Evaluation of Different Sweet Potato Genotypes in Mid-Hill Environment of Khumaltar, Lalitpur

Prakash Bhattarai* and Giridhari Subedi
National Potato Research Programme/NARC, Khumaltar15, Lalitpur, Nepal
*Corresponding author's email: prakash.narc.nprp@gmail.com
*ORCID iD: 0000-0002-7016-9472

Abstract

Sweet potato is one of the world's most important underexploited crops. The field experiments were carried out at Khumaltar, Lalitpur (1360 masl), Nepal from July to November 2021 and 2022 to select superior and high-yielding sweet potato genotypes particularly, in the mid-hills of Nepal. The trial was laid out in a randomized complete block design (RCBD) with three replications and consisted of ten sweet potato genotypes (CIP 194540.5, CIP 199062.1, CIP 105086.1, CIP 106861.3, CIP 440132, CIP 440293, CIP 187020.1, CIP 106906.1, CIP 105085.2, Kimichaur Seto) with two checks (Suntale Sakharkhand-1 and Benshisahar White). Significant differences were observed in vine length, marketable number and weight of tuberous roots per plant and yield. The pooled result revealed that the maximum number (5.73plant^{-1}) of marketable tuber was produced in CIP 105085.2 followed by CIP 187020.1(5.27plant^{-1}) but CIP 106906.1 produced the highest number (10.4plant^{-1}) of non-marketable tuber. The genotype CIP 440293 produced the highest marketable tuber weight (0.561kgplant^{-1}) and marketable tuber yield (31.16 tha^{-1}) followed by CIP 105085.2 (0.555 kgplant^{-1} & 30.82 tha^{-1}). Likewise, CIP 105085.2 produced the highest total tuberous root yield (37.32tha^{-1}) followed by CIP 199062.1 (35.46 tha^{-1}). The genotypes varied in terms of moisture, reducing sugar and β-carotene content, with the orange-fleshed CIP genotypes having higher levels of β-carotene than the white-fleshed local genotypes. Thus, the improved sweet potato genotypes namely CIP 105085.2, CIP 199062.1, CIP 440293 and CIP 187020.1 can be recommended to test on-farm for confirming the on-station result.

Keywords: Genotypes, marketable tuber weight, tuberous root yield, mid-hill, sweet potato

Introduction:

Sweet potato (*Ipomoea batatas* L.) is the world's seventh most important crop (Low et al., 2015; CIP, 2017).). After potatoes and cassava, it is the third-most widely grown root crop in the world (FAO, 2015; Markos and Loha, 2016). It is grown on 7.40 million hectares of land in more than a hundred countries around the world, yielding an average of 12.09 t ha^{-1} (FAO, 2020). Africa (32.18%), the Americas (4.25%) and Oceania (1.0%) are the next largest producers of sweet potatoes in the world after Asia (62.55%) (FAO, 2020). It is tolerant to drought, has a high yield potential, is widely adaptable and requires low input (Nhanala and yencho, 2021; Musumbi et al., 2015). It is regarded as a vital, versatile and underutilized food security crop in the world, particularly in underdeveloped countries (Laurie et al., 2015).

Infertile marginal soils with scarce water supplies are often where sweet potatoes are produced. Sweet potatoes are believed to aid in reducing food shortages and malnutrition since they produce a lot of energy per unit area of per unit of time (Nedunchezhiyan et al., 2012). It is considered to be an excellent source of dietary fiber, minerals and vitamins (Vimala et al., 2011; Low et al., 2007). Carotenoids and ß-carotene levels in orange-fleshed sweet potatoes (OFSP) are high (Jakahata et al., 1993). Due to these nutritive qualities, OFSP is an excellent food security crop and a crucial tool in the global fight against vitamin A deficiency in regions where vitamin A-rich food resources are hard to come by.

It is known in Nepal by the name of *Sakhar Khand* and grown throughout the mid-hills and terai in the kitchen garden for home consumption (Gautam, 1991). From the production point of view, Nepal still lacks reliable statistics on areas and the production of sweet potatoes and its cultivation in Nepal is marginal. Commercially it is one of the neglected and underexploited crops in Nepal as Nepalese agriculture has not given priority to sweet potato production but people eat sweet potatoes during festivals like *Makar Sakranti and Shiva Ratri* as a religious value. Farmers usually plant local cultivars of indigenous red and white type sweet potatoes that require long-duration to produce tuberous roots.

Nutritional insecurity, particularly vitamin A deficiency, has occurred in ethnic communities and scheduled cast groups of Nepal. Thus, sweet potato would play an important role in food security in flood-prone and marginalized areas of the mid-hills and terai. In this connection, research works on sweet potato were initiated in few years and also private sector involvement and area of this crop in Nepal appears to be expanding. The production of tuber is low and at the same time quality is inferior in indigenous varieties in Nepal. The poor selection of cultivars is one of the main factors causing low productivity. Consequently, using improved cultivars could boost sweet potato productivity. Yield is influenced by cultivars (Antiaobong, 2007). Perhaps the environment had an impact on the genotypes' yield potential. The choosing of improved varieties is one of the most important factors affecting productivity because they have a high yield potential (Gairhe et al*.,* 2017).

