Original Research Article

Performance of high yielding sweet potato varieties under different seasons

ABSTRACT

Field experiments were conducted during *Kharif*, *Rabi* and Summer seasons from 2021 to 2022 with an objective to assess the seasonal influence on growth and tuber yield of five sweet potato varieties [High yielding varieties were Bhu Krishna (V_1), Sree Arun (V_2), Sree Bhadra (V_3), Bhu Sona (V_4) and local variety was Kanjanghad Local (V_5)]. Randomized Block Design was followed with four replications. The growth and yield parameters differed significantly with varieties as well as with the season. Variety Bhu Sona recorded significantly the highest vine length (211.38 cm) compared to other varieties and variety Sree Bhadra (114.71 cm) and variety Kanjanghad Local (112.54 cm) recorded significantly lower vine length. Vine length was comparable in *Kharif* (182.36 cm) and *Rabi* seasons (176.78 cm). Significant differences were observed in number of tubers per plant, average weight of tuber and tuber yield among varieties and seasons. Sree Arun and Bhu Sona were the superior varieties and recorded significantly higher average tuber weight (236.77 g/plant and 219.14 g/plant, respectively), tuber yield per plant (514.65 g/plant and 404.22 g/plant, respectively) and tuber yield per ha (18.92 tha^{-1} and 15.96 tha^{-1} ,respectively). *Rabi* season was found ideal for all sweet potato varieties with higher average tuber weight (188.96 g/plant) and tuber yield per ha (20.17 tha^{-1}). Average tuber yield in *Kharif* was 58 per cent lower than that in *Rabi*. Per cent contribution of total dry matter to tuber dry matter was more in *Rabi* season for Sree Arun and Sree Bhadra varieties. Interaction effect was significant between varieties and seasons.

Keywords

Sweet potato, Varieties, Season, Yield, Dry matter

1. Introduction

Tuber crops play a prominent role in meeting global food demands. They also provide raw materials to processing industries and used as animal feed. Sweet potato (*Ipomoea batatas* L. Lam) is an important tuber crop, well adapted to a variety of climatic conditions due to its short duration and climate resilient nature. However, being a photosensitive crop, it requires sunny days and cooler nights for tuber initiation and development. The crop shows very high genetic diversity and a number of its varieties have been released for cultivation. However, the response of these varieties varies widely depending on soil and climatic factors.

Changes in daylight hours, maximum and minimum temperature, and precipitation have a significant impact on photosynthesis and productivity. Selection of varieties which are suitable for specific climatic condition is an important step towards enhancing productivity of

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this crop. Scientists are currently working on creating new varieties that would perform better under changing climate scenario. Numerous intervarietal changes can be observed in the performance of these varieties across various geographical and seasonal contexts. There are numerous sweet potato varieties available, some of which are bio-fortified and behave differently depending on the season. Favourable weather parameters can result in increased root- shoot ratio because of proper phloem loading and unloading. Season also play a major role in tuber initiation and bulking. Tuberization is an important event in the life stage of this crop and any unfavourable weather conditions during this period can lead to formation of fibrous roots instead of tuberous roots. Productivity of tuberous roots is predominantly a function of dry matter accumulation and it is affected by many environmental factors like solar radiation, temperature, rainfall etc. The interaction between these factors affect translocation of assimilates from source to sink (Hahn, 1977).

Root activity is very important for higher productivity in tuber crops especially during the tuber bulking stage. Root crops are able to retain a high root activity because carbohydrates are predominantly supplied to underground organs, which are the economic part in these crops (Osaki *et al*., 1996). For this, reallocation of assimilates from vegetative parts to underground parts are needed. Favourable weather conditions are required during tuber initiation and bulking stage for this reallocation.

Because of variability in seasonal performance, selection of varieties is very important in sweet potato, so that farmers can get higher profit. Therefore, response of high yielding sweet potato varieties in different cropping seasons was planned.

