Potassium utilization efficiency and seasonal response in photosynthates partitioning of high yielding sweet potato varieties

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(2019-21-023)

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DECLARATION

I hereby declare that the thesis entitled **"Potassium utilization efficiency and seasonal response in photosynthates partitioning of high yielding sweet potato varieties"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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Jeena Mary

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CERTIFICATE

Certified that this thesis entitled **"Potassium utilization efficiency and seasonal response in photosynthates partitioning of high yielding sweet potato varieties"** is a record of research work done independently by Ms. Jeena Mary under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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Introduction

1. INTRODUCTION

Tuber crops play an important role in human diet and are staple food crops in many parts of the world. A diverse variety of foods can be made from tuber crops. Among the tuber crops, sweet potato (*Ipomoea batatas* [L.] Lam.) is gaining importance across the world as a climate resilient crop that can add nutrition and stability to the food production systems. Compared to other tuber crops, the short growth period and good tuber output result in very high edible energy yield per unit area in this crop. It also has alternative uses as a forage crop and as a raw material for starch industry. Apart from its nutritional value, it is considered as an excellent functional food due to the presence of antioxidants, β-carotene and anthocyanins. As the crop duration is only 3.5-4 months, it can fit in to existing cropping systems. It is one among the few crops selected by NASA for space programmes and hence designated as a 'space crop'. China is the world's biggest producer and consumer of sweet potato. Area, production and productivity of sweet potato in India are 1.08 lakh ha, 11.41 lakh tonnes and 10.56 t/ha, respectively (GoI, 2021). In Kerala, it is cultivated in an area of 309.04 ha with a production of 4356.52 tonnes (GoK, 2022).

Sufficient supply of major nutrients such as nitrogen, phosphorus and potassium is essential to get maximum productivity of any crop. Among these, potassium nutrition is very important in tuber crops as it is associated with many metabolic and physiological activities related to tuber initiation and bulking. This nutrient is called as a 'work horse' nutrient because of its direct and indirect involvement in basic plant processes (Usherwood, 1994). Reduced potassium availability will slow down the photosynthetic rate of plants and assimilate partitioning. Tuber crops have high requirement for potassium compared to cereals, as the content of potassium in the harvested roots is high (O'Sullivan *et al*., 1997). In tuber crops, potassium influences the nutrient transport and carbohydrates movement from leaves to tuber, which is the active sink (Byju and George, 2005).

Sweet potato is considered as a crop with high K requirement. The nitrogen, phosphorus, and potassium ratio for sweet potato nutrition is 2:1:4 (Dong-Wang *et al*., 2015). Compared to N and P deficiencies, sweet potato is far more susceptible to K deficiency. Despite the general assumption that most tropical soils have sufficient levels of potassium to support crop growth, potassium can still become a limiting nutrient during continuous cropping, particularly with root and tuber crops like cassava and sweet potato. While, a drop in the K utilization efficiency and also luxury absorption of potassium would result from excessive K application in sweet potatoes (Shi *et al*., 2002; Foloni *et al*., 2013 and Li *et al*., 2015). There is a high risk of overuse of K fertilizer since tuber crops need higher levels of K for optimal yields, which would raise production expenses. Therefore, there is a need to improve the utilization efficiency of this nutrient by increasing tuber yield and thereby reducing cost of cultivation.

Kerala soils have higher levels of phosphorus and low to moderate levels of nitrogen and potassium (Venugopal *et al*., 2018). Thus, planting nutrient-efficient types and improving crop nutrition can significantly increase sweet potato yield even in low fertile regions of Kerala. Additionally, potassium nutrition is said to increase a crop's capacity to utilise nitrogen effectively, as well as its yield and nutritional value. Tuber crops show varietal differences in response to potassium levels, and ICAR-Central Tuber Crops Research Institute (ICAR-CTCRI) has recently released a K-efficient genotype of cassava 'Sree Pavithra'. In sweet potato also, there are many high yielding varieties available for cultivation. A study on response of high yielding sweet potato varieties to different potassium doses can help in finding out K efficient types, if any.

Apart from soil fertility status, choosing ideal season for cultivation and suitable varieties are also important in attaining full potential of a crop. Being a photosensitive crop, sweet potato needs short days and cooler nights for tuber initiation. However, this crop exhibits a very high level of genetic variability. Also there are reports that depending on the soil and climatic conditions, varietal responses vary greatly (Felistus *et al*., 2018).

ICAR-CTCRI has released several bio fortified varieties (Eg. Bhu Sona and Bhu Krishna) and other high yielding short and medium duration varieties (Eg. Sree Arun, Sree Bhadra, Sree Kanaka, Sree Varun *etc*.) which can be grown in different states of India. Local varieties are also under cultivation (Eg. Kanjanghad Local in Kerala). The amount of precipitation, maximum and minimum temperature and sunshine hours have a profound impact on photosynthesis and productivity of this crop. Hence the choice of cultivars that are appropriate for a given climatic situation is crucial in enhancing the productivity. Also, there is a need to identify potassium efficient varieties for commercial cultivation.

In this context, the present study was formulated with the following objectives

- Assessment of potassium utilization efficiency of few high yielding sweet potato varieties for identifying K efficient variety
- Evaluation of performance of sweet potato varieties under *kharif, rabi* and summer seasons to assess seasonal changes in source-sink relation and productivity.

Review of Literature

2. REVIEW OF LITERATURE

Tuber crops meet local food preferences and give high productivity even in marginal soils. Among tuber crops, sweet potato (*Ipomoea batatas* L. Lam) plays a major role in meeting food and nutritional security. Short growth period together with high tuber yield contribute to a very high edible energy yield per unit area compared with other staple food crops. It also has alternative uses as a forage crop and a raw material in starch industry. It is regarded as the fifth most important food crop in the tropics and seventh in the world food production (FAO, 2016) and also considered to be a 'famine relief crop' (Mukhopadhyay *et al*., 2011).

2.1. Importance of mineral nutrition in crop production

For all crops, achieving a target yield depends on factors related to nutrients, soil type as well as weather conditions. Nutrient removal by crops depends on crop demand and nutrient supplying capacity of soil. Negative balance in this demand and supply relationship will essentially lead to yield gap.

The availability and uptake of nutrients in the soil influence the nutrition of plants. Among the essential elements, primary nutrients such as nitrogen, phosphorus and potassium play an important role in plant growth and development. Numerous cellular functions including the upkeep of membrane structures, the creation of proteins and the emergence of high-energy molecules depend on these nutrients. Additionally, it supports glucose metabolism, enzyme activation and inactivation, and cell division (Malhotra *et al*., 2018).

To achieve high crop yield and improved quality, an appropriate and well-balanced nutrition with mineral nutrients is needed (Cakmak, 2010). It is crucial to apply nutrients in right quantities. For increasing crop production, scientists have developed and released many varieties for different crops. The response of these varieties to available nutrients also varies with existing conditions. As primary nutrients have a major role in plant metabolism, physiology as well as yield production, the response of different crop varieties to these applied nutrients is important. Therefore, development of nutrient efficient varieties is a major concern in producing maximum yield with minimum nutrient input.

Plant nutrition takes care of the interrelationship between soil nutrients and plant growth. Each nutrient is essential for plants to carry out their physiological processes and promote healthy plant growth. Hence, a better understanding on plant nutrition would help to enhance crop productivity for the growing world population (Karthika *et al*., 2018).

2.2. Importance of potassium nutrition in crops

Among the primary nutrients, potassium (K^+) is well known for its role in balanced plant nutrition and is termed as a 'work horse' nutrient because of its direct and indirect involvement in basic plant processes (Usherwood, 1994). In addition, it's role is crucial in many physiological functions connected to plant's biotic and abiotic stress tolerance. Crop production needs a lot of K especially during reproductive stages for the proper growth and development. Being an abundant cation in plant cells having high mobility, potassium is involved in short distance as well in long distance transport through xylem and phloem (Broadley *et al*., 1995).

It is also referred as quality element and optimum potassium supply is important for getting better crop yield and quality. Potassium nutrition is essential for maintaining turgor, stomatal movement, osmoregulation, enzyme activation, charge balance *etc*. which are required for optimum plant growth. It is well known that for maintaining a high rate of photosynthetic activity and for promoting assimilate transport into grains and tubers; require a sufficient supply of K (Pettigrew, 2008). Being a primary nutrient, it has a major impact on a variety of physiological processes in plants, such as photosynthesis, transport and storage of assimilates, which influence general growth and development of the plant (Wang and Wu, 2013). Potassium also improves water use efficiency of crops especially under stress conditions (Grzebisz *et al*., 2013).

Potassium nutrition has also an impact on the effective uptake and utilization of other nutrients in plants. The interaction of potassium with macro as well as micro nutrients is important in attaining targeted crop yield and quality. High concentration of some nutrients like calcium and magnesium can affect the uptake and utilization of potassium in plants. Because of the antagonistic interactions between potassium with other nutrients in the process of their absorption, transportation and assimilation, there is a need to maintain a homeostatic balance between these nutrients in response to varying nutrient status in the soil for optimal growth and productivity (Rhodes *et al*., 2018; Xie *et al*., 2021).

Potassium transport is essential for the modulation of membrane potential, enzyme activity and cytoplasmic and luminal pH in endosomes. Unsurprisingly, plants have developed a diverse group of K^+ transporters that have specific roles in root nutrient uptake, vacuole storage, and ion transfer between tissues and organs (Ragel *et al*., 2019).

Different plant species respond to K supply in different ways, either because of differences in how well they can use potassium physiologically for vegetative and reproductive growth, or because of differences in how well they can take up K from the soil. The demand of different crops to available or applied potassium also varied from species to species. Some crops require less K fertilizer to achieve maximum yield. To obtain maximum yields, K supply and demand must be synced since crops have different temporal potassium demands that are related to their unique phenologies (White *et al*., 2021). Generally, Huai *et al*. (2022) observed that lower doses of potassium promoted root initiation and tuberization in crops while vegetative growth enhancement took place at increased K levels.

The K content of the soil has a big impact on how plants grow and develop. Soil K has greatly dropped, and the overall K balance has showed a deficit due to the current cultivation practices as well as the unbalanced nutrient input in traditional agriculture management practice. The sources of potassium fertilizer for agriculture are very limited and majority of this nutrient need can be met through imports in India. The development of agricultural production in our country has been significantly constrained by soil K deficit and the lack of K fertilizer. Therefore, alternate ways to be found out to meet the plants' potassium needs while using the least amount of fertilizer as possible in order to achieve environmental friendly and sustainable agricultural output due to limited resources. So, studies have to be undertaken to identify K efficient varieties in different crops (Fan *et al*., 2013; Dreyer, 2014).

In the 21st century, nutrient efficient plants especially of primary nutrients will play a significant role in increasing crop yields compared to the 20th century. This is primarily because of the depletion of available resources for crop production, the higher cost of inorganic fertilizer inputs, the global trend of declining crop yields and growing environmental concerns. Moreover, at least 60 per cent of the world's cultivated lands have issues with mineral deficiency or elemental toxicity, and on these soils, lime amendments and fertilizers are crucial for enhancing crop yields (Fageria *et al*., 2008). For a variety to be called as a nutrient efficient one it should have the ability to produce a high yield in a soil that is limiting in that element for a standard genotype (Graham, 1984). Therefore, identification of potassium efficient variety is needed to optimise the application of this nutrient for the growth and development of crops as cost of this fertilizer is also high.

2.3. Potassium utilization efficiency of different tuber crops

Tuber yield and quality in tuber crops are influenced by many factors like varietal characteristics, soil fertility, management practices and weather parameters. Among this, ample supply of nutrients has prime importance. It is reported that the response to applied nutrients is also influenced by genetic makeup of the varieties of a particular crop. Potassium affects more the efficiency of converting light into dry matter than the amount of light intercepted in tuber crops (Ezui *et al*., 2017).

Karam *et al*. (2009) reported that in potato, potassium uptake increased in different genotypes with increase in potassium application rate. Potassium @ 192 kg K_2O/ha recorded 19 and 61 per cent higher potassium utilization efficiency (KUE) than other potassium levels @ 92 kg and 288 kg K_2O/ha, respectively. They also reported that aggregate tuber yield (45.8 t/ha) and medium and large sized tuber grades increased quadratically with increasing K levels up to 192 kg K_2O/ha irrespective of varieties. Differences in varietal response to applied potassium were also reported. K uptake or utilization efficiency, which is crucial for the selection of high K efficient crops, has often been the focal point of attention in research on K efficiency. Zhenpeng *et al*. (2021) reported that there was genetic variation in tuber yield, plant and tuber K content, plant K uptake efficiency and K harvest index. Based on the tuber yield, K application rate and relative yield, twenty potato genotypes could be classified into four types: high efficiency at low and high K application, high efficiency at low K application, high efficiency at high K application and low efficiency at low and high K application.

Mali *et al*. (2018) studied the influence of potassium levels on physical and chemical parameters of yam bean tubers and reported that highest tuber diameter was recorded for K level @ 100 kg K_2O/ha (11.85 cm) and lowest @ 40 kg K_2O/ha (9.69 cm) with mean of 10.77 cm and the difference was significant. Also, shelf life of tubers significantly varied with potassium levels.

Umeh *et al*. (2015) showed the importance of inclusion of potassium fertilizer in cassava nutrition for improving tuber yield and recorded higher tuber yield of cassava at N_0K_{50} and $N_{45}K_{50}$ than at N_0K_0 and $N_{45}K_0$ fertilizer rates. Chua *et al*. (2020) examined the effect of potassium nutrition in cassava and documented a positive effect of potassium fertilizer on cassava root yield *ie*. up to 39 per cent yield increase compared to no K at early harvest and 21 per cent at late harvest. They also reported that total potassium content in the cassava plants increased with increase in K application.

The linkage of cassava storage root development with potassium nutrition was attributed to the involvement in photosynthate partitioning was given by Omondi *et al.* (2020). In this study, the effects of K @ 10, 40, 70, 100, 150 and 200 mg/L through fertigation on photosynthetic attributes, starch, metabolites, growth and yield were studied in green house condition. Both stomatal conductance and net photosynthesis of cassava increased significantly with increased potassium concentration in the solution. The stomatal conductance, net photosynthesis, number of storage roots and root yield were the highest at K @ 150 mg/L.

A research work was conducted by John *et al*. (2020) to screen cassava germplasm with an objective to find K efficient varieties that can produce well even if potassium is deficient in order to minimise the need for external K application. The selection of K efficient types proceeded with the initial examination of 83 elite genotypes. The observations included tuber yield, tuber characteristics, plant dry matter, plant nutrient content, tuber quality and physiological efficiency. This study helped to identify six K efficient varieties by comparing these parameters and further detailed work was carried out at different potassium levels.

Later, using the six selected genotypes (Aniyoor, W-19, 7 Sahya-2, 6-6, CR 43-8 and 7 III E3-5), studies conducted on screening potassium efficient cassava genotypes which were evaluated under different K levels (0, 50, 100 and 150 kg/ha). Potassium doses significantly influenced the nutrient use efficiency parameters such as nutrient harvest index and uptake ratio and K @ 50 kg/ha had highest impact on these parameters. Genotype CR 43-8 had the highest tuber yield under K (28.79 t/ha) and was on par with genotypes *viz.,* Aniyoor and W-19 under different K levels. Harvest index was highest without K (0.461) but was on par with K at 50 and 100 kg/ha (0.458 and 0.426, respectively). Similarly, potassium harvest index and K uptake ratio were highest for K_0 (0.49 and 1.072, respectively), but was on par with K @ 50 kg/ha (0.46 and 0.920, respectively). While comparing the response of each variety to applied potassium and its effective translocation to storage roots, the genotypes *viz.,* Aniyoor (edible) and 7III E3-5 (industrial) were identified as K efficient. The root biomass and leaf area index confirmed these genotypes' ability to scavenge the fixed native soil potassium and improve its performance at K_{50} and K_0.The genotype Aniyoor was released as the first K efficient cassava variety by name 'Sree Pavithra' (John *et al*., 2014 and John *et al*., 2020).

Similarly, positive effect of higher potassium rates on cassava tuber yield and quality was reported by Merumba *et al*. (2022). They reported that application of 40, 80 or 120 kg potassium per ha significantly increased cassava root yield from 14.56 to 39.94 MT/ha as compared to other fertilizers.

The importance of potassium nutrition in *Dioscorea* species was also reported by many scientists. Senanayake *et al*. (2022) documented the influence of K application along with nitrogen fertilizer and found out how much potassium accumulated in tubers of *Dioscorea alata* in comparison with total uptake. At harvest, the belowground organs had accumulated 56 to 60 per cent of the total K taken up by the yam plant in first season and 75 to 81 per cent in second season. The highest K uptake was observed when 88 kg K_2O/ha was applied along with 180 kg N/ha (96.1 kg K/ha in first season and 60.4 kg K/ha in second season). Similarly, in yam, significantly higher and comparable tuber yield was recorded when potassium was applied @ 88 kg/ha and 176 kg/ha.

Aswani (2021) studied the influence of different levels of potassium on the growth and tuber yield of coleus and found out that when potassium application rates were increased, tuber yield significantly increased. When 100 kg/ha of K_2O was applied, increase in tuber yield was 19 per cent over control (13.80, 14.94, and 16.46 t/ha, at 0, 60, and 100 kg/ha K_2O, respectively).

2.3.1. Potassium fertilization on growth and yield of sweet potato

Potassium is an essential nutrient for the growth and development of sweet potato and it depletes this nutrient from soil significantly. Sweet potato is a crop with a relatively high requirement of potassium compared to nitrogen and phosphorus (Byju and George, 2005). According to Sreelatha *et al*. (1999), it required an average of 12.36 kg nitrogen, 1.01 kg phosphorus, and 10.72 kg potassium per hectare to produce 1 tonne of tuber. But, according to Mohankumar and Nair (1990), the crop removed roughly 41 kg N, 13 kg P and 68 kg K to produce an average tuber yield of 18 t/ha because of high dry matter production/unit area/unit time and rapid nutrient uptake.

Several studies have been undertaken to know the role of potassium in tuberization of this crop.

Sokoto *et al*. (2007) examined the influence of different potassium fertilizer rates (0, 50, 100, 150 and 200 kg potassium/ha) on the performance of a local variety of sweet potato 'Ex-Fateka'. Results indicated that potassium fertilizer had no significant effect on leaf area index as well as crop growth rate, but had an influence on marketable tuber yield. Potassium fertilizer applied @ 150 and 200 kg K per ha out yielded other doses (0, 50 and 100 kg K/ha) with 6.66 t/ha and 6.44 t/ha, respectively. The effect of varied doses of potassium fertilizer (60 kg, 90 kg, 120 kg and 150 kg K_2O/0.42 ha) on sweet potato plants was studied by El-Baky *et al*. (2010) and reported that the highest values of growth characters such as vine length, number of leaves and branches, total fresh weight and leaf area and also tuber yield (1188 g/plant) were recorded for the treatment that received 150 kg potassium.

Uwah *et al*. (2013) studied about the response of two improved sweet potato varieties (TIS 8164 and Ex-Igbariam) to five rates of potassium fertilizer (0, 40, 80, 120 and 160 kg K/ha). This study showed that variety Ex-Igbariam responded to K application better than TIS 8164 at all potassium levels used. Vine length, number of leaves, and number of branches per plant increased significantly when K was applied at 160 kg/ha, whereas the dry weight of the vine, the diameter of the tubers and the weight of the tubers per plant did not differ statistically between 120 and 160 kg potassium/ha. The application of 40, 80, 120 and 160 kg K/ha, gave an aggregate yield increase of 149, 493, 682 and 786 per cent respectively, over no potassium.

El-Seifi *et al*. (2014) studied the effect of potassium (0 kg, 48 kg and 72 kg K_2O/0.42 ha) on the growth and yield of sweet potato plants and reported that K application @ 72 kg K_2O/0.42 ha was superior. It had significantly higher vine length, number of branches, leaf area, canopy dry weight/plant and total chlorophyll content of leaves compared to control. Similar trend was seen for tuber yield also and potassium applied @ 72 kg/0.42 ha recorded significantly higher tuber yield per plant (965.35 g/plant) and marketable tuber yield (13.78 t/0.42 ha) compared to other K levels.

Dong Wang *et al*. (2015) investigated the intraspecific variation in the uptake and utilization of potassium among different genotypes of sweet potato and found that potassium application increased the yield of sweet potato up to 300 kg K_2SO_4/ha and a decreasing trend noticed at higher dose of 450 kg K_2SO_4/ha. Also, Ji22 and Xu083 genotypes were classified as K uptake inefficient, while Nan88 and Xu082 were evaluated as K efficient based on K accumulation at various growth stages with various amounts of potassium availability.

According to Cecilio-Filho *et al*. (2016), maximum marketable tuber yield (24.3 t/ha) was obtained at the dose of 85 kg K_2O/ha for the sweet potato cultivar Beauregard in potassium deficient soils. Similarly, Saif-Eldeen and Baddour (2016) assessed the influence of different potassium fertilizer sources on growth and tuber yield of sweet potato. The results indicated that the combined application of 72 kg K_2O/0.42 ha as potassium sulphate + 24 kg K_2O/0.42 ha as feldspar + silicate dissolving bacteria (SDB) induced vegetative growth characters (vine length, canopy weight and number of branches) while, application of 48 kg K_2O/0.42 ha as potassium sulphate + 48 kg K_2O/0.42 ha as feldspar + SDB had the highest and significant value among treatments in total yield, marketable yield, tuber root characteristics (weight, diameter and dry matter percentage).

Biswal *et al*. (2017) studied the effect of different potassium levels on growth and yield of sweet potato variety Sankar. Potassium applied @ 0, 50, 75, 100 and 125 kg K_2O/ha. Significantly higher vine length, number of leaves per plant and LAI were registered when potassium applied @ 125 kg K_2O/ha. But, significantly higher tuber girth and tuber weight were produced when potassium applied @ 75 kg K_2O/ha. Significantly lower values were registered for control plot. In the same study, they also found out that there was variation in total dry matter production at different levels of potassium and dry matter production was higher at potassium applied @ 125 kg K_2O/ha which was on par with K level @ 75 and 100 kg K_2O/ha (Biswal *et al*., 2017[a]).

Dong-Wang *et al*. (2017) assessed potassium partitioning and redistribution in terms of potassium use efficiency (KIUE) under potassium deficiency in sweet potato. In this study, genotypes 'Xu28' (high KIUE) and 'Ji22' (low KIUE) were identified and analyzed under conditions of K deficiency (K_0) and adequate K supply (K_1). The results revealed that there was significant interaction between potassium supply and genotypes.

Dumbuya *et al*. (2017) carried out an experiment to evaluate the effect of potassium fertilizer levels (0, 60, 120 and 180 kg K_2O/ha) on the growth and yield components of the sweet potato variety Okumkom. The application of 60 kg K_2O/ha of potassium fertilizer produced the longest vines, the highest number of leaves, branches and tubers as well as the highest marketable tuber yield per plant. Liu *et al*. (2017) documented the comparison between two different low potassium tolerant varieties ('Xushu 32' - tolerant to K deficiency and 'Ningzishu 1' - sensitive to K deficiency) in terms of their physiological responses to potassium deficient conditions (K levels – 0 mmol/L (K_0), 5 mmol/L (K_1), and 20 mmol/L (K_2). The total dry weight of 'Ningzishu 1' significantly decreased at potassium deficient conditions (K_0 and K_1 levels) at 32 per cent and 19 per cent, respectively compared to K_2. But for 'Xushu 32', the corresponding decrease of K_0 and K_1 was at 14 per cent and 8 per cent, respectively. Deficiency of potassium decreased root activity in the two cultivars, but only 'Ningzishu 1' showed significant differences between K_0 and K_2 level.

Putra and Edy (2018) conducted a study on the effect of different levels of potassium (K_0 = 0 kg/ha, K_1 = 78 kg/ha, K_2 = 137 kg/ha, K_3 = 196 kg/ha and K_4 = 255 kg/ha) on growth and tuberization of various sweet potato varieties (Gunung Kawi and Cilembu). The findings indicated that both varieties had a positive interaction with applied K levels and potassium application @ 196 kg/ha resulted in higher tuber yields of 28.7 t/ha and 16.3 t/ha, respectively for the varieties Gunung Kawi and Cilembu. Pushpalatha *et al*. (2018) also studied the effect of different graded levels of potassium on yield of sweet potato and reported that potassium @ 100 kg/ha significantly increased the tuber yield (19.597 q/ha) compared to 0 and 75 kg/ha (15.447 and 18.825 q/ha, respectively).

According to Aboyeji *et al*. (2019), tuber yield (24.6 t/ha) and vine length (2.46 m) of sweet potato significantly increased with potassium application @ 80 kg/ha compared to control and there was no significant difference at higher doses of 120 and 160 kg potassium. However, Sulistiani *et al.* (2020) found that potassium fertilizer @ 100 kg/ha resulted in higher tuber yield compared to 0, 50 and 150 kg potassium per ha in sweet potato variety Antin-1.

Uddin *et al*. (2020) reported the influence of potassium levels (K_0- 120 kg/ha; K_1- 140 kg/ha; K_2- 160 kg/ha and K_3- 180kg/ha) on the growth and yield of sweet potato germplasm. The highest vine length was found in K_3 and the lowest in K_0 treatment. The highest number of root tuber per plant was obtained with K_3 (8.8) followed by K_2 (8.7), while the minimum number (8.0) was recorded in K_0 treatment. The results revealed that application of potassium @ 180 kg/ha resulted in 11 per cent yield increase over control.

Similarly, Darko *et al*. (2020) studied the sweet potato productivity as influenced by different fertilizer levels in various agro-ecologies in Ghana and reported that one of the key strategies for increasing the yield of sweet potato storage roots was the use of the proper fertilizer input. Potassium application favoured the dry matter translocation to the tubers and increased the number of tubers per plant.

Du *et al*. (2020) reported varietal variation in response to K application with respect to average number of storage roots per plant (8 % to 25 % increase in YS25 and 10 % to 33 % increase in BJ553) and yield at harvest (17.08 % to 17.31 % increase and 14.96 % to 18.45 % increase, respectively for YS25 and BJ553), compared to control. The yield was highest at K applied @ 24 g/m^2 and a decrease in yield was recorded at higher rate of K_2O (36 g/m^2). Findings of Gao *et al.* (2021) showed that in sweet potato, potassium application significantly enhanced the plant and storage root biomass, while, treatments at high levels of K, i.e., 300–375 kg K_2O/ha, greatly decreased plant biomass and storage root production.

In contrast to these studies, Darko *et al.* (2021) documented the effect of potassium fertilizer (T_1: 30-30-30 kg/ha NPK, T_2: 30-30-60 kg NPK + 50 kg Muriate of Potash, T_3: 30-30-90 kg/ha NPK+ 100 kg Muriate of Potash and T_4: Control) on root yield of different sweet potato varieties. Results indicated that the fertilizer rates did not influence root yield but varietal differences were significant. Lestari *et al*. (2021) also reported that tuber yield was not affected by added potassium levels and resulted in non significant values for 50, 100 and 150 kg potassium rates (971.11 g, 880 g and 977.78 g per plant, respectively).

Similarly, Al-Qodri *et al*. (2021) also assessed the interaction between three sweet potato varieties (Cilembu, Atin 3, and Beta 1) and four doses of potassium fertilizer (0, 150, 300 and 450 kg/ha) and found out that no significant interaction between the dose of KCl fertilizer and the three varieties of sweet potato.