Since a long time, most farmers have solely grown low yielding native landraces. Poor agronomic practices such as production technology and poor variety selection according to location are all factors that contribute to the crop's low sustainable yield in farmers' conditions. Farmers are primarily looking for excellent varieties that are specifically adapted to their environment and have a high level of long-term stability (Scott and Maldonando, 1998). Due to its high carotenoid content (a precursor to vitamin A) and good yields, as well as rich carbohydrates, vitamins and minerals (Low et al., 2015; CIP, 2017), orange-fleshed sweet potatoes (OFSP) are considered resilient crops that can improve the nutrition of underprivileged farmers in many developing countries. The demand for high-yielding varieties of sweet potato with high Vitamin A (β- carotene) has remained always very high for a long time in Nepal. This paper shows the results of the performance of some potential sweet potato genotypes under coordinated varietal trial (CVT) which were high yielding and well-adapted in study area in previous exploratory experiments and initial evaluation trials. Therefore, this study was carried out to evaluate the yield performance of sweet potato genotypes and to select the best genotypes for on-farm production at Khumaltar, Lalitpur condition of Nepal.

Materials and Methods

Experimental site and climate

The field experiments were carried out in 2021 and 2022 at National Potato Research Programme (NPRP), Khumaltar, Lalitpur, Nepal. The site is located at longitude 85°19'E and latitude 27°39'N with a mean altitude of 1360 m above sea level. The Department of Hydrology and Meteorology (DHM), Babarmahal, Kathmandu, Nepal, provided monthly meteorological data (Table 1) for the corresponding year.

Table 1. Monthly weather during cropping season of 2021 and 2022 experimentation period at Khumaltar, Lalitpur, Nepal

Months	Rainfall (mm)		Temp. (°C) 2021		Temp. (°C) 2022		Relative humidity (%)	
	2021	2022	Min	Max	Min	Max	2021	2022
July	386.7	289.61	20.85	27.35	21.20	28.86	84.99	78.56
August	263.3	336.9	20.56	27.30	20.89	29.62	85.41	80.32
September	124.9	121.1	19.45	27.86	19.90	28.54	84.44	83.91
October	24.2	107.0	16.68	26.64	14.24	26.71	83.27	78.86
November	0	0	8.29	22.31	8.42	23.49	79.45	75.96
Mean								

Source: DHM, 2023

Experimental treatments and design

The experiment was laid out in a randomized complete block design (RCBD) with three replications and comprised of total twelve treatments of ten sweet potato genotypes (CIP 194540.5, CIP 199062.1, CIP 105086.1, CIP 106861.3, CIP 440132, CIP 440293, CIP 187020.1, CIP 106906.1, CIP 105085.2, Kimichaur Seto) with two checks

(Suntale Sakharkhand-1 and Benshisahar White). The experimental area was ploughed, harrowed, pulverized and ridged before planting. The gross plot size was measured 3.6 m^2. Sweet potato vines (middle portions) of each genotype were cut with three nodes and planted on ridges with about two nodes buried in the soil uniformly for all treatments. The sweet potato vines (cuttings) were planted on July 20, 2021 and 2022 by hand in rows 60 cm apart and 30 cm between plants within rows. Blocks were separated by 1m whereas each plot was spaced between 75cm within the block. At planting time, each plot was fertilized with the recommended N: P_2O_5: K_2O fertilizers @ of 30:30:50 $kgha^{-1}$. Urea and DAP fertilizers were applied serving as the nitrogen and phosphorus source. Farm yard manure was applied as compost@ 20 tha^{-1}. All crop management procedures, such as cultivation, weeding and so on, are carried out as desired during the crop growing period.

Data collection, measurements and statistical analysis

Data on vine length, tuber yield and quality parameters were recorded during the study period. Observations were done on five plants chosen randomly from each plot and averaged for the variable. The length of the main vine was measured with a measuring tape at 60 days after planting (DAP), while storage root characters were scored at 120 DAP during harvest. The experimental plots were harvested on the 14^{th} and 15^{th} of November, 2021 and 2022 respectively. Tuberous roots were also graded as marketable (>50 g) and unmarketable (<50 g) on a weight basis and the number and weight were taken accordingly. The total tuberous root weight per harvested plot was recorded with the help of electronic balance and the estimated yield per hectare was calculated based on tuberous root weight/plot.

Moisture, reducing sugar and beta carotene contents were analyzed by the AOAC method (AOAC, 2005). Reducing sugar (%) was determined by the di-nitrosalicyclic colorimetric method (Miller, 1959). Light absorbance was recorded in a spectrophotometer (Agilent Technologies, Cary 60 UV-VIS, USA) at 510 nm. The ß-carotene content of the sweet potato tuber samples was determined by the solvent partition method as described in Rangana (2007). The data were analyzed by using Genstat version 18 software for windows (VSN International, 2016). Means were separated by Duncan's Multiple Range Test at a 5% level of significance.