2. Materials and methods

2.1. Experiment: Performance of high yielding sweet potato varieties in Kharif, Rabi and Summer seasons

The experiments were conducted at the Agronomy Farm, Department of Agronomy, College of Agriculture, Vellanikkara, Thrissur, Kerala. The field is situated at 13º 32' N latitude and 76º 26' E longitude, at an altitude of 40 m above mean sea level. The texture of the experimental site was sandy clay loam and was acidic in reaction with a pH of 4.82 and electrical conductivity of 0.083 dSm^{-1}. The available nitrogen (alkaline permanganate method), phosphorus (ascorbic acid reduced molybdo phosphoric blue colour method) and potassium (neutral normal ammonium acetate extraction and estimation by flame photometry) content of soil of the experimental site were 163 $kgha^{-1}$, 83 $kgha^{-1}$ and 100 kg ha^{-1}, respectively. Weather conditions during the growing period are depicted in Figure 1, 2 and 3.

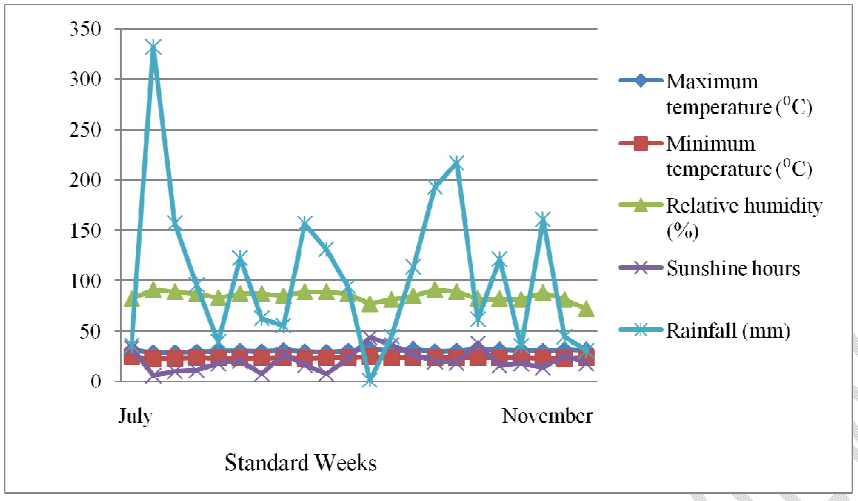

Fig.1. Weather data during *Kharif* season (July to November, 2021)

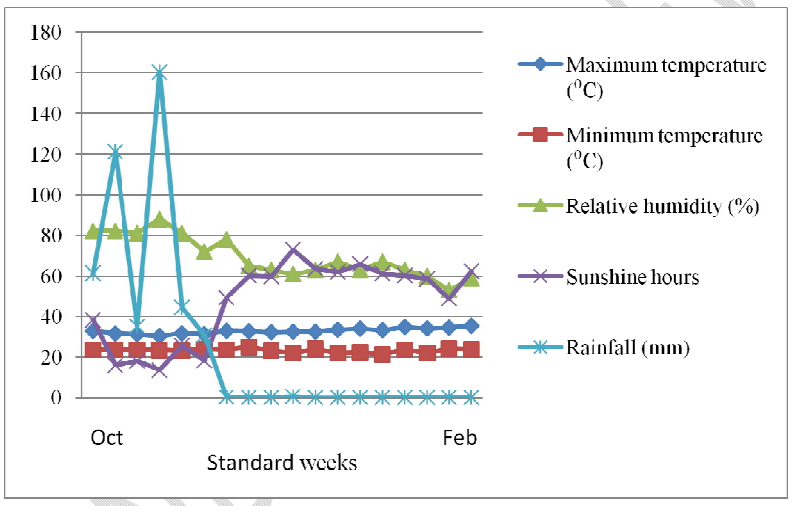

Fig. 2. Weather data during *Rabi* season (October, 2021 to February, 2022)