2.3.2. Potassium fertilization and quality of sweet potato tubers

Sweet potato varieties differed noticeably in phenotypic, sensory, physicochemical and nutritional characteristics. Application of potassium also influences quality of sweet potato tubers as K is essential for the formation of sugars and starch. Constantin *et al*. (1977) reported that varying rates of potassium fertilizer from 0 to 140 kg/ha had a significant influence on quality parameters of sweet potato tubers. The results revealed that protein content was decreased by applied K doses, but, crude fibre content showed marginal increase. Carotenoid content was not influenced by added K doses.

El-Baky *et al*. (2010) conducted an experiment to understand the effect of potassium fertilizer (60 to 150 kg K_2O/0.42 ha) on quality of sweet potato tubers and reported that tuber quality parameters such as carotenoids, total carbohydrates, total sugars and crude protein were increased with increased potassium levels (150 kg/0.42 ha).

Effect of different levels of potassium (0, 50, 75, 100 and 125 kg K_2O/ha) on the quality of sweet potato tubers was documented by Biswal *et al*. (2017). The starch content (65 % on dry weight basis) was significantly increased up to 100 kg K_2O/ha while protein content (7.01 % on dry weight basis) up to 75 kg K_2O/ha. In contrast, sugar content (14 %), ß- carotene (2.46 mg/100g) and vitamin C (66.66 mg/100g) were higher when no K fertilizer was applied.

Pushpalatha *et al*. (2017) studied the effect of graded levels of potassium on quality of sweet potato tubers and recorded significantly higher reducing sugar (0.23 %), non reducing sugars (6.23 %), total sugar (6.46 %), carbohydrates (17 %) and protein (8.70 %) for potassium applied @ 100 kg K_2O/ha over control. Sulistiani *et al*. (2018) also confirmed that potassium would increase yield and quality as well as increase the translocation of sugar and starch.

Aboyeji *et al*. (2019) assessed the performance of sweet potato at various potassium levels (0, 40, 80, 120 and 160 kg/ha) and found that potassium @ 80 kg/ha influenced parameters such as vitamin C, fibre content and carbohydrate significantly compared to no potassium. Protein content was significantly higher at 40 kg potassium/ ha, while moisture content increased with K level (0-160 kg/ha).

Similarly, Sulistiani *et al.* (2020) reported the effect of potassium fertilizer on biochemical parameters of the sweet potato variety 'Antin -1' and documented significant changes in anthocyanin and glucose production. Potassium @ 100 kg/ha resulted in significantly higher anthocyanin content (0.54 mg/100g) compared to other K levels. Du *et al*. (2020) assessed the storage root development and sucrose metabolism in sweet potato under potassium nutrition. During storage root production, K considerably decreased the sucrose concentration while dramatically increased the glucose and fructose content. K applied @ 24 g/m^2 had the greatest impact, whereas K level increased up to 36 g/m^2 enhanced sucrose content but decreased glucose and fructose contents in potential storage roots.

Gao *et al*. (2021) also reported that in comparison with the no K treatment, the content of sucrose, amylose and amylopectin decreased by 9 - 34 per cent, 9 - 23 per cent and 6 - 19 per cent, respectively, but starch accumulation increased by 11 - 21 per cent under potassium application (75-375 kg K_2O/ha) in two sweet potato varieties (Ningzishu 1 and Xushu 32).

2.4. Seasonal influence on productivity of crops

Cultivation of crops and its productivity are highly dependent on growing season. Seasonality refers to both a changing environment and the biological responses conditioned by that environment. The seasonal cycle influences plant growth and development; hence the seasons serve as a natural integrator (Battey, 2000). The most significant fundamental physical variables affecting the environment are the temperature and rainfall because they influence the climatic conditions in a certain area, which have an impact on agricultural productivity. Agriculture and climate change have a complex relationship. As climate change is a serious issue today, identifying suitable crop varieties as well as management practices are important. It will be easier to develop the appropriate management practises for taking advantage of the favourable weather conditions and avoiding risks due to climatic factors for obtaining optimal and suitable agricultural productivity if one is aware of a region's climatic conditions as well as the effects of weather on crops (Neenu *et al*., 2013; Panda and Sahu, 2019). A pressing concern in a sustainable environment is the fluctuation of rainfall, temperature and relative humidity since agricultural production and yield are crucial to the local economy and people's quality of life (Obafemi and Adebolu, 2018).

2.5. Seasonal response in photosynthetic partitioning of tuber crops

Many high yielding tuber crop varieties have been released and information on the suitability of these varieties to different seasons can help the farmers in choosing appropriate varieties to maximize production.

Season has also an influence on the assimilate partitioning in different tuber crops as tuber initiation is highly depend on weather parameters. Growth and quality of tubers are also affected by environmental factors. Seasonal variation has a major effect on growth, tuberization and physiological processes in tuber crops by changing its phenological processes (Puangbut *et al*., 2015). This phenomenon is influenced by climatic, edaphic, and biotic variables. Photoperiod, temperature, light (intensity and quality), mineral nutrition, soil moisture status are the crucial variables. The amount of photosynthate available for storage in tubers may also be impacted by the environment by influencing the frequency and length of photosynthesis and respiration (Posthumus, 1973).

Singh *et al*. (1990) evaluated the effect of planting time (planted on the 15th day of each month from January to July) on crop stand, tuberization rate and tuber yield of medicinal yam (*Dioscorea floribunda*) in Uttar Pradesh. The study revealed that *Dioscorea* tubers planted on January, February and March showed higher survival rate, tuberization rate and also registered higher tuber yield as against tubers planted at June and July.

Khan *et al*. (2011) studied the tuber bulking rate of potato as influenced by seasonal variation at the Agricultural Research Institute, Dera Ismail Khan, Pakistan. The results revealed that early planting produced significantly higher tuber yield (15.57 t/ha) than planting at a later time. However, delayed planting had increased dry matter. Similarly, seasonal variation on the performance of cassava genotypes (CMR38-125-77, Kasetsart 50, and Rayong 11) planted at different dates (20 April, 30 June, 5 October, and 15 December) was studied by Janket *et al*. (2018) at Field Crop Research Station, Khon Kaen, Thailand. The results were useful for selecting suitable genotypes for different growing seasons in order to obtain higher tuber yield and starch content. The study indicated that cassava planted on 15th December produced significantly higher starch yield compared to other planting dates but was on par with cassava planted on 5th October for the variety CMR38-125-77.

Likewise, a study conducted at Khon Kaen University, Thailand by Phosaengsri *et al*. (2019) on the performance of tapioca varieties (Kasetsart 50, Rayong 9, Rayong 11 and CMR38-125-77) in different seasons (20 May, 30 June, 5 October and 3 November) and its connection with biomass production. The results indicated that genotype Kasetsart 50 planted on 30th June produced significantly higher leaf area duration compared to other varieties and planting dates, while higher LAI was registered for variety Rayong 9 planted on 30th June. It was inferred that varieties planted at 30th June performed significantly better compared to other genotypes.

Janket *et al*. (2020) assessed the performance of cassava variety 'Rayong 9' planted at different growing seasons [hot-dry, early-rainy, late-rainy and cool seasons] in Thailand. The results indicated that both storage root dry weight and starch yield were significantly higher for variety planted at 15th December (20628 kg/ha and 17779 kg/ha, respectively).

Mahakosee *et al*. (2020) studied the effect of variation in seasons (early rainy season - May and late rainy season - November) on the canopy size and photosynthetic activity of three cassava genotypes (KU50, Rayong 11 and CMR38-125-77) in Thailand. November planting resulted in significantly higher biomass, storage root dry weight, shoot dry weight, harvest index and starch content for the variety KU50. Santanoo *et al.* (2020) also documented the seasonal variation (20th April, 30th June, 10th November and 15th December) in performance of tapioca genotypes (Rayong 9, Rayong 11, Kasetsart 50 and CMR38-125-77) in Thailand and the results indicated that planting dates at wet season produced the most robust growth with maximum values of all canopy characteristics [plant height, canopy height, total number of leaves, internodal length and LAI]. The highest LAI was recorded in CMR38-125-77, followed by Rayong 11, Rayong 9, and Kasetsart 50.

In a similar study in potato by Escuredo *et al.* (2020), investigated the changes in the morphological characteristics of 16 potato cultivars in relation to seasonal variability (between April and September) in A Limia, Spain. The crop duration with the highest temperatures and least accumulated rainfall resulted in plants with a higher number of leaflets, which were shorter in length. The crop cycle with a lower temperature and more rainfall had the tallest plants, the highest degree of flowering and the highest length of the floral peduncle. Varieties Kennebec and Fontane showed the least variability in morphological characteristics during the seasons analyzed.

Naik *et al.* (2022) investigated the effect of *kharif* and *rabi* seasons on tuber yield of potato under aeroponic technique at GKVK, Bengaluru. Yield was more in *rabi* due to favourable climate. Normally, potatoes were cultivated in the *rabi* season, and during the *kharif* season, the crop was forced to develop more mini-tubers due to the minimum environmental requirements for crop growth, development, and tuberization. The *rabi* crop had the highest plant height, number of leaves per plant, longest root, leaf area and the highest fresh and dry weights.

2.5.1. Influence of different seasons on growth and tuber yield of sweet potato

Sweet potato is described as a climate resilient crop, it is essentially a photosensitive crop which 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. Wide variations in yield among the varieties and individual plants in the same cultivar have been ascribed to varieties, environment and soil factors. Genetic and seasonal factors influence leaf area, photosynthetic rate, assimilate partitioning and also tuber formation and development (Ravi and Indira, 2010; Felistus *et al.*, 2018). Tuberization is an important event in life stages of sweet potato and any unfavourable weather conditions during this time can cause the production of fibrous roots rather than tuberous roots. Productivity of the crop is primarily a function of dry matter accumulation, which is influenced by environmental conditions and transportation from source to sink which is also influenced by interplay between these elements (Hahn, 1977).

Nedunchezhiyan and Byju (2005) studied the effect of planting season on the growth and yield of sweet potato varieties (Sankar, Gouri, Sree Nandini, Sree Bhadra, Pusa Safed and Samrat) at Bhubaneswar and reported that total and marketable tuber yield was higher during *rabi* than in *kharif*. Sree Nandini recorded longer vine length (182 cm and 131 cm, respectively), higher number of leaves (111 and 99, respectively) and also shoot fresh weight per plant (172 g/plant and 149 g/plant, respectively) which was comparable with variety Pusa Safed and Sree Bhadra during *kharif* and *rabi* seasons. Among the seasons, Sree Nandini (7.2 t/ha), Sree Bhadra (7.1 t/ha) and Samrat (7.1 t/ha) recorded the highest total yield in *kharif* and Samrat (18.7 t/ha) in *rabi*.

Sreekanth *et al*. (2011) studied the response of different genotypes of sweet potato (four orange fleshed and two white fleshed varieties) during *kharif* and *rabi* seasons in Bhubaneswar and reported that between the growing seasons, higher yield was observed in *rabi* than in *kharif* season. Interaction between genotypes and seasons was also significant.

Deka *et al.* (2013) assessed the suitability of different sweet potato varieties in Assam in various seasons and reported that the tuber yield was greater in *rabi* season than *kharif* in all the cultivars tried. Among the varieties, Kothal Kuhia (local) proved to be superior in both *kharif* and *rabi* seasons with respect to vine length (246 cm and 230 cm, respectively), number of primary branches per plant, tuber yield (16.67 t/ha and 26.17 t/ha, respectively) and starch content (19.22 % and 24.99 %, respectively).

Evaluation of a few orange fleshed sweet potato genotypes were conducted during *kharif* and *rabi* seasons in the field of ICAR-Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram by Nair *et al*. (2017) and recorded wide range of variability for tuber yield and dry matter content. The tuber yield ranged from 8.66 to 32.86 t/ha in *rabi* and *kharif* seasons. Genotype ST-14-47 recorded significantly higher tuber yield (32.86 t/ha) during *rabi* season while, genotype KS-115 recorded highest yield (31.81 t/ha) in *kharif* season. The lowest yield was obtained by ST-14-48 in *rabi* season and CO3-50-34 in the *kharif* season. The variety CO3-50-43 had the highest dry matter content during both seasons, whereas ST-14-34 and SV3-8 had the lowest dry matter content in *rabi* and *kharif*, respectively.

Gupta *et al*. (2018) documented the performance of 16 sweet potato varieties during *rabi* season in Udaipur and found out that there was significant difference for growth and yield parameters among the varieties. Variety CO-3-4 produced significantly higher tuber yield of 40.73 t/ha. Navsari Local, Samrat, Sree Vardhini and SV-71 recorded significantly lower yield during *rabi* season. Mishra *et al*. (2019) studied the effect of different planting dates (20 July, 30 July and 9 August) on the growth and yield of sweet potato varieties (Kishan, ST-13, ST-14 and Local Check) in Keonjhar district of Odisha. Crop planted on 30 July recorded the highest weight of the above ground plant parts which was significantly higher than planting of 20 July and 9 August. Significantly higher above ground plant biomass was found in variety Kishan.

Meena *et al*. (2020) studied the influence of planting dates [20^{th} May, 30^{th} May, 10^{th} June and 20^{th} June] on growth and yield attributes of sweet potato variety CO-3-4 in Udaipur. Planting dates had an effect on time taken to 50 per cent sprouting, maximum vine length, number of leaves per vine. Sweet potato planted on 10^{th} June recorded significantly higher vine length, minimum days to 50 per cent sprouting, more number of leaves, maximum number of tubers per plant (5.08), tuber length (17.39 cm), tuber diameter (8.85 cm) and yield (30.50 t/ha). Significantly lower growth and yield parameters obtained for sweet potato planted on 20^{th} May.

Imamsaheb *et al*. (2022) evaluated the performance of eight orange fleshed sweet potato varieties (TSp16-3, TSp16-5, TSp16-6, TSp16-7, TSp16-9, TSp16-10, Bhu Sona and Sree Bhadra) for yield and quality parameters during *kharif* season in Dharwad, Karnataka. Among the varieties, Sree Bhadra registered highest total and marketable tuber yield of 26.75 and 23.53 t/ha, respectively which were on par with TSp 16-10 recording highest total and marketable tuber yield of 26.67 and 23.17 t/ha, respectively. The lowest yield of 14.53 t/ha was for variety TSp16-5.

The performance of sweet potato varieties during different seasons is studied by different scientists around the world. Growth and tuberization of different sweet potato varieties across various environments as well as different seasons in Kenya was evaluated by Mwololo *et al*. (2012). Vegetative growth was comparatively more for long rainy season than short rainy period. Tuber yield was 2.6 times higher in long rainy season compared to short rainy season in studied locations.

Varietal evaluation of eight different sweet potato genotypes during wet and dry seasons in Philippines was conducted by Limon and Sampaga (2013). Study indicated that Bengueta, Tocano, Inubi as well as PSBSp 22 were ideal for planting in wet and dry season. But, variety Super Beaurelli was specifically for rainy season and also varieties NSIC 30 and Japanese Ubi for dry season. In rainy season, significantly higher tuber yield was recorded by the variety Bengueta (35.43 t/ha) which was comparable with Inubi (32.34 t/ha) and PSBSp 22 (27.43 t/ha). During dry season, significantly higher tuber yield was recorded by Bengueta (33 t/ha), Tocano (29.7 t/ha), NSIC 30 (32.34 t/ha) and Inubi (32.34 t/ha) which was comparable with local check PSBSp 22 (24.09 t/ha).

Wariboko and Ogidi (2014) evaluated the performance of four high yielding varieties along with one local variety in Bayelsa State, Nigeria from March to June. Significantly higher tuber yield was registered for variety Ex-Igbariam (7.39 t/ha).

Liu *et al*. (2015) conducted an experiment to study the differences in transport of photosynthates between high yielding and local sweet potato varieties for the vines cultivated in China during May to October and the highest fresh tuber yield was reported for high yielding varieties compared to local varieties. Among the high yielding varieties, the tuber yields of L9 (68.16 t/ha) and HXJ (62.47 t/ha) were higher than that of S8 (51.36 t/ha) and T6 (57.10 t/ha).

The performance of 16 improved sweet potato lines during wet season (May-September) and dry season (October-April) at Kano, Sudan savanna in Nigeria was compared and found that in both seasons, local variety – Kantayiidda recorded significantly higher yield (10315 kg/ha) and mean number of marketable roots per plot (41.70) compared to other advanced lines (Yahaya *et al.*, 2015).

Evaluation of ten sweet potato varieties was carried out in Indonesia during rainy season by Widaryanto and Saitama (2017). Results revealed that varieties Papua Sollos (7.13), Antin-1 (7.14), Sawentar (7.23) and Beta-1 (7.06) had significantly higher LAI and dry matter accumulation and resulted in more assimilate partitioning during rainy season compared to other varieties under study.

A multi location assessment of various sweet potato varieties (eight improved varieties – AO305, Centennial, Delvia, King J, Lourdes, Mothers delight, Sumaia, T121 and one local variety – Danchina) was carried out by Abdulkadir *et al*. (2017) during rainy season in Kano State of Nigeria and found out that T121 registered significantly higher marketable tuber yield than all other improved varieties, despite having a low leaf area index at six weeks after planting. Hence, it can be characterised as having a high sink capacity among all other introduced types during *kharif* season. The findings showed considerable variations in growth traits and tuber yield between the cultivars and geographical locations during rainy season.

Similarly, Mbusa *et al*. (2018) assessed the agronomic performance of 25 Kenyan orange fleshed sweet potato genotypes in short rainy season (October to December) and the long rainy season (March to May) and results showed that there was significant variations among different varieties and seasons especially for number of marketable roots and fresh root yield. The mean fresh root was 32.19 t/ha, with the genotype Ininda expressing the highest fresh root yield of 54.79 t/ha and the varietal performance varied with season.

Makunde *et al*. (2018) assessed the growth and development of 29 sweet potato genotypes in Mozambique to changing climate. The study revealed that length of sprouts measured six weeks after sprouting and the number of sprouts per root were both significantly varied with genotype and location which influenced the expression of qualitative characteristics of tuber. Among the genotypes, Caelan performed better compared to other genotypes and produced significantly higher number of sprouts and average length of sprout.

Field evaluation of 15 sweet potato varieties were done in Calabar, Nigeria by Bassey *et al*. (2019) during *rabi* season and recorded that variety SOLOMON produced significantly higher vine length (244.90 cm), leaf area index (5.71), biomass yield (4.95 t/ha) and mean tuber yield (15.85 t/ha).

It is reported that in sweet potato, some varieties are tolerant to moisture stress. Laurie *et al*. (2009) reported the influence of moisture stress on the growth and tuberization of orange fleshed sweet potato varieties (Resisto, W-119, Sunset Purple and Isondlo) planted during dry season (December to May) in South Africa. Results revealed that even under extreme moisture stress, the variety W-119 performed better than the other types and variety Resisto was found to be extremely vulnerable to moisture stress. Variety Isondlo exhibits promising results in terms of yield and water use efficiency.

Genotypes and environment interactions were studied for selecting drought tolerant varieties in sweet potato during dry seasons in Mozambique by Andrade *et al*. (2016). The study revealed that there were significant differences noticed for storage root yield, vine yield as well as total biomass between selected genotypes with respect to various climatic factors. Here, four clones greatly outperformed "Tanzania," the best check cultivar in drought conditions, in terms of storage root output (t/ha).

Nwankwo *et al*. (2018) investigated the performance of different sweet potato landraces (16 accessions) harvest index and also for high root yield during wet and dry seasons in Umudike, South eastern Nigeria. The results revealed that climatic variations have had considerable influence on the performance of sweet potato genotypes. Variety Kwara had a harvest index of 0.51, Agege and Buttermilk both had a harvest index of 0.49, ABOM had a harvest index of 0.48, and ABCHI and Ex-Igbariam each had a harvest index of 0.47.

Bunphan and Anderson (2019) assessed about the effect of different seasons (rainy and dry seasons) on the growth and yield of sweet potato variety Japanese Orange and concluded that all parameters were influenced by seasons except number of branches per plant. The average tuber yield in rainy season (8.07 t/ha) was significantly higher than summer season (6.12 t/ha). Also, number of tubers per plant was significantly higher for rainy season (5.2) compared to dry season (2.6). Mau *et al*. (2019) studied the performance of sweet potato hybrids during dry season in Indonesia and out of 20 genotypes, six F_1 hybrids were selected as drought-tolerant genotypes with high yield in both no stress and water-stressed conditions.

Materials and Methods

3. MATERIALS AND METHODS

The research work entitled 'Potassium utilization efficiency and seasonal response in photosynthates partitioning of high yielding sweet potato varieties' was conducted during the period from July 2021 to May 2022 at Agronomy Farm, Department of Agronomy, College of Agriculture, Vellanikkara, Thrissur. The objectives of the study included the assessment of potassium utilization efficiency of selected high yielding sweet potato varieties for identifying K efficient variety and evaluation of their performance under *kharif*, *rabi* and summer seasons to assess seasonal changes in source-sink relation and productivity. Materials and methodology used for the study are described in this chapter.

3.1. Location, climate and soil

The experiment was conducted at Agronomy Farm, Department of Agronomy, College of Agriculture, Vellanikkara. The field is situated at 10° 54' N latitude and 76° 28' E longitude, at an altitude of 40 m above mean sea level, coming under Agro Ecological Unit (AEU) – 10 (Northern Central Laterites) of Kerala.

The data on weather parameters (maximum temperature, minimum temperature, relative humidity, total sunshine hours and rainfall) during the growing period are given in Appendix 1 and Fig.1, 2 and 3.

Sweet potato vines were planted on 12th July 2021 and harvested on November during *kharif* season (from 27th to 48th standard weeks). During this season, the maximum and minimum temperature range was 28.7 °C to 32.8 °C and 22.5 °C to 24.5 °C, respectively. Total sunshine hours and relative humidity range were 456.4 hours and 72-91 per cent, respectively. Total rainfall during cropping period was 2303.5 mm. The highest amount of rainfall recorded at 28th standard week (331.9 mm) followed by 42nd standard week (216.6 mm).

The soil of the experimental site was sandy clay loam with a pH of 4.82 and electrical conductivity of 0.083 dS/m. The physico-chemical properties of soil in *kharif* season and methods used for the estimation of available nutrients are given in Table 1.

In *rabi* season, sweet potato vines were planted on 27th October 2021 and harvested in the month of February [from 43rd standard week (October) to 8th standard week (February)]. During this season, the maximum and minimum temperature range was 30.3 °C to 35.3 °C and 21.3 °C to 24.9 °C, respectively. Total sunshine hours and relative humidity range were 853.8 hours and 53-88 per cent, respectively. Total rainfall during cropping period was 454.2 mm. The highest amount of rainfall was recorded at 46^{th} standard week (160.5 mm).

The soil of the experimental site was sandy clay loam with a pH of 4.6 and electrical conductivity of 0.12 dS/m. The physico-chemical properties of soil and methods used for the estimation of available nutrients are given in Table 2.

In summer season, sweet potato vines were planted on 17^{th} December 2021 and harvested during April-May, 2022 [from 51^{st} standard week (December) to 20^{th} standard week (May)]. During the experiment period, the maximum and minimum temperature range was 28 ^{o}C to 37.2 ^{o}C and 21.3 ^{o}C to 26 ^{o}C, respectively. Total sunshine hours and relative humidity range were 1081.8 hours and 41-91 per cent, respectively. Total rainfall during cropping period was 416.8 mm. The highest amount of rainfall recorded at 20^{th} standard week (148.3 mm).

The soil of the experimental site was sandy clay loam with a pH of 4.5 and electrical conductivity of 0.11 dS/m.

3.2. Experiment details

The experiment under *kharif* and *rabi* were laid out with 20 treatment combinations (Fig. 4 and Table 3) and these combinations included five varieties of sweet potato and four potassium levels in Factorial Randomized Block Design replicated thrice. The plot size was 4.5 m x 4.5 m and three vine cuttings were planted on mounds at a spacing of 75 cm x 75 cm. Varieties used were Bhu Krishna (V_1), Sree Arun (V_2), Sree Bhadra (V_3), Bhu Sona (V_4) and Kanjanghad Local (V_5). Four potassium levels studied were 0 (K_1), 50 (K_2), 75 (K_3) and 100 kg K_2O/ha (K_4). N and P_2O_5 were applied @ 75 kg/ha and 50 kg/ha (as per Package of Practices recommendations by Kerala Agricultural University) uniformly for all treatments. Half of the nitrogen dose and full P and K were applied as basal and remaining half N was applied at four weeks after planting.

In summer season, the experiment was laid out with five treatments which included five varieties of sweet potato. The design was Randomized Block Design replicated four times (Fig. 5). The plot size was 4.5 m x 4.5 m and three vine cuttings were planted on mounds at a spacing of 75 cm x 75 cm. Varieties used were Bhu Krishna (V_1), Sree Arun (V_2), Sree Bhadra (V_3), Bhu Sona (V_4) and Kanjanghad Local (V_5).

N, P_2O_5 and K_2O were applied @ 75 kg/ha, 50 kg/ha and 75 kg/ha (as per Package of Practices recommendations by Kerala Agricultural University) uniformly for all treatments. Half of the nitrogen dose and full P and K were applied as basal and remaining half N was applied at four weeks after planting. Farmyard manure @ 10 t/ha and lime @ 600 kg/ha, were applied basally at the time of land preparation.

Observations taken were similar to *kharif* and *rabi* seasons. Harvesting was done at different dates for different varieties, when the vines showed yellowing. Tubers were dug out carefully using spade. Field operations carried out in summer season are given in Plates 9 to 11.

3.3. Varietal description

Bhu Sona and Bhu Krishna are the varieties developed by the Regional centre, ICAR-CTCRI, Bhubaneswar, Odisha and are rich in ß-carotene (14.0 mg/100g) and anthocyanin (90.0 mg/100g), respectively. Sree Arun and Sree Bhadra are the varieties released from ICAR-CTCRI, Sreekaryam, Thiruvananthapuram, Kerala. Kanjanghad Local is a selection from local type grown in North Kerala released from Kerala Agricultural University which is having longer duration compared to other varieties. Photographs of the varieties are given in plates from 1 to 3. Varietal duration and average tuber yield are given in Table 4. Nutritional composition of the five varieties is given in Table 5.