Results

Vine length

The pooled data showed that genotypes showed significant variation in vine length (Table 2). The genotype Bensisahar White had longer vines (324.5 cm) followed by CIP 440132 (298.5 cm) and CIP 440293 (265.2 cm) while CIP 106906.1 produced shorter vines (88.0 cm). Year and genotype by year interaction also showed a significant difference in vine length.

Marketable tuber number and weight per plant

Sweet potato genotypes revealed a significant variation in marketable tuber number $plant^{-1}$ during both years (Table 2). Genotype and year interaction was found highly significant. Pooled analysis over the years showed that CIP 105085.2 (5.73 $plant^{-1}$) yielded the maximum number of marketable tuber number followed by CIP 187020.1 (5.27 $plant^{-1}$) and CIP 440132 (4.81 $plant^{-1}$) and a minimum (2.75 $plant^{-1}$) of tubers number were produced by the check variety Suntale Sakharkhand -1. Likewise, the pooled data showed that the marketable tuber weight per plant was highly significant among the genotypes (Table 2). Year and genotype and year interaction were found non-significant among the genotypes in marketable tuber number per plant. The pooled data of both years showed that the highest marketable tuber weight $plant^{-1}$ (0.561 kg) was obtained by the genotype CIP 440293 followed by CIP 105085.2 (0.555kg) and CIP 199062.1 (0.553 kg) while the lowest (0.283 kg) by the genotype CIP 106861.3.

Table 2. Vine length, marketable tuber number and weight per plant of sweet potato genotypes evaluated at NPRP, Khumaltar, Lalitpur during 2021-2022

Genotypes	Vine length (Cm)			Marketable tuber plant^{-1} (No.)			Wt. of marketable tuber plant^{-1} (kg)		
	2021	**2022**	**Mean**	**2021**	**2022**	**Mean**	**2021**	**2022**	**Mean**
CIP 194540.5	122.2^{de}	95.0	108.6^{c}	3.00^{bc}	3.52^{b}	3.2^{cd}	0.285^{de}	0.356	0.320^{c}
CIP 199062.1	132.6^{cde}	134.0	133.5^{bc}	4.25^{b}	3.83^{b}	4.04^{bcd}	0.534^{ab}	0.573	0.553^{a}
CIP 105086.1	139.9^{cd}	112.0	125.9^{bc}	3.72^{bc}	4.53^{ab}	4.13^{bcd}	0.271^{de}	0.441	0.356^{bc}
CIP 106861.3	110.7^{de}	111.0	111.0^{c}	3.50^{bc}	4.42^{ab}	3.96^{bcd}	0.264^{de}	0.302	0.283^{c}
CIP 440132	374.8^{ab}	222.0	298.5^{a}	5.25^{ab}	4.37^{ab}	4.81^{ab}	0.349^{cde}	0.522	0.435^{abc}
CIP 440293	324.3^{b}	206.0	265.2^{a}	3.95^{b}	4.80^{ab}	4.38^{abc}	0.511^{abc}	0.611	0.561^{a}
CIP 187020.1	151.3^{cd}	125.0	138.3^{bc}	6.67^{a}	3.87^{b}	5.27^{ab}	0.406^{bcd}	0.245	0.325^{c}
CIP 106906.1	69.6^{e}	106.0	88.0^{c}	3.35^{bc}	5.92^{a}	4.63^{abc}	0.198^{e}	0.398	0.298^{c}
CIP 105085.2	106.0^{de}	206.0	155.8^{bc}	5.40^{ab}	6.07^{a}	5.73^{a}	0.507^{abc}	0.603	0.555^{a}
Suntale Sakharkhand-1 (ch)	140.5^{cd}	173.0	156.9^{bc}	1.57^{c}	3.93^{b}	2.75^{d}	0.203^{e}	0.403	0.303^{c}
Bensisahar White (ch)	407.3^{a}	242.0	324.5^{a}	4.68^{ab}	3.17^{b}	3.93^{bcd}	0.335^{cde}	0.355	0.345^{bc}
Kimichaur Seto	198.1^{c}	188.0	193.1^{b}	5.25^{ab}	3.32^{b}	4.28^{abc}	0.607^{a}	0.405	0.506^{ab}
Grand Mean	198.8	160.0	174.9	4.22	4.31	4.26	0.372	0.434	0.403
Genotype (G)	***	ns	***	**	*	**	***	ns	***
Year (Y)	-	-	*	-	-	ns	-	-	ns
G*Y	-	-	**	-	-	**	-	-	ns
LSD (0.05)	62.07	123.7	66.06	2.112	1.664	1.326	0.1634	0.236	0.1607
CV %	19.3%	45.6	32.5	29.6	22.8	26.8	25.9%	32.2	34.3

*ns= not significant, * Significant at P<0.05, **Significant at P<0.01, *** Significant at P<0.001.*
Same small letters in column are not significantly different by DMRT at 0.05 level of significance

Non-marketable root number and weight per plant

The non-marketable root number and weight per plant showed a significant difference among the genotypes (Table 3). The mean of both year results showed that the genotype CIP 10690.1 produced the maximum number (10.4) of tubers plant^{-1} followed by CIP 106861.3 (9.17) while the highest (0.1171 kg) root weight plant^{-1} was noticed in CIP 105085.2 and the lowest (0.0479 kg)) of tubers weight were produced by the genotype CIP 440132. Year and genotype and year interaction were found significant for non-marketable roots per plant.