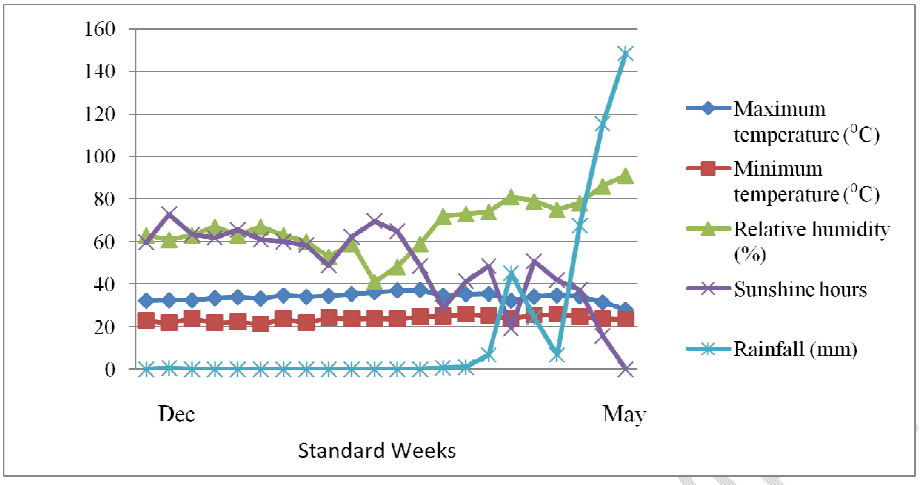

Fig. 3. Weather data during summer season (December, 2021 to May, 2022)

The experiment in *Kharif* season was conducted during July- November, 2021, *Rabi* season during October, 2021 to February, 2022 and summer season during December, 2021 to May, 2022. Randomized Block Design was adopted using five varieties and four replications. The plot size was 4.5 m x 4.5 m and vines were planted on mounds taken at a spacing of 75 cm x 75 cm. Three vine cuttings were planted per mound. Varieties used were high yielding types such as Bhu Krishna (V_1), Sree Arun (V_2), Sree Bhadra (V_3), Bhu Sona (V_4) and one local variety *ie*. Kanjanghad Local (V_5). Fertilizer dose of N, P_2O_5 and K_2O were applied @ 75 kgha^{-1}, 50 kgha^{-1} and 75 kgha^{-1} (as per Package of Practices recommendations, 2016 by Kerala Agricultural University), respectively. Half of the nitrogen dose and full P and K were applied as basal and remaining half N was applied four weeks after planting. Farmyard manure was applied @ 10 tha^{-1} and lime @600kgha^{-1}, which were applied basally at the time of land preparation.

2.2. Field observations and statistical analysis

Biometric observations were taken at 20 days interval and at harvest [at 20, 40, 60 and 80 days after planting (DAP)]. Yield and yield parameters were recorded during each season. The data collected were subjected to analysis of variance and computed statistically by utilizing statistical package of KAU GRAPES (General R-shiny based Analysis Platform Empowered by Statistics) developed by Kerala Agricultural University (Gopinath *et al.*, 2020)

3. Results

3.1. Biometric observations

Significant differences were observed between the varieties planted in various seasons. Variety Bhu Sona recorded significantly higher vine length (211.38 cm). Variety Sree Bhadra (114.71 cm) and variety Kanjanghad Local (112.54 cm) recorded significantly lower vine

length. Comparing the performance of varieties under different seasons, vine length was comparable in *Kharif* season (182.36 cm) and *Rabi* season (176.78 cm). Significantly lower vine length was observed in summer season (100.93 cm) and this was about 44 per cent lower than the average vine length produced in *Kharif* and *Rabi* seasons, due to less moisture availability.

Significantly higher LAI (60 DAP) was recorded in *Kharif* season (1.99) compared to *Rabi* and Summer. Leaf Area Index was significantly higher for the variety Kanjanghad Local in all seasons and there were no significant changes in LAI for other varieties. The interaction between varieties and seasons was also significant and significantly higher LAI was recorded for the variety Kanjanghad Local in *Kharif* season (3.46).

The total dry matter production also varied with seasons and variety. The variety Sree Arun recorded significantly higher total dry matter at harvest (421.05 g/plant) compared to other varieties. For all the varieties, total dry matter at harvest was significantly higher for *Rabi* season (390.34 g/plant) compared to *Kharif* (269.06 g/plant) and Summer season (285.02 g/plant). Interaction between varieties and seasons was significant and variety Sree Arun grown during *Rabi* season recorded significantly higher total dry matter production (485.28 g/plant), comparable with its dry matter production in Summer (461.20 g/plant). Significantly least total dry matter recorded by variety Sree Bhadra in Summer season (129.33 g/plant).