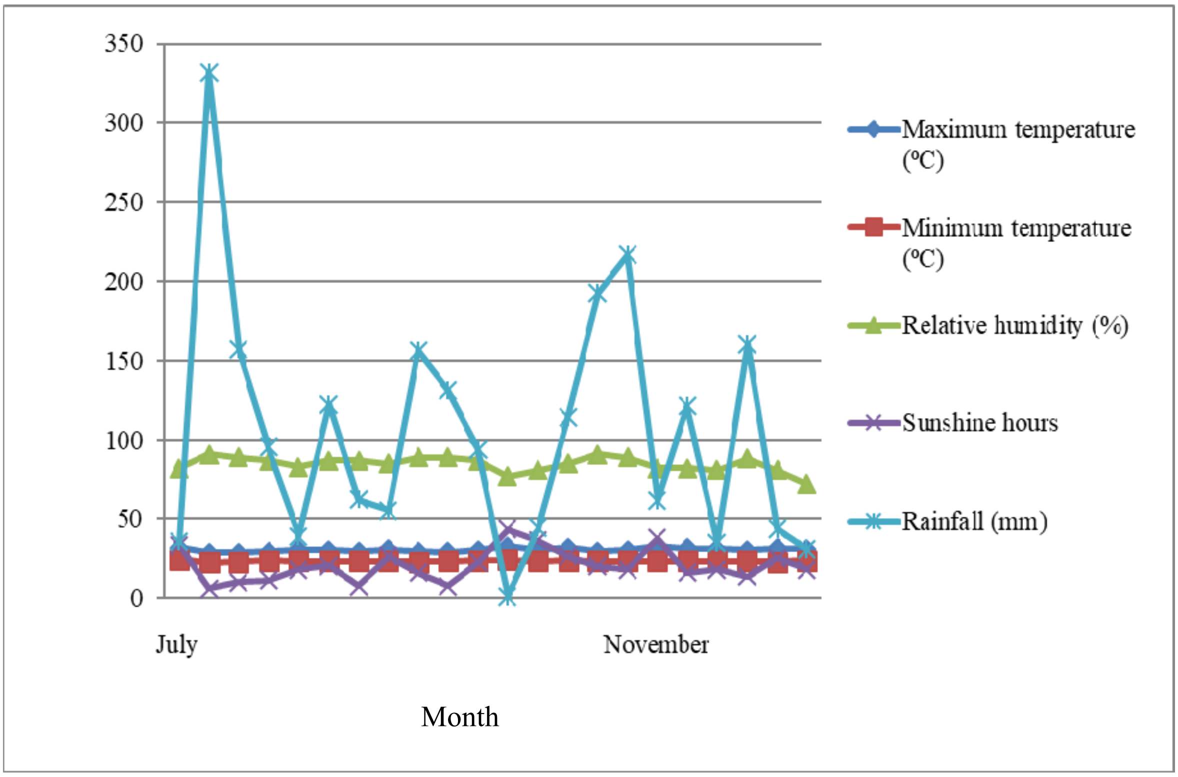


Fig.1. Weather data during *kharif* season (July to November, 2021)

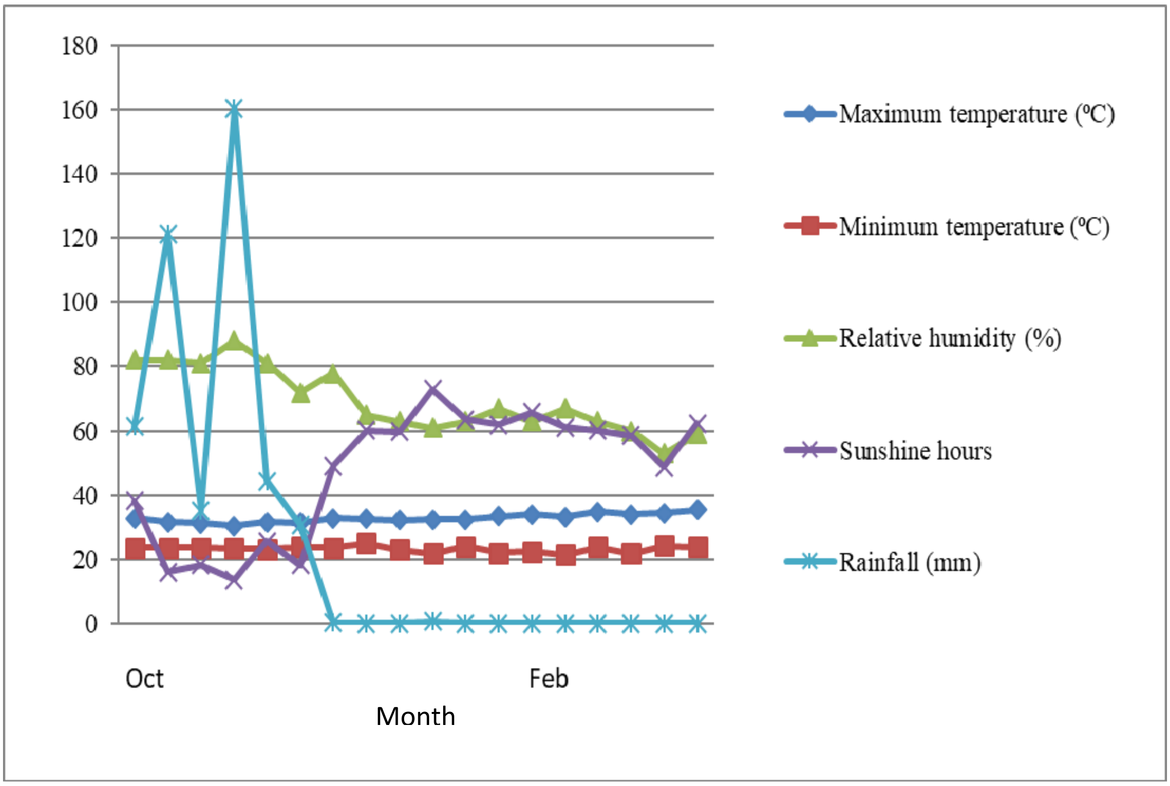


Fig. 2. Weather data during *rabi* season (October, 2021 to February, 2022)

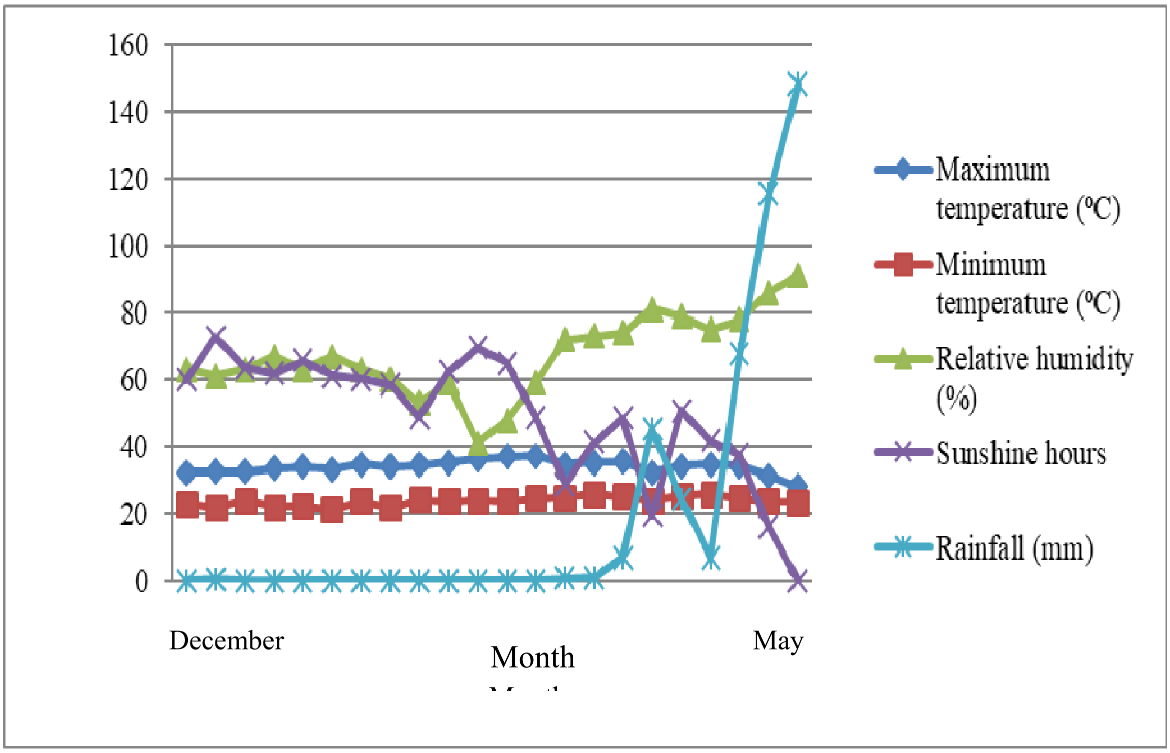


Fig. 3. Weather data during summer season (December, 2021 to May, 2022)

Table 1. Physico-chemical properties of soil before the experiment in *kharif* and summer seasons

Particulars	Value	Method used
1. Physical properties (Particle size composition - %)		
Coarse sand Fine sand Silt Clay	31.90 27.30 18.64 22.16	Robinson's international pipette method (Piper,1966)
2. Chemical properties		
pH	4.82	1:2.5 soil water ratio (Jackson,1958)
Electrical Conductivity (dS/m)	0.080	Electrical conductivity meter (Jackson, 1958)
Organic carbon (%)	1.45	Walkley and Black method (Jackson, 1958)
Available Nitrogen (kg/ha)	125 (low)	Alkaline permanganate method (Subbiah and Asija, 1956)
Available Phosphorus (kg/ha)	83 (high)	Ascorbic acid reduced molybdo phosphoric acid blue colour method (Bray and Kurtz,1945; Watanabe and Olsen,1965)
Available Potassium (kg/ha)	100 (low)	Neutral normal ammonium acetate extraction and estimation using flame photometry (Jackson, 1958)

Table 2. Physico-chemical properties of soil before the experiment in *rabi* season

Particulars	Value	Method used
1. Physical properties (Particle size composition - %)		
Coarse sand Fine sand Silt Clay	31.90 27.30 18.64 22.16	Robinson's international pipette method (Piper,1966)
2. Chemical properties		
pH	4.60	1:2.5 soil water ratio (Jackson,1958)
Electrical Conductivity (dS/m)	0.12	Electrical conductivity meter (Jackson, 1958)
Organic carbon (%)	1.48	Walkley and Black method (Jackson, 1958)
Available Nitrogen (kg/ha)	100 (low)	Alkaline permanganate method (Subbiah and Asija, 1956)
Available Phosphorus (kg/ha)	95 (high)	Ascorbic acid reduced molybdo phosphoric acid blue colour method (Bray and Kurtz,1945; Watanabe and Olsen,1965)
Available Potassium (kg/ha)	102.50 (low)	Neutral normal ammonium acetate extraction and estimation using flame photometry (Jackson, 1958)

Table 3. Details of the treatment combinations

Treatment combinations	Varieties & K_2O levels
V_1K_1	Bhu Krishna (without K_2O)
V_1K_2	Bhu Krishna at 50 kg K_2O/ha
V_1K_3	Bhu Krishna at 75 kg K_2O/ha
V_1K_4	Bhu Krishna at 100 kg K_2O/ha
V_2K_1	Sree Arun (without K_2O)
V_2K_2	Sree Arun at 50 kg K_2O/ha
V_2K_3	Sree Arun at 75 kg K_2O/ha
V_2K_4	Sree Arun at 100 kg K_2O/ha
V_3K_1	Sree Bhadra (without K_2O)
V_3K_2	Sree Bhadra at 50 kg K_2O/ha
V_3K_3	Sree Bhadra at 75 kg K_2O/ha
V_3K_4	Sree Bhadra at 100 kg K_2O/ha
V_4K_1	Bhu Sona (without K_2O)
V_4K_2	Bhu Sona at 50 kg K_2O/ha
V_4K_3	Bhu Sona at 75 kg K_2O/ha
V_4K_4	Bhu Sona at 100 kg K_2O/ha
V_5K_1	Kanjanghad Local (without K_2O)
V_5K_2	Kanjanghad Local at 50 kg K_2O/ha
V_5K_3	Kanjanghad Local at 75 kg K_2O/ha
V_5K_4	Kanjanghad Local at 100 kg K_2O/ha

Table 4. Duration and average yield of sweet potato varieties

Variety	Duration (days)	Average tuber yield (t/ha)
Bhu Krishna	110 days	16-18 t/ha
Sree Arun	90-100 days	20-28 t/ha
Sree Bhadra	90-105 days	20-27 t/ha
Bhu Sona	100-105 days	18-20 t/ha
Kanjanghad Local	105-120 days	10-12 t/ha

Table 5. Nutritional composition of sweet potato varieties

(As per analysis done at harvest stage of crop raised at Vellanikkara)

Composition	**Bhu Krishna**	**Sree Arun**	**Sree Bhadra**	**Bhu Sona**	**Kanjanghad Local**
ß-Carotene (mg/100g)	14.42	8.34	4.88	17.70	17.14
Ascorbic acid (mg/100g)	22.85	11.42	17.14	22.85	17.74
Crude protein (%)	8.50	7.80	8.60	10.00	7.30
Crude fibre (%)	3.87	12.00	10.47	7.50	13.50
Total sugar (%)	6.28	6.50	5.00	4.45	3.00
Starch (%)	19.50	30.00	20.00	20.00	30.00
Iron (ppm)	4.33	2.97	2.18	1.99	2.04
Manganese (ppm)	0.24	0.45	0.31	0.28	0.15
Copper (ppm)	0.08	0.12	0.18	0.17	0.10
Calcium (ppm)	260.19	290.38	140.72	240.16	80.12
Magnesium (ppm)	155.06	150.65	120.44	135.58	60.66

3.4. Cultivation practices

a. Field preparation

The selected experimental field was disc ploughed and leveled with a cultivator. Stubbles and weeds were removed and experiment was laid out. The plot size was 4.5 m x 4.5 m and three vine cuttings were planted on mounds at a spacing of 75 cm x 75 cm. Bunds were made around the plots and channels were given for drainage.

b. Application of lime, manures and fertilizers

Farmyard manure was applied basally @ 10 t/ha as per the ‘Package of Practices Recommendations-Crops’ of the Kerala Agricultural University (KAU, 2016) and incorporated into each mound. Lime @ 600 kg/ha was also applied basally at the time of land preparation. Diammonium phosphate (18 per cent N and 46 per cent P_2O_5), Urea (46 per cent N) and Muriate of potash (60 per cent K_2O) were used as the sources of nitrogen (N), phosphorus (P) and potassium (K). Half of the nitrogen dose and full P and K were applied as basal and remaining half N was applied at four weeks after planting.

N

R-III	V_2K_1	V_1K_3	V_2K_4	V_3K_3	V_4K_2
	V_1K_4	V_5K_4	V_4K_3	V_1K_2	V_3K_4
	V_5K_1	V_4K_1	V_3K_1	V_2K_3	V_5K_3
	V_3K_2	V_4K_4	V_5K_2	V_1K_1	V_2K_2

R-II	V_2K_3	V_1K_2	V_3K_1	V_4K_4	V_5K_1
	V_4K_2	V_5K_3	V_2K_4	V_3K_3	V_1K_4
	V_2K_1	V_3K_4	V_1K_3	V_5K_4	V_4K_1
	V_3K_2	V_4K_3	V_5K_2	V_1K_1	V_2K_2

R-I	V_2K_4	V_1K_3	V_2K_1	V_4K_3	V_5K_1
	V_4K_1	V_2K_2	V_5K_3	V_3K_1	V_4K_4
	V_3K_2	V_5K_4	V_1K_2	V_5K_2	V_3K_3
	V_1K_4	V_4K_2	V_3K_4	V_2K_3	V_1K_1

Fig. 4. Lay out of the experiment in *kharif* and *rabi* season

R – IV	**V_2**	**V_5**	**V_4**	**V_3**	**V_1**
R – III	**V_3**	**V_1**	**V_2**	**V_5**	**V_4**
R – II	**V_5**	**V_4**	**V_1**	**V_2**	**V_3**
R - I	**V_1**	**V_2**	**V_3**	**V_4**	**V_5**

Fig. 5. Layout of summer season

c. Planting

Planting was done on 12th July (*kharif*), 27th October 2021 (*rabi*) and 17th December 2021 (summer). Vine cuttings of 15-20 cm length were prepared and three vine cuttings were planted per mound. Gap filling was done two weeks after planting to maintain optimum plant population.

d. Weeding and earthing up

Manual weedings were done at 30 and 60 days after planting and earthing up was done to facilitate tuber formation.

e. Irrigation

Rainfall was the main source of water during *kharif* season and as there was continuous rainfall during the season, irrigation was not provided. But, in *rabi* and summer season, intermittent irrigation was given for the crop during establishment and vegetative growth period.

f. Plant protection

Some minor pests were found and no major incidence of sweet potato weevil. The crop was free from diseases. Deficiency symptoms were noticed and given in Plate 12.

g. Harvesting

Harvesting was done at different dates for different varieties, when the vines showed yellowing. Tubers were dug out carefully using spade.

Field operations carried out during *kharif*, *rabi* and summer seasons are given in Plates 4 to 11.

3.5. Observations

Observations on biometric parameters, chlorophyll content, yield parameters and yield of sweet potato were recorded and the mean values were calculated.

Sampling process

For taking observations on growth and yield, five plants were selected at random and tagged from each plot omitting border rows. For measuring dry matter production and plant analysis, destructive sampling was done.

1. Growth observations

a) Vine length

Measured from the base to the tip of longest branch of plant at 20 days interval

b) Number of branches per vine

Recorded the total number of branches of plant from the base to tip at each observation at 20 days interval

c) Leaf area index (LAI)

Sample plants were uprooted at 20 days interval. Then, total number of leaves per plant was counted and length and width of representative leaves were measured. Leaf area was estimated using graph method.

Leaf area of Kanjanghad Local = average leaf length x average breadth x 0.4 x total number of leaves per plant

Leaf area of other varieties = average leaf length x average breadth x 0.45 x total number of leaves per plant

Leaf area index (Watson, 1937) was calculated by ratio of leaf area (cm^2) to land area (cm^2)

d) Herbage yield

Fresh weight of vines (kg/ha) was taken at harvest. Plants were carefully uprooted and roots were removed to obtain weight of fresh vines at harvest.

e) Dry matter production

Dry matter accumulation per vine (g/plant) was recorded at 20 days interval and at harvest by destructive sampling of random plants. These plants were carefully uprooted without causing damage to roots and stem. Then plants were dried under shade and then oven dried at 70±5 °C till constant weights obtained. Shoot, root and tuber dry matter were weighed at above mentioned intervals. Total dry matter was obtained by adding shoot, root and tuber dry matter. Total dry matter was multiplied with plant population to get dry matter production per ha (t/ha).

2. Leaf chlorophyll content

Leaf samples were collected at 60 DAP and chlorophyll was estimated by DMSO method (Dimethyl sulfoxide) and expressed as mg/g fresh weight (Hiscox and Israelstam, 1979).

$$\text{Chlorophyll a} = [(12.7 \times A_{663})-(2.69 \times A_{645})] \times \frac{V}{1000 \times w}$$

$$\text{Chlorophyll b} = [(22.9 \times A_{645})-(4.68 \times A_{663})] \times \frac{V}{1000 \times w}$$

$$\text{Total chlorophyll} = [(8.02 \times A_{663}) + (20.2 \times A_{645})] \times \frac{V}{1000 \times w}$$

Where,

A = Absorbance at specific wave length (nm)

V = Volume of the sample (ml)

w = Fresh weight of the sample (g)

3. Yield and yield attributes

a. Total number of tubers per plant

Total number of tubers of selected plants from each plot were counted and averaged to get number of tubers per plant.

b. Average weight of tuber (g)

Weight of single tuber from all the selected tubers was taken and averaged to get weight of tuber (g).

c. Tuber yield

Total weight of tubers from each plant was recorded (g/plant) and yield was expressed as t/ha.

d. Weight of unmarketable tuber

Weevil infested, under sized and tubers with cracks from each plant were collected and weighed (g/plant)

e. Marketable tuber yield

Well developed tubers from each plant (> 100 g) were collected and weighed and expressed as t/ha.

f. Harvest Index

Shoot and underground parts of sweet potato were weighed separately at harvest for calculating harvest index (Donald, 1962). It is the ratio of economic yield to biological yield.

g. Incidence of pests and diseases

Incidence of pests and diseases during crop period was monitored and timely control measures were adopted.

4. Quality parameters of tuber

After harvest, tuber samples were analyzed for crude fibre, crude protein, reducing, non reducing and total sugars, starch and moisture content (Table 6). Moisture content can be estimated by subtracting dry weight of tuber from fresh weight and then divided by fresh weight, multiplied by 100.

Table 6. Methods used for analysing quality of tuber

Parameters	Methods used	Reference
Crude fibre	Muslin cloth method	Maynard (1970)
Crude protein	Modified micro Kjeldhal method	Jackson, 1958
Reducing, non reducing and total sugar	Lane and Eynon method	Lane and Eynon (1934)
Starch	Anthrone method	Hodge and Hofreiter (1962)

5. Plant analysis

The content of primary nutrients of index leaf at active growth phase (60 DAP) and of whole plant (shoot and tuber) at harvest were analysed. Index leaf is the lamina of the 7^{th} to 9^{th} youngest leaf from the tip of vine. The collected samples were dried to constant weight in an electric hot air oven at 70±5 °C, ground into fine powder and used for analysing nitrogen, phosphorus and potassium as per procedure mentioned in Table 7. Uptake of nutrients was also calculated at harvest stage by multiplying dry matter production and nutrient content in percentage and denoted as kg/ha.

6. Soil analysis

Soil samples were analysed at 60 DAP and at harvest. At 60 DAP, soil was analysed for available nitrogen, phosphorus and potassium. But at harvest stage, it was also analysed for pH, electrical conductivity, organic carbon along with available nitrogen, phosphorus and potassium as per standard procedures mentioned in Table 1 and 2.

Table 7. Methods used for plant analysis

Nutrient	Method used	Reference
N	Modified micro Kjeldahl method	Jackson, 1958
P	Vanado-molybdo phosphoric yellow colour method	Piper, 1966
K	Flame photometry	Piper, 1966

7. Potassium use efficiency

a. Utilization efficiency

In order to find out the K efficient variety of sweet potato, potassium utilization efficiency of different varieties was calculated. Nutrient utilization efficiency is the fraction of nutrients present in the plant that is used to produce the desired biomass or yield.

$$\text{Potassium utilization efficiency (KUE)} - \frac{\text{Tuber yield}}{\text{Total K uptake}}$$

b. Physiological efficiency

It is the additional biological yield produced due to application of nutrients over unfertilized control per unit of additional nutrient uptake over unfertilized control. It is expressed in kg/kg.

$$\text{Physiological efficiency (PE)} - \frac{BY_n - BY_0}{NU_n - NU_0}$$

Where,

BY_n= Biological yield with nutrients

BY_0= Biological yield without nutrients

NU_n= Nutrient uptake with nutrients

NU_0= Nutrient uptake without nutrients

c. Nutrient efficiency ratio

It is the total biomass produced per unit of nutrient uptake. It is expressed in kg/kg.

$$\text{Nutrient efficiency ratio (NER)} = \frac{\text{Biological yield}}{\text{Nutrient uptake}}$$

d. Nutrient harvest index (NHI)

$$\text{Nutrient harvest index (NHI)} - \frac{\text{Nutrient uptake by tuber}}{\text{Total nutrient uptake}}$$

8. Root – Shoot ratio

Removed the plants from soil and washed off the soil. Dried the plants and separated roots from the top. Separately weighed and recorded the root and shoot portion for each plant.

$$\text{Root/shoot ratio} = \frac{\text{Dry weight of roots}}{\text{Dry weight of shoot}}$$

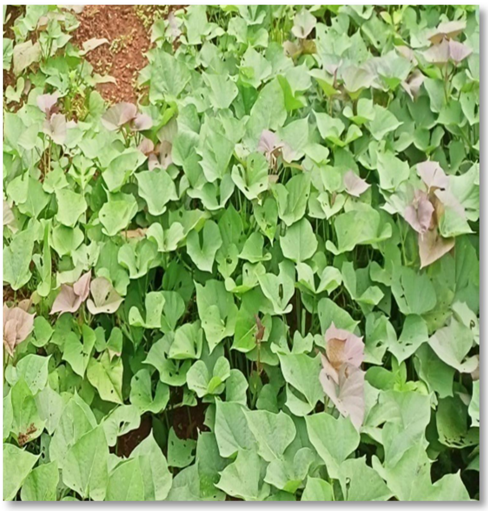
3. 6. Cost-Benefit Analysis

Cost of cultivation was calculated based on the expenditure incurred. For working out the gross income, the market price of sweet potato was considered. Net income was calculated by subtracting cost of cultivation from gross income (expressed as ₹/ha). Benefit cost ratio was calculated as the ratio of total cash benefit to the total cash cost.

3.7. Statistical Analysis

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).

Bhu Krishna



Sree Arun

Sree Bhadra

Bhu Sona

Kanjanghad Local

Plate 1. Leaf morphology of sweet potato varieties

Bhu Krishna

Sree Arun

Sree Bhadra

Bhu Sona

Kanjanghad Local

Plate 2. Tubers of sweet potato varieties

Bhu Krishna **Sree Arun**

Sree Bhadra

Bhu Sona **Kanjanghad Local**

Plate 3. Tuber cross section

Plate 4. Various field operations in *kharif* season

Plate 5. General view of experimental plot at harvest in *kharif* season

Plate 6. Various field operations in *rabi* season

Plate 7. General view of the field at 60 DAP and at harvest in *rabi* season

Plate 8. Field visit by advisory committee in *rabi* season

Plate 9. General view of the field at 60 DAP and at harvest in summer season

Plate 10. Harvesting of sweet potato tubers in summer season

Plate 11. Field visit by advisory committee (summer crop)

Bhu Sona

Bhu Krishna

Kanjanghad Local

Plate 12. Nutrient deficiency symptoms observed during the crop period

Results

4. RESULTS

The research work entitled "Potassium utilization efficiency and seasonal response in photosynthates partitioning of high yielding sweet potato varieties" was conducted at College of Agriculture, Vellanikkara. Study consisted of three experiments and the results obtained from each experiment are presented below.

A critical analysis of yield data of the five varieties over *kharif*, *rabi* and summer seasons showed that the performance of all the varieties were good in *rabi*. This indicated the photosensitive nature of crop. The deviation from this general behaviour was observed in variety Bhu Sona, which gave good tuber yield in *kharif* as well as in *rabi*. And one of the objectives of the present study was assessment of seasonal response. Due to the wide variation in varietal performance in *kharif* and *rabi*, it was found that the pooling of data generated with respect to potassium nutrition will lead to erroneous results. Hence, the results of Experiment I and II are presented separately.

4.1 Experiment I and II: Identification of K efficient sweet potato variety in response to different doses of potassium under *kharif* and *rabi* seasons

4.1.1 Growth parameters of sweet potato in *kharif* season

a) Vine length

Vine length was measured at 20, 40, 60, 80 days after planting (DAP) and at harvest. It differed significantly among varieties and also with varied potassium levels (Table 8).

At 20 DAP, Bhu Krishna (V_1) as well as Bhu Sona (V_4) recorded significantly higher vine length (62.40 cm and 60.07 cm, respectively) which were statistically comparable. Kanjanghad Local (V_5) recorded the lowest vine length of 29.71 cm. At later growth stages and at harvest stage, significantly higher vine length was observed for the variety Bhu Sona (171.62 cm 249.55 cm, 311.99 and 330.45 cm, respectively), followed by Bhu Krishna (149.75 cm, 217.38 cm, 260.58 cm and 308.75 cm, respectively). Variety Kanjanghad Local and variety Sree Bhadra recorded significantly lower vine length.

Potassium application @ 50, 75 and 100 kg/ha resulted in higher and comparable vine length at 20 DAP (average - 46.86 cm) compared to no potassium (43.52 cm).Among these doses, 75kg/ha was best (47.76 cm). Potassium application @ 50, 75 and 100 kg/ha resulted in significantly higher vine length at 40 DAP (124.52 cm, 123.96 cm and 123.37 cm, respectively) compared to no potassium (113.41 cm) and vine length at 50 kg/ha was best. While, at 60, 80 DAP and at harvest, significantly higher vine length was observed for potassium @ 75 kg/ha which was on par with potassium application @ 50 kg/ha. There was no significant interaction effect between varieties and potassium levels.

b) Number of branches

Number of branches differed significantly among varieties. However no significant difference was observed for varied K levels (Table 9).

At 20 DAP, variety Bhu Krishna (5.58), variety Kanjanghad Local (4.92) and variety Bhu Sona (4.83) recorded comparable and higher number of branches per plant. Significantly lower number of branches was registered by variety Sree Bhadra (2.50).

As the growth progressed, significantly higher number of branches was observed for the variety Kanjanghad Local compared to other varieties. Number of branches of all other varieties was on par with each other. Effect of various potassium doses on number of branches was also non significant at different growth stages. Interaction effect was also non significant.

c) Leaf Area Index (LAI)

Data on Leaf Area Index at different growth stages of the crop is presented in Table 10.