Table 3. Non-marketable root number and weight plant^{-1} of sweet potato genotypes evaluated at NPRP, Khumaltar, Lalitpur during 2021-2022

Genotypes	Non-marketable roots plant^{-1} (No.)			Wt. of non-marketable roots plant^{-1} (kg)		
	2021	**2022**	**Mean**	**2021**	**2022**	**Mean**
CIP 194540.5	7.45^{bcd}	5.15	6.30^{cd}	0.1480	0.0417^{c}	0.0948^{abc}
CIP 199062.1	4.87^{cd}	2.90	3.88^{d}	0.1365	0.0342^{c}	0.0853^{abc}
CIP 105086.1	6.82^{bcd}	3.83	5.32^{cd}	0.1440	0.0392^{c}	0.0916^{abc}
CIP 106861.3	11.38^{ab}	6.97	9.17^{ab}	0.1281	0.0850^{a}	0.1066^{ab}
CIP 440132	6.22^{cd}	2.17	4.19^{cd}	0.0707	0.0250^{c}	0.0479^{c}
CIP 440293	3.85^{d}	3.58	3.72^{d}	0.0793	0.0400^{c}	0.0596^{bc}
CIP 187020.1	5.63^{cd}	8.58	7.11^{bc}	0.0647	0.0642^{b}	0.0645^{abc}
CIP 106906.1	13.72^{a}	7.08	10.4^{a}	0.1703	0.0633^{b}	0.1168^{a}
CIP 105085.2	9.50^{abc}	2.60	6.05^{cd}	0.1925	0.0417^{c}	0.1171^{a}
Suntale Sakharkhand-1 (ch)	5.97^{cd}	2.75	4.36^{cd}	0.0992	0.0275^{c}	0.0633^{abc}
Bensisahar White (ch)	5.42^{cd}	3.67	4.54^{cd}	0.0692	0.0458^{bc}	0.0575^{bc}
Kimichaur Seto	4.28^{d}	3.05	3.67^{d}	0.0667	0.0375^{c}	0.0521^{bc}
Grand Mean	7.09	4.36	5.73	0.1141	0.0454	0.0798
Genotype	**	***	***	ns	***	*
Year	-	-	***	-	-	***
G*Y	-	-	*	-	-	ns
LSD (0.05)	4.287	2.465	2.563	0.0933	0.0194	0.0489
CV %	35.7	33.4	38.5	48.3	25.2	52.8

*ns= not significant, * Significant at P<0.05, **Significant at P<0.01, *** Significant at P<0.001.*
Same small letters in column are not significantly different by DMRT at 0.05 level of significance

Total tuberous roots number and weight per plant

The total tuberous root number per plant ranged from 7.53 to 17.07 and 6.37 to 13.0 in the first and second years respectively (Table 4). The tuberous root number per plant was significantly influenced by the sweet potato genotypes and the highest number (13.13) was recorded in CIP 106861.3 followed by CIP 187020.1 (12.38) from the pooled result. The pooled result also showed that the sweet potato genotypes showed a significant difference in total tuberous fresh root weight plant^{-1} (Table 4). The genotype CIP 105085.2 produced the highest tuberous root weight (0.672kgplant^{-1}) followed by CIP 199062.1 (0.638 kg plant^{-1}).

Table 4. Total tuberous roots number and weight plant^{-1} of sweet potato genotypes evaluated at NPRP, Khumaltar, Lalitpur during 2021-2022