Table 1
Vine length, LAI and Total dry matter of different varieties at *Kharif*, *Rabi* and Summer seasons

Treatments	Vine length at 60 DAP (cm)	LAI at 60 DAP	Total dry matter at harvest (g/plant)
Variety (V)			
V_1 – Bhu Krishna	191.05^{b}	1.09^{b}	307.36^{b}
V_2 – Sree Arun	137.10^{c}	1.12^{b}	421.05^{a}
V_3 – Sree Bhadra	114.71^{d}	1.13^{b}	283.59^{b}
V_4 – Bhu Sona	211.38^{a}	1.31^{b}	296.03^{b}
V_5 – Kanjanghad local	112.54^{d}	2.59^{a}	266.01^{b}
SEm	5.48	0.07	16.45
CD (0.05)	15.90	0.22	47.66
Season (S)			
S_1- *Kharif*	182.36^{a}	1.99^{a}	269.06^{b}
S_2 – *Rabi*	176.78^{a}	1.35^{b}	390.34^{a}
S_3 – Summer	100.93^{b}	1.01^{c}	285.02^{b}
SEm	4.25	0.06	12.74
CD (0.05)	12.31	0.17	36.91
Interaction (V x S)			
V_1S_1	216.83^{b}	1.08^{de}	265.66^{def}
V_1S_2	229.66^{b}	1.18^{d}	381.69^{bc}

V_1S_3	126.66^{cdef}	1.02^{de}	274.72^{def}
V_2S_1	153.53^{c}	1.65^{c}	316.68^{cde}
V_2S_2	141.76^{cde}	0.78^{ef}	485.28^{a}
V_2S_3	116.00^{ef}	0.94^{def}	461.20^{ab}
V_3S_1	144.16^{cd}	1.93^{c}	259.65^{ef}
V_3S_2	132.63^{cdef}	0.86^{def}	461.80^{ab}
V_3S_3	67.33^{g}	0.60^{f}	129.33^{g}
V_4S_1	261.00^{a}	1.84^{c}	233.45^{f}
V_4S_2	261.16^{a}	1.19^{d}	343.78^{cd}
V_4S_3	112.00^{f}	0.90^{def}	310.86^{cdef}
V_5S_1	136.30^{cdef}	3.46^{a}	269.87^{def}
V_5S_2	118.66^{def}	2.73^{b}	279.16^{def}
V_5S_3	82.66^{g}	1.58^{c}	249.00^{ef}
SEm	9.51	0.13	28.49
CD (0.05)	27.54	0.38	82.54

Treatments with same letters are not significantly different

3.2. Yield and yield parameters

Significant differences were observed in number of tubers per plant, average weight of tuber and tuber yield among different varieties and seasons (Table 2 and 3). Number of tubers produced per plant by different varieties registered significant variation among seasons and significantly higher number of tubers (3.26) was registered in *Rabi* season. In both *Kharif* and summer season, comparable number of tubers per plant, 1.87 and 2.13, respectively were obtained. There was no significant difference noticed among varieties as well as interaction.

Average weight of tuber per plant as well as tuber yield was greatly influenced by the seasons. Sree Arun and Bhu Sona were the superior varieties and recorded significantly higher average tuber weight (236.77 g/plant and 219.14 g/plant, respectively), tuber yield per plant (514.65 g/plant and 404.22 g/plant, respectively) and tuber yield per ha (18.92 tha^{-1} and 15.96 tha^{-1} ,respectively). Variety Kanjanghad Local was inferior among the varieties. Among the seasons, *Rabi* was more suited with significantly higher average weight of tuber (188.96 g/plant), tuber yield per plant (595.48 g/plant) and tuber yield per ha (20.17 tha^{-1}). The lowest tuber yield was recorded in *Kharif* season (8.55tha^{-1}). Interaction between varieties and seasons was also significant. Variety Sree Arun performed significantly better during *Rabi* and summer seasons and tuber yield produced was 27.90$tha^{-1}$and 23.20tha^{-1}, respectively. Variety Sree Bhadra and Sree Arun yielded more during *Rabi* season (23.19 tha^{-1} and 27.90 tha^{-1}). In contrast, Variety Bhu Sona recorded significantly higher average weight of tuber (280.33 g/plant) as well as tuber yield (15.22tha^{-1}) during *Kharif* season. Significantly lower tuber yield was recorded by Kanjanghad Local during *Kharif* (5.95 tha^{-1})

and *Rabi* (12.14 tha^{-1}) seasons. Variety Sree Bhadra registered significantly lower tuber yield during summer (2.66 tha^{-1}). While considering the per cent dry matter partitioning from whole plant to tuber (Fig. 5), higher translocation of assimilates to tuber took place during *Rabi* season (50 – 65 %) compared to *Kharif* (14 - 38 %) and Summer (25 – 60 %).

Table 2

Influence of different seasons on average weight of tuber and number of tubers of sweet potato varieties

Treatments	Average weight of tuber (g/plant)	No. of tubers/plant
Variety (V)		
V_1 – Bhu Krishna	118.36[b]	3.22
V_2 – Sree Arun	236.77[a]	2.67
V_3 – Sree Bhadra	132.36[b]	1.77
V_4 – Bhu Sona	219.14[a]	2.44
V_5 – Kanjanghad local	89.24[b]	2.00
SEm	23.17	0.35
CD (0.05)	67.12	NS
Season (S)		
S_1- *Kharif*	120.48[b]	1.87[b]
S_2 – *Rabi*	188.96[a]	3.26[a]
S_3 – Summer	168.08[ab]	2.13[b]
SEm	17.95	0.27
CD (0.05)	51.99	0.78

Treatments with same letters are not significantly different

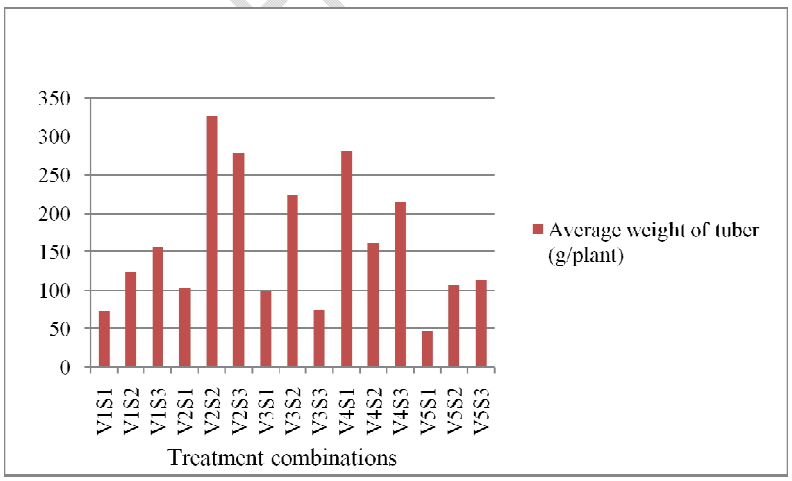

Fig. 4 Seasonal influence on average tuber weight of sweet potato varieties

Table 3

Influence of different seasons on tuber yield per plant and tuber yield per ha of sweet potato varieties

Treatments	Tuber yield (g/plant)	Tuber yield (tha^{-1})
Variety (V)		
V_1 – Bhu Krishna	354.48b	12.96bc
V_2 – Sree Arun	514.65a	18.92a
V_3 – Sree Bhadra	347.88b	11.49cd
V_4 – Bhu Sona	404.22ab	15.96ab
V_5 – Kanjanghad local	213.33c	8.55d
SEm	38.53	1.06
CD (0.05)	111.63	3.07
Season (S)		
S_1- *Kharif*	180.29c	8.55c
S_2 – *Rabi*	595.48a	20.17a
S_3 – Summer	324.96b	12.01b
SEm	29.84	0.82
CD (0.05)	86.47	2.37
Interaction (V x S)		
V_1S_1	137.66fg	7.29efg
V_1S_2	596.11ab	19.86bc
V_1S_3	329.66cdef	11.72de
V_2S_1	106.80g	5.66fg
V_2S_2	784.66a	27.90a
V_2S_3	652.50ab	23.20ab
V_3S_1	213.33defg	8.64ef
V_3S_2	755.33a	23.19ab
V_3S_3	75.00g	2.66g
V_4S_1	331.33cde	15.22cd
V_4S_2	499.67bc	17.76c
V_4S_3	381.66cd	14.90cd
V_5S_1	112.33g	5.95fg
V_5S_2	341.66cde	12.14de
V_5S_3	186.00efg	7.55efg
SEm	66.74	1.83
CD (0.05)	193.35	5.31