At 20 DAP, all varieties except Sree Bhadra recorded significantly higher LAI which were at par. But by 40 DAP, significantly higher LAI values were observed for variety Kanjanghad Local (1.12) and Bhu Sona (1.03) which were statistically at par. The lowest LAI was recorded for variety Bhu Krishna (0.59). At 60 and 80 DAP and at harvest, significantly higher LAI was registered for the variety Kanjanghad Local. Significantly lower LAI recorded by variety Bhu Krishna.

Table 8 Vine length of sweet potato varieties as influenced by K nutrition

Treatments	Vine length (cm)				
	20 DAP	40 DAP	60 DAP	80 DAP	At harvest
Variety (V)					
V_1 – Bhu Krishna	62.40	149.75	217.38	260.58	308.75
V_2 – Sree Arun	43.35	108.20	149.12	203.18	229.99
V_3 – Sree Bhadra	34.63	85.24	131.52	181.35	211.11
V_4 – Bhu Sona	60.07	171.62	249.55	311.99	330.45
V_5 – Kanjanghad local	29.71	91.75	123.72	162.70	196.87
SEm (±)	0.93	3.25	3.92	4.77	6.15
CD (0.05)	2.66	9.31	11.22	13.67	17.63
K levels (K)					
K_1- 0 kg/ha	43.52	113.41	162.18	209.91	239.33
K_2 – 50 kg/ha	46.21	124.52	181.83	231.86	263.94
K_3 – 75 kg/ha	47.76	123.96	182.36	235.65	269.96
K_4 – 100 kg/ha	46.63	123.37	170.66	218.42	248.51
SEm (±)	0.83	2.91	3.50	4.27	5.51
CD (0.05)	2.37	8.33	10.03	12.23	15.77
V x K interaction was non significant					

Table 9 Number of branches of sweet potato varieties as influenced by K nutrition

Treatments	Number of branches				
	20 DAP	40 DAP	60 DAP	80 DAP	At harvest
Variety (V)					
V_1 – Bhu Krishna	5.58	7.08	7.33	8.08	8.92
V_2 – Sree Arun	4.00	6.58	7.00	7.83	8.50
V_3 – Sree Bhadra	2.50	6.00	7.00	7.92	8.42
V_4 – Bhu Sona	4.83	7.08	7.75	9.50	10.33
V_5 – Kanjanghad local	4.92	9.08	9.75	12.08	12.75
SEm (±)	0.31	0.36	0.32	0.47	0.40
CD (0.05)	0.89	1.04	0.91	1.36	1.13
K levels (K)					
K_1- 0 kg/ha	4.06	7.07	7.60	9.27	9.80
K_2 – 50 kg/ha	4.00	7.07	7.86	8.80	9.33
K_3 – 75 kg/ha	4.60	7.66	7.73	8.93	9.93
K_4 – 100 kg/ha	4.80	6.86	7.86	9.33	10.07
SEm (±)	0.28	0.32	0.28	0.42	0.35
CD (0.05)	NS	NS	NS	NS	NS
V x K interaction was non significant					

At potassium application @ 75 kg/ha resulted in higher LAI (0.37) compared to other doses at 20 DAP. There was no interaction between varieties and potassium levels with respect to LAI at 20 and 40 DAP. Significantly higher LAI was registered at potassium applied @ 50 and 75 kg/ha (0.98 and 1.04, respectively) compared to no potassium application (0.73) at 40 DAP. Maximum LAI recorded at 75 kg/ha potassium level (1.99) which was significantly higher than other potassium rates and interaction effect of varieties and potassium levels on LAI was significant at 60 DAP. Significantly higher LAI registered for variety Kanjanghad Local with 75 kg/ha potassium dose (3.46), followed by Kanjanghad Local applied with 50 and 100 kg/ha potassium (2.96 and 2.91, respectively).

At 80 DAP and at harvest stage also, significantly higher LAI registered for potassium applied @ 75 kg/ha (2.46 and 2.63, respectively), which was followed by 100 kg/ha potassium level (2.33 and 2.45, respectively). Significant interaction effect was noticed at 80 DAP and at harvest. Significantly higher LAI was registered for variety Kanjanghad Local with 75 kg/ha potassium dose (4.15 and 4.30, respectively). The lowest LAI was for variety Bhu Krishna when no potassium was supplied (1.42 and 1.61, respectively), which was comparable with variety Bhu Krishna with 50 kg potassium (1.47 and 1.68, respectively).

d) Leaf chlorophyll content at 60 DAP

Significant variation was observed for chlorophyll a, b and total chlorophyll content among sweet potato varieties and with potassium doses (Table 11).

Variety Sree Bhadra had significantly higher chlorophyll a (1.11 mg/g fresh weight), chlorophyll b (0.39 mg/g fresh weight) and total chlorophyll content (1.50 mg/g fresh weight) compared to all other varieties. Other varieties had comparable values of chlorophyll content, with an average value of 1.10 mg/g.

Potassium applied @ 50 and 75 kg/ha resulted in significantly higher and comparable chlorophyll a (0.99 mg/g and 1.01 mg/g fresh weight, respectively), chlorophyll b (0.37 mg/g and 0.34 mg/g fresh weight, respectively) and total chlorophyll content (1.35 mg/g and 1.33 mg/g fresh weight, respectively). There was significant interaction between varieties and K levels for chlorophyll a and total chlorophyll content. Significantly higher chlorophyll a (1.29 mg/g, 1.27 mg/g and 1.07 mg/g fresh weight, respectively) and total chlorophyll (1.72 mg/g, 1.71 mg/g and 1.49 mg/g fresh weight, respectively) was for variety Sree Bhadra at all K levels (50, 75 and 100 kg/ha). The lowest chlorophyll a and total chlorophyll content were observed for variety Bhu Krishna (0.48 mg/g and 0.67 mg/g, respectively) and variety Bhu Sona (0.51 mg/g and 0.69 mg/g, respectively) when no potassium fertilizers were applied.

e) Dry matter production at different growth stages

Significant variation was noticed among varieties and potassium levels in terms of dry matter production (Table 12). At 20 DAP, variety Sree Arun registered significantly higher dry matter production of aerial parts (shoot) (9.00 g/plant) compared to other varieties and this variety continued to register higher values even at 80 DAP. The least dry matter was observed for variety Bhu Krishna at all stages of growth. At 40 DAP, significantly higher dry matter produced by variety Sree Arun (62.71 g/plant), which was on par with variety Sree Bhadra (59.50 g/plant). Varieties Sree Arun, Sree Bhadra, Bhu Sona and Kanjanghad Local produced comparable dry matter at 60 DAP (111.21 g/plant, 102.62 g/plant, 111.50 g/plant and 107.75 g/plant, respectively). At 80 DAP, variety Bhu Sona produced significantly higher dry matter (216.50 g/plant), followed by variety Sree Arun (194.62 g/plant).

In general, application of varied doses of potassium (50, 75 and 100 kg/ha) resulted in significantly higher dry matter production over no K at all stages of growth. At 40 DAP, potassium applied @ 75 and 100 kg/ha recorded significantly higher dry matter (59.53 g/plant and 59.40 g/plant, respectively). At 60 and 80 DAP, similar trend was noticed as that at 20 and 40 DAP with respect to K levels. Dry matter production increased with increase in potassium doses.

Interaction effect between varieties and K levels was non significant at all stages of growth.

Table 10 Leaf Area Index of sweet potato varieties as influenced by K nutrition

Treatments	Leaf Area Index				
	20 DAP	40 DAP	60 DAP	80 DAP	At harvest
Variety (V)					
V_1 – Bhu Krishna	0.34	0.59	0.97	1.53	1.71
V_2 – Sree Arun	0.32	0.81	1.44	1.94	2.09
V_3 – Sree Bhadra	0.22	0.98	1.63	2.02	2.18
V_4 – Bhu Sona	0.35	1.03	1.65	2.07	2.13
V_5 – Kanjanghad local	0.30	1.12	2.87	3.62	3.82
SEm (±)	0.02	0.04	0.05	0.04	0.03
CD (0.05)	0.06	0.12	0.16	0.12	0.10
K levels (K)					
K_1- 0 kg/ha	0.27	0.73	1.38	1.93	2.09
K_2 – 50 kg/ha	0.30	0.98	1.79	2.23	2.36
K_3 – 75 kg/ha	0.37	1.04	1.99	2.46	2.63
K_4 – 100 kg/ha	0.29	0.86	1.68	2.33	2.45
SEm (±)	0.02	0.04	0.05	0.04	0.03
CD (0.05)	0.05	0.11	0.14	0.11	0.09
Interaction (V x K)					
V_1K_1	0.31	0.52	0.74	1.42	1.61
V_1K_2	0.32	0.62	1.01	1.47	1.68
V_1K_3	0.40	0.63	1.08	1.55	1.80
V_1K_4	0.30	0.57	1.03	1.69	1.74
V_2K_1	0.28	0.64	1.04	1.60	1.67
V_2K_2	0.31	0.97	1.56	1.93	2.07
V_2K_3	0.41	0.95	1.65	2.23	2.44
V_2K_4	0.28	0.67	1.48	2.01	2.17
V_3K_1	0.17	0.78	1.39	1.87	2.09
V_3K_2	0.17	1.02	1.68	2.04	2.13
V_3K_3	0.29	1.09	1.93	2.20	2.34
V_3K_4	0.22	1.02	1.53	1.98	2.14
V_4K_1	0.29	0.69	1.56	1.93	1.96
V_4K_2	0.36	1.11	1.74	2.13	2.17
V_4K_3	0.40	1.28	1.84	2.17	2.29
V_4K_4	0.32	1.01	1.46	2.04	2.12
V_5K_1	0.27	1.01	2.15	2.83	3.13
V_5K_2	0.31	1.17	2.96	3.58	3.74
V_5K_3	0.32	1.24	3.46	4.15	4.30
V_5K_4	0.30	1.03	2.91	3.92	4.10
SEm (±)	0.04	0.08	0.11	0.08	0.07
CD (0.05)	NS	NS	0.33	0.25	0.21

Table 11 Chlorophyll a, b and total chlorophyll content of sweet potato varieties at 60 DAP as influenced by K nutrition

Treatments	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Total chlorophyll (mg/g)
Variety (V)			
V_1 – Bhu Krishna	0.80	0.28	1.08
V_2 – Sree Arun	0.84	0.27	1.09
V_3 – Sree Bhadra	1.11	0.39	1.50
V_4 – Bhu Sona	0.81	0.31	1.12
V_5 – Kanjanghad local	0.82	0.29	1.11
SEm (±)	0.04	0.02	0.06
CD (0.05)	0.12	0.06	0.17
K levels (K)			
K_1- 0 kg/ha	0.66	0.23	0.88
K_2 – 50 kg/ha	0.99	0.37	1.35
K_3 – 75 kg/ha	1.01	0.34	1.33
K_4 – 100 kg/ha	0.85	0.29	1.14
SEm (±)	0.04	0.02	0.05
CD (0.05)	0.10	0.06	0.15
Interaction (V x K)			
V_1K_1	0.48	0.18	0.67
V_1K_2	0.79	0.28	1.07
V_1K_3	1.06	0.41	1.48
V_1K_4	0.86	0.22	1.09
V_2K_1	0.85	0.28	1.14
V_2K_2	0.89	0.32	1.16
V_2K_3	0.87	0.22	1.09
V_2K_4	0.74	0.24	0.98
V_3K_1	0.81	0.27	1.08
V_3K_2	1.29	0.42	1.72
V_3K_3	1.27	0.44	1.71
V_3K_4	1.07	0.42	1.49
V_4K_1	0.51	0.21	0.69
V_4K_2	1.05	0.45	1.50
V_4K_3	0.97	0.33	1.31
V_4K_4	0.71	0.25	0.96
V_5K_1	0.62	0.22	0.83
V_5K_2	0.95	0.35	1.30
V_5K_3	0.84	0.27	1.07
V_5K_4	0.86	0.32	1.18
SEm (±)	0.08	0.05	0.12
CD (0.05)	0.23	NS	0.34

Table 12 Dry matter production of sweet potato varieties as influenced by K nutrition

Treatments	Dry matter production (g/plant)			
	20 DAP	40 DAP	60 DAP	80 DAP
Variety (V)				
V_1 – Bhu Krishna	5.79	47.04	76.29	157.87
V_2 – Sree Arun	9.00	62.71	111.21	194.62
V_3 – Sree Bhadra	7.50	59.50	102.62	164.91
V_4 – Bhu Sona	7.27	55.50	111.50	216.50
V_5 – Kanjanghad local	6.93	50.42	107.75	172.25
SEm (±)	0.37	2.45	5.49	6.78
CD (0.05)	1.06	7.03	15.72	19.43
K levels (K)				
K_1- 0 kg/ha	6.16	48.26	88.00	166.03
K_2 – 50 kg/ha	7.43	52.93	103.60	184.63
K_3 – 75 kg/ha	7.73	59.53	108.80	193.60
K_4 – 100 kg/ha	7.86	59.40	107.10	180.66
SEm (±)	0.33	2.19	4.91	6.07
CD (0.05)	0.95	6.29	14.05	17.38
V x K interaction was non significant				

f) Dry matter production of shoot and tuber at harvest

Data on dry matter production of shoot and tuber varied significantly among varieties and K levels (Table 13). Significantly higher shoot dry matter production was observed for variety Sree Arun (253.75 g/plant) whereas variety Bhu Sona (102.91 g/plant) was superior with respect to tuber dry matter production. Shoot dry matter was significantly lower for variety Bhu Sona (130.45 g/plant). All varieties except Bhu Sona registered statistically comparable values of tuber dry matter.

Shoot dry matter was higher and comparable at all K levels except at no potassium application. Significantly higher and comparable tuber dry matter production was recorded for 50 kg and 75 kg potassium levels (62.59 g/plant and 54.86 g/plant, respectively). There was no significant interaction effect with respect to shoot dry matter production and K nutrition. However with respect to tuber dry matter production, significantly higher value was noticed for variety Bhu Sona at no potassium (124.36 g/plant), followed by 50, 75 and 100 kg potassium.

g) Total dry matter production at harvest

Total dry matter production also significantly differed with varieties and potassium levels (Table 13). Variety Sree Arun registered significantly higher total dry matter (296.35 g/plant and 11.85 t/ha), followed by variety Kanjanghad Local (270.51 g/plant and 10.82 t/ha) and variety Sree Bhadra (249.64 g/plant and 9.98 t/ha). Application of varied levels of K resulted in significantly higher and comparable total dry matter compared to no potassium.

h) Fresh herbage yield at harvest

Significant difference was observed for fresh herbage yield also (Table 14). Variety Sree Arun was superior with the highest fresh herbage yield of 31821 kg/ha. This was followed by Kanjanghad Local (27555 kg/ha) and Sree Bhadra (26879 kg/ha) which were comparable statistically. Significantly lower herbage yield recorded for variety Bhu Sona (13718 kg/ha).

Comparing different potassium levels, all K doses (50, 75 and 100 kg/ha) except no potassium application resulted in significantly higher fresh herbage yield (25407 kg/ha, 26576 kg/ha and 25180 kg/ha, respectively). There was no significant interaction effect.

i) Root-shoot ratio

There was no significant difference in root-shoot ratio during *kharif* season among varieties and with varied levels of K fertilizer application (Table 14).

Table 13 Shoot, tuber and total dry matter production of sweet potato varieties at harvest as influenced by K nutrition

Treatments	Dry matter production (g/plant)			Total dry matter (t/ha)
	Shoot	Tuber	Total	
Variety (V)				
V_1 – Bhu Krishna	179.16	44.04	223.21	8.93
V_2 – Sree Arun	253.75	42.60	296.35	11.85
V_3 – Sree Bhadra	206.33	43.31	249.64	9.98
V_4 – Bhu Sona	130.45	102.91	233.37	9.33
V_5 – Kanjanghad local	227.75	42.76	270.51	10.82
SEm (±)	7.37	3.25	8.38	0.33
CD (0.05)	21.12	9.31	24.01	0.96
K levels (K)				
K_1- 0 kg/ha	173.33	49.23	222.56	8.90
K_2 – 50 kg/ha	209.25	62.59	271.84	10.87
K_3 – 75 kg/ha	214.20	54.86	269.06	10.76
K_4 – 100 kg/ha	201.18	53.82	255.00	10.20
SEm (±)	6.59	2.91	7.50	0.30
CD (0.05)	18.88	8.32	21.47	0.86
Interaction (V x K)				
V_1K_1	142.33	29.13	171.46	6.85
V_1K_2	185.33	58.03	243.36	9.73
V_1K_3	218.50	47.16	265.66	10.62
V_1K_4	170.50	41.85	212.35	8.49
V_2K_1	219.00	29.59	248.59	9.94
V_2K_2	260.66	55.15	315.82	12.63
V_2K_3	272.33	44.34	316.68	12.66
V_2K_4	263.00	41.31	304.31	12.17
V_3K_1	182.33	29.29	211.63	8.46
V_3K_2	213.08	41.16	254.25	10.17
V_3K_3	208.83	50.82	259.65	10.38
V_3K_4	221.08	51.96	273.05	10.92
V_4K_1	107.33	124.36	231.70	9.26
V_4K_2	132.33	101.07	233.40	9.33
V_4K_3	144.83	88.62	233.45	9.34
V_4K_4	137.33	97.60	234.93	9.39
V_5K_1	215.66	33.74	249.40	9.97
V_5K_2	254.83	57.57	312.40	12.49
V_5K_3	226.50	43.37	269.87	10.79
V_5K_4	214.00	36.36	250.36	10.01
SEm (±)	14.75	6.50	16.76	0.67
CD (0.05)	NS	18.61	NS	NS

Table 14 Fresh herbage yield at harvest and root- shoot ratio of sweet potato varieties as influenced by K nutrition

Treatments	Fresh herbage yield (kg/ha)	Root-shoot ratio at 60 DAP
Variety (V)		
V_1 – Bhu Krishna	21250	0.083
V_2 – Sree Arun	31821	0.078
V_3 – Sree Bhadra	26879	0.081
V_4 – Bhu Sona	13718	0.075
V_5 – Kanjanghad local	27555	0.099
SEm (±)	1226	0.009
CD (0.05)	3510	NS
K levels (K)		
K_1- 0 kg/ha	19815	0.081
K_2 – 50 kg/ha	25407	0.077
K_3 – 75 kg/ha	26576	0.083
K_4 – 100 kg/ha	25180	0.093
SEm (±)	1096	0.008
CD (0.05)	3139	NS
V x K interaction was non significant		

4.1.2 Yield and yield parameters

Data on yield parameters are furnished in Table 15.

a) Number of tubers per plant

Varieties differed in number of tubers produced. Significantly higher number of tubers per plant was observed in variety Bhu Krishna (3.17). This was followed by varieties Bhu Sona (2.17) and Kanjanghad Local (1.67) which were comparable. Sree Arun (1.33) and Sree Bhadra (1.42) were inferior to other varieties.

No significant difference could be noticed between potassium levels. Interaction effect of varieties and potassium levels was also not significant.

b) Average weight of tuber

Varietal differences were significant and potassium nutrition influenced the average weight of tuber (Table 15).

Variety Bhu Sona had significantly higher average weight of tuber (251.72 g). However, no significant difference could be noticed among varied potassium levels.

Interaction between varieties and potassium levels was significant. Variety Bhu Sona had the highest average weight of tuber (354.33 g) even without K application. The next higher value of 280.33 g was registered at 75 kg potassium and it was statistically not comparable. All other varieties showed comparable tuber weight at all levels of applied K from 0 – 100 kg and as the yield was poor, the response to applied K could not be inferred.

c) Tuber yield per plant

Significant difference was recorded in tuber yield per plant among varieties during *kharif* season and Bhu Sona was the only variety which produced good yield. No significant variation was noticed for different K levels or interaction between varieties and K (Table 16), mainly due to the photosensitivity of the varieties which resulted in poor yield.

Variety Bhu Sona recorded significantly higher tuber yield per plant (291.17 g/plant) compared to other varieties. Tuber yield per plant of other varieties were statistically on par with each other.

d) Weight of unmarketable tuber

The highest unmarketable tuber weight per plant was recorded by variety Sree Bhadra (63.42 g/plant), which was significantly higher than other varieties and least was recorded by variety Bhu Sona (24.17 g/plant) (Table 16). Over potassium levels, all doses (50, 75 and 100 kg/ha) except no potassium (35.13 g/plant) recorded significantly on par unmarketable tuber weight per plant (48.20 g, 51.46 g and 46.87 g/plant, respectively). There was no significant interaction effect.

e) Marketable tuber yield

Significant difference between varieties and potassium levels was noticed in the case of marketable tuber yield (Table 17). Variety Bhu Sona recorded significantly higher marketable tuber yield of 15.74 t/ha. Yield of other four varieties were considerably low with average yield of 4.43 t/ha and were at par statistically.

Table 15 Average weight of tuber and number of tubers per plant of sweet potato varieties as influenced by K nutrition

Treatments	Average weight of tuber (g)	No. of tubers/plant
Variety (V)		
V_1 – Bhu Krishna	71.94	3.17
V_2 – Sree Arun	88.30	1.33
V_3 – Sree Bhadra	77.50	1.42
V_4 – Bhu Sona	251.72	2.17
V_5 – Kanjanghad local	53.33	1.67
SEm (±)	10.72	0.23
CD (0.05)	30.68	0.65
K levels (K)		
K_1- 0 kg/ha	120.87	1.93
K_2 – 50 kg/ha	100.17	2.00
K_3 – 75 kg/ha	120.49	1.87
K_4 – 100 kg/ha	92.71	2.00
SEm (±)	9.58	0.20
CD (0.05)	NS	NS
Interaction (V x K)		
V_1K_1	56.33	3.67
V_1K_2	77.66	4.00
V_1K_3	73.44	2.33
V_1K_4	80.33	2.67
V_2K_1	73.33	1.00
V_2K_2	87.86	1.33
V_2K_3	103.67	1.00
V_2K_4	88.33	2.00
V_3K_1	76.00	1.33
V_3K_2	89.67	1.33
V_3K_3	98.33	1.67
V_3K_4	46.00	1.33
V_4K_1	354.33	2.33
V_4K_2	170.00	1.67
V_4K_3	280.33	2.66
V_4K_4	202.20	2.00
V_5K_1	44.33	1.33
V_5K_2	75.67	1.67
V_5K_3	46.66	1.67
V_5K_4	46.67	2.00
SEm (±)	21.43	0.45
CD (0.05)	61.37	NS

Table 16 Tuber yield per plant and weight of unmarketable tuber per plant of sweet potato varieties as influenced by K nutrition

Treatments	Tuber yield per plant (g/plant)	Weight of unmarketable tuber per plant (g/plant)
Variety (V)		
V_1 – Bhu Krishna	125.58	48.58
V_2 – Sree Arun	101.07	46.83
V_3 – Sree Bhadra	128.75	63.42
V_4 – Bhu Sona	291.17	24.17
V_5 – Kanjanghad local	114.04	44.08
SEm (±)	33.15	3.41
CD (0.05)	94.89	9.75
K levels (K)		
K_1- 0 kg/ha	128.17	35.13
K_2 – 50 kg/ha	164.86	48.20
K_3 – 75 kg/ha	180.29	51.46
K_4 – 100 kg/ha	135.17	46.87
SEm (±)	29.65	3.05
CD (0.05)	NS	8.73
V x K interaction was non significant		

Potassium application @ 50 and 75 kg/ha led to significantly higher marketable tuber yield (7.69 t/ha and 6.72 t/ha, respectively) which were at par.

Variety Bhu Sona with no potassium recorded significantly higher marketable tuber yield (19.97 t/ha), which was comparable with its tuber yield when 50 kg/ha potassium was applied (16.64 t/ha). Various doses of potassium from 0 to 100 kg/ha did not influence the yield in other varieties and the yield was at par statistically.

f) Total tuber yield

The same trend as that of marketable tuber yield was found with respect to total tuber yield also (Table 17). The highest tuber yield was produced by variety Bhu Sona (17.01 t/ha) which was significantly higher than all other varieties. Potassium application @ 50 kg and 75 kg/ha recorded significantly higher tuber yield (9.53 t/ha and 8.55 t/ha, respectively) which were on par.

Performance of variety Bhu Sona was superior even when no K was applied (21.62 t/ha). Tuber yield of all other varieties was at par at all potassium levels.

g) Harvest Index (HI)

As in the case of tuber yield, varieties differed significantly with respect to HI as influenced by potassium levels (Table 17). The highest harvest index was recorded for the variety Bhu Sona (0.44). Very low harvest index was registered in other varieties due to poor tuber yield. Effect of K doses was also not evident in these varieties. In interaction, the highest HI was registered for variety Bhu Sona when no potassium was applied (0.53) and lowest for variety Sree Arun without having any potassium (0.11).

4.1.3 Quality parameters of tuber

a) Crude fibre

Significant difference was noticed for crude fibre content (%) of sweet potato varieties and it was influenced by varied K levels also (Table 18). Variety Kanjanghad Local and variety Sree Arun recorded significantly higher crude fibre (12.26 % and 11.50 %, respectively) whereas variety Bhu Krishna registered significantly lower crude fibre (4.94 %). Crude fibre content significantly increased with increasing K levels. Higher crude fibre content was recorded when potassium was applied @ 100 and 75 kg/ha (11.48 % and 10.76 %, respectively), which were statistically at par. The lowest fibre content was observed when potassium was not applied (6.19 %). Interaction effect of varieties x K levels was not significant.

b) Crude protein

Data on crude protein content of sweet potato tubers is given in Table 18. Significantly higher crude protein was observed for variety Bhu Sona (14.07 %), followed by variety Sree Bhadra (12.17 %). Among the potassium levels, maximum crude protein content was recorded when potassium was applied @ 50 and 75 kg/ha (12.83 % and 12.54 %, respectively), which was followed by 100 kg/ha potassium. There was significant difference between treatment combinations and variety Bhu Sona applied with potassium @ 75 kg/ha recorded significantly higher crude protein (15.95 %) which was on par with variety Kanjanghad Local provided with 50 kg/ha potassium (15.32 %) as well as variety Bhu Sona with no potassium (14.21 %).