Genotypes	Total tuberous roots plant^{-1} (No)			Wt. of total tuberous roots plant^{-1} (kg)		
	2021	2022	Mean	2021	2022	Mean
CIP 194540.5	10.45^{bc}	8.07^{b}	9.56^{cde}	0.433^{cd}	0.397	0.415^{de}
CIP 199062.1	9.12^{c}	6.73^{b}	7.93^{e}	0.670^{a}	0.607	0.638^{ab}
CIP 105086.1	10.53^{bc}	8.37^{b}	9.45^{cde}	0.415^{cd}	0.480	0.448^{cde}
CIP 106861.3	14.88^{ab}	11.38^{a}	13.13^{ab}	0.392^{cd}	0.387	0.390^{de}
CIP 440132	11.47^{bc}	6.53^{b}	9.0^{de}	0.420^{cd}	0.547	0.483^{bcde}
CIP 440293	7.80^{c}	8.38^{b}	8.09^{e}	0.590^{ab}	0.651	0.620^{abc}
CIP 187020.1	12.30^{abc}	12.45^{a}	12.38^{abc}	0.470^{bc}	0.309	0.390^{de}
CIP 106906.1	17.07^{a}	13.00^{a}	15.03^{a}	0.368^{cd}	0.461	0.415^{de}
CIP 105085.2	14.90^{ab}	8.67^{b}	11.78^{bcd}	0.699^{a}	0.644	0.672^{a}
Suntale Sakharkhand-1 (ch)	7.53^{c}	6.68^{b}	7.11^{e}	0.302^{d}	0.431	0.367^{e}
Bensisahar White (ch)	10.10^{bc}	6.83^{b}	8.47^{e}	0.404^{cd}	0.407	0.402^{de}
Kimichaur Seto	9.53^{bc}	6.37^{b}	7.95^{e}	0.673^{a}	0.443	0.558^{abcd}
Grand Mean	11.31	9.67	9.99	0.487	0.480	0.483
Genotype	*	***	***	***	ns	***
Year	-	-	***	-	-	ns
G*Y	-	-	ns	-	-	ns
LSD (0.05)	4.961	2.423	2.706	0.1379	0.2294	0.1636
CV %	25.9%	16.5	23.3	16.7	28.2	29.1

*ns= not significant, * Significant at P<0.05, **Significant at P<0.01, *** Significant at P<0.001.*
Same small letters in column are not significantly different by DMRT at 0.05 level of significance

Marketable, Non-marketable and Total root yield

The mean data of both years showed a highly significant effect of genotypes in marketable tuber yield (t/ha), but year and genotype and year interaction were found non-significant (Table 5). The highest marketable tuber yield (31.16 t/ha) was obtained by the genotype CIP 440293 followed by CIP 105085.2 (30.82 t/ha) and CIP 199062.1 (30.72 t/ha) and the lowest (10.61 t/ha) by the genotype CIP 106861.3 (15.72 t/ha). The average marketable root yield was highest in 2022 (24.1 t/ha) than in 2021 (20.69 t/ha). The pooled data also showed a significant effect on non-marketable tuber yield (t/ha). The results (Table 5) indicated that the total tuberous root yield (t/ha) was significantly influenced by the genotypes in both years. The pooled data showed the genotype CIP 105085.2 produced the highest tuberous root yield (37.32 tha^{-1}) followed by CIP 199062.1 (35.46 tha^{-1}) and CIP 440293 (34.47 tha^{-}1).

Table 5. Marketable, non-marketable tuber and total tuberous roots yield (tha^{-1}) of sweet potato genotypes evaluated at NPRP, Khumaltar, Lalitpur during 2021-2022

Genotypes	Marketable tuber yield (t/ha)			Non-marketable tuber yield (t/ha)			Total tuberous roots yield (t/ha)		
	2021	2022	Mean	2021	2022	Mean	2021	2022	Mean
CIP 194540.5	15.82^{de}	19.8	17.79^{c}	8.22	2.31^{c}	5.27^{abc}	24.04^{cd}	22.1	23.06^{de}
CIP 199062.1	29.64^{ab}	31.8	30.72^{a}	7.58	1.90^{c}	4.74^{abc}	37.22^{a}	33.7	35.46^{ab}
CIP 105086.1	15.08^{de}	24.5	19.79^{bc}	8.00	2.18^{c}	5.09^{abc}	23.08^{cd}	26.7	24.87^{cde}
CIP 106861.3	14.68^{de}	16.8	15.72^{c}	7.12	4.72^{a}	5.92^{ab}	21.80^{cd}	21.5	21.64^{de}
CIP 440132	19.40^{cde}	29.0	24.19^{abc}	3.93	1.39^{c}	2.66^{c}	23.33^{cd}	30.4	26.85^{bcde}
CIP 440293	28.38^{abc}	33.9	31.16^{a}	4.40	2.22^{c}	3.31b^{c}	32.79^{ab}	36.2	34.47^{abc}
CIP 187020.1	22.54^{bcd}	13.6	18.07^{c}	3.60	3.56^{b}	3.58^{abc}	26.13^{bc}	17.2	21.65^{de}
CIP 106906.1	11.00^{e}	22.1	16.54^{c}	9.46	3.52^{b}	6.49^{a}	20.46^{cd}	25.6	23.03^{de}
CIP 105085.2	28.16^{abc}	33.5	30.82^{a}	10.69	2.31^{c}	6.50^{a}	38.86^{a}	35.8	37.32^{a}
Suntale Sakharkhand-1 (ch)	11.30^{e}	22.4	16.85^{c}	5.51	1.53^{c}	3.52^{abc}	16.81^{d}	23.9	20.37^{e}
Bensisahar White (ch)	18.61^{cde}	19.7	12.17^{bc}	3.84	2.55^{bc}	3.19^{bc}	22.45^{cd}	22.3	22.36^{de}
Kimichaur Seto	33.70^{a}	22.5	28.10^{ab}	3.70	2.08^{c}	2.89^{bc}	37.41^{a}	24.6	31.0^{abcd}
Grand Mean	20.69	24.1	22.41	6.34	2.52	4.43	27.03	26.7	26.84
Genotype (G)	***	ns	***	ns	***	*	***	ns	***
Year (Y)	-	-	ns	-	-	***	-	-	ns
G*Y	-	-	ns	-	-	ns	-	-	ns
LSD (0.05)	9.079	13.15	8.930	5.184	1.078	2.720	7.662	12.74	9.091
CV %	25.9	32.2	34.3	48.3	25.2	52.8	16.7	28.2	29.1

*ns= not significant, * Significant at $P<0.05$, **Significant at $P<0.01$, *** Significant at $P<0.001$.*

Quality attributes

Quality attributes of sweet potato roots such as moisture, reducing sugar and β-carotene content were analyzed in 2022 and found variations among the tested genotypes are given in Table 6. The highest (80.47 %) moisture content of sweet potato root was recorded in CIP 440132 followed by CIP105086.1(78.29%) and CIP 105085.2 (77.74%) while the lowest (57.55%) was observed in the genotype CIP 187020.1. Likewise, the highest reducing sugar content was in CIP 105085.2 and the lowest was found in the genotypes CIP 199062.1(0.03 g/100g), CIP 105086.1(0.05 g/100g), CIP 440293(0.05 g/100g) and Kimichaur Seto (0.05 g/100g). The result showed the highest β-carotene content (453.97 mg/1000gm) was noticed in CIP 106906.1 followed by CIP 440132 (386.39 mg/100g), Suntale Sakharkhand-1 (339.11 mg/100g) and CIP 105085.2 (307.17 mg/100g) and the lowest were noticed in white-fleshed genotypes CIP 187020.1 (2.83 mg/100g), Bensisahar White (2.96 mg/100g) and Kimichaur Seto (3.83 mg/100gm).

Same small letters in column are not significantly different by DMRT at 0.05 level of significance

Table 6. Moisture, reducing sugar and β- carotene content of sweet potato genotype evaluated at NPRP, Khumaltar, Lalitpur during 2022

Genotypes	Moisture (%)	Reducing sugar (g/100g) fwb	β-carotene (mg/100g) dwb
CIP 194540.5	64.18	0.85	235.97
CIP 199062.1	72.32	0.03	70.76
CIP 105086.1	78.29	0.05	210.62
CIP 106861.3	73.27	2.41	143.28
CIP 440132	80.47	0.36	386.39
CIP 440293	68.26	0.05	14.25
CIP 187020.1	57.55	1.57	2.83
CIP 106906.1	62.95	2.79	453.97
CIP 105085.2	77.74	4.07	307.17
Suntale Sakharkhand-1 (ch)	64.37	2.00	339.11
Bensisahar White (ch)	70.91	0.14	2.96
Kimichaur Seto	70.44	0.05	3.83

dwb= dry weight basis; fwb= fresh weight basis

Discussion:

The results showed significant differences in vine length among sweet potato genotypes (Table 2). The pooled analysis of both years showed that genotype Benshisahar White produced the longest vines, while CIP 106906.1 produced the shortest vines. The majority of local genotypes exhibited longer vines than OFSP (Bhattarai et al., 2017). Siddique (1985) found that the vine length ranged from 93.3 to 488.7 cm which is consistent with the present study and supports our findings. Similar results were also reported by Gebremeskel et al. (2018) in sweet potatoes who reported that vine length (plant height) was highly significant ($P<0.001$) among the varieties.

Genotypes showed a significant variation in marketable tuber number and weight per plant. The genotype CIP 105085.2 yielded the maximum tubers (5.73) per plant at the pooled result and CIP 440293 had the highest combined mean tuber weight (0.561 kgplant^{-1}). The variation in tuber number per plant may be explained by the genotypic makeup of the plants. The findings are consistent with those of Rahman et al. (2013), who found that different cultivars had different numbers of tuberous roots per plant. According to Omiat et al. (2005), the varietal effect had a significant impact on sweet potato marketable tuberous root as well as total tuberous root yield. Likewise, the genotypes showed a significant variation in non-marketable tuber number and weight per plant and this variation might be due to the genetic makeup of the different sweet potato genotypes.

The results (Table 4 & 5) indicate that the total tuberous roots number, weight per plant, marketable, non-marketable and total root yield were significantly influenced by the genotypes. The combined result of both years showed that the genotype CIP 105085.2 produced the highest tuberous root yield (37.32 tha^{-1}) followed by CIP 199062.1 (35.46 t/ha) and the lowest yield was recorded in Suntale Sakharkhand-1 (20.37 t/ha). Kathabwalika et al. (2013) also reported significant differences in tuber yield among sweet potato genotypes. The differences in marketable root yield could be attributed to the genetic variation among orange-fleshed sweet potato (OFSP) varieties in partitioning photosynthates (Nedunchezhiyan et al*.,* 2007). Besides, Yooyongwech et al. (2014) also reported that the yield potentiality of sweet potato depends on the genetic makeup plant. In Bangladesh, Rahman et al. (2013) found that sweet potato tuber yields varied significantly among genotypes. CIP 194513.15 genotype produced the highest tuber yield (31.6 tha^{-1}), followed by CIP 440267.2 genotype (30.97 tha^{-1}). Genotypes had significant differences in non-marketable yield. But Nwankwo et al. (2012) observed non-significant differences in non-marketable tuberous root yield.

Regarding quality traits, the high moisture content (80.47%) was observed in CIP 440132, while the lowest was in CIP 194540.5 (64.18 %). The reducing sugar and β-carotene content varied among the genotypes. The variation in reducing sugar might be due to the genotypic nature of sweet potato genotypes. Kosambo et al. (1999) and Teow et al. (2007) reported significant variations for ß -carotene content among sweet potato genotypes and orange flesh had higher ß -carotene content than white flesh. The genetic component initially governed this beta-carotene yield (Mahmud et al., 2021).

Conclusion

This study examined the yield and quality characteristics of twelve sweet potato genotypes in Khumaltar, Lalitpur, Nepal. Marketable and non-marketable root numbers, weight and yield varied greatly across genotypes. The genotypes varied across the year in terms of the marketable tuber. The genotype CIP 440293 produced the highest marketable tuber weight (0.561kgplant^{-1}) and marketable tuber yield (31.16 tha^{-1}) followed by CIP 105085.2 (0.555 kgplant^{-1} & 30.82 tha^{-1}). Likewise, CIP 105085.2 produced the highest total tuberous root yield (37.32tha^{-1}) followed by CIP 199062.1 (35.46 tha^{-1}). Based on these results, genotypes CIP 105085.2, CIP 199062.1 and CIP 440293 had the best performance in the majority of yield and yield contributing parameters and hence these genotypes can be identified as the highest tuberous root yielding and adaptable genotypes to grow on-farm of the study area.

Acknowledgement:

The authors would like to acknowledge the Nepal Agricultural Research Council, National Potato Research Programme, Khumaltar, Lalitpur for providing all the facilities to conduct the research.

Conflict of interest:

The authors declare no conflict of interest.

Authors' contribution:

P. Bhattarai was the lead investigator and also responsible for data collection from the field, literature search and write-up. G. D. Subedi was responsible for guidance and monitoring research activities.

References

Antiaobong, E. E. (2007). Life cycle, economic threshold and control of sweet potato weevils, *Cylas puncticollis* Boh (*Coleoptera: Curculionidae*) in Akwa Ibom State, Nigeria (Ph.D. Thesis). Michael Okpara University of Agriculture, Umudike Nigeria. pp. 3-5.

AOAC. (2005). Official Method of Analysis (Horwitz, W. &Latimer, G.W., Eds.) (18th edit.), USA: AOAC International.

Bhattarai, P., Khatri B.B., & Neupane, J.D. (2017). Sweet potato is a nutritious crop *(A booklet in Nepali).* National Potato Research Programme, Khumaltar, Laitpur, Neapl.

CIP, (2017). International Potato Centre. Available online: http://cipotato.org/research/sweet potato-in-Africa (accessed on11 August 2021)

DHM, (2023). Department of Hydrology and Meterology, Babarmahal, Kathmandu, Nepal

FAO. (2015). Statistical databases, Food and Agriculture Organization of the United Nations, Rome, Italy

FAO. (2020). Food and Agriculture Organization of the United Nations. FAOSTAT. Availablefrom: http://www.fao.org/faostat/en/#data/QCL (Accessed 4/27/2022)

Gairhe, S., Gauchan, D., & Timsina, K. (2017). Adoption of improved potato varieties in Nepal. *J. Nepal Agricultural Research Council*, 3:38-44.

Gautam, D. M. (1991). Production, post-harvest handling and utilization of sweet potato in Nepal. *Sweet potato in South Asia: Postharvest handling, processing, storage and use (Proceedings)*, 23.

Gebremeskel, H., Jaleto, K., Biratu, W., &Abebe, H. (2018). Growth and yield response of sweet potato (*Ipomoea batatas* L.) varieties to lowland agro-ecology of Raya Azebo, Ethiopia. Agriculture and Food Science Research, 5(2), 52-56.

Jakahata, Y., Noda, T., & Nagata, T. (1993). HPLC determination of β-carotene in sweet potato cultivars and its relationship with color value. *Japan Journal of Breed*, 43,421-427.

Kathabwalika, D. M., Chilembwe, E. H. C., Mwale, V. M., Kambewa, D., & Njoloma, J. P. (2013). Plant growth and yield stability of orange fleshed sweet potato (*Ipomoea batatas*) genotypes in three agro-ecological zones of Malawi. *Int. Res. J. Agric. Sci. Soil Sci*, *3*(11), 383-392.

K'osambo, L. M., Carey, E. E., Misra, A. K., Wilkes, J., &Hagenlmana, V. (1999). Influence of age, farming site and boiling on pro-vitamin-A content in sweet potato (*Ipomoea batats* (L.) Lam.) storage roots. *Journal of Food Technology in Africa*, *4* (3).

Laurie, S., Faber, M., Adebola, P. & Belete, A. (2015). Bio-fortification of sweet potato for food and nutrition security in South Africa. *Food Res. Int.,* 76:962-970.

Low, J. W., Arimond, M., Osman, N., Cunguara, B., Zano, F., &Tschirley, D. (2007). A food-based approach introducing orange-fleshed sweet potatoes increased vitamin A intake and serum retinol concentrations in young children in rural Mozambique. *The Journal of nutrition*, *137*(5), 1320-1327.

Low, J., Nyongesa, M., Quinn, S. and Parker, M. (Eds.). (2015). Potato and Sweet potato in Africa. Transforming the Value Chains for Food and Nutrition Security; CABI International: Boston, MA, USA. p632, ISBN 978-1-78064-420-2.

Mahmud, A. A., Alam, M. J., Heck, S., Grüneberg, W. J., Chanda, D., Rahaman, E. S., & Hossain, A. (2021). Assessing the Productivity, Quality and Profitability of Orange Fleshed Sweet Potatoes Grown in Riverbank of the Tista Floodplain Agro-Ecological Zone of Bangladesh. *Agronomy*, *11*(10), 2046.

Markos, D., &Loha, G. (2016). Sweet potato agronomy research in Ethiopia: Summary of past findings and future research directions. *Agriculture and Food Sciences Research*, *3*(1), 1-11.

Miller G.L. (1959). Use of dinitrosalicyclic acid reagent for determination of reducing sugar. *Analytical Chemistry*, 31,426. DOI: 10.1021/ac60147a030

Musembi, K.B., Githiri, S.M., Yencho, G.C. and Sibiya, J. (2015). Combining ability and heterosis for yield and drought tolerance traits under managed drought stress in sweet potato. *Euphytica.* 201: 423–440.

Nedunchezhiyan, M., Byji, G. and Jata, S. K. (2012). Sweet Potato Agronomy; *Journal of Agricultural University Puerto Rico*, 60(2): 163-171.

Nedunchezhiyan, M., Byju, G., &Naskar, S. K. (2007). Sweet potato (*Ipomoea batatas* L.) as an intercrop in a coconut plantation: growth, yield and quality. *J. Root Crops*, *33*(1), 26-29.

Nhanala, S.E.C. and Yencho G.C. (2021). Assessment of the potential of wild Ipomoea spp. for the improvement of drought tolerance in cultivated sweet potato *Ipomoea batatas* (L.). *Crop Sci*ence, 61: 234-249.

Nwankwo, I. I. M., Bassey, E. E., Afuape, S. O., Njoku, J., Korieocha, D. S., Nwaigwe, G., & Echendu, T. N. C. (2012). Morpho-agronomic characterization and evaluation of in-country sweet potato accessions in southeastern Nigeria. *Journal of Agricultural Science*, *4*(11), 281-288.

Omiat, E. G., Kapinga, R. E., Tumwegamire, S., Odong, T. L., & Adipala, E. (2005). On-farm evaluation of orange-fleshed sweet potato varieties in Northeastern Uganda. In *African Crop Science Conference Proceedings* (Vol. 7, No. pt. 2 of 3, pp. 603-609).

Rahman, M. H., Alam Patwary, M. M., Barua, H., Hossain, M., & Nahar, S. (2013). Evaluation of orange fleshed sweet potato (*Ipomoea batatas* L.) genotypes for higher yield and quality. *The Agriculturists*, 11(2), 21-27.

Rangana, S. (2007). Handbook of Analysis and Quality control for fruits and vegetable products, 2nd Edition. *Tata Mchraw-Hill Publishing Company Ltd*. New Delhi.

Scott, G. J., & Maldonado, L. (1998). Sweet potato for the new millennium: Trends in production and utilization in developing countries. *CIP program report 1997-1998,* Lima, Peru.

Siddique, M. A. R. (1985). Studies on the morphology, growth and yield of some sweet potato genotypes. *M. Sc. (Agriculture) thesis, Dept. of Horticulture, Bangladesh Agricultural University, Mymensingh*.

Teow, C. C., Truong, V. D., McFeeters, R. F., Thompson, R. L., Pecota, K. V., &Yencho, G. C. (2007). Antioxidant activities, phenolic and β-carotene contents of sweet potato genotypes with varying flesh colours. *Food chemistry*, *103*(3), 829-838.

Vimala, B., Nambisan, B., &Hariprakash, B. (2011). Retention of carotenoids in orange-fleshed sweet potato during processing. *Journal of food science and technology*, *48*(4), 520-524.

VSN International. (2016). GenStat for Windows 18th Edition. VSN International, Hemel Hempstead, UK.

Yooyongwech, S., Samphumphuang, T., Theerawitaya, C., & Cha-Um, S. (2014). Physio-morphological responses of sweet potato [Ipomoea batatas (L.) Lam.] genotypes to water deficit stress. *Plant Omics J.,* 7: 361-368.