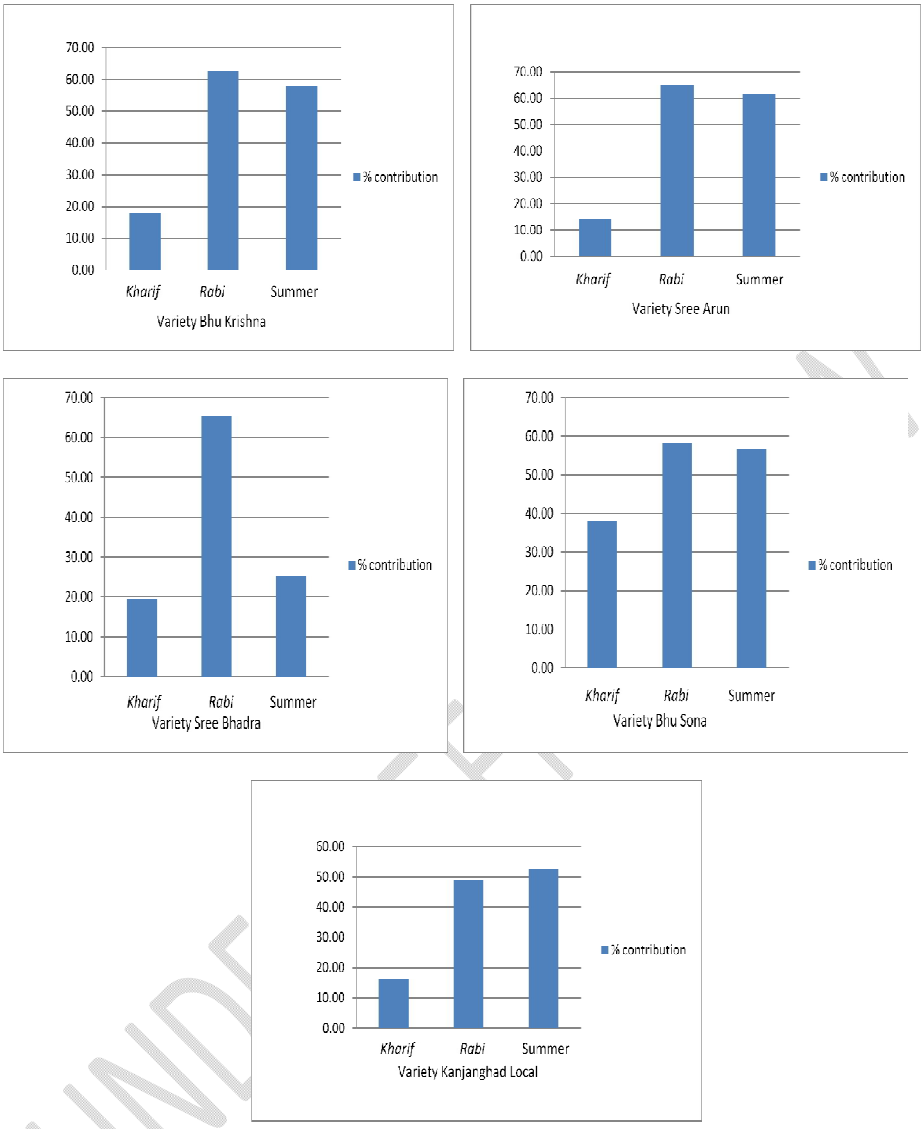

Fig. 5 Varietal variations in source – sink partitioning in sweet potato

4. Discussion

The field experiments showed that the plant growth and tuberization of sweet potato varieties were influenced by seasons. Wide variability in tuber yield among sweet potato varieties has been attributed to environmental and edaphic factors (Ravi and Indira, 1999). The influence of light intensity and quality is also important for better growth of plants. While comparing the weather parameters of three seasons during the study, total rainfall received in *Kharif* season (2303 mm) was five to six times more than *Rabi* and Summer. Total sunshine hours received in *Kharif* were two to three times less compared to *Rabi* and Summer seasons. From

Fig.1, it is clear that there was continuous rainfall during growing period of the crop and this favoured vegetative growth at the expense of tuber formation during *Kharif* season. Generally, sunny days and cool nights are required for tuber development in sweet potato. Assimilates partitioning from vegetative parts to sink was affected as shown by higher vine length and dry matter production. Canopy development took place at the expense of tuberization which led to the formation of more fibrous roots.

In sweet potato, the adventitious roots formed at the nodes, develop into fibrous roots and tuberous roots (Togari and Fujise, 1962). The development of fibrous roots to tuberous roots depends upon the activity of primary cambium and degree of lignification of stele cells which again depends on climatic conditions prevailing in the growing region (Alvim and Kozlowski, 2013). Photosynthetic activity has an effect on the activity of cambium in relation to existing weather parameters. Favourable environmental conditions are thus needed for cambium formation and thus thickening of tubers. Generally, photosynthetic activity is highest during early growth stages and declines towards maturity. But, absence of consistent photosynthetic rate of different varieties in various seasons and also at different growing periods in same season is mainly due to the interaction of photosynthetic activity with prevailing environmental factors and growing period. Source strength decides the tuber bulking (Ravi and Saravanan, 2012). In the case of sweet potato, the tuber formation depends on day light hours, even though the plants' source activity is higher, it cannot start tuberization. In this experiment, the total sunshine hours obtained during *Kharif* season was less (456.4 hours) during growing period and probably the plant did not trigger tuberization and thus yield has reduced. This also reduced the sink capacity.

Optimum leaf area index also has an influence on yield in tuber crops. Variety Kanjanghad Local recorded significantly higher leaf area and leaf area index irrespective of seasons. This higher LAI resulted in mutual shading between leaves and less net assimilation rate, ultimately poor tuber yield. Net photosynthetic activity should be maintained for a longer period of time to improve net assimilation value for increasing tuber yield (Fujise and Tsuno, 1962).

Performance of varieties also varies with sink capacity. There will be good response of sink to source for a variety having large sink capacity. Even with good source capacity, poor sink size and capacity can lead to less response to available assimilates. In this experiment, Kanjanghad Local had good source with higher leaf area and photosynthetic activity, presence of fibrous roots rather than tuberous roots resulted in poor yield performance in all seasons. Storage organs are robust sink tissues that compete with plant growth during tuber formation (Zierer *et al*., 2021).

Compared to *Kharif*, performance of varieties were good during *Rabi* season. Favourable weather conditions especially days with full of sunshine and cool nights resulted in the better performance of varieties during *Rabi* (temperature range was 21°C to 35°C). Among the varieties, significantly higher tuber yield was realised for variety Sree Arun. Its response was comparatively good for available weather conditions and utilized the available resources efficiently than other varieties. Kanjanghad Local has comparatively longer duration than

others and response was less for the available resources. While comparing the duration of varieties during different seasons, it was clear from the weather graphs (Fig.1, 2 and 3) that varieties took more days to initiate tuberization and bulking in *Kharif* than other seasons. Varieties took lesser days for reaching maturity during *Rabi* and yield was also more during this season. In *Kharif*, varieties took about 22 weeks from planting to harvesting compared to *Rabi* (18 weeks). These much variations in growing duration at different seasons resulted in significant variations in the performance of varieties.

Conclusion

Variations in growing period could be noticed in performances of varieties under different seasons. This clearly indicates need for specific varietal recommendation for each season. In this study, variety Sree Arun performed better during *Rabi* and Summer seasons and variety Bhu Sona during *Kharif* season. Therefore, variety Sree Arun can be recommended for *Rabi* and Summer seasons and variety Bhu Sona for *Kharif* season.

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