Table 17 Marketable tuber yield, total tuber yield and harvest index of sweet potato varieties as influenced by K nutrition

Treatments	Marketable tuber yield (t/ha)	Total tuber yield (t/ha)	Harvest Index
Variety (V)			
V_1 – Bhu Krishna	4.68	6.32	0.19
V_2 – Sree Arun	4.11	5.77	0.14
V_3 – Sree Bhadra	4.48	6.74	0.17
V_4 – Bhu Sona	15.74	17.01	0.44
V_5 – Kanjanghad local	4.47	6.04	0.16
SEm (±)	0.43	0.40	0.01
CD (0.05)	1.24	1.15	0.03
K levels (K)			
K_1- 0 kg/ha	6.81	8.19	0.22
K_2 – 50 kg/ha	7.69	9.53	0.24
K_3 – 75 kg/ha	6.72	8.55	0.21
K_4 – 100 kg/ha	5.56	7.23	0.22
SEm (±)	0.39	0.36	0.01
CD (0.05)	1.11	1.03	NS
Interaction (V x K)			
V_1K_1	2.78	3.80	0.16
V_1K_2	6.61	8.54	0.23
V_1K_3	5.03	7.29	0.17
V_1K_4	4.28	5.64	0.19
V_2K_1	3.27	4.40	0.11
V_2K_2	5.89	7.61	0.17
V_2K_3	3.46	5.66	0.14
V_2K_4	3.79	5.42	0.13
V_3K_1	4.59	6.47	0.14
V_3K_2	2.95	5.52	0.16
V_3K_3	6.27	8.64	0.19
V_3K_4	4.12	6.33	0.18
V_4K_1	19.97	21.62	0.53
V_4K_2	16.64	17.96	0.43
V_4K_3	14.34	15.22	0.37
V_4K_4	12.00	13.25	0.41
V_5K_1	3.42	4.66	0.13
V_5K_2	6.35	8.05	0.18
V_5K_3	4.52	5.95	0.16
V_5K_4	3.62	5.51	0.14
SEm (±)	0.86	0.80	0.02
CD (0.05)	2.47	2.31	0.06

Plate 13. Effect of varied K levels on tuber yield of variety Bhu Sona

Kanjanghad Local **Bhu Krishna**

Sree Arun **Sree Bhadra**

Plate 14. Poor tuberization in *kharif* season

Table 18 Crude fibre and crude protein content of sweet potato varieties as influenced by K nutrition

Treatments	Crude fibre (%)	Crude protein (%)
Variety (V)		
V_1 – Bhu Krishna	4.94	9.39
V_2 – Sree Arun	11.50	10.82
V_3 – Sree Bhadra	9.71	12.17
V_4 – Bhu Sona	8.42	14.07
V_5 – Kanjanghad local	12.26	11.94
SEm (±)	0.35	0.37
CD (0.05)	1.01	1.06
K levels (K)		
K_1- 0 kg/ha	6.19	9.75
K_2 – 50 kg/ha	9.03	12.83
K_3 – 75 kg/ha	10.76	12.54
K_4 – 100 kg/ha	11.48	11.59
SEm (±)	0.32	0.33
CD (0.05)	0.91	0.95
Interaction (V x K)		
V_1K_1	2.52	8.23
V_1K_2	5.06	9.52
V_1K_3	5.80	9.51
V_1K_4	6.37	10.30
V_2K_1	7.16	6.90
V_2K_2	10.93	12.34
V_2K_3	14.08	12.30
V_2K_4	13.83	11.76
V_3K_1	6.83	12.19
V_3K_2	9.59	13.54
V_3K_3	10.93	11.41
V_3K_4	11.47	11.55
V_4K_1	6.23	14.21
V_4K_2	7.98	13.44
V_4K_3	8.73	15.95
V_4K_4	10.74	12.68
V_5K_1	8.20	7.25
V_5K_2	11.57	15.32
V_5K_3	14.27	13.53
V_5K_4	14.99	11.67
SEm (±)	0.71	0.74
CD (0.05)	NS	2.12

c) Reducing, non reducing and total sugar

Data on reducing, non reducing and total sugar content of sweet potato tuber is furnished in Table 19. The highest reducing sugar was recorded in variety Bhu Sona (2.38 %), which was significantly higher than other varieties. The lowest reducing sugar and total sugar content was observed for variety Kanjanghad Local (0.51 % and 1.85 %, respectively). Content of non reducing sugar and total sugar were significantly higher for variety Sree Arun followed by variety Bhu Krishna. Least content was recorded for variety Bhu Sona (0.84 %).

The data pertaining to sugar content as influenced by various potassium levels indicated that sugar content increased with increasing potassium doses. Significantly higher reducing sugar (1.64 %), non reducing sugar (2.52 %) and total sugar (4.16 %) were registered for potassium level @ 100 kg/ha. Significantly lower values were observed when K was not supplied (0.94 %, 1.72 % and 2.66 %, respectively).

Interaction between varieties x K doses was also significant and higher non reducing sugar and total sugar content were obtained for the treatment combination of variety Sree Arun applied with 100 kg/ha potassium (4.45 % and 6.16 %, respectively) which was significantly higher than all other treatment combinations. Interaction was given 2.74 per cent of reducing sugar under the combination of variety Bhu Sona with 100 kg K application.

d) Starch content

Starch content of tuber showed an increasing trend with increasing potassium levels and it varied among varieties (Table 20). Significantly higher starch content was observed for variety Kanjanghad Local (32.04 %), followed by variety Sree Arun (29.24 %) and Sree Bhadra (24.15 %). The lowest starch content was recorded for variety Bhu Krishna (16.68 %). Potassium applied @ 75 kg/ha and 100 kg/ha resulted in significantly higher and comparable starch content. The lowest starch content of 21.70 per cent was registered when no K was applied. There was no significant interaction effect.

e) Moisture content

Data on moisture content of tubers is furnished in Table 20. Variety Bhu Krishna had significantly higher moisture content (68.19 %) compared to all other varieties. An average moisture content of 60 per cent was registered for varieties Sree Arun, Sree Bhadra and Bhu Sona which were statistically at par.

Significantly higher moisture content was obtained for potassium dose @ 75 and 100 kg/ha (63.78 % and 63.25 %, respectively) which were at par. Significant interaction effect between varieties and potassium levels could be noticed. Among the treatment combinations, the highest moisture content (70.70 %) was noticed under variety Bhu Krishna with 75 kg/ha K application.

4.1.4 Plant analysis

a) Primary nutrient content in index leaf

NPK content of index leaf was analysed at active growth phase (ie. 60 DAP) and significant variation was observed and it varied with varieties and potassium levels (Table 21). However, variation in nitrogen content was non significant among varieties. Nitrogen content in the index leaf showed an increasing trend with applied potassium compared to no K application (4.03 %). Average N content was 5.02 per cent and the highest value noted for K applied @ 75 kg/ha (5.54 %). There was no significant interaction effect.

In the case of leaf phosphorus content, there was significant variation among varieties and potassium nutrition. Significantly higher phosphorus content was noticed for variety Bhu Sona (0.31 %), followed by variety Bhu Krishna (0.29 %). The lowest phosphorus content was for variety Sree Bhadra (0.21 %). K application @ 50 and 75 kg/ha recorded significantly higher leaf phosphorus content (0.28 %). There was no significant interaction effect between varieties x K levels.

Potassium content in the index leaf also varied significantly. Significantly higher K content was observed for variety Bhu Sona (5.71 %) which was on par with varieties Bhu Krishna and Sree Arun (5.29 % and 5.20 %, respectively). Potassium applied @ 50 and 75 kg/ha resulted in higher potassium content in index leaf (5.65 % and 5.51 %, respectively) compared to no K or 100 kg K.

Table 19 Reducing, non reducing and total sugar content of tubers of sweet potato varieties as influenced by K nutrition

Treatments	Reducing sugar (%)	Non reducing sugar (%)	Total sugar (%)
Variety (V)			
V_1 – Bhu Krishna	1.32	3.31	4.63
V_2 – Sree Arun	1.29	4.16	5.45
V_3 – Sree Bhadra	1.14	1.03	2.17
V_4 – Bhu Sona	2.38	0.84	3.22
V_5 – Kanjanghad local	0.51	1.35	1.85
SEm (±)	0.03	0.03	0.05
CD (0.05)	0.08	0.10	0.13
K levels (K)			
K_1- 0 kg/ha	0.94	1.72	2.66
K_2 – 50 kg/ha	1.24	1.99	3.24
K_3 – 75 kg/ha	1.49	2.31	3.80
K_4 – 100 kg/ha	1.64	2.52	4.16
SEm (±)	0.03	0.03	0.04
CD (0.05)	0.08	0.09	0.12
Interaction (V x K)			
V_1K_1	0.94	2.77	3.71
V_1K_2	1.29	3.07	4.36
V_1K_3	1.51	3.61	5.11
V_1K_4	1.54	3.79	5.33
V_2K_1	0.73	3.88	4.61
V_2K_2	1.13	4.05	5.17
V_2K_3	1.58	4.25	5.84
V_2K_4	1.72	4.45	6.16
V_3K_1	0.66	0.55	1.22
V_3K_2	1.09	0.97	2.07
V_3K_3	1.29	1.20	2.49
V_3K_4	1.49	1.38	2.88
V_4K_1	2.00	0.29	2.29
V_4K_2	2.28	0.60	2.88
V_4K_3	2.50	1.13	3.64
V_4K_4	2.74	1.33	4.06
V_5K_1	0.33	1.11	1.44
V_5K_2	0.42	1.29	1.72
V_5K_3	0.55	1.35	1.91
V_5K_4	0.71	1.62	2.33
SEm (±)	0.06	0.07	0.09
CD (0.05)	0.17	0.20	0.26

Table 20 Starch and moisture content of sweet potato tubers as influenced by K nutrition

Treatments	Starch content (%)	Moisture content (%)
Variety (V)		
V_1 – Bhu Krishna	16.68	68.19
V_2 – Sree Arun	29.24	60.91
V_3 – Sree Bhadra	24.15	61.05
V_4 – Bhu Sona	18.34	60.32
V_5 – Kanjanghad local	32.04	62.50
SEm (±)	0.31	0.52
CD (0.05)	0.88	1.48
K levels (K)		
K_1- 0 kg/ha	21.70	61.09
K_2 – 50 kg/ha	23.86	62.24
K_3 – 75 kg/ha	25.17	63.78
K_4 – 100 kg/ha	25.63	63.25
SEm (±)	0.27	0.46
CD (0.05)	0.79	1.33
Interaction (V x K)		
V_1K_1	13.83	65.63
V_1K_2	15.96	67.10
V_1K_3	18.41	70.70
V_1K_4	18.51	69.33
V_2K_1	26.73	58.36
V_2K_2	28.30	62.50
V_2K_3	30.68	61.60
V_2K_4	31.24	61.16
V_3K_1	20.63	61.66
V_3K_2	24.56	60.03
V_3K_3	25.53	61.56
V_3K_4	25.86	60.93
V_4K_1	16.93	58.30
V_4K_2	18.14	59.46
V_4K_3	19.13	63.76
V_4K_4	19.16	59.73
V_5K_1	30.37	61.50
V_5K_2	32.32	62.10
V_5K_3	32.12	61.30
V_5K_4	33.36	65.10
SEm (±)	0.61	1.03
CD (0.05)	NS	2.96

b) Primary nutrient content of shoot and tuber at harvest

In general, nitrogen, phosphorus and potassium content of aerial portion and tuber varied among different varieties and potassium nutrition (Table 22).

Nitrogen

No significant difference observed in shoot nitrogen content of varieties. However, nitrogen content in tuber was significantly higher for the variety Bhu Sona (2.33 %) and for 50 kg/ha potassium level (2.18 %) compared to other treatments. Interaction effect was significant for shoot and tuber nitrogen content. Significantly higher and comparable shoot nitrogen content was observed in varieties Bhu Krishna, Sree Arun, Sree Bhadra, Bhu Sona and Kanjanghad Local at varied K doses. Tuber N content was significantly higher for variety Bhu Sona with 75 kg/ha potassium (2.95 %) which was on par with variety Kanjanghad Local with 50 kg/ha potassium (2.66 %).

Phosphorus

Significant difference was noticed among varieties and with applied potassium levels. Among the five varieties, Sree Arun as well as Bhu Sona showed significantly higher shoot phosphorus content (0.20 % and 0.18 %, respectively) which were at par. But, Tuber P content was significantly higher for variety Bhu Krishna (0.17 %), followed by Kanjanghad Local and Bhu Sona (0.15 %).

Significantly higher shoot phosphorus content was observed when no potassium was applied (0.21 %). While, tuber phosphorus content was higher for potassium applied @ 50 and 75 kg/ha (0.16 % and 0.17 %, respectively) and it declined at 100 kg K per ha. Interaction between variety x K level was also significant and variety Bhu Sona under no potassium showed higher shoot and tuber P content (0.27 % and 0.23 %, respectively).

Potassium

With respect to potassium content in shoot of sweet potato, varieties Sree Bhadra, Bhu Krishna and Sree Arun were at par with average K content of 5.45 per cent. The lowest content was in Kanjanghad Local (4.64 %). With increase in potassium dose, potassium content in aerial part increased. Higher value was reported for potassium application @ 75 kg/ha (5.65 %), which was comparable to 50 and 100 kg/ha (5.19 % and 5.61 %, respectively).

Significant difference was observed among varieties and potassium rates with respect to tuber potassium content. The tuber potassium content of variety Bhu Sona was significantly higher (1.48%) compared to other varieties. The potassium concentration in tubers and shoots showed a similar trend. Potassium applied @ 50, 75 and 100 kg/ha showed significantly higher and comparable tuber K content (1.07 %, 1.15 % and 1.11 %, respectively).

In the case of interaction between varieties and K levels, shoot K content registered higher for varieties Sree Bhadra, Bhu Krishna and Sree Arun at higher doses of potassium. Bhu Sona registered significantly higher and comparable tuber K content at no K as well as K @ 50 kg/ha.

Table 21 Nitrogen, phosphorus and potassium content of index leaf of sweet potato varieties at 60 DAP as influenced by K nutrition

Treatments	**Leaf N content (%) at 60 DAP**	**Leaf P content (%) at 60 DAP**	**Leaf K content (%) at 60 DAP**
Variety (V)			
V_1 – Bhu Krishna	4.58	0.29	5.29
V_2 – Sree Arun	4.88	0.25	5.20
V_3 – Sree Bhadra	5.36	0.21	4.74
V_4 – Bhu Sona	5.13	0.31	5.71
V_5 – Kanjanghad local	5.16	0.26	5.00
SEm (±)	0.19	0.003	0.19
CD (0.05)	NS	0.01	0.55
K levels (K)			
K_1- 0 kg/ha	4.03	0.25	4.67
K_2 – 50 kg/ha	5.16	0.28	5.65
K_3 – 75 kg/ha	5.54	0.28	5.51
K_4 – 100 kg/ha	5.35	0.25	4.93
SEm (±)	0.17	0.003	0.17
CD (0.05)	0.49	0.01	0.49
V x K interaction was non significant			

Table 22 Nutrient status of sweet potato varieties at harvest as influenced by K

Treatments	Nitrogen (%)		Phosphorus (%)		Potassium (%)	
	Shoot	Tuber	Shoot	Tuber	Shoot	Tuber
Variety (V)						
V_1 – Bhu Krishna	4.81	1.52	0.17	0.17	5.56	1.01
V_2 – Sree Arun	4.09	1.59	0.20	0.13	5.08	1.13
V_3 – Sree Bhadra	4.09	1.80	0.15	0.11	5.71	0.92
V_4 – Bhu Sona	3.97	2.33	0.18	0.15	4.95	1.48
V_5 – Kanjanghad local	4.41	1.55	0.17	0.15	4.64	0.77
SEm (±)	0.31	0.05	0.01	0.004	0.24	0.06
CD (0.05)	NS	0.16	0.03	0.01	0.70	0.17
K levels (K)						
K_1- 0 kg/ha	4.10	1.57	0.21	0.09	4.30	0.93
K_2 – 50 kg/ha	4.27	2.18	0.15	0.16	5.19	1.07
K_3 – 75 kg/ha	4.28	2.03	0.17	0.17	5.65	1.15
K_4 – 100 kg/ha	4.44	1.25	0.16	0.12	5.61	1.11
SEm (±)	0.28	0.05	0.01	0.004	0.22	0.05
CD (0.05)	NS	0.15	0.02	0.01	0.63	0.15
Interaction (V x K)						
V_1K_1	3.52	1.81	0.26	0.17	4.04	0.68
V_1K_2	5.81	1.52	0.12	0.18	5.16	0.97
V_1K_3	4.37	1.52	0.13	0.18	6.46	1.16
V_1K_4	5.52	1.24	0.15	0.14	6.57	1.22
V_2K_1	3.04	0.90	0.16	0.06	4.14	0.89
V_2K_2	3.81	2.18	0.22	0.14	4.99	1.01
V_2K_3	4.66	2.34	0.24	0.17	5.81	1.30
V_2K_4	4.85	0.92	0.19	0.13	5.36	1.32
V_3K_1	4.28	1.95	0.19	0.06	3.64	0.82
V_3K_2	3.52	2.37	0.13	0.14	6.24	0.89
V_3K_3	4.66	1.66	0.12	0.14	6.32	1.01
V_3K_4	3.90	1.21	0.16	0.08	6.65	0.96
V_4K_1	5.09	2.27	0.27	0.23	5.15	1.77
V_4K_2	3.90	2.15	0.16	0.12	5.30	1.65
V_4K_3	2.66	2.95	0.19	0.16	4.90	1.41
V_4K_4	4.23	1.92	0.09	0.11	4.43	1.09
V_5K_1	4.57	0.89	0.15	0.09	4.51	0.48
V_5K_2	4.33	2.66	0.14	0.16	4.25	0.82
V_5K_3	5.04	1.68	0.17	0.19	4.77	0.84
V_5K_4	3.71	0.96	0.22	0.12	5.02	0.94
SEm (±)	0.62	0.11	0.02	0.01	0.49	0.12
CD (0.05)	1.78	0.33	0.05	0.03	1.40	0.33

c) Uptake of primary nutrients at harvest

Data on uptake of primary nutrients by sweet potato varieties as influenced by varied K levels is given in Table 23. Comparing the shoot nitrogen uptake of sweet potato, all the varieties, with the exception of Bhu Sona, had higher shoot nitrogen uptake. However in the case of nitrogen uptake by tuber, a reverse trend was seen with variety Bhu Sona (86.06 kg/ha) with higher uptake than that of the other varieties. Shoot N uptake did not vary significantly with K application rate. The nitrogen taken up by tubers significantly varied with different potassium doses, with higher value at potassium level of 50 kg/ha (48.56 kg/ha). There was also significant interaction effect and variety Bhu Sona registered higher uptake of 113.96 kg/ha even at no K compared to other treatment combinations.

Shoot phosphorus uptake was higher for variety Sree Arun (18.93 kg/ha), which was statistically superior than all other varieties. While no significant influence of varied K levels was observed for shoot P uptake. Among the treatment combinations, variety Sree Arun with potassium applied @ 50, 75 and 100 kg/ha recorded significantly higher P uptake. In the case of P uptake by tuber, variety Bhu Sona recorded significantly higher value (4.02 kg/ha). Potassium applied @ 50 and 75 kg/ha resulted in comparable P uptake (3.52 kg/ha and 3.31 kg/ha, respectively).

There was significant variation in potassium uptake by different sweet potato varieties (Table 23). Uptake of potassium by aerial parts was maximum in variety Sree Arun and Sree Bhadra (245.45 kg/ha and 237.54 kg/ha, respectively) compared to other varieties. Shoot potassium uptake increased with increase in K levels and higher uptake was noticed when 75 and 100 kg/ha K was applied (229.43 kg/ha and 215.64 kg/ha, respectively). While comparing the treatment combinations, varieties Sree Arun (240.44 kg/ha, 296.81 kg/ha and 280.35 kg/ha, respectively) and Sree Bhadra (239.64 kg/ha, 281.06 kg/ha and 315.05 kg/ha, respectively) applied with 50, 75 and 100 kg/ha potassium resulted in higher shoot potassium uptake, which was comparable with shoot K uptake of variety Bhu Krishna applied with 75 kg/ha potassium (256.60 kg/ha). While comparing tuber K uptake of different varieties, variety Bhu Sona had taken up maximum K through tubers (55.68 kg/ha) compared to other varieties. There was no significant difference noticed among potassium levels. While, tuber K uptake was more for variety Bhu Sona applied with no potassium (78.75 kg/ha) which was significantly higher than other treatment combinations.

Table 23 N, P, K uptake of sweet potato varieties at harvest as influenced by K

Treatments	Nitrogen (kg/ha)		Phosphorus (kg/ha)		Potassium (kg/ha)	
	Shoot	Tuber	Shoot	Tuber	Shoot	Tuber
Variety (V)						
V_1 – Bhu Krishna	177.89	23.94	9.58	2.91	180.94	16.29
V_2 – Sree Arun	207.69	26.11	18.93	2.03	245.45	17.50
V_3 – Sree Bhadra	174.08	27.16	11.29	1.76	237.54	14.97
V_4 – Bhu Sona	84.59	86.06	8.97	4.02	101.83	55.68
V_5 – Kanjanghad local	179.85	26.48	13.77	2.31	191.50	12.17
SEm (±)	9.62	2.82	0.96	0.17	14.64	2.00
CD (0.05)	27.55	8.07	2.76	0.49	41.93	5.73
K levels (K)						
K_1- 0 kg/ha	125.39	34.87	12.43	1.40	125.00	22.02
K_2 – 50 kg/ha	172.43	48.56	11.82	3.52	195.74	26.27
K_3 – 75 kg/ha	189.78	41.23	13.34	3.31	229.43	23.25
K_4 – 100 kg/ha	171.68	27.15	12.46	2.19	215.64	21.74
SEm (±)	8.60	2.52	0.86	0.15	13.10	1.79
CD (0.05)	24.64	7.22	NS	0.44	37.51	NS
Interaction (V x K)						
V_1K_1	101.31	18.87	10.41	1.78	93.42	6.90
V_1K_2	218.93	32.20	8.03	4.70	182.73	20.17
V_1K_3	216.79	26.00	10.20	3.00	256.60	19.82
V_1K_4	174.53	18.69	9.71	2.14	191.01	18.26
V_2K_1	121.10	9.44	13.33	0.71	164.22	9.47
V_2K_2	203.94	43.61	20.51	2.84	240.44	20.02
V_2K_3	251.11	37.42	23.25	2.72	296.81	20.64
V_2K_4	254.59	13.98	18.65	1.84	280.35	19.88
V_3K_1	150.26	20.64	13.22	0.66	114.41	8.89
V_3K_2	153.62	34.86	9.86	2.13	239.64	13.75
V_3K_3	206.51	30.37	9.45	2.65	281.06	18.76
V_3K_4	185.92	22.77	12.66	1.63	315.05	18.49
V_4K_1	79.48	113.96	13.35	2.65	79.66	78.75
V_4K_2	82.32	76.98	7.70	4.48	113.29	60.33
V_4K_3	84.51	85.83	10.06	5.16	116.73	43.96
V_4K_4	92.07	67.50	4.79	3.78	97.64	39.70
V_5K_1	174.80	11.44	11.84	1.21	173.30	6.10
V_5K_2	203.35	55.15	13.01	3.43	202.58	17.11
V_5K_3	189.96	26.52	13.73	3.02	195.95	13.07
V_5K_4	151.30	12.80	16.48	1.60	194.17	12.38
SEm (±)	19.25	5.64	1.93	0.34	29.29	4.00
CD (0.05)	55.11	16.15	5.53	NS	NS	11.47

4.1.5 Soil analysis

a) Soil status of primary nutrients at 60DAP

In general, no significant variation could be observed for the soil nutrient status at 60 DAP (Table 24). However, soil available potassium content varied at different K levels and significantly higher potassium content was noticed for the soil applied with 100 kg/ha potassium (184.35 kg/ha). There was no interaction effect observed between varieties and K doses.

Table 24 Soil available nitrogen, phosphorus and potassium at 60 DAP

Treatments	Soil available nutrients at 60 DAP (kg/ha)		
	Nitrogen	Phosphorus	Potassium
Variety (V)			
V_1 – Bhu Krishna	119.17	133.31	153.53
V_2 – Sree Arun	123.35	113.93	132.44
V_3 – Sree Bhadra	105.58	119.68	125.91
V_4 – Bhu Sona	117.07	123.74	128.89
V_5 – Kanjanghad local	110.80	117.58	123.11
SEm (±)	9.76	8.92	9.32
CD (0.05)	NS	NS	NS
K levels (K)			
K_1- 0 kg/ha	126.27	127.65	80.49
K_2 – 50 kg/ha	113.73	115.14	121.78
K_3 – 75 kg/ha	110.38	123.00	144.48
K_4 – 100 kg/ha	110.39	120.81	184.35
SEm (±)	8.73	7.98	8.33
CD (0.05)	NS	NS	23.86
V x K interaction was non significant			

b) pH, Electrical conductivity and organic carbon of soil after harvest

Data on pH, EC and organic carbon of soil after harvest is given in Table 25. These parameters did not vary significantly among treatments.

Table 25 Soil pH, EC and organic carbon after harvest

Treatments	pH	EC (dS/m)	OC (%)
Variety (V)			
V_1 – Bhu Krishna	6.14	0.086	1.46
V_2 – Sree Arun	6.11	0.088	1.44
V_3 – Sree Bhadra	6.07	0.083	1.50
V_4 – Bhu Sona	6.13	0.089	1.30
V_5 – Kanjanghad local	6.03	0.080	1.37
SEm (±)	0.05	0.006	0.09
CD (0.05)	NS	NS	NS
K levels (K)			
K_1- 0 kg/ha	6.11	0.086	1.47
K_2 – 50 kg/ha	6.15	0.089	1.39
K_3 – 75 kg/ha	6.07	0.084	1.34
K_4 – 100 kg/ha	6.06	0.083	1.45
SEm (±)	0.04	0.006	0.08
CD (0.05)	NS	NS	NS
V x K interaction was non significant			

c) Soil available nitrogen, phosphorus and potassium after harvest

Data on soil available nutrients after harvest is furnished in Table 26. Variety Bhu Sona registered higher soil nitrogen content which was on par with soil nitrogen content of variety Sree Arun (173.52 kg/ha and 152.62 kg/ha, respectively). Interaction effect was also significant among treatment combinations. Soil available phosphorus was significant for the treatment combinations and all varieties showed significant difference at varied potassium levels. Potassium content of the soil at harvest also significantly varied among varieties with respect to different potassium doses and significantly higher soil available potassium noticed for the varieties applied with 100 kg/ha K (133.34 kg/ha) which was comparable with 75 kg/ha (119.84 kg/ha).

Table 26 Available nitrogen, phosphorus and potassium content of soil after harvest

Treatments	Soil available nutrients at harvest (kg/ha)		
	Nitrogen	Phosphorus	Potassium
Variety (V)			
V_1 – Bhu Krishna	129.62	114.90	108.08
V_2 – Sree Arun	152.62	97.62	104.77
V_3 – Sree Bhadra	148.44	93.68	109.52
V_4 – Bhu Sona	173.52	107.85	122.18
V_5 – Kanjanghad local	111.85	89.50	100.61
SEm (±)	8.58	7.21	6.53
CD (0.05)	24.57	NS	NS
K levels (K)			
K_1- 0 kg/ha	142.16	100.60	74.00
K_2 – 50 kg/ha	148.85	91.68	108.94
K_3 – 75 kg/ha	140.49	109.26	119.84
K_4 – 100 kg/ha	141.33	101.31	133.34
SEm (±)	7.68	6.45	5.84
CD (0.05)	NS	NS	16.73
Interaction (V x K)			
V_1K_1	125.44	152.64	76.53
V_1K_2	175.61	96.93	117.57
V_1K_3	121.25	94.29	101.36
V_1K_4	96.17	115.75	136.85
V_2K_1	117.07	82.58	76.01
V_2K_2	158.89	84.15	95.76
V_2K_3	163.07	96.56	131.17
V_2K_4	171.43	127.17	116.16
V_3K_1	129.62	111.24	80.46
V_3K_2	137.98	83.56	120.24
V_3K_3	154.71	102.86	109.94
V_3K_4	171.43	77.07	127.42
V_4K_1	188.16	91.65	88.48
V_4K_2	183.97	130.45	98.80
V_4K_3	171.43	140.36	137.30
V_4K_4	150.52	68.96	164.16
V_5K_1	150.52	64.90	48.53
V_5K_2	87.80	63.28	112.37
V_5K_3	91.98	112.24	119.41
V_5K_4	117.07	117.57	122.13
SEm (±)	17.17	14.42	13.06
CD (0.05)	49.15	41.28	NS

4.1.6 Pest and disease incidence

No major pests or diseases were observed during *kharif* season except minor incidence of sweet potato weevil.

4.1.7 Cost benefit analysis

The cost of cultivation ranged from ₹ 1,01,841 to ₹ 1,06,961 (Table 27). The lowest cost was registered when no potassium was applied and the highest cost of cultivation was for 100 kg/ha potassium applied plots. Among the varieties, the highest net return was realized for the variety Bhu Sona during k*harif* season. While comparing treatment combinations, variety Bhu Sona with no potassium registered higher net returns (₹ 3,97,530). The lowest net return was from plots planted with variety Bhu Krishna with no potassium application.

In various treatment combinations, B-C ratios ranging from 0.68 to 4.90 was registered. Maximum benefit-cost ratio of 4.90 was associated with variety Bhu Sona without K application. While, the lowest B-C ratio of 0.68 was registered for variety Bhu Krishna without K application.

4.2. Performance of sweet potato varieties in *rabi* season as influenced by K nutrition

4.2.1 Growth parameters of sweet potato in *rabi* season

a) Vine length

Vine length was measured periodically till harvest (Table 28). At 20, 40, 60, 80 DAP and at harvest, significantly higher vine length was recorded for variety Bhu Sona (61.20 cm, 169.27 cm, 246.44 cm, 276.34 cm and 308 cm, respectively). Variety Kanjanghad Local registered the lowest vine length compared to all other varieties at 20 DAP as well as at harvest (27.34 cm and 183.06 cm, respectively).

Plants showed significant variations in vine length with respect to applied potassium at 20 DAP and the highest vine length (46.03 cm) was recorded for 75 kg K_2O/ha, followed by 50 kg/ha and 100 kg/ha potassium. While comparing potassium levels at 40, 60, 80 DAP and at harvest, potassium applied @ 50 kg/ha (113.33 cm, 176.29 cm, 216.01cm and 242.67 cm, respectively) and 75 kg/ha (114.92 cm, 176.78 cm, 217.25 cm and 245.53 cm, respectively) resulted in higher and comparable vine length at all stages.

Table 27 Cost benefit analysis of sweet potato varieties with varied K levels

Treatment combinations	Yield (t/ha)	Total cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B-C ratio
V_1K_1	2.78	101841	69631	-32210	0.68
V_1K_2	6.61	105301	165354	60053	1.57
V_1K_3	5.03	106141	125817	19676	1.19
V_1K_4	4.28	106961	107051	90	1.00
V_2K_1	3.27	101841	81917	-19924	0.80
V_2K_2	5.89	105301	147339	42038	1.40
V_2K_3	3.46	106141	86696	-19445	0.82
V_2K_4	3.79	106961	94895	-12066	0.89
V_3K_1	4.59	101841	114928	13087	1.13
V_3K_2	2.95	105301	73771	-31530	0.70
V_3K_3	6.27	106141	156742	50601	1.48
V_3K_4	4.12	106961	123765	16804	1.16
V_4K_1	19.97	101841	499371	397530	4.90
V_4K_2	16.64	105301	416037	310736	3.95
V_4K_3	14.34	106141	358461	252320	3.38
V_4K_4	12.00	106961	300056	193095	2.81
V_5K_1	3.42	101841	85489	-16352	0.84
V_5K_2	6.35	105301	158809	53508	1.51
V_5K_3	4.52	106141	112990	6849	1.06
V_5K_4	3.62	106961	90393	-16568	0.85

Significant interaction effect between varieties and potassium levels was observed at 20 DAP and higher vine length was obtained for variety Bhu Sona with potassium @ 75 kg/ha (65.50 cm) which was on par with 100 kg per ha potassium for the same variety (62.56 cm). Variety Kanjanghad Local recorded the lowest vine length at all potassium levels from 0 to 100 kg/ha (25.03 cm, 28.16 cm, 28.96 cm and 27.20 cm, respectively). Interaction effect was noticed at harvest stage also and variety Bhu Sona applied with 50, 75 and 100 kg/ha potassium recorded significantly higher vine length (318 cm, 317.50cm and 306.66 cm, respectively) which was on par with the vine length obtained for variety Bhu Krishna with 75 kg/ha potassium applied (306.86 cm).

b) Number of branches per plant

Data on the effect of treatments on number of branches at 20, 40, 60, 80 DAP and at harvest is given in Table 29. Number of branches produced by sweet potato varieties differed significantly and there was no significant variation due to the influence of potassium application.

At 20 DAP, significantly higher number of branches were observed in variety Bhu Krishna (3.58) and variety Kanjanghad Local (3.08) and was at par. At 40, 60, 80 DAP and at harvest, variety Kanjanghad Local recorded significantly higher number of branches (6.66, 9.50, 10.42 and 11.83, respectively) compared to all other varieties.

c) Leaf area index

The data on leaf area index at various growth stages are furnished in Table 30. Significantly higher LAI was registered for variety Kanjanghad Local throughout crop growth period (0.74, 1.55, 2.70, 3.01 and 3.43). The lowest LAI recorded for variety Sree Bhadra (1.33 and 1.49, respectively) at 80 DAP and at harvest.

Significant response to applied potassium was observed at 60, 80 DAP and at harvest. LAI of sweet potato varieties were comparable at 50, 75 and 100 kg per ha potassium application. There was no significant variety x K interaction effect.

d) Leaf chlorophyll content at 60 DAP

Chlorophyll a and total chlorophyll content varied significantly among varieties. It was also influenced by potassium levels (Table 31). However, no significant variation in chlorophyll b could be observed. Among the varieties, significantly higher and comparable chlorophyll a and total chlorophyll were observed in varieties Sree Bhadra (0.89 mg/g fresh weight and 1.14 mg/g fresh weight, respectively), Bhu Krishna (0.84 mg/g and 1.09 mg/g fresh weight, respectively) and Kanjanghad Local (0.84 mg/g and 1.07 mg/g fresh weight, respectively).

K application @ 75 and 100 kg/ha led to significantly higher and comparable chlorophyll a (0.97 mg/g and 0.85 mg/g fresh weight, respectively) and total chlorophyll content (1.20 mg/g and 1.13 mg/g fresh weight, respectively). There was no significant interaction effect.

Table 28 Vine length of sweet potato varieties as influenced by K nutrition

Treatments	Vine length (cm)				
	20 DAP	40 DAP	60 DAP	80 DAP	At harvest
Variety (V)					
V_1 – Bhu Krishna	56.16	140.01	211.69	250.19	285.47
V_2 – Sree Arun	40.97	96.13	138.77	183.34	210.21
V_3 – Sree Bhadra	30.91	63.52	129.53	160.18	192.27
V_4 – Bhu Sona	61.20	169.27	246.44	276.34	308.00
V_5 – Kanjanghad local	27.34	65.55	112.45	172.89	183.06
SEm (±)	0.57	2.64	4.43	6.33	2.33
CD (0.05)	1.62	7.57	12.68	18.13	6.69
K levels (K)					
K_1- 0 kg/ha	39.85	94.26	157.69	197.91	218.35
K_2 – 50 kg/ha	44.49	113.33	176.29	216.01	242.67
K_3 – 75 kg/ha	46.03	114.92	176.78	217.25	245.53
K_4 – 100 kg/ha	42.88	105.08	160.35	203.19	236.66
SEm (±)	0.51	2.37	3.96	5.66	2.09
CD (0.05)	1.45	6.77	11.34	NS	5.99
Interaction (V x K)					
V_1K_1	51.93	121.66	197.00	237.60	250.36
V_1K_2	61.36	146.03	226.10	256.00	292.50
V_1K_3	58.50	156.66	229.67	262.83	306.86
V_1K_4	52.83	135.66	194.00	244.33	292.16
V_2K_1	38.93	90.83	134.33	175.30	201.90
V_2K_2	40.93	103.87	141.33	194.43	211.56
V_2K_3	43.23	95.50	141.77	188.87	218.13
V_2K_4	40.76	94.33	137.67	174.77	209.26
V_3K_1	27.36	54.66	121.00	150.43	184.73
V_3K_2	31.23	65.03	139.50	166.77	196.98
V_3K_3	33.96	70.96	132.63	165.10	197.16
V_3K_4	31.06	63.43	125.00	158.43	190.20
V_4K_1	55.96	150.33	226.00	264.10	289.86
V_4K_2	60.76	177.23	260.50	282.43	318.00
V_4K_3	65.50	182.50	261.17	293.33	317.50
V_4K_4	62.56	167.00	238.10	265.50	306.66
V_5K_1	25.03	53.80	110.13	162.10	164.90
V_5K_2	28.16	74.46	114.00	180.43	194.33
V_5K_3	28.96	68.96	118.67	176.10	187.98
V_5K_4	27.20	64.96	107.00	172.93	185.03
SEm (±)	1.13	5.29	8.86	12.66	4.67
CD (0.05)	3.24	NS	NS	NS	13.39

Table 29 Number of branches of sweet potato varieties as influenced by K nutrition

Treatments	Number of branches				
	20 DAP	40 DAP	60 DAP	80 DAP	At harvest
Variety (V)					
V_1 – Bhu Krishna	3.58	5.50	6.50	6.50	7.50
V_2 – Sree Arun	2.00	4.58	5.75	5.42	5.92
V_3 – Sree Bhadra	2.17	3.83	5.42	5.42	5.50
V_4 – Bhu Sona	2.83	5.33	6.17	6.17	7.00
V_5 – Kanjanghad local	3.08	6.66	9.50	10.42	11.83
SEm (±)	0.20	0.28	0.30	0.38	0.50
CD (0.05)	0.57	0.82	0.87	1.09	1.44
K levels (K)					
K_1- 0 kg/ha	2.60	5.60	6.47	6.40	7.40
K_2 – 50 kg/ha	2.67	4.87	6.60	6.87	7.67
K_3 – 75 kg/ha	2.86	5.06	6.67	6.87	7.80
K_4 – 100 kg/ha	2.80	5.20	6.93	7.00	7.33
SEm (±)	0.18	0.26	0.27	0.34	0.45
CD (0.05)	NS	NS	NS	NS	NS
V x K interaction was non significant					

Table 30 Leaf area index of sweet potato varieties as influenced by K nutrition

Treatments	Leaf Area Index				
	20 DAP	40 DAP	60 DAP	80 DAP	At harvest
Variety (V)					
V_1 – Bhu Krishna	0.39	0.54	1.06	1.33	1.68
V_2 – Sree Arun	0.50	0.65	0.85	1.32	1.56
V_3 – Sree Bhadra	0.44	0.52	0.80	1.33	1.49
V_4 – Bhu Sona	0.45	0.53	1.06	1.58	1.71
V_5 – Kanjanghad local	0.74	1.55	2.70	3.01	3.43
SEm (±)	0.03	0.04	0.09	0.04	0.05
CD (0.05)	0.10	0.12	0.26	0.12	0.15
K levels (K)					
K_1- 0 kg/ha	0.44	0.76	1.10	1.53	1.81
K_2 – 50 kg/ha	0.55	0.84	1.46	1.69	1.99
K_3 – 75 kg/ha	0.52	0.75	1.35	1.83	2.10
K_4 – 100 kg/ha	0.52	0.68	1.26	1.80	2.02
SEm (±)	0.03	0.04	0.08	0.03	0.05
CD (0.05)	NS	NS	0.23	0.10	0.14
V x K interaction was non significant					

Table 31 Chlorophyll a, b and total chlorophyll content of sweet potato varieties as influenced by varied K levels

Treatments	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Total chlorophyll (mg/g)
Variety (V)			
V_1 – Bhu Krishna	0.84	0.25	1.09
V_2 – Sree Arun	0.70	0.24	0.94
V_3 – Sree Bhadra	0.89	0.25	1.14
V_4 – Bhu Sona	0.67	0.18	0.85
V_5 – Kanjanghad local	0.84	0.23	1.07
SEm (±)	0.06	0.03	0.07
CD (0.05)	0.16	NS	0.19
K levels (K)			
K_1- 0 kg/ha	0.57	0.16	0.73
K_2 – 50 kg/ha	0.77	0.24	1.01
K_3 – 75 kg/ha	0.97	0.23	1.20
K_4 – 100 kg/ha	0.85	0.28	1.13
SEm (±)	0.05	0.03	0.06
CD (0.05)	0.15	NS	0.17
V x K interaction was non significant			

e) Dry matter production at different growth stages

Significant variation was noticed among varieties and potassium levels in terms of dry matter production (Table 32). At 20 DAP, variety Sree Arun (6.02 g/plant) registered significantly higher dry matter production and the lowest for variety Kanjanghad Local (4.17 g/plant). At 40 DAP also, significantly higher dry matter was registered for variety Sree Arun (41.44 g/plant). Variety Sree Bhadra (20.27 g/plant) accumulated the lowest dry matter. Varieties Bhu Krishna, Sree Arun, Bhu Sona and Kanjanghad Local produced comparable dry matter at 60 DAP (113.83 g/plant, 123.85 g/plant, 116.88 g/plant and 120.58 g/plant, respectively). But at 80 DAP, variety Sree Arun (202.97 g/plant) and variety Bhu Sona (184.83 g/plant) registered significantly higher and comparable dry matter production.

Potassium applied @ 50, 75 and 100 kg/ha resulted significantly higher and comparable dry matter (5.41 g/plant, 5.56 g/plant and 5.75 g/plant, respectively) over no K at 20 DAP. At 40 DAP, potassium applied @ 50 and 75 kg/ha recorded significantly higher and comparable dry matter (32.54 g/plant and 34.90 g/plant, respectively). At 60 and 80 DAP also, dry matter production increased with increase in potassium doses up to 75 kg/ha. The lowest dry matter was for no potassium which was comparable with 100 kg/ha potassium at both 40 and 80 DAP.

There was significant interaction effect noticed at 40 DAP and variety Sree Arun applied with 50, 75 and 100 kg potassium produced significantly higher dry matter (45.60 g/plant, 44.16 g/plant and 38.93 g/plant, respectively) which was comparable with dry matter production of variety Kanjanghad Local at no potassium and 75 kg potassium and also variety Bhu Krishna with 75 kg applied potassium level. At 80 DAP also, significant interaction effect noticed and variety Sree Arun applied with 75 kg potassium produced higher dry matter (243.22 g/plant) which was on par with 50 kg applied potassium for same variety (217.83 g/plant).

f) Shoot and tuber dry matter production at harvest

Significant variation was observed in shoot and tuber dry matter production (Table 33). Among the varieties, Sree Arun registered significantly higher shoot and tuber dry matter (158.81 g/plant and 271.89 g/plant, respectively). Potassium applied @ 50, 75 and 100 kg/ha recorded significantly higher shoot dry matter, while, 50 and 75 kg/ha potassium doses recorded significantly higher tuber dry matter compared to other doses.

There was significant interaction effect also. Variety Sree Arun with 50, 75 and 100 kg produced significantly higher shoot (170.91 g/plant, 171.41 g/plant and 157.41 g/plant, respectively) and tuber dry matter (284.93 g/plant, 313.86 g/plant and 268.06 g/plant, respectively) compared to other combinations. Shoot and tuber dry matter produced by variety Sree Arun was on par with the dry matter of variety Sree Bhadra applied with 75 kg/ha potassium.

g) Total dry matter production at harvest

Total dry matter production also significantly differed among varieties as influenced by potassium levels (Table 33). Variety Sree Arun resulted significantly higher total dry matter (430.71 g/plant and 15.50 t/ha) compared to other varieties and the lowest total dry matter registered by variety Kanjanghad Local (247.69 g/plant and 8.91 t/ha).

Potassium applied @ 75 kg/ha resulted significantly higher total dry matter (390.34 g/plant and 14.05 t/ha), followed by 50 kg/ha potassium (359.12 g/plant and 12.92 t/ha).

Interaction effect was also significant and variety Sree Arun applied with 50, 75 and 100 kg/ha recorded significantly higher total dry matter (16.41 t/ha, 17.47 t/ha and 15.31 t/ha, respectively). This was on par with total dry matter recorded by variety Sree Bhadra with 75 kg/ha potassium (16.62 t/ha).

h) Fresh herbage yield at harvest

Significant difference was noticed for fresh herbage yield of different varieties applied with varied doses of potassium (Table 34). Significantly higher and comparable fresh herbage yield was obtained by varieties Bhu Sona (26737 kg/ha), Sree Arun (24115 kg/ha) and Kanjanghad Local (23641 kg/ha). Among the potassium levels, significantly higher fresh herbage yield was noticed for 50 kg and 75 kg/ha (25628 kg/ha and 25682 kg/ha, respectively). There was no significant interaction effect.

i) Root- Shoot ratio at 60 DAP

Root to shoot ratio at active growth phase also varied with respect to varieties and potassium doses (Table 34). Higher ratio was noticed for variety Sree Arun (0.85) and variety Bhu Sona (0.83) which were on par. Significantly higher root-shoot ratio was observed for 75 and 50 kg/ha potassium dose (0.85 and 0.75, respectively). There was no significant interaction effect.

Table 32 Dry matter production of sweet potato varieties as influenced by varied K levels

Treatments	Dry matter production (g/plant)			
	20 DAP	40 DAP	60 DAP	80 DAP
Variety (V)				
V_1 – Bhu Krishna	5.16	35.33	113.83	162.63
V_2 – Sree Arun	6.02	41.44	123.85	202.97
V_3 – Sree Bhadra	5.83	20.27	102.62	152.25
V_4 – Bhu Sona	4.69	27.25	116.88	184.83
V_5 – Kanjanghad local	4.17	36.05	120.58	172.79
SEm (±)	0.25	1.28	4.13	7.67
CD (0.05)	0.73	3.66	11.82	21.96
K levels (K)				
K_1- 0 kg/ha	3.98	30.08	105.16	160.53
K_2 – 50 kg/ha	5.41	32.54	120.83	185.99
K_3 – 75 kg/ha	5.56	34.90	122.59	194.11
K_4 – 100 kg/ha	5.75	30.76	113.63	159.75
SEm (±)	0.23	1.14	3.69	6.86
CD (0.05)	0.65	3.27	10.57	19.64
Interaction (V x K)				
V_1K_1	4.08	29.23	101.27	141.83
V_1K_2	5.47	34.86	126.83	195.98
V_1K_3	5.62	42.43	121.37	184.83
V_1K_4	5.48	34.80	105.90	127.90
V_2K_1	4.53	37.06	114.20	167.33
V_2K_2	6.66	45.60	135.00	217.83
V_2K_3	6.71	44.16	129.67	243.22
V_2K_4	6.16	38.93	116.53	183.52
V_3K_1	4.43	16.66	76.33	108.50
V_3K_2	6.28	19.13	106.16	146.16
V_3K_3	5.88	21.16	111.66	184.00
V_3K_4	6.75	24.13	116.33	170.33
V_4K_1	3.67	28.50	118.33	195.50
V_4K_2	4.46	27.16	113.48	179.83
V_4K_3	4.87	27.23	125.83	197.66
V_4K_4	5.75	26.13	109.90	166.33
V_5K_1	3.19	38.96	115.68	189.50
V_5K_2	4.16	35.93	122.66	190.16
V_5K_3	4.74	39.50	124.50	160.83
V_5K_4	4.63	29.80	119.50	150.66
SEm (±)	0.51	2.56	8.25	15.34
CD (0.05)	NS	7.32	NS	43.92

Table 33 Shoot, tuber and total dry matter production of sweet potato varieties at harvest as influenced by varied K levels

Treatments	Dry matter production at harvest (g/plant)			Total dry matter production (t/ha)
	Shoot	Tuber	Total	
Variety (V)				
V_1 – Bhu Krishna	130.35	192.73	323.09	11.63
V_2 – Sree Arun	158.81	271.89	430.71	15.50
V_3 – Sree Bhadra	143.08	208.53	351.61	12.65
V_4 – Bhu Sona	137.33	183.70	321.04	11.55
V_5 – Kanjanghad local	134.39	113.30	247.69	8.91
SEm (±)	3.75	10.97	11.89	0.42
CD (0.05)	10.73	31.41	34.04	1.22
K levels (K)				
K_1- 0 kg/ha	122.81	152.45	275.27	9.91
K_2 – 50 kg/ha	142.56	216.56	359.12	12.92
K_3 – 75 kg/ha	152.15	238.19	390.34	14.05
K_4 – 100 kg/ha	145.65	168.92	314.57	11.32
SEm (±)	3.35	9.81	10.63	0.38
CD (0.05)	9.60	28.10	30.44	1.09
Interaction (V x K)				
V_1K_1	118.58	116.82	235.40	8.47
V_1K_2	132.91	239.73	372.65	13.41
V_1K_3	143.25	238.44	381.69	13.74
V_1K_4	126.66	175.95	302.62	10.89
V_2K_1	135.50	220.73	356.23	12.82
V_2K_2	170.91	284.93	455.85	16.41
V_2K_3	171.41	313.86	485.28	17.47
V_2K_4	157.41	268.06	425.47	15.31
V_3K_1	106.16	134.91	241.08	8.67
V_3K_2	135.50	236.53	372.03	13.39
V_3K_3	159.66	302.13	461.80	16.62
V_3K_4	171.00	160.53	331.53	11.93
V_4K_1	127.75	194.35	322.10	11.59
V_4K_2	141.00	201.33	342.33	12.32
V_4K_3	143.91	199.86	343.78	12.37
V_4K_4	136.66	139.27	275.94	9.93
V_5K_1	126.08	95.46	221.55	7.97
V_5K_2	132.50	120.27	252.76	9.10
V_5K_3	142.50	136.67	279.16	10.05
V_5K_4	136.50	100.80	237.30	8.54
SEm (±)	7.50	21.94	23.78	0.85
CD (0.05)	21.47	62.83	68.08	2.45

Table 34 Fresh herbage yield at harvest and root-shoot ratio of sweet potato varieties at harvest as influenced by varied K levels

Treatments	Fresh herbage yield (kg/ha)	Root-shoot ratio at 60 DAP
Variety (V)		
V_1 – Bhu Krishna	21881	0.59
V_2 – Sree Arun	24115	0.85
V_3 – Sree Bhadra	18927	0.71
V_4 – Bhu Sona	26737	0.83
V_5 – Kanjanghad local	23641	0.51
SEm (±)	1341	0.04
CD (0.05)	3842	0.12
K levels (K)		
K_1- 0 kg/ha	20216	0.50
K_2 – 50 kg/ha	25628	0.75
K_3 – 75 kg/ha	25682	0.85
K_4 – 100 kg/ha	20714	0.69
SEm (±)	1200	0.04
CD (0.05)	3436	0.11
V x K interaction was non significant		

4.2.2 Yield and yield parameters

a) Number of tubers per plant

Significant difference was observed in number of tubers produced per plant (Table 35). Variety Bhu Krishna (3.66) as well as variety Sree Arun (3.58) produced significantly higher and comparable number of tubers. Number of tubers recorded by other three varieties ie. Sree Bhadra, Bhu Sona and Kanjanghad Local were on par with each other with an average tuber number of 2.41 per plant.

Potassium applied @ 50, 75 and 100 kg/ha recorded higher and comparable number of tubers (3.33, 3.26 and 2.60, respectively). There was no interaction effect noticed between treatment combinations.

b) Average weight of tuber

Data pertaining to the average weight of tuber produced by sweet potato varieties as influenced by potassium levels is given in Table 35. Variety Sree Arun recorded significantly higher average weight of tuber (262.62 g). All the other four varieties (Bhu

Krishna, Sree Bhadra, Bhu Sona and Kanjanghad Local) were on par with each other with respect to average tuber weight.

Application of 50 kg and 75 kg/ha potassium resulted in maximum average weight of tuber (192.37 g and 188.95 g, respectively) which was significantly higher than other potassium levels. There was no significant interaction effect noticed.

c) Tuber yield per plant

Significant variation observed for tuber yield produced per plant among varieties as well as with applied potassium doses (Table 36). The highest tuber yield per plant was registered for variety Sree Arun (679.74 g/plant) which differed significantly from other varieties. Performance of variety Kanjanghad Local was inferior with the lowest tuber yield of 283.25 g/plant.

Potassium application @ 50 kg as well as 75 kg/ha resulted in higher and statistically comparable tuber yield per plant (541.40 g/plant and 595.48 g/plant, respectively), whereas when no potassium was applied, the least tuber yield per plant (381.14 g/plant) was realized.

Interaction effect was also significant. Variety Sree Arun applied with 50, 75 and 100 kg potassium per ha recorded significantly higher and comparable tuber yield per plant (712.33 g/plant, 784.66 g/plant and 670.15 g/plant, respectively). Tuber yield of variety Sree Bhadra applied with 75 kg potassium (755.33 g/plant) was also comparable to this. Variety Kanjanghad Local recorded significantly lower tuber yield per plant at all potassium levels.

d) Weight of unmarketable tuber per plant

Significant variation was noticed in unmarketable tuber yield per plant of sweet potato varieties (Table 36). Unmarketable tuber yield was higher for variety Bhu Krishna (64.38 g/plant) which was significantly different from other varieties. Variety Kanjanghad Local had the lowest unmarketable tuber yield per plant (37.58 g/plant).

Among the potassium doses, significantly higher unmarketable tuber yield was recorded at 100 kg/ha (62.86 g/plant) compared to lower doses. While comparing the treatment combinations, variety Sree Arun with 100 kg/ha potassium level recorded significantly higher unmarketable tuber yield (78.66 g/plant) which was on par with variety Bhu Krishna and variety Sree Bhadra without any potassium fertilizer application (72.20 g/plant and 67.66 g/plant, respectively).

Table 35 Number of tubers per plant and average weight of tuber of sweet potato varieties as influenced by varied K levels

Treatments	Average weight of tuber (g)	No. of tubers/plant
Variety (V)		
V_1 – Bhu Krishna	130.23	3.66
V_2 – Sree Arun	262.62	3.58
V_3 – Sree Bhadra	162.12	2.41
V_4 – Bhu Sona	139.20	2.16
V_5 – Kanjanghad local	109.75	2.66
SEm (±)	20.6	0.31
CD (0.05)	58.97	0.88
K levels (K)		
K_1- 0 kg/ha	126.38	2.40
K_2 – 50 kg/ha	192.37	3.33
K_3 – 75 kg/ha	188.95	3.26
K_4 – 100 kg/ha	135.44	2.60
SEm (±)	18.42	0.27
CD (0.05)	52.75	0.78
V x K interaction was non significant		

e) Marketable tuber yield

Data on marketable tuber yield of sweet potato is furnished in Table 37. Variety Sree Arun performed better with significantly higher marketable tuber yield of 22.15 t/ha and lowest yield was recorded by variety Kanjanghad Local (9.06 t/ha).

Potassium applied @ 50 kg and 75 kg/ha resulted in significantly higher as well as comparable marketable tuber yield (17.57 t/ha and 18.56 /ha, respectively).

There was significant interaction effect. Variety Sree Arun with 75 kg/ha potassium recorded significantly higher marketable tuber yield (26.82 t/ha). The performance of this variety at potassium doses of 50 kg and 100 kg/ha was also good. Variety Sree Bhadra also produced the highest yield at 75 kg/ha potassium dose.

f) Total tuber yield

Significant variation was noted in total tuber yield of sweet potato varieties (Table 37). Variety Sree Arun produced the superior tuber yield of 23.92 t/ha and the lowest total tuber yield was for variety Kanjanghad Local (10.40 t/ha).

Significantly higher tuber yield was realised with potassium applied @ 50 kg and 75 kg/ha (19.11 t/ha and 20.17 t/ha, respectively) which were at par. The lowest tuber yield was observed when no K was applied (13.48 t/ha).

The same trend as that of marketable tuber yield was observed in the case of total tuber yield, with respect to variety x K interaction. Significantly higher tuber yield was realised for variety Sree Arun with 75 kg/ha applied potassium (27.90 t/ha), which was followed by potassium applied @ 50 kg and 100 kg/ha for the same variety (24.32 t/ha and 23.82 t/ha, respectively) and also for variety Sree Bhadra applied with 50 kg and 75 kg/ha potassium (21.02 t/ha and 23.19 t/ha, respectively).

g) Harvest Index (HI)

Harvest index differed significantly and variety Sree Arun had significantly higher HI of 0.66 compared to other varieties (Table 37). The lowest value of 0.45 was recorded for variety Kanjanghad Local.

Potassium nutrition also significantly affected the harvest index and potassium applied @ 50 and 75 kg/ha registered the higher values of HI (0.62 and 0.63, respectively), which were at par.

Significant difference was observed in the case of treatment combinations. Significantly higher HI at various levels of potassium was observed for varieties Sree Arun and Sree Bhadra. Significantly higher HI obtained for variety Sree Bhadra with 75 kg/ha potassium (0.68), which was on par with potassium @ 50 kg/ha for the same variety (0.67) and also for variety Sree Arun applied with all potassium levels. Variety Bhu Krishna also registered higher HI at increased K levels.

Table 36 Tuber yield per plant and weight of unmarketable tuber per plant of sweet potato varieties as influenced by K nutrition

Treatments	Tuber yield per plant (g/plant)	Weight of unmarketable tuber per plant (g/plant)
Variety (V)		
V_1 – Bhu Krishna	481.84	64.38
V_2 – Sree Arun	679.74	49.75
V_3 – Sree Bhadra	521.32	55.16
V_4 – Bhu Sona	459.26	48.41
V_5 – Kanjanghad local	283.25	37.58
SEm (±)	27.43	2.19
CD (0.05)	78.54	6.29
K levels (K)		
K_1- 0 kg/ha	381.14	52.77
K_2 – 50 kg/ha	541.40	43.40
K_3 – 75 kg/ha	595.48	45.20
K_4 – 100 kg/ha	422.31	62.86
SEm (±)	24.54	1.96
CD (0.05)	70.25	5.63
Interaction (V x K)		
V_1K_1	292.05	72.20
V_1K_2	599.33	62.33
V_1K_3	596.11	61.66
V_1K_4	439.88	61.33
V_2K_1	551.83	55.00
V_2K_2	712.33	35.00
V_2K_3	784.66	30.33
V_2K_4	670.15	78.66
V_3K_1	337.29	67.66
V_3K_2	591.33	43.00
V_3K_3	755.33	48.33
V_3K_4	401.33	61.66
V_4K_1	485.88	32.00
V_4K_2	503.33	45.33
V_4K_3	499.66	54.66
V_4K_4	348.18	61.66
V_5K_1	238.66	37.00
V_5K_2	300.66	31.33
V_5K_3	341.66	31.00
V_5K_4	252.00	51.00
SEm (±)	54.87	4.39
CD (0.05)	157.09	12.58

4.2.3 Quality parameters of tuber

a) Crude fibre

Quality of tuber varied among varieties and with potassium levels. There was significant difference in crude fibre content (Table 38) and the highest crude fibre content was noted for variety Kanjanghad Local (14.23 %), followed by variety Sree Arun (12.90 %). Significantly lower crude fibre was for variety Bhu Krishna (4.20 %).

Crude fibre content increased with increase in potassium and potassium applied @ 75 and 100 kg/ha registered higher and comparable crude fibre content (10.94 % and 11.30 %, respectively) compared to other potassium levels. Interaction effect also was significant. Variety Kanjanghad Local recorded significantly higher and comparable crude fibre content (15.38 %, 15.94 % and 15.11 %, respectively) with varied K fertilizer application rates compared to others. Significantly lower crude fibre was noticed for variety Bhu Krishna with no potassium application (2.28 %).

b) Crude protein

Significant variation among varieties and potassium levels (Table 38) could be observed. Variety Bhu Sona had significantly higher crude protein (10.21 %), followed by varieties Bhu Krishna (8.58 %), Sree Arun (8.21 %) and Sree Bhadra (8.67 %). Among the potassium levels, higher crude protein was noticed when 50 kg or 75 kg/ha potassium doses were applied (9.70 % and 9.64 %, respectively) which were significantly superior.

Significant variation was noticed among different treatment combinations also. Higher crude protein was registered for variety Bhu Sona (no potassium, 50 kg and 75 kg/ha potassium) which was comparable with values obtained for variety Bhu Krishna @ 50 and 75 kg/ha applied potassium levels (10.96 % and 9.97 %, respectively), variety Sree Arun @ 50 kg/ha potassium (9.89 %) and variety Sree Bhadra @ 100 kg/ha potassium (10.01 %).

Table 37 Marketable tuber yield, total tuber yield and harvest index of sweet potato varieties as influenced by varied K levels

Treatments	Marketable tuber yield (t/ha)	Total tuber yield (t/ha)	Harvest Index
Variety (V)			
V_1 – Bhu Krishna	14.43	16.71	0.61
V_2 – Sree Arun	22.15	23.92	0.66
V_3 – Sree Bhadra	15.99	17.95	0.60
V_4 – Bhu Sona	14.36	16.00	0.59
V_5 – Kanjanghad local	9.06	10.40	0.45
SEm (±)	0.62	0.61	0.02
CD (0.05)	1.763	1.75	0.04
K levels (K)			
K_1- 0 kg/ha	11.61	13.48	0.54
K_2 – 50 kg/ha	17.57	19.11	0.62
K_3 – 75 kg/ha	18.56	20.17	0.63
K_4 – 100 kg/ha	13.05	15.28	0.55
SEm (±)	0.55	0.54	0.01
CD (0.05)	1.58	1.56	0.04
Interaction (V x K)			
V_1K_1	8.48	11.05	0.48
V_1K_2	18.09	20.31	0.67
V_1K_3	17.67	19.86	0.65
V_1K_4	13.46	15.64	0.61
V_2K_1	17.66	19.62	0.65
V_2K_2	23.08	24.32	0.65
V_2K_3	26.82	27.90	0.68
V_2K_4	21.03	23.82	0.66
V_3K_1	9.58	11.99	0.57
V_3K_2	19.49	21.02	0.67
V_3K_3	21.47	23.19	0.68
V_3K_4	13.41	15.60	0.51
V_4K_1	16.12	17.27	0.62
V_4K_2	15.28	16.89	0.60
V_4K_3	15.82	17.76	0.61
V_4K_4	10.18	12.38	0.53
V_5K_1	6.17	7.48	0.40
V_5K_2	11.91	13.02	0.46
V_5K_3	11.04	12.14	0.51
V_5K_4	7.14	8.96	0.44
SEm (±)	1.23	1.22	0.03
CD (0.05)	3.52	3.49	0.08

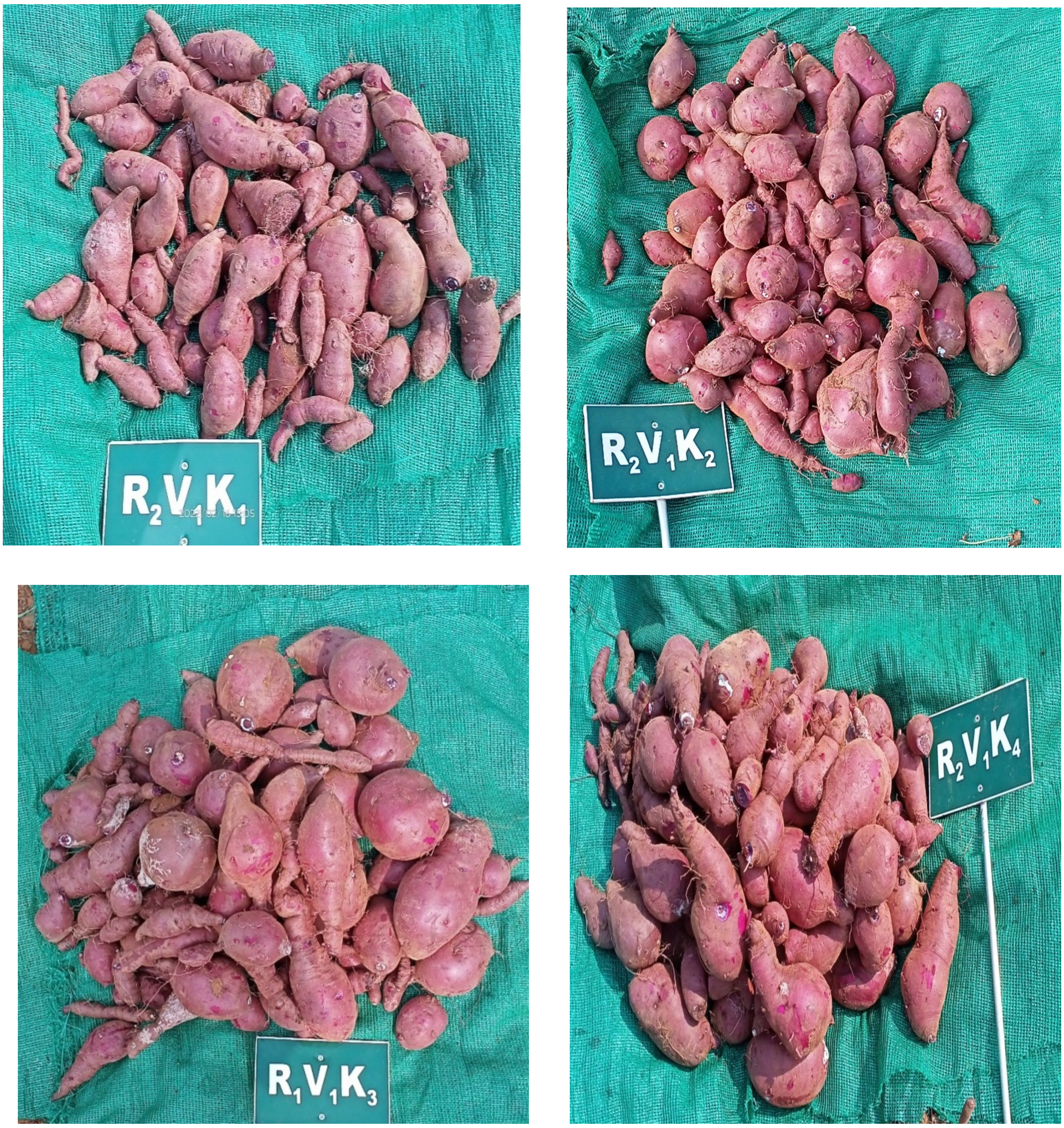


Plate 15. Effect of varied K levels on tuber yield of variety Bhu Krishna

Plate 16. Effect of varied K levels on tuber yield of variety Sree Arun

Plate 17. Effect of varied K levels on tuber yield of variety Sree Bhadra

Plate 18. Effect of varied K levels on tuber yield of variety Bhu Sona

Plate 19. Effect of varied K levels on tuber yield of variety Kanjanghad Local

c) Reducing, non reducing and total sugar

Reducing, non reducing and total sugar content of tuber are given in Table 39. The highest reducing sugar was recorded in variety Bhu Sona (3.53 %), which was significantly higher than other varieties. Significantly lower reducing sugar content was recorded for variety Kanjanghad Local (0.90 %). But, non reducing sugar was the highest for variety Sree Arun (6.09 %), followed by variety Bhu Krishna (4.77 %). The lowest value was recorded for variety Bhu Sona (1.42 %). Similar to non reducing sugar, significantly higher total sugar was recorded for variety Sree Arun (7.86 %) followed by Bhu Krishna (6.42 %) and lowest in variety Kanjanghad Local (2.99 %).

The data pertaining to sugar content as influenced by various potassium levels indicated that sugar content increased with increasing potassium doses and significantly higher reducing sugar (2.06 %), non reducing sugar (3.73 %) and total sugar (5.78 %) were recorded for potassium @ 100 kg/ha which was on par with 75 kg/ha potassium (2.12 %, 3.74 % and 5.86 %, respectively). Significantly lower values were recorded when no potassium was applied (1.28 %, 2.65 % and 3.93 %, respectively).

Interaction between variety x K was also significant and higher total sugar content was observed for variety Sree Arun applied with 50, 75 and 100 kg/ha potassium doses which was significantly higher than all other treatment combinations.

d) Starch content

Starch content also increased with increase in potassium level and it varied with varieties (Table 40). Variety Kanjanghad Local (32.46 %) had significantly higher starch content followed by variety Sree Arun (30.49 %) and Sree Bhadra (24.75 %). Variety Bhu Krishna registered the lowest starch content of 16.71 %. Potassium application @ 75 and 100 kg/ha led to significantly higher starch content (25.54 % and 26.18 % respectively) compared to no potassium level (22.31 %). Interaction effect was non significant.

Table 38 Crude fibre and crude protein content of sweet potato varieties as influenced by varied K levels

Treatments	Crude fibre (%)	Crude protein (%)
Variety (V)		
V_1 – Bhu Krishna	4.20	8.58
V_2 – Sree Arun	12.90	8.21
V_3 – Sree Bhadra	11.59	8.67
V_4 – Bhu Sona	8.42	10.21
V_5 – Kanjanghad local	14.23	7.33
SEm (±)	0.29	0.24
CD (0.05)	0.83	0.71
K levels (K)		
K_1- 0 kg/ha	8.29	6.28
K_2 – 50 kg/ha	10.45	9.70
K_3 – 75 kg/ha	10.94	9.64
K_4 – 100 kg/ha	11.30	8.78
SEm (±)	0.26	0.22
CD (0.05)	0.74	0.63
Interaction (V x K)		
V_1K_1	2.28	5.19
V_1K_2	3.75	10.96
V_1K_3	4.91	9.97
V_1K_4	5.86	8.19
V_2K_1	10.93	5.78
V_2K_2	13.24	9.89
V_2K_3	13.39	9.05
V_2K_4	14.03	8.11
V_3K_1	10.84	5.92
V_3K_2	11.51	9.29
V_3K_3	11.59	9.47
V_3K_4	12.43	10.01
V_4K_1	6.89	10.40
V_4K_2	8.38	10.35
V_4K_3	8.86	10.97
V_4K_4	9.55	9.12
V_5K_1	10.48	4.09
V_5K_2	15.38	7.99
V_5K_3	15.94	8.77
V_5K_4	15.11	8.45
SEm (±)	0.58	0.49
CD (0.05)	1.66	1.42

e) Moisture content

Variety Bhu Krishna recorded significantly higher moisture content of 63.54 per cent compared to all other varieties (Table 40). Moisture content of varieties Sree Arun (57.99 %) and Sree Bhadra (56.56 %) were on par with each other. Comparing moisture content influenced by potassium levels, significantly higher and comparable moisture content was registered for potassium dose @ 75 and 100 kg/ha (59.42 % and 59.58 %, respectively). There was significant interaction effect between varieties and potassium levels. Significantly higher and comparable moisture content was registered for variety Bhu Krishna applied with 75 and 100 kg/ha potassium (67.51 % and 68.05 %, respectively).

4.2.4 Plant analysis

a) The content of primary nutrients in index leaf

Data pertaining to the primary nutrient status of index leaf at 60 DAP is given in Table 41. Among the nutrients, nitrogen content was significantly higher for the variety Sree Arun and variety Kanjanghad Local (8.08 % and 7.96 %, respectively). While, nitrogen content showed a decreasing trend from no potassium to 100 kg/ha K application (7.24 % to 8.14 %). There was significant interaction effect also and nitrogen content was significantly higher for variety Sree Arun applied with 50 kg/ha potassium (8.76 %) which was on par with variety Sree Bhadra at no potassium (8.76 %) and variety Kanjanghad Local at no potassium and 75 kg/ha potassium (8.95 % and 8.66 %, respectively).

Leaf phosphorus content also varied significantly and variety Kanjanghad Local had significantly higher P content (0.30 %) compared to other varieties. There was significant interaction effect and variety Sree Arun applied with 75 kg/ha and no potassium recorded higher P content on index leaves (0.33 % and 0.31 %, respectively). This was on par with P content of variety Sree Bhadra with 75 kg/ha potassium (0.34 %) and variety Kanjanghad Local with no potassium and 50 kg/ha potassium (0.34 % each).

Leaf potassium content was significantly higher for variety Sree Arun (5.16 %), which was on par with variety Bhu Sona (5.01 %). Potassium concentration of the index leaf increased with increase in K application up to 75 kg/ha (5.42 %) and then showed a decline. Comparing the interaction of treatment combinations, variety Sree Arun applied with 75 kg and 100 kg/ha potassium recorded significantly higher K concentration (5.85 % and 5.54 %, respectively), which was comparable with variety Bhu Sona with potassium applied @ 75 kg/ha (5.78 %).

Table 39 Reducing, non reducing and total sugar content of sweet potato varieties as influenced by varied K levels

Treatments	Reducing sugar (%)	Non reducing sugar (%)	Total sugar (%)
Variety (V)			
V_1 – Bhu Krishna	1.65	4.77	6.42
V_2 – Sree Arun	1.76	6.09	7.86
V_3 – Sree Bhadra	1.45	2.27	3.73
V_4 – Bhu Sona	3.53	1.42	4.94
V_5 – Kanjanghad local	0.90	2.09	2.99
SEm (±)	0.065	0.077	0.109
CD (0.05)	0.19	0.221	0.311
K levels (K)			
K_1- 0 kg/ha	1.28	2.65	3.93
K_2 – 50 kg/ha	1.98	3.21	5.18
K_3 – 75 kg/ha	2.12	3.74	5.86
K_4 – 100 kg/ha	2.06	3.73	5.78
SEm (±)	0.058	0.069	0.097
CD (0.05)	0.17	0.198	0.278
Interaction (V x K)			
V_1K_1	1.04	3.75	4.79
V_1K_2	1.84	4.82	6.66
V_1K_3	1.94	5.31	7.24
V_1K_4	1.77	5.20	6.97
V_2K_1	1.16	5.39	6.55
V_2K_2	1.96	6.17	8.14
V_2K_3	2.02	6.53	8.55
V_2K_4	1.90	6.29	8.19
V_3K_1	0.96	1.62	2.58
V_3K_2	1.48	1.83	3.31
V_3K_3	1.69	2.79	4.49
V_3K_4	1.67	2.86	4.53
V_4K_1	2.58	0.80	3.38
V_4K_2	3.65	1.22	4.87
V_4K_3	3.91	1.78	5.69
V_4K_4	3.95	1.86	5.81
V_5K_1	0.63	1.69	2.32
V_5K_2	0.94	1.99	2.93
V_5K_3	1.04	2.26	3.31
V_5K_4	1.00	2.41	3.41
SEm (±)	0.13	0.155	0.217
CD (0.05)	NS	NS	0.622

Table 40 Starch and moisture content of sweet potato varieties as influenced by varied K levels

Treatments	Starch content (%)	Moisture content (%)
Variety (V)		
V_1 – Bhu Krishna	16.71	63.54
V_2 – Sree Arun	30.49	57.99
V_3 – Sree Bhadra	24.75	56.56
V_4 – Bhu Sona	18.77	55.64
V_5 – Kanjanghad local	32.46	55.13
SEm (±)	0.37	0.50
CD (0.05)	1.07	1.44
K levels (K)		
K_1- 0 kg/ha	22.31	53.92
K_2 – 50 kg/ha	24.50	58.17
K_3 – 75 kg/ha	25.54	59.42
K_4 – 100 kg/ha	26.18	59.58
SEm (±)	0.33	0.45
CD (0.05)	0.95	1.30
Interaction (V x K)		
V_1K_1	14.52	58.58
V_1K_2	16.08	60.03
V_1K_3	17.72	67.51
V_1K_4	18.53	68.05
V_2K_1	27.74	55.15
V_2K_2	30.00	60.04
V_2K_3	31.84	57.48
V_2K_4	32.37	59.31
V_3K_1	21.05	53.88
V_3K_2	25.42	60.53
V_3K_3	25.86	56.04
V_3K_4	26.66	55.80
V_4K_1	17.04	51.01
V_4K_2	18.39	55.46
V_4K_3	19.80	61.73
V_4K_4	19.84	54.38
V_5K_1	31.23	51.00
V_5K_2	32.64	54.80
V_5K_3	32.49	54.35
V_5K_4	33.48	60.37
SEm (±)	0.74	1.01
CD (0.05)	NS	2.88

Table 41 Primary nutrient content of index leaf of sweet potato varieties at 60 DAP as influenced by varied K levels

Treatments	N content (%)	P content (%)	K content (%)
Variety (V)			
V_1 – Bhu Krishna	7.09	0.23	4.93
V_2 – Sree Arun	8.08	0.28	5.16
V_3 – Sree Bhadra	7.25	0.26	4.83
V_4 – Bhu Sona	7.51	0.25	5.01
V_5 – Kanjanghad local	7.96	0.30	4.93
SEm (±)	0.06	0.01	0.06
CD (0.05)	0.17	0.02	0.17
K levels (K)			
K_1- 0 kg/ha	8.14	0.27	4.02
K_2 – 50 kg/ha	7.63	0.25	5.26
K_3 – 75 kg/ha	7.29	0.27	5.42
K_4 – 100 kg/ha	7.24	0.27	5.18
SEm (±)	0.05	0.01	0.05
CD (0.05)	0.15	NS	0.16
Interaction (V x K)			
V_1K_1	7.52	0.24	4.07
V_1K_2	6.81	0.19	5.12
V_1K_3	7.85	0.19	5.16
V_1K_4	6.19	0.27	5.38
V_2K_1	8.57	0.31	3.75
V_2K_2	8.76	0.21	5.49
V_2K_3	7.39	0.33	5.85
V_2K_4	7.61	0.25	5.54
V_3K_1	8.76	0.19	4.18
V_3K_2	7.47	0.23	5.44
V_3K_3	5.52	0.34	5.03
V_3K_4	7.24	0.29	4.66
V_4K_1	6.90	0.23	4.05
V_4K_2	7.30	0.30	5.07
V_4K_3	7.07	0.22	5.78
V_4K_4	8.76	0.26	5.11
V_5K_1	8.95	0.34	4.07
V_5K_2	7.83	0.34	5.16
V_5K_3	8.66	0.25	5.27
V_5K_4	6.39	0.25	5.23
SEm (±)	0.12	0.01	0.12
CD (0.05)	0.33	0.03	0.35

b) Primary nutrient status of shoot and tuber at harvest

Nitrogen, phosphorus and potassium content of both aerial portion and tuber varied among varieties with different potassium levels (Table 42).

Nitrogen

The nitrogen content in sweet potato varieties ranged from 3.88 to 4.90 per cent in shoot and 1.17 to 1.63 per cent in tuber. Significant difference was observed and higher nitrogen concentration in shoot was recorded for variety Bhu Krishna, Sree Arun and Kanjanghad Local were at par (4.56 %). But, tuber nitrogen content was significantly higher for the variety Bhu Sona (1.63 %). Tuber N concentration was significantly higher and comparable for potassium applied @ 50 and 75 kg/ha (1.55 % and 1.54 %, respectively).

Interaction effect was significant for shoot and tuber nitrogen content. Significantly higher shoot nitrogen content was recorded for varieties Bhu Krishna when no potassium was applied and 75 kg/ha (5.47 % and 6.85 %, respectively) and also for variety Sree Arun with K applied @ 0 and 100 kg/ha (5.99 % and 5.80 %, respectively). Tuber N content was significantly higher for varieties Bhu Krishna, Sree Arun, Sree Bhadra and Bhu Sona at varied K levels.

Phosphorus

The phosphorus content in sweet potato varieties ranged from 0.07 to 0.13 per cent in shoot and 0.14 to 0.23 per cent in tuber. Among the varieties, Bhu Krishna, Sree Bhadra and Bhu Sona had significantly higher phosphorus content in shoot (0.13 %, 0.12 % and 0.11 %, respectively). But, Tuber P content was significantly higher for variety Sree Arun (0.22 %), on par with variety Sree Bhadra (0.23 %). Among the potassium levels, significantly higher tuber phosphorus content was noticed for 50 kg/ha potassium level (0.21 %) compared to other doses.

Interaction between different factors was also significant and varieties Bhu Krishna, Sree Arun, Sree Bhadra and Bhu Sona recorded significantly higher shoot P content at different K levels. While, tuber P content was significantly higher for varieties Sree Arun and Sree Bhadra applied with 50 kg/ha potassium (0.29 % and 0.31 % respectively).

Potassium

The potassium content in sweet potato varieties ranged from 2.70 to 4.44 per cent in shoot and 0.88 to 1.70 per cent in tuber. Shoot potassium concentration significantly differed among varieties and variety Sree Bhadra recorded higher K concentration (4.44 %) compared to other varieties. Potassium content in shoot showed an increasing trend with increase in K application. Significantly higher value was noticed for potassium applied @ 100 kg/ha (4.69 %), which was followed by 75 and 50 kg/ha (4.16 % and 3.12 %, respectively).

While considering potassium content in tuber, there was significant difference observed among varieties and potassium rates. The potassium content of the tubers of the variety Sree Arun was much higher (1.70 %), followed by varieties Bhu Sona (1.34 %) and Bhu Krishna (1.37 %). The potassium concentration in tubers and shoots showed a similar trend. 100 kg/ha of applied potassium had a significantly higher tuber K content (1.60 %), which was comparable to potassium level of 75 kg/ha (1.58 %).

In the case of interaction between factors, variety Sree Arun under 50, 75 and 100 kg/ha potassium gave significantly higher tuber K concentrations, which was comparable with variety Bhu Sona applied with 100 kg/ha potassium (1.66 %).

c) Primary nutrient uptake by shoot and tuber at harvest

Nitrogen

Among the varieties, nitrogen uptake by shoot and tuber was more for variety Sree Arun (274.86 kg/ha and 125.73 kg/ha, respectively). Nitrogen uptake by aerial portions did not vary with potassium levels. But, potassium applied @ 50 and 75 kg/ha resulted significantly higher tuber N uptake irrespective of varieties (121.49 kg/ha and 130.97 kg/ha). There was also significant interaction effect between varieties at different K levels (Table 43).

Table 42 N, P, K content of shoot and tuber at harvest as influenced by varied K

Treatments	Nitrogen (%)		Phosphorus (%)		Potassium (%)	
	Shoot	Tuber	Shoot	Tuber	Shoot	Tuber
Variety (V)						
V_1 – Bhu Krishna	4.67	1.37	0.13	0.14	3.32	1.37
V_2 – Sree Arun	4.90	1.31	0.08	0.22	2.70	1.70
V_3 – Sree Bhadra	3.88	1.38	0.12	0.23	4.44	1.27
V_4 – Bhu Sona	3.93	1.63	0.11	0.15	3.86	1.34
V_5 – Kanjanghad local	4.13	1.17	0.07	0.14	3.09	0.88
SEm (±)	0.27	0.04	0.01	0.01	0.14	0.06
CD (0.05)	0.78	0.11	0.02	0.02	0.41	0.17
K levels (K)						
K_1- 0 kg/ha	4.53	1.01	0.11	0.18	1.96	0.75
K_2 – 50 kg/ha	4.10	1.55	0.09	0.21	3.12	1.32
K_3 – 75 kg/ha	4.36	1.54	0.09	0.17	4.16	1.58
K_4 – 100 kg/ha	4.23	1.40	0.10	0.15	4.69	1.60
SEm (±)	0.24	0.03	0.01	0.01	0.12	0.05
CD (0.05)	NS	0.10	NS	0.02	0.36	0.15
Interaction (V x K)						
V_1K_1	5.47	0.83	0.15	0.13	2.35	0.97
V_1K_2	3.43	1.75	0.11	0.17	2.51	1.10
V_1K_3	6.85	1.59	0.11	0.15	3.29	1.66
V_1K_4	2.95	1.31	0.15	0.12	5.12	1.75
V_2K_1	5.99	0.92	0.09	0.15	1.33	0.79
V_2K_2	4.18	1.58	0.11	0.29	2.16	1.98
V_2K_3	3.61	1.44	0.05	0.27	3.97	2.08
V_2K_4	5.80	1.29	0.06	0.17	3.35	1.96
V_3K_1	3.33	0.94	0.11	0.21	2.21	0.73
V_3K_2	4.76	1.48	0.13	0.31	4.61	1.28
V_3K_3	4.66	1.51	0.15	0.25	5.46	1.50
V_3K_4	2.76	1.60	0.09	0.15	5.46	1.56
V_4K_1	3.64	1.66	0.14	0.24	2.21	0.96
V_4K_2	3.80	1.65	0.08	0.11	3.68	1.23
V_4K_3	3.42	1.75	0.08	0.09	4.58	1.51
V_4K_4	4.85	1.46	0.13	0.16	5.00	1.66
V_5K_1	4.18	0.65	0.08	0.17	1.70	0.31
V_5K_2	4.32	1.28	0.05	0.16	2.63	1.01
V_5K_3	3.23	1.40	0.07	0.10	3.49	1.13
V_5K_4	4.76	1.35	0.06	0.14	4.52	1.09
SEm (±)	0.54	0.08	0.02	0.01	0.28	0.12
CD (0.05)	1.56	0.23	0.05	0.04	0.81	0.35

Phosphorus

Shoot phosphorus uptake was more in the case of variety Bhu Krishna (6.01 kg/ha) and variety Sree Bhadra (6.29 kg/ha), which was on par with variety Bhu Sona (5.28 kg/ha). There was no significant influence of K application on shoot P uptake. Among the treatment combinations, variety Bhu Krishna with potassium applied @ 0 and 100 kg/ha significantly resulted higher P uptake which was on par with variety Sree Arun applied with 50 kg/ha potassium, variety Sree Bhadra with 50 and 75 kg/ha K and variety Bhu Sona with no potassium. In the case of tuber P uptake, variety Sree Arun recorded significantly higher value (22.43 kg/ha). Potassium applied @ 50 and 75 kg/ha obtained higher P uptake among different K levels (17.36 kg/ha and 16.52 kg/ha, respectively). There was significant interaction effect noticed and varieties Sree Arun (30.53 kg/ha and 30.39 kg/ha, respectively) and Sree Bhadra (26.74 kg/ha and 26.91 kg/ha, respectively) applied with 50 and 75 kg/ha potassium recorded significantly higher tuber P uptake.

Potassium

There was significant variation noticed for potassium uptake by sweet potato varieties (Table 43). The highest uptake of potassium (tuber and shoot) was registered for varieties Sree Arun and Sree Bhadra. Shoot potassium uptake increased with increase in K levels and maximum uptake was noticed for both 75 and 100 kg/ha K levels (219.25 kg/ha and 231.75 kg/ha, respectively). While for tuber K uptake, maximum value noticed for the potassium applied @ 75 kg/ha (113.77 kg/ha).

Comparing the treatment combinations, variety Sree Bhadra registered significantly higher shoot K uptake with potassium applied @ 75 and 100 kg/ha. While tuber K uptake was more for variety Sree Arun applied with 50 and 75 kg/ha potassium.

Table 43 N, P, K uptake of sweet potato varieties as influenced by varied K levels

Treatments	N uptake (kg/ha)		P uptake (kg/ha)		K uptake (kg/ha)	
	Shoot	Tuber	Shoot	Tuber	Shoot	Tuber
Variety (V)						
V_1 – Bhu Krishna	221.75	101.06	6.01	10.10	148.68	79.36
V_2 – Sree Arun	274.86	125.73	4.45	22.43	153.15	147.07
V_3 – Sree Bhadra	200.13	107.42	6.29	18.07	224.16	79.12
V_4 – Bhu Sona	193.58	108.53	5.28	10.01	188.67	68.53
V_5 – Kanjanghad local	199.45	48.84	3.36	6.02	146.50	26.22
SEm (±)	16.35	5.63	0.48	1.00	9.17	4.43
CD (0.05)	46.83	16.11	1.39	2.88	26.28	12.70
K levels (K)						
K_1- 0 kg/ha	201.85	57.50	5.06	10.22	83.74	30.31
K_2 – 50 kg/ha	209.63	121.49	4.90	17.36	154.20	89.28
K_3 – 75 kg/ha	237.63	130.97	5.24	16.52	219.25	113.77
K_4 – 100 kg/ha	222.70	83.30	5.11	9.20	231.75	86.87
SEm (±)	14.63	5.03	0.43	0.90	8.21	3.96
CD (0.05)	NS	14.41	NS	2.57	23.50	11.36
Interaction (V x K)						
V_1K_1	235.75	33.54	6.27	5.42	98.36	23.86
V_1K_2	161.08	151.46	5.20	14.32	116.15	76.74
V_1K_3	355.52	136.82	5.56	13.10	165.13	121.86
V_1K_4	134.66	82.42	7.01	7.55	215.09	94.98
V_2K_1	290.51	69.31	4.45	12.13	62.33	46.23
V_2K_2	258.77	155.37	6.83	30.53	129.76	176.66
V_2K_3	220.66	158.04	3.19	30.39	235.76	196.56
V_2K_4	329.49	120.20	3.30	16.66	184.77	168.83
V_3K_1	127.21	45.31	4.25	10.21	82.69	20.58
V_3K_2	231.84	126.77	6.17	26.74	220.23	93.33
V_3K_3	268.49	165.54	8.86	26.91	293.08	127.77
V_3K_4	172.96	92.06	5.89	8.43	300.64	74.80
V_4K_1	167.13	116.66	6.32	17.15	99.09	54.07
V_4K_2	191.65	119.16	3.90	7.55	181.80	71.64
V_4K_3	175.23	125.24	4.55	7.10	232.33	79.93
V_4K_4	240.32	73.05	6.36	8.24	241.45	68.48
V_5K_1	188.67	22.69	4.00	6.19	76.23	6.80
V_5K_2	204.80	54.71	2.39	7.66	123.05	28.04
V_5K_3	168.25	69.20	4.06	5.12	169.96	42.75
V_5K_4	236.09	48.76	2.98	5.12	216.78	27.27
SEm (±)	32.71	11.26	0.97	2.01	18.35	8.87
CD (0.05)	93.67	32.23	2.79	5.76	52.56	25.40

4.2.5 Soil analysis

a) Soil status of primary nutrients at 60 DAP

There was no significant difference with respect to the soil available nitrogen and phosphorus status at 60 DAP (Table 44). But, soil available potassium was significantly higher at higher potassium doses. Compared to no potassium level, higher doses such as 50, 75 and 100 kg/ha resulted in significantly higher soil potassium content.

Table 44 Primary nutrient status of soil at 60 DAP as influenced by varied K levels

Treatments	Soil available nutrients at 60 DAP (kg/ha)		
	Nitrogen	Phosphorus	Potassium
Variety (V)			
V_1 – Bhu Krishna	93.03	103.04	166.23
V_2 – Sree Arun	83.63	123.32	206.83
V_3 – Sree Bhadra	91.99	134.68	193.57
V_4 – Bhu Sona	95.12	97.07	158.39
V_5 – Kanjanghad local	87.81	122.92	167.81
SEm (±)	8.61	17.58	15.35
CD (0.05)	NS	NS	NS
K levels (K)			
K_1- 0 kg/ha	91.15	118.94	111.40
K_2 – 50 kg/ha	81.95	104.92	183.90
K_3 – 75 kg/ha	82.79	107.91	204.51
K_4 – 100 kg/ha	105.37	133.06	214.44
SEm (±)	7.69	15.73	13.73
CD (0.05)	NS	NS	39.31
V x K interaction was non significant			

b) Soil pH, electrical conductivity and organic carbon after harvest

There was no significant difference noticed in pH, EC and organic carbon content of soil after harvest of the crop and the data are furnished in Table 45. An increase in pH compared to initial value of 4.60 was observed due to lime application. No marked variation was observed in organic carbon status.

Table 45 pH, EC and OC of soil after harvest of sweet potato

Treatments	pH	EC (dS/m)	OC (%)
Variety (V)			
V_1 – Bhu Krishna	5.79	0.12	1.46
V_2 – Sree Arun	5.86	0.13	1.48
V_3 – Sree Bhadra	5.95	0.13	1.55
V_4 – Bhu Sona	5.84	0.13	1.54
V_5 – Kanjanghad local	5.91	0.12	1.49
SEm (±)	0.07	0.01	0.06
CD (0.05)	NS	NS	NS
K levels (K)			
K_1- 0 kg/ha	5.89	0.12	1.55
K_2 – 50 kg/ha	5.81	0.12	1.50
K_3 – 75 kg/ha	5.92	0.13	1.50
K_4 – 100 kg/ha	5.86	0.12	1.46
SEm (±)	0.06	0.01	0.05
CD (0.05)	NS	NS	NS
V x K interaction was non significant			

c) Soil available nitrogen, phosphorus and potassium after harvest of sweet potato

Data on soil available nutrients after harvest is furnished in Table 46. Effect of potassium fertilizer application was not noticed for soil nitrogen and phosphorus content after harvest of different varieties.

Potassium content in the soil varied significantly among varieties and significantly higher soil available potassium was noticed for the varieties Kanjanghad Local (93.64 kg/ha) followed by variety Bhu Sona (81.76 kg/ha). While, the highest K content in soil noticed for the potassium level @ 100 kg/ha (115.74 kg/ha) and was significantly higher than other doses. Among the treatment combinations, significantly higher soil available potassium was recorded at higher doses of potassium irrespective of varieties (Table 46).

Table 46 Primary nutrient status of soil after harvest of *rabi* crop of sweet potato

Treatments	Soil available nutrients at harvest (kg/ha)		
	Nitrogen	Phosphorus	Potassium
Variety (V)			
V_1 – Bhu Krishna	116.03	77.85	71.85
V_2 – Sree Arun	140.07	75.47	77.22
V_3 – Sree Bhadra	110.80	75.22	77.46
V_4 – Bhu Sona	129.62	74.32	81.76
V_5 – Kanjanghad local	113.94	80.54	93.64
SEm (±)	9.53	2.80	2.37
CD (0.05)	NS	NS	6.81
K levels (K)			
K_1- 0 kg/ha	122.09	75.81	41.18
K_2 – 50 kg/ha	108.71	76.20	70.71
K_3 – 75 kg/ha	127.11	76.10	93.91
K_4 – 100 kg/ha	130.46	78.61	115.74
SEm (±)	8.53	2.50	2.12
CD (0.05)	NS	NS	6.09
Interaction (V x K)			
V_1K_1	112.89	78.80	40.34
V_1K_2	117.07	78.61	69.74
V_1K_3	91.98	80.56	79.08
V_1K_4	142.16	73.45	98.22
V_2K_1	125.44	69.70	46.40
V_2K_2	129.62	70.34	68.25
V_2K_3	167.25	82.10	87.98
V_2K_4	137.98	79.76	106.26
V_3K_1	125.44	73.70	36.84
V_3K_2	96.17	72.36	66.23
V_3K_3	104.53	73.22	91.57
V_3K_4	117.07	81.59	115.21
V_4K_1	150.52	68.28	35.09
V_4K_2	108.71	73.58	71.80
V_4K_3	150.52	70.43	98.53
V_4K_4	108.71	85.01	121.61
V_5K_1	96.17	88.60	47.24
V_5K_2	91.98	86.13	77.53
V_5K_3	121.25	74.19	112.38
V_5K_4	146.34	73.23	137.40
SEm (±)	19.06	5.60	4.75
CD (0.05)	NS	NS	13.62

4.2.6 Potassium use efficiency of different varieties in *rabi* season

Data on different potassium use efficiency parameters calculated is given in Table 47. In general, all the efficiency parameters decreased at higher K levels for all varieties. Variety Sree Arun registered higher potassium utilization efficiency (39.18 kg/kg), nutrient efficiency ratio (57.37 kg/kg) and nutrient harvest index (0.48) compared to other varieties. Variety like Bhu Sona was efficient in utilizing K even from available soil potassium pool in no potassium applied plots and registered significantly higher potassium harvest index of 0.35 at no potassium plot compared to higher doses. But, physiological efficiency was significantly higher for variety Bhu Krishna (28.37 kg/kg) and among treatment combinations, variety Bhu Krishna applied with 50 kg/ha potassium registered significantly higher physiological efficiency of 69.30 kg/kg.

4.2.7 Pest and disease incidence

Incidence of pests and diseases during crop period was monitored and timely control measures taken. In r*abi* also, no major diseases were observed. But, porcupine was the major vertebrate pest and crop was protected by wire mesh fencing. Mild attack of sweet potato weevil was noticed and insecticide chlorantraniliprole 0.4 % was applied.

4.2.8 Cost benefit analysis

The analysis of cost of production and net returns can help to arrive at suitable varieties and its fertilizer dose for commercial production of sweet potato (Table 48). The tuber yield of varieties at different K levels varied from 6.17 to 26.82 t/ha. Among the treatment combinations, the highest yield of 26.82 t/ha was recorded for variety Sree Arun applied with 75 kg/ha potassium, followed by potassium dose of 50 kg/ha for the same variety. Lower yields were obtained from varieties Bhu Krishna and Kanjanghad Local when no potassium fertilizer was applied.

The cost of cultivation ranged from ₹ 136841 to ₹ 143161. The lowest cost was registered when no potassium was applied and the highest for 100 kg/ha potassium. Among the varieties, the highest net return was realized for the variety Sree Arun during *rabi* season which gave the highest tuber yield. Variety Sree Arun applied with 75 kg/ha potassium registered higher net returns (₹ 528187). The lowest net return of ₹ 17422 for variety Kanjanghad Local raised without K fertilizer application.

The various treatment combinations in the experiment gave the B-C ratios ranging from 1.13 to 4.71. Maximum benefit-cost ratio of 4.71 was associated with variety Sree Arun @ 75 kg/ha potassium. While, the lowest B-C ratio of 1.13 was registered for variety Kanjanghad Local at no K application.

Table 47 Potassium use efficiencies of sweet potato varieties at different K levels

Treatments	K utilization efficiency(kg/kg)	Physiological efficiency(kg/kg)	Nutrient efficiency ratio	Nutrient harvest index
Variety (V)				
V_1 – Bhu Krishna	31.76	28.37	55.85	0.33
V_2 – Sree Arun	39.18	10.76	57.37	0.48
V_3 – Sree Bhadra	28.45	14.95	50.40	0.25
V_4 – Bhu Sona	27.82	3.95	49.40	0.27
V_5 – Kanjanghad local	27.75	8.99	56.91	0.14
SEm (±)	3.08	0.75	2.46	0.02
CD (0.05)	NS	2.17	NS	0.05
K levels (K)				
K_1- 0 kg/ha	49.08	0.00	82.05	0.25
K_2 – 50 kg/ha	31.36	26.84	54.99	0.35
K_3 – 75 kg/ha	25.17	18.33	43.39	0.33
K_4 – 100 kg/ha	18.36	8.44	35.52	0.27
SEm (±)	2.75	0.67	2.20	0.02
CD (0.05)	7.89	1.94	6.31	0.04
Interaction (V x K)				
V_1K_1	34.46	0.00	70.52	0.19
V_1K_2	43.68	69.30	69.91	0.39
V_1K_3	29.08	31.62	47.90	0.42
V_1K_4	19.81	12.56	35.06	0.30
V_2K_1	71.70	0.00	91.14	0.43
V_2K_2	32.79	18.20	54.17	0.58
V_2K_3	25.51	14.45	40.65	0.45
V_2K_4	26.73	10.39	43.51	0.47
V_3K_1	47.36	0.00	87.63	0.21
V_3K_2	26.58	22.47	42.91	0.30
V_3K_3	24.91	25.34	39.31	0.30
V_3K_4	14.96	11.98	31.77	0.20
V_4K_1	44.70	0.00	76.15	0.35
V_4K_2	27.60	8.08	48.53	0.28
V_4K_3	23.16	4.93	40.66	0.25
V_4K_4	15.81	2.80	32.26	0.22
V_5K_1	47.17	0.00	84.79	0.09
V_5K_2	26.18	16.13	59.42	0.17
V_5K_3	23.18	15.33	48.41	0.20
V_5K_4	14.48	4.50	35.02	0.11
SEm (±)	6.16	1.51	4.93	0.04
CD (0.05)	NS	4.34	14.12	0.10

Table 48 Cost – benefit analysis of sweet potato varieties with varied K levels

Treatment combinations	Yield (t/ha)	Total cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B-C ratio
V_1K_1	8.48	136841	212098	75257	1.55
V_1K_2	18.09	141501	452342	310841	3.20
V_1K_3	17.67	142341	441736	299395	3.10
V_1K_4	13.46	143161	336499	193338	2.35
V_2K_1	17.66	136841	441638	304797	3.23
V_2K_2	23.08	141501	577083	435582	4.08
V_2K_3	26.82	142341	670528	528187	4.71
V_2K_4	21.03	143161	525773	382612	3.67
V_3K_1	9.58	136841	239677	102836	1.75
V_3K_2	19.49	141501	487416	345915	3.44
V_3K_3	21.47	142341	536788	394447	3.77
V_3K_4	13.41	143161	394378	251217	2.75
V_4K_1	16.12	136841	403458	266617	2.95
V_4K_2	15.28	141501	382118	240617	2.70
V_4K_3	15.82	142341	395563	253222	2.78
V_4K_4	10.18	143161	254691	111530	1.78
V_5K_1	6.17	136841	154263	17422	1.13
V_5K_2	11.91	141501	297745	156244	2.10
V_5K_3	11.04	142341	276153	133812	1.94
V_5K_4	7.14	143161	178671	35510	1.25

4.3 Experiment III – Performance of high yielding sweet potato varieties in summer season

4.3.1 Growth parameters

In general, the vegetative growth of crop was poor in summer season even though the crop was irrigated.

a) Vine length

Varieties showed significant difference in vine length during summer season also (Table 49). Variety Bhu Sona recorded significantly higher vine length at all stages (40.25 cm, 95.41 cm, 116.75 cm, 171.50 cm and 185 cm, respectively), which was at par with variety Bhu Krishna at harvest.

b) Leaf Area Index

Significant varietal differences were observed in the case of LAI also (Table 50). Variety Kanjanghad Local recorded significantly higher LAI at 20, 40, 60, 80 DAP and at harvest (0.44, 1.60, 2.30, 2.31 and 2.57, respectively) compared to other varieties. While, the lowest LAI values were noticed for variety Sree Bhadra (0.07, 0.27 0.61, 0.71 and 0.82, respectively).

c) Dry matter production of sweet potato

Varieties differed with respect to dry matter accumulation during summer season (Table 51). At 20 DAP, varieties Sree Bhadra and Sree Arun recorded significantly higher dry matter production (4.95 g/plant and 5.96 g/plant, respectively) compared to other varieties. At 40 DAP, significantly higher dry matter was produced by variety Kanjanghad Local (26.09 g/plant) followed by variety Sree Arun (19.56 g/plant).

These two varieties continued to register higher dry matter at 60 DAP also. Significantly lower dry matter produced by variety Sree Bhadra (39.36 g/plant). At 80 DAP, almost a similar trend was observed. Variety Sree Arun recorded significantly higher dry matter (159.80 g/plant) followed by variety Kanjanghad Local (116.67 g/plant). Variety Sree Bhadra recorded significantly lower dry matter production (65.92 g/plant) at 80 DAP.

d) Tuber dry matter production at harvest

Different varieties showed significant variations in tuber dry matter production at harvest (Table 52). Significantly higher tuber dry matter production was recorded for variety Sree Arun (10.48 t/ha). The next higher values are for varieties Bhu Sona (4.53 t/ha) and Bhu Krishna (3.67 t/ha) which were at par. Variety Sree Bhadra (0.87 t/ha) was inferior to all other varieties in tuber dry matter accumulation.

e) Total dry matter production at harvest

The same trend as in the case of tuber dry matter production was observed (Table 52). Variety Sree Arun registered significantly higher total dry matter at harvest (16.41 t/ha) compared to other varieties. The variety Sree Bhadra registered the lowest total dry matter (4.56 t/ha). The other three varieties were at par with each other, with average dry matter accumulation of 9.82 t/ha.

f) Fresh herbage yield at harvest

Fresh herbage yield at harvest was on par with each other for all varieties except for Sree Bhadra (16399 kg/ha) being statistically inferior to other varieties. Herbage yield of the varieties Sree Arun, Bhu Sona, Bhu Krishna and Kanjanghad Local were 24927 kg/ha, 24381 kg/ha, 23501 kg/ha and 21172 kg/ha, respectively, and were statistically comparable (Table 52).

Table 49 Vine length of sweet potato varieties during summer season

Variety	Vine length (cm)				
	20 DAP	40 DAP	60 DAP	80 DAP	At harvest
V_1 – Bhu Krishna	33.25	69.83	120.25	186.00	204.50
V_2 – Sree Arun	26.12	74.12	120.50	127.75	158.75
V_3 – Sree Bhadra	22.62	46.14	70.75	81.62	117.00
V_4 – Bhu Sona	40.25	95.41	116.75	171.50	185.00
V_5 – Kanjanghad local	26.62	46.62	87.25	97.75	153.00
SEm (±)	2.52	3.64	8.80	11.04	13.74
CD (0.05)	7.77	11.21	27.13	34.04	42.34

Table 50 Leaf Area Index of sweet potato varieties during summer season

Variety	Leaf Area Index				
	20 DAP	40 DAP	60 DAP	80 DAP	At harvest
V_1 – Bhu Krishna	0.16	0.28	1.02	1.20	1.32
V_2 – Sree Arun	0.12	0.34	0.96	1.03	1.20
V_3 – Sree Bhadra	0.07	0.27	0.61	0.71	0.82
V_4 – Bhu Sona	0.14	0.55	0.85	1.13	1.37
V_5 – Kanjanghad local	0.44	1.60	2.30	2.31	2.57
SEm (±)	0.03	0.08	0.12	0.07	0.11
CD (0.05)	0.09	0.25	0.37	0.22	0.36

Table 51 Dry matter production of sweet potato varieties during summer season

Variety	Dry matter production (g/plant)			
	20 DAP	40 DAP	60 DAP	80 DAP
V_1 – Bhu Krishna	3.81	13.72	54.62	101.45
V_2 – Sree Arun	4.95	19.56	70.56	159.80
V_3 – Sree Bhadra	5.96	17.81	39.36	65.92
V_4 – Bhu Sona	4.63	12.78	54.16	111.74
V_5 – Kanjanghad local	3.39	26.09	75.45	116.67
SEm (±)	0.41	0.46	1.74	4.74
CD (0.05)	1.27	1.43	5.35	14.62

Table 52 Tuber dry matter, total dry matter production and fresh herbage yield of sweet potato varieties at harvest during summer season

Variety	Tuber dry matter (t/ha)	Total dry matter (t/ha)	Fresh herbage yield (kg/ha)
V_1 – Bhu Krishna	3.67	9.53	23501
V_2 – Sree Arun	10.48	16.41	24927
V_3 – Sree Bhadra	0.87	4.56	16399
V_4 – Bhu Sona	4.53	10.91	24381
V_5 – Kanjanghad local	3.39	9.02	21172
SEm (±)	0.34	1.08	1557
CD (0.05)	1.06	3.34	4799

4.3.2 Yield and yield parameters

a) Total number of tubers per plant

Significant difference was observed for number of tubers produced by the varieties (Table 53). Significantly higher number of tubers per plant was registered for varieties Bhu Krishna (3.75) as well as Sree Arun (2.50) which were at par. Number of tubers produced by varieties Sree Bhadra, Bhu Sona and Kanjanghad Local were comparable statistically, values ranging from 1 to 2.25 numbers per plant.

b) Average weight of tuber

Data on average weight of tuber produced by different varieties is given in Table 53. Varieties Sree Arun (344.90 g) and Bhu Sona (260 g) were superior statistically. Smaller tubers were produced by variety Sree Bhadra and average tuber weight registered was 76 g which was on par with other two varieties Bhu Krishna (174.97 g) and Kanjanghad Local (124.25 g).

c) Tuber yield per plant

Varieties showed significant difference with respect to tuber yield per plant and is furnished in Table 53. Significantly higher tuber yield per plant was observed for variety Sree Arun (622.87 g/plant). While, the lowest tuber yield of 76 g/plant was registered for variety Sree Bhadra.

d) Weight of unmarketable tuber yield per plant

Trend was different for unmarketable tuber yield per plant (Table 54). Significantly higher unmarketable tuber yield was observed for variety Bhu Krishna (71.25 g/plant) which was on par with variety Kanjanghad Local (59.75 g/plant). Unmarketable tuber yield of other varieties (Sree Arun, Sree Bhadra and Bhu Sona) were lower and comparable (42.50 g/plant, 40 g/plant and 37.25 g/plant, respectively).

e) Marketable tuber yield

There was significant difference among varieties with respect to marketable tuber yield under summer season (Table 54). Variety Sree Arun produced significantly higher marketable tuber yield (20.63 t/ha) compared to other varieties and the least marketable tuber yield was recorded for variety Sree Bhadra (0.86 t/ha).

f) Total tuber yield

Varietal differences were significant and data are furnished in Table 54. As in the case of marketable tuber yield, significantly higher total tuber yield was recorded for the variety Sree Arun (22.15 t/ha), followed by variety Bhu Sona (12.89 t/ha) which differed statistically. Significantly lower total tuber yield was observed for variety Sree Bhadra (2.27 t/ha), comparable with varieties Bhu Krishna (9.73 t/ha) and Kanjanghad Local (6.91 t/ha).

g) Harvest Index

Harvest Index also significantly differed among varieties (Table 54). The highest harvest index was registered for variety Sree Arun (0.64) and the lowest harvest index was observed for variety Sree Bhadra (0.19).

Table 53 Number of tubers per plant, average weight of tuber and tuber yield per plant of sweet potato varieties during summer season

Variety	Average weight of tuber (g)	No. of tubers/plant	Tuber yield/plant (g/plant)
V_1 – Bhu Krishna	174.97	3.75	273.75
V_2 – Sree Arun	344.90	2.50	622.87
V_3 – Sree Bhadra	76.00	1.00	76.00
V_4 – Bhu Sona	260.00	2.25	362.75
V_5 – Kanjanghad local	124.25	1.25	194.50
SEm (±)	42.22	0.472	70.85
CD (0.05)	130.11	1.45	218.32

Table 54 Unmarketable tuber yield, marketable tuber yield, total tuber yield and harvest index of sweet potato varieties during summer season

Variety	Unmarketable tuber yield (g/plant)	Marketable tuber yield (t/ha)	Total tuber yield (t/ha)	Harvest Index
V_1 – Bhu Krishna	71.25	7.20	9.73	0.40
V_2 – Sree Arun	42.50	20.63	22.15	0.64
V_3 – Sree Bhadra	40.00	0.86	2.27	0.19
V_4 – Bhu Sona	37.25	11.57	12.89	0.42
V_5 – Kanjanghad local	59.75	4.79	6.91	0.37
SEm (±)	7.96	1.12	0.92	0.04
CD (0.05)	24.53	3.44	2.82	0.12

Plate 20. Tuber yield of variety Sree Arun in summer season

Bhu Krishna **Bhu Sona** **Kanjanghad Local** **Sree Bhadra**

Plate 21. Fibrous and hard root formation of sweet potato varieties in summer season

4.3.3. Quality parameters

a) Crude fibre

Significant difference was observed among varieties and the content showed a wide variation from 4.31 to 12.89 per cent (Table 55). Variety Sree Arun recorded the highest crude fibre content of 12.89 per cent and the lowest content was recorded for variety Bhu Krishna (4.31 %).

b) Sugar content

Non reducing sugar constituted the major share of total sugar content of tubers and values ranged from 1.11 to 3.21 per cent (Table 55). Varieties Bhu Krishna and Sree Bhadra registered significantly higher and comparable reducing sugar (1.66 % and 1.55 %, respectively), non reducing sugar (3.21 % and 3.14 %, respectively) