On-Farm Evaluation of Orange Fleshed Sweet Potato Genotypes in the Eastern Terai of Nepal

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Abstract

Advanced sweet potato genotypes selected from different on-station trials were evaluated in the farmer's field of Sunsari district (136 masl), Eastern Terai of Nepal during the years 2014-2016 to identify the high yielding genotypes adaptable in the study area. Five sweet potato genotypes namely CIP 440015, CIP 440021, CIP 440012, CIP 440328 and CIP 440267 including 'Japanese Red' (a standard check) and 'Sunsari-1'(farmer's local check) were evaluated in randomized complete block design (RCBD) with three replications. Overall, the orange fleshed genotypes received from International Potato Center (CIP), Lima, Peru performed better than other lines. The results of three years data revealed that the highest total tuberous root yield (22.56 t/ha) was recorded in CIP 440267 followed by CIP 440012 (20.63 t /ha). Also, these two genotypes were found tolerant to pest damage and highly preferred by the farmers in the farmers' preference rating. Sunsari-1 produced the least mean tuberous root yield (5.98 t/ha) compared to all other tested genotypes. The results showed that CIP 440267 and CIP 440012 gave the best performance in majority of the yield and yield contributing parameters and hence preferably the best orange fleshed genotype among the tested genotypes having optimum yield potential and better adaptability in the Eastern Terai of Nepal.

Keywords: *Eastern Terai, on-farm, sweet potato, yield*

Introduction

Sweet potato (*Ipomoea batatas* L.) is cultivated in more than 100 countries in the world (Woolfe, 1992) in diverse environments, often by small farmers in marginal soils using minimum inputs (Manrique and Hermann, 2000). It is one of the most traditional root crops in many countries including Nepal. It is regarded as a 'poor man's crop' as it is consumed mostly by poor people. The plant is herbaceous type with perennial vine usually grown as an annual crop. It gives satisfactory yield under adverse climatic conditions, as well as under low or no use of external inputs (Carey *et al.*, 1999; Ndolo *et al*., 2001; Githunguri and Migwa, 2004).

It is the seventh importance crop among all food crops worldwide from the point of view of total production, thirteenth in term of value of production and fifth in caloric contribution to human diet (Bouwkamp, 1985; Tortoe, 2010). Among the tuber crops grown in the world, sweet potato ranks second after cassava (Ray and Ravi, 2005).

In Nepal, sweet potato is one of the most important tuberous root (usally called tuber) crop grown throughout the mid hills and Terai region in kitchen garden (Gautam, 1991). As reported by Shah (1991) approximately 7000 ha of land are covered by sweet potato with productivity of 8.48 t/ha. Sweet potato has religious importance and roots are usually consumed during Shivratri and Makarsakranti (festivals). In some places of terai sweet potato tubers are used as a substitute of staple food (Regmi, 1982). In eastern part of Nepal, sweet potato is grown mainly in the low lands. Siraha, Sunsari, Jhapa, Morang, Saptari, Sarlahi and Dhanusa are more potential districts for this crop. Currently, the area of this crop in this region is increasing rapidly due to its high nutritional value and low input requirement for cultivation.

Vitamin-A deficiency is widespread and has severe consequences for young children in developing countries (Low *et al*., 2007) including Nepal especially in ethnic communities and schedule cast groups. In the flood prone and marginalized areas of Eastern Terai of Nepal, sweet potato would have great role for food and nutritional security. It is good source of vitamin C, vitamin E (0.280 mg/100 g fresh weight), dietary fiber, potassium, and iron. Orange-fleshed sweet potato (OFSP) are rich in ß-carotene (the precursor of vitamin A) (Low *et al*., 2007; Teow *et al*., 2007). Despite its potential, lack of improved sweet potato varieties suitable for different agro-ecologies and resistant to insect pests are some of the factors that hinder the crop expansion.

Farmers are basically interested in superior and specifically adapted varieties to their condition and with a high degree of stability over time (Scott and Maldonando, 1998). Due to its higher productivity and drought tolerance, it can play vital role in achieving food self sufficiency of the region. Even though Eastern Terai region of Nepal has wider agro-ecological zones and suitable for sweet potato production, unavailability of improved sweet potato varieties that can give higher yield and tolerance against major insect pests is a major problem in most sweet potato growing areas. A series of on-station studies on selection and evaluation trial was undertaken at different agro-ecological domains of Nepal during the years 2010 to 2016. Therefore, the objective of this study was to evaluate selected improved genotypes for adaptation and higher root yield potential with a view to selecting superior ones for introduction into the production system in the study area.

Materials and Methods

An on- farm trials was conducted at Sunsari district (136 masl), outreach research site of Regional Agricultural Research Station, Tarahara during the years 2014 to 2016. Five advanced promising orange fleshed sweet potato (OFSP) genotypes received from International Potato Center (CIP), Peru, Lima identified from two years on-station varietal trials namely, CIP 440015, CIP 440021, CIP 440012, CIP 440328 and CIP 440267 were compared with standard check ‘Japanese Red’ and farmer's local check variety ‘Sunsari-1’. Sunsari-1, widely adopted in the locality, was compared with promising genotypes. The experiments were laid out in RCBD with three replications. The area of each unit plot was 3.6 m^2. The crop was fertilized @ 30:30:50 kg/h NPK together with 20 t/h of compost as basal dose. Two-to-three nodal vine cuttings were planted at 60 x 30 cm row to row and plant to plant spacing during rainy season in the month of July.

Plant, yield and yield attributing parameters were recorded. Data on ground foliage coverage (%) was taken at 90 days after planting. Tuberous roots were harvested after 150 days of transplanting. With respect to the storage root characters, five tubers were selected as samples and scored. Length of main vine (plant type) were measured with a measuring tape. For the storage root attributes, visual observations were made. On-farm studies from 2014 to 2016, farmers’ preferences on tested clones along with the check varieties was scored as Fair (F), good (G) and very good (VG) in the parameters such as root appearance, flesh color and taste at the harvest. A panel of ten farmers participated to assess the quality and taste parameters of the genotypes. All the quantitative data were analyzed through GENSTAT 3.2 computer package.

Results and Discussion

Ground Cover

From pooled data it is revealed that percent ground cover showed significant variation among the germplasms (Table 1). The ground cover was recorded the highest (92%) in farmer's local variety Sunsari-1 and lowest (84%) in genotype CIP 440267. Significant variation in ground coverage might be due to the effect of genotypic character. Local genotype Sunsari-1 had the highest ground cover because majority of local genotypes exhibited longer vine than OFSP.

Marketable Tuberous Root Number

Pooled value showed the significant differences in the number of marketable tuber among the sweet potato genotypes tested (Table 1). The highest number of marketable tuberous roots (3.99/plant) was recorded in the genotype CIP 440267 followed by CIP 440012 (3.67/plant). The lowest number of marketable tuberous roots (1.70/plant) was recorded from the farmer's local Sunsari-1 variety.

Table 1. Plant and yield contributing characters of sweet potato genotypes under on-farm condition at Sunsari district during 2014-016.

Genotype	Ground cover (%)	Number of tuberous root/plant			Tuberous root wt. /plant (kg)		
		Marketable	Non marketable	Total	Marketable	Non marketable	Total
CIP 440015	91	3.18	3.41	6.58	0.196	0.055	0.250
CIP 440021	91	3.54	3.56	7.10	0.223	0.047	0.270
CIP 440012	88	3.67	3.05	6.72	0.465	0.058	0.524
CIP 440328	88	3.62	2.73	6.35	0.256	0.039	0.295
CIP 440267	84	3.99	4.02	8.01	0.521	0.057	0.577
Japanese Red (ch)	91	3.26	2.44	5.71	0.263	0.051	0.314
Sunsari-1 (ch)	92	1.70	2.46	4.16	0.137	0.036	0.174
P value	0.002	<.001	0.173	0.002	<.001	0.405	<.001
LSD (0.05)	3.534	0.885	1.347	1.677	0.087	0.023	0.093
CV %	4.2	28.3	45.7	27.6	31.2	50.7	28.5

*** Significant at P <.001. Marketable = >20 g, Non-marketable = <20 g

Total number of tuberous root per plant

Total number of tuberous roots per plant showed significant differences among the seven sweet potato genotype tested (Table 1). The highest number of tuberous root per plant (8.01) was recorded in the genotype CIP 440267 followed by CIP 440021(7.10). On the other hand, the lowest mean number of tuberous root per plant (4.16) was recorded in the farmer's check Sunsari-1. The difference perceived among the OFSP genotypes in number of tuberous roots per plant could be attributed to the differences in their genotypic composition. These results are closely related with those reported by Anonymous (2009-10) where the number of tuberous root per plant was about 5.13 in CIP 440267.2. Farooque and Husain (1973) reported that the number of tubers per plant varied from 4.70 to 11.76. Siddique (1985) also found the number of tubers per plants which varied from 1.73 to 6.03.

Tuberous root weight per plant

Pooled result showed that total and marketable tuberous root weight of sweet potato differed significantly among the genotypes (Table 1). The highest root weight per plant was observed in the genotype CIP 440267 (0.577 kg) where marketable root weight was 0.521 kg and non-marketable was 0.057 kg followed by CIP 440012 (0.524 kg). The differences in marketable tuberous root yield could be attributed to the genetic variations among the orange fleshed varieties in partitioning photosynthates (Nedunchezhiyan *et al*., 2007). The result of the current study is in consistent with the finding of Omiat *et al*. (2005). Non-marketable tuberous root weight (kg) did not differ significantly among the genotypes tested in the experiment. Nwankwo *et al*. (2012) also obtained same results in unmarketable tuberous root yield among sweet potato varieties in their study.

Total tuberous root yield (t/ha)

Significant differences occurred in total tuberous root yield (t/ha) among the sweet potato genotypes evaluated except in the experimental year 2015 (Table 2). The genotype CIP 440267 produced the highest total tuberous root yield (27.25 t/ha) followed by CIP 440012 (19.27 t/ha) in the year 2014. In 2015, tuberous root yield showed non-significant differences among the tested genotypes. Though the tuberous root yield (t/ha) did not significantly differed among the genotypes evaluated, the highest yield of tuberous roots (7.45 t/ha) was recorded in the genotype CIP 440015 which was statistically at par with CIP 440021 (7.13 t/ha). Likewise, the highest tuberous root yield (37.2 t/ha) was recorded in CIP 440012 followed by CIP 440267 (36.5 t/ha) during 2016. The three year mean data table revealed that highest total tuberous root yield (22.56 t/ha) was recorded in CIP 440267 followed by the genotype

CIP 440012 (20.63 t /ha) (Table 2). This shows that these two genotypes converted most of their photosynthetic products into carbohydrates stored in tuberous roots below ground. Most carbohydrate accumulated by the genotype was translocated to the roots but not to the above ground plant parts and this increase in tuberous roots at the expense of the above ground plant parts growth was also reported by Parwada *et al*. (2011). Farmer's local check Susari-1 variety produced the least mean tuberous root yield (5.98 t/ha) compared to all other genotypes tested. The current finding is in good agreement with Omiat *et al*. (2005), who indicated that varietal effect had a significant influence on the total tuberous root yield of sweet potato crop. Kathabwalika *et al*. (2013) also observed significant differences in total tuberous root yield among sweet potato varieties in their trial. OFSP genotypes provided better root yield compared to other lines in this research. The differences in total tuberous root yield could be attributed to varietal differences among the OFSP varieties (Antiaobong, 2007). This result is in line with Amare *et al*. (2014), who also found significant differences in total tuberous root yield among varieties in their trial. Similarly, Wariboko and Ogidi (2014) also concluded that improved OFSP varieties were higher in total tuberous root yield.

Roots of CIP 440021 and farmer's check Sunsari-1 were damaged moderately and at lower extent respectively by rats in the year 2014 while rat damaged symptoms were seen in the Japanese Red and Sunsari-1 at lower level in 2015. There was no any pest damage found on evaluated genotypes during 2016 because roots were not infested by rats.

Table 2. Total tuberous root yield of sweet potato genotypes evaluated under on-farm condition at Sunsari district during 2014-016

Genotype	Tuberous root yield (t/ha)			Mean yield (t/ha)	Tuberous roots damage+		
	2014	2015	2016		2014	2015	2016
CIP 440015	9.86	7.45	12.8	10.03	0	0	0
CIP 440021	6.44	7.13	16.6	10.05	5	0	0
CIP 440012	19.27	5.42	37.2	20.63	0	0	0
CIP 440328	8.02	6.16	23.4	12.52	0	0	0
CIP 440267	27.25	3.93	36.5	22.56	0	0	0
Japanese Red (ch)	15.44	4.26	19.1	12.93	0	3	0
Sunsari-1 (ch)	8.93	4.31	4.7	5.98	1	1	0
P value	<.001	0.146	0.002				
LSD(0.05)	3.875	3.129	13.83				
CV%	16.0	31.8	36.2				

*** Significant at P <.001, +: 0=No damage, 3=low damage, 5=moderately damage, 7= highly damage, 9=totally damage

Root yield is one of the most important traits that drive the adoption of new varieties by farmers. Therefore, several crop breeders have always considered the development of high yielding varieties first before improvement of other traits. The root yield and yield components of sweet potato studied in this field trial indicated significant genotypic differences (Table 1 and 2). The dominant sweet potato varieties grown mostly by Nepalese farmers especially in eastern terai have white or cream flesh, which contains little or no beta carotene (Stathers *et al.,* 2005). Farmers have been growing only local landraces since long time due to unavailability of other alternative varieties of sweet potato and no systematic research and development work was carried out in the past. Low yield of present local landraces (white fleshed), sustainability problems of yield and availability of quality planting materials of improved varieties are the major issues for this crop to grow in commercial scale in the study area. Generally, yields in farmer's plots are low (Njoku *et al*., 2009) due to the use of local genotypes. Yields could have been increased considerably with improved varieties (Nwankwo *et al*., 2012). Therefore, demand of high yielding orange fleshed varieties especially enriched with β-carotene has remained always very high since long time.

Vine and Root Characters

Among the evaluated lines, semi-erect plant type were observed in CIP 440015 while CIP 440021 and CIP 440012 were semi-compact type, but the remaining genotypes including Sunsari-1 were spreading in nature of vine length in all the years (Table 3). Five CIP lines showed orange flesh color whereas Japanese Red and Sunsari-1 had light yellow and white color of flesh respectively. Flesh color is usually under the control of genes with little or no effect of environment. Orange color is a result of accumulation of beta-carotene, a precursor to vitamin-A in these cultivars. The skin color of the sweet potato genotypes in this study were yellow, orange, red, purple red and white. Root size were from small to medium large and large, while raw taste were predominantly light sweet and sweet except farmer's check Sunsari-1 which was very sweet.

Table 3. Vine and qualitative characters of sweet potato genotypes evaluated under on-farm condition during 2014-016

Genotype	Plant type	Skin color	Flesh color	Root size	Raw taste
CIP 440015	Semi-erect	Yellow	Orange	Medium Large	Light sweet
CIP 440021	Semi-compact	Purple Red	Dark Orange	Large	Light sweet
CIP 440012	Semi-compact	Light Yellow	Orange	Medium	Light sweet
CIP 440328	Spreading	Light Orange	Orange	Small	Sweet
CIP 440267	Spreading	Light Red	Orange	Medium	Sweet
Japanese Red (ch)	Spreading	Dark Red	Light Yellow	Medium Large	Sweet
Sunsari-1 (ch)	Spreading	White	White	Medium	Very sweet

Farmers' preferences on genotypes

Participating farmers' response to key indicators over preference of sweet potato genotypes varied (Table 4). Based on the root appearance, flesh color and cooked taste, majority of the farmers preferred genotypes CIP 440267 and CIP 440012 among the evaluated genotypes. Results showed these genotypes were mostly ranked as very good (VG) and preferred by the participants in all the three years of assessment.

Table 4. Farmer's rating on sweet potato genotypes evaluated under on-farm condition during 2014-016

Genotype	Root Appearance			Flesh Color			Taste		
	2014	2015	2016	2014	2015	2016	2014	2015	2016
CIP 440015	VG	G	G	G	VG	G	G	G	F
CIP 440021	G	G	G	G	VG	VG	F	G	G
CIP 440012	G	VG	VG	VG	G	VG	G	VG	G
CIP 440328	F	G	G	G	G	G	G	F	G
CIP 440267	G	VG	VG	VG	VG	VG	VG	G	VG
Japanese Red (ch)	F	G	G	G	F	F	G	VG	G
Sunsari-1 (ch)	F	F	F	G	F	F	VG	VG	G

Conclusion

The yield and yield contributing parameters: number of marketable tuberous roots per plant, marketable tuberous root weight and total tuberous root yield varied significantly among the sweet potato genotypes evaluated. The three years' mean results revealed that the highest total tuberous root yield (22.56 t/ha) was recorded in CIP 440267 followed by the genotype CIP 440012 (20.63 t /ha). These genotypes were also highly preferred by the farmers. It is concluded that CIP 440267 and CIP 440012 can be used as the best OFSP genotypes with optimum yield and the highest adaptability in the Eastern Terai of Nepal and having potentially to combat Vitamin-A deficiency at community level.

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