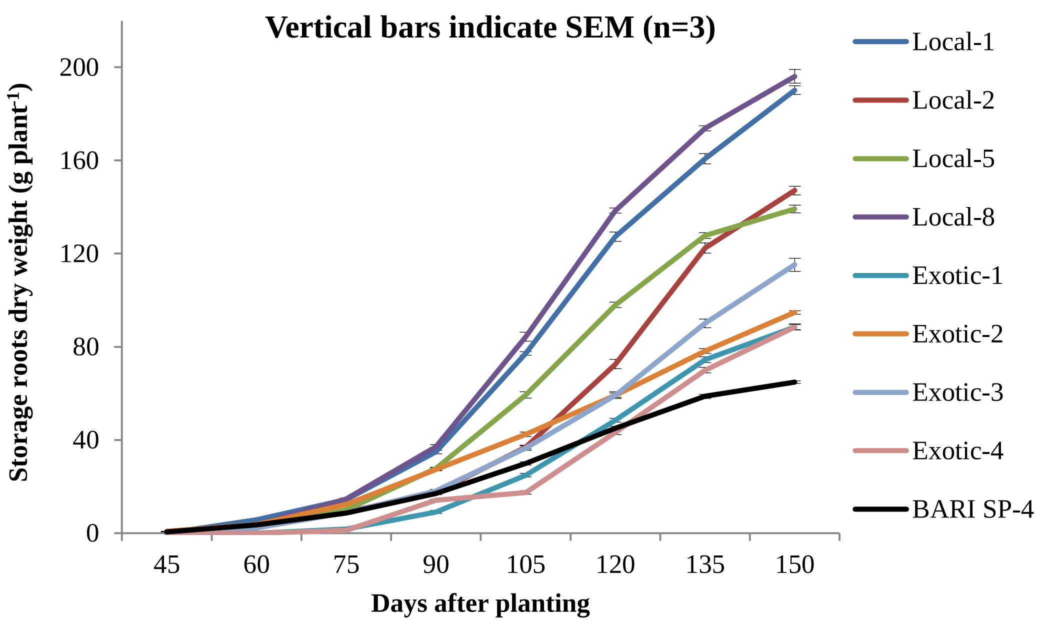

Fig. 4. Storage roots dry weight at different days after planting (DAP)

Total fresh weight (g plant^{-1})

Total fresh weight increased with plant age upto final harvest (Table 3). The rate of fresh weight increment from 45 to 75 DAP was slow, it became the highest at 135 DAP with rapid growth and then slowed down upto 150 DAP. The maximum total fresh weight was in Local-1 (1210 g) followed by Local-8 (1111.0 g) and the lowest was in Exotic-4 (556.5 g) and check variety BARI SP-4 (556.2 g) at 150 DAP.

Dry matter partitioning into leaves (%)

At initial stage dry matter partitioning into leaves was high and then reduced gradually upto final harvest (Fig. 5). At 45 DAP, the highest dry matter partitioning into leaves was in Exotic-3 (73.21%) followed by Exotic-1 (59.79%) and the lowest was in Local-8 (46.19%). After 150 days of planting, the highest dry matter partitioning into leaves was in BARI SP-4 (23.09%) followed by Exotic-2 (21.62%), and the lowest was in Exotic-4 (21.62%), Local-8 and Exotic-3.

Dry matter partitioning into vines (%)

At beginning dry matter partitioning into vines was high and then reduced gradually upto final harvest with some exceptions (Fig. 6). At 45 DAP, the highest dry matter partitioning into vines was in Local-8 (49.93%) followed by Local-2 (48.04%), and the lowest was in Exotic-3 (22.38%). At final harvest, the highest dry matter partitioning into vines was in Exotic-1 (33.40 %) followed by Exotic-4 (32.1%), and the lowest was in Exotic-3 (13.95%).

Dry matter partitioning into fibrous roots (%)

Initially, dry matter partitioning into fibrous roots was greater and then gradually reduced upto final harvest (Fig. 7). At 45 DAP, the highest dry matter partitioning was in Exotic-3 (4.41%) similar to Exotic-4 and the lowest was in Exotic-2 (1.92%). After 150 days of planting, the highest dry matter partitioning was in Locl-2 (0.67%) and the lowest was in Exotic-2 (0.27%).

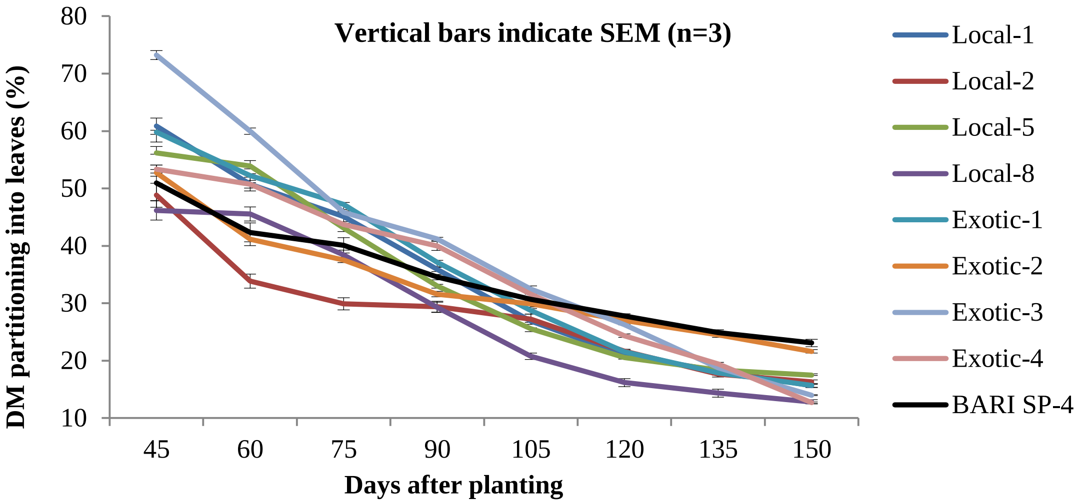

Fig. 5. Dry matter partitioning into leaves at different days after planting (DAP)

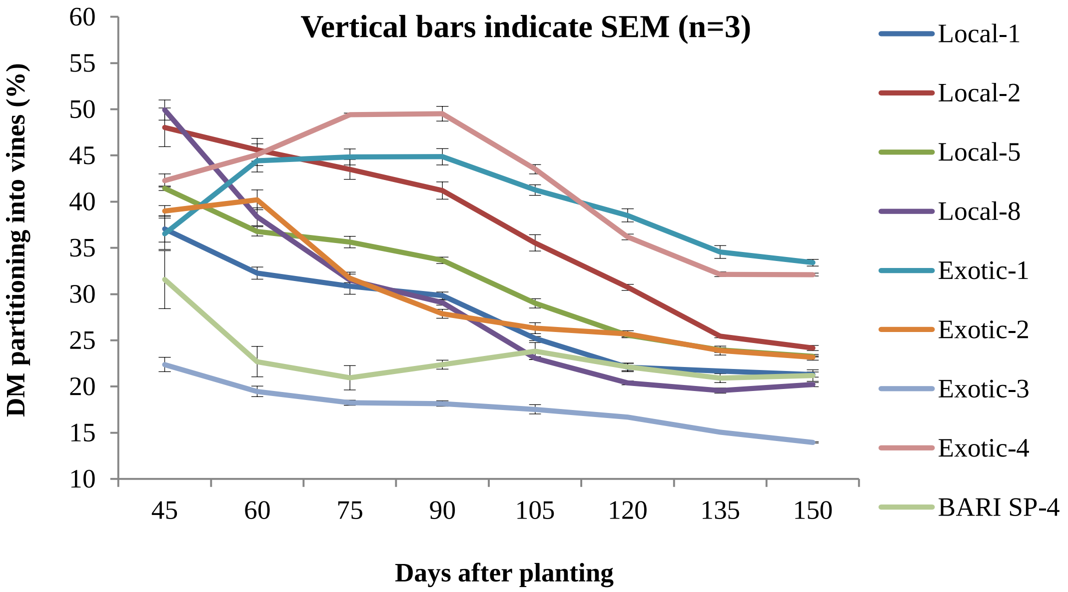

Fig. 6. Dry matter partitioning into vines at different days after planting (DAP)

Table 3. Total fresh weight of sweetpotato genotypes at different days of planting (n=3)

Genotypes	Total fresh weight of sweetpotato at different DAP (g plant^{-1})							
	45	60	75	90	105	120	135	150
Local-1	128.3±5.79 a	219.5±3.65 a	351.6±1.97 a	534.1±3.48 a	764.1±3.72 a	995.7±3.16 a	1123.0±3.25a	1210.0±2.60 a
Local-2	67.9±2.24 de	131.0±0.66 e	205.6±1.57 d	320.1±2.93 e	485.5±3.79 d	689.7±4.32 d	902.9±5.07 c	995.5±2.76 c
Local-5	103.1±3.63 b	194.1±5.21 b	293.4±6.24 b	430.7±7.39 c	580.3±9.11 c	732.1±12.30 c	839.4±8.73 d	866.3±8.90 d
Local-8	74.0±1.77 d	173.7±1.64 c	297.5±2.41 b	464.9±2.45 b	682.6±5.34 b	912.1±5.70 b	1051.0±3.71b	1111.0±3.70b
Exotic-1	75.0±0.32 d	115.7±4.24 f	182.9±6.20 e	294.2±8.02 f	421.0±7.48 e	552.9±4.37 e	657.2±3.71 e	695.1±5.50 e
Exotic-2	86.9±3.87 c	143.4±5.19 d	243.8±4.80 c	356.5±4.49 d	467.8±3.65 d	566.1±5.53 e	641.8±3.15 e	675.8±4.40 e
Exotic-3	58.3±2.89 e	98.7±3.99 g	157.8±6.39 f	258.9±3.56 g	381.4±6.06 f	498.5±7.91 f	607.2±3.21 f	677.4±13.88e
Exotic-4	72.6±1.34 d	108.8±2.46 fg	186.0±3.37 e	275.1±3.66 fg	354.6±4.40 g	465.9±4.19 g	549.0±6.81 g	556.5±8.68 f
BARI SP-4	27.9±0.94 f	72.3±1.52 h	145.3±2.19 f	238.8±3.88 h	374.0±1.47fg	474.6±1.56 fg	539.0±2.34 g	556.2±2.09 f
CV %	6.01	3.63	2.94	2.27	1.86	1.69	1.30	1.41
LSD $_{0.01}$	11.06	12.11	16.08	19.26	22.21	26.32	23.77	27.41

Figures (Mean± SEM) in a column having same letters do not differ significantly at 1% level of significance by Duncan's Multiple Range Test (DMRT).
SEM = Standard error of mean

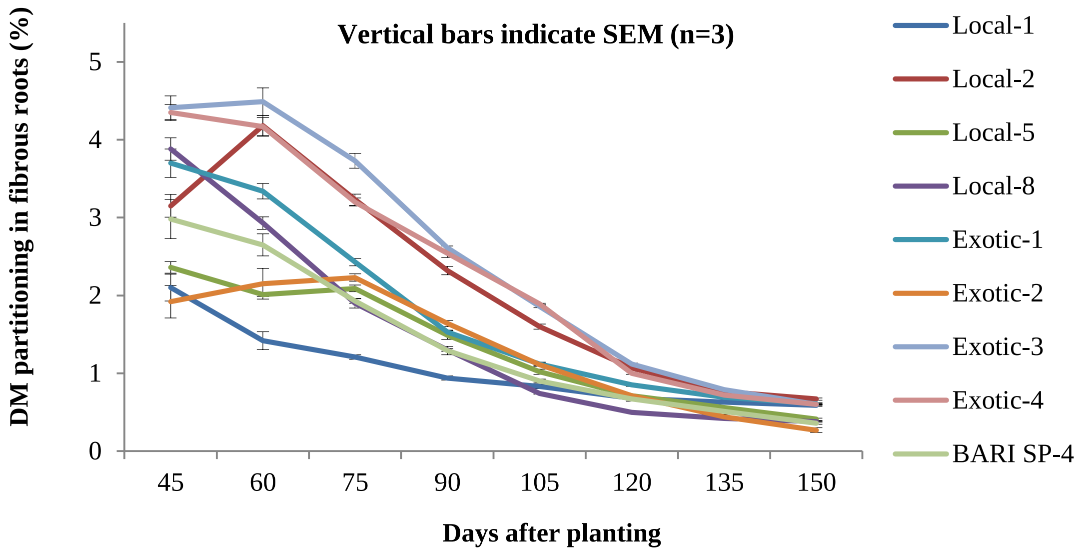

Fig. 7. Dry matter partitioning into fibrous roots at different days after planting (DAP)

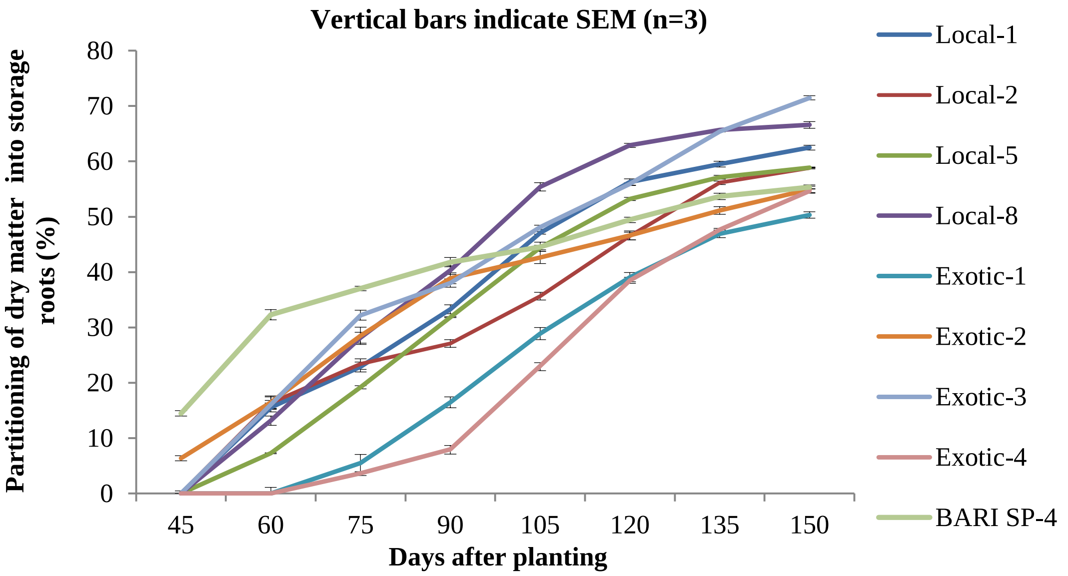

Fig. 8. Dry matter partitioning into storage roots at different days after planting (DAP)

Dry matter partitioning into storage roots (%)

Dry matter partitioning into storage roots increased gradually upto 90 DAP and then increased rapidly upto 120 DAP; after that it slowed down (Fig. 8). After 150 days of planting, the highest dry matter partitioning was in Exotic-3 (71.47%) followed by Local-8 (66.59%), and the lowest was in Exotic-4 (50.31%).

Dry matter content in storage roots (%)

Dry matter content increased gradually with plant age (Fig. 9). At final harvest, the maximum dry matter content was in Exotic-2 (37.9%) and Exotic-4 (37.90%) followed by Local-5 (31.92%), and the lowest was in check variety BARI SP-4 (24.90%). The dry matter content ranged from 18.6 to 37.9% during the period from 45 to 150 DAP.

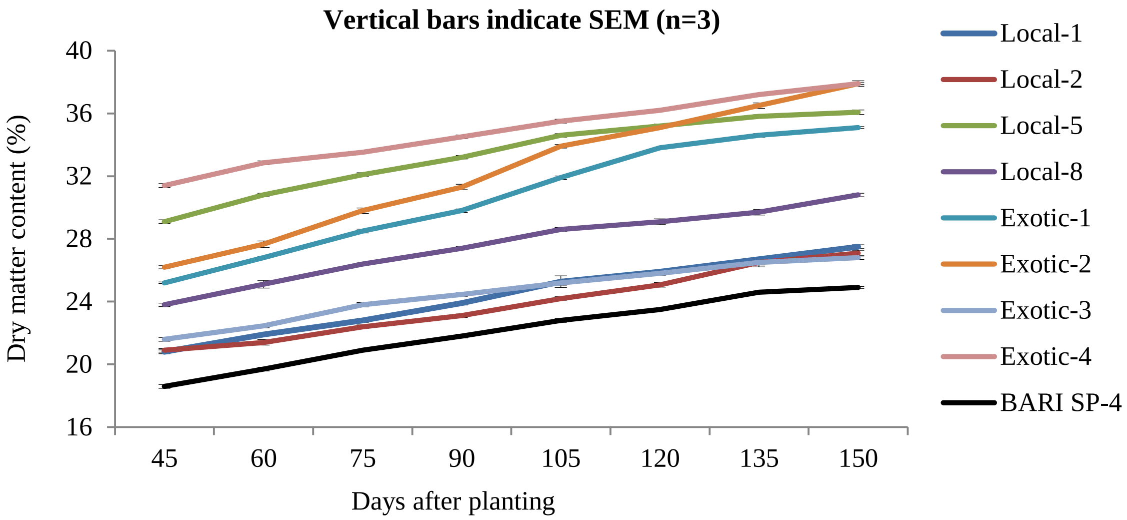

Fig. 9. Dry matter content of storage roots at different days after planting (DAP)

Harvest index (%)

Harvest index increased rapidly upto 120 DAP in all genotypes and then slowed down the rate upto reaching the peak position except Exotic-3 and Exotic-4 (Fig. 11). At final harvest, the highest harvest index was in Exotic-3 (63.48%) followed by Local-8 (57.31%) and Local-1 (57.17%), and the lowest were in Exotic-1 (36.28%).

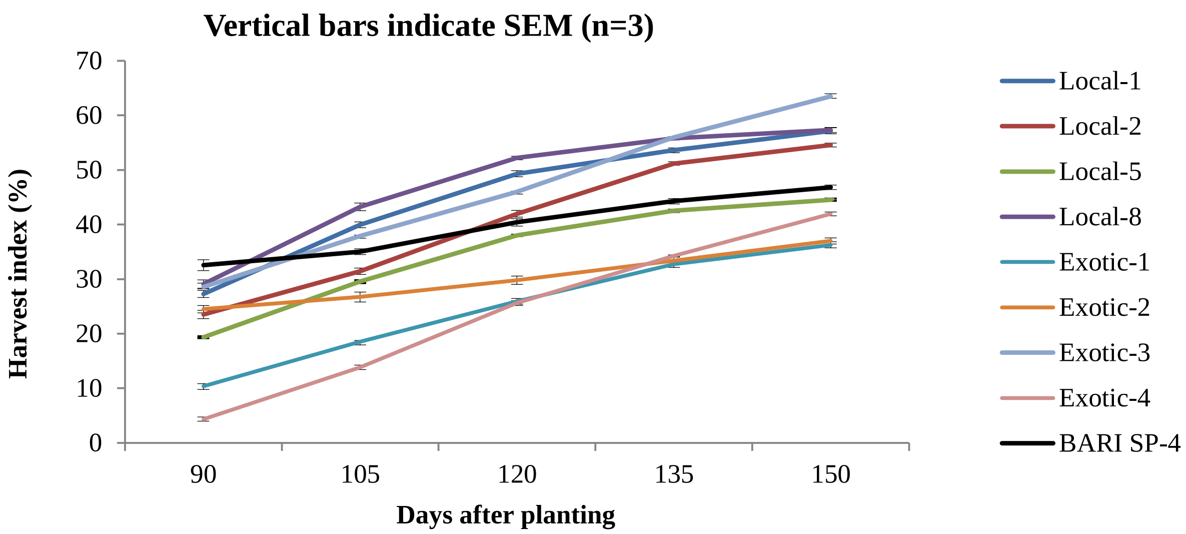

Fig. 11. Harvest index at different days after planting (DAP)

Storage roots bulking rate (g day^{-1})

Bulking rates were slow from 60 to 75 DAP, rapid from 105 to 120 DAP and then declined from 135 to 150 DAP (Fig. 10) with some exceptions. Bulking rates of Local-2, Exotic-3 and Exotic-2 were high upto 135 DAP and then declined. The highest bulking rate was in Local-1 (12.40 g day^{-1}) which was similar to Local-8 (12.06 g day^{-1}), and the lowest rate was in Exotic-2 (2.92 g day^{-1}) from 105 to 120 DAP.

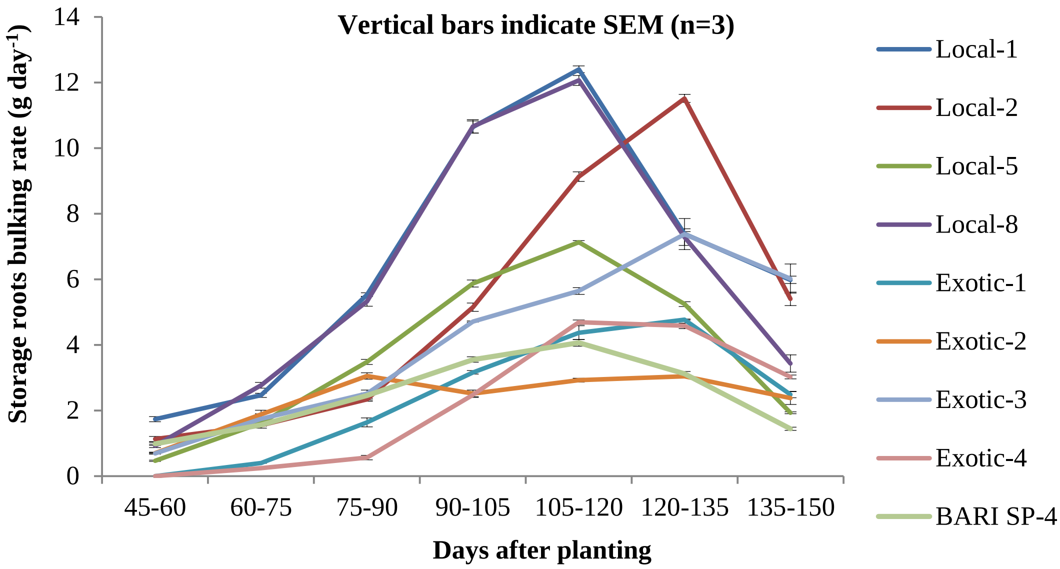

Fig. 10. Storage roots bulking rate at different days after planting (DAP)

Yield contributing characters and yield

The highest storage roots weight plant^{-1} was in Local-1 (691.7 g) followed by Local-8 (636.7 g), and the lowest (233.3 g) was in Exotic-4 (Table 4). The result agrees with the findings of Siddique (2005) where the recorded yield ranged from 260 to 1120 g plant^{-1}. The highest number of storage roots plant^{-1} was in Exotic-2 (7.17) followed by Local-2 (6.17) and Local-8 (5.90). The lowest number was in Exotic-4 (2.17). The longest storage roots were recorded in Local-1 (15.50 cm) followed by Local-2 (13.83 cm). The shortest storage roots were in Local-8 (7.17 cm). The results partially agree with the results of Rahman and Haque (1983) where they stated that number of storage roots plant^{-1} depends on the variety and ranged from 3.09 to 6.88.

The highest diameter was recorded in Local-1 (5.62 cm) followed by Local-8 (5.02 cm) (Table 4). The thinnest storage roots were in Exotic-1 (1.94 cm). Diameter of storage roots of 9 genotypes ranged from 1.94 to 5.62 cm. The highest fodder yield (9.36 t ha^{-1}) was in Local-1 followed by Local-2, Local-5 and Local-8 (Table 4). The lowest fodder yield (3.75 t ha^{-1}) was in Exotic-3 (Table 4).

The genotype Local-1 gave the highest storage roots yield (44.06 t ha^{-1}) followed by Local-8 (38.82 t ha^{-1}) and Local-2 (25.99 t ha^{-1}) (Table 4). The lowest yield of storage roots was in Exotic-1 (10.90) that was statistically similar to Local-5 and Exotic-4. Among the genotypes, yield of Local-1, Local-2, Local-8, Exotic-2 and Exotic-3 were optimistic. Hoque (2002) obtained the yield of eight sweetpotato genotypes ranging from 10.08 to 32.79 t ha^{-1}.

Total soluble solids (Brix %) in storage roots

Total soluble solids of storage roots of the genotypes varied significantly (Table 4). Among the genotypes, the highest Brix % was in Exotic-4 (14.0) followed by Exotic-3 (13.0) and Local-2 (12.0). The lowest Brix % was in Local-5 (10.0).

Conclusion

Morphological, physiological and yield attributes revealed that Local-1, Local-8, Local-2 and Local-5 performed better over check variety BARI SP-4. It can be concluded that Local-1 and Local-8 may be selected for piedmont soils for yield. Genotypes Local-2, Exotic-3 may be needed for further investigation.

Table 4. Performance of yield and yield contributing characters of sweetpotato genotypes (n=3)

Genotypes	Number of storage roots plant^{-1}	Length of storage roots (cm)	Diameter of storage roots (cm)	Fresh weight of storage roots (g plant^{-1})	Fodder yield (t ha^{-1})	Yield of storage roots (t ha^{-1})	Total soluble solids (Brix %)
Local-1	3.57±0.12 c	15.50±0.87 a	5.62±0.16 a	691.7±7.24 a	9.363±0.10 a	44.06±1.65 a	10.83±0.17 de
Local-2	6.17±0.33 b	13.83±0.43 ab	3.16±0.11 de	543.0±2.37 c	8.443±0.07 b	25.99±0.81 c	12.00±0.29 bc
Local-5	2.77±0.15 cd	11.87±0.23 bc	2.99±0.08 de	386.0±3.06 e	8.033±0.10 c	14.18±0.49 e	10.00±0.29 e
Local-8	5.90±0.17 b	7.17±0.20 e	5.02±0.07 b	636.7±7.26 b	8.100±0.11 c	38.82±0.71 b	10.67±0.17 de
Exotic-1	3.33±0.17 c	12.27±0.20 bc	1.94±0.02 f	252.2±4.04 fg	7.197±0.08 d	10.90±0.78 e	11.10±0.21 c-e
Exotic-2	7.17±0.17 a	11.80±0.29 bc	3.19±0.08 de	250.0±2.31 fg	6.433±0.10 e	17.81±0.81 d	11.50±0.29 cd
Exotic-3	6.00±0.29 b	10.30±0.17 cd	3.33±0.03 d	430.0±11.55 d	3.753±0.06 h	18.65±0.56 d	13.00±0.29 ab
Exotic-4	2.17±0.17 d	9.43±0.01 d	4.12±0.09 c	233.3±3.18 g	6.040±0.12 f	11.67±0.16 e	14.00±0.29 a
BARI SP-4	3.33±0.17 c	8.23±0.17 de	2.79±0.15 e	260.3±2.60 f	4.320±0.03 g	22.88±0.06 c	10.77±0.15 de
CV %	8.20	7.81	4.41	2.49	2.0	6.65	3.80
Lsd 0.01	0.876	2.078	0.377	24.28	0.329	3.613	1.045

Figures (Mean± SEM) in a column having same letters do not differ significantly at 1% level of significant by Duncan's Multiple Range Test (DMRT). SEM = Standard error of mean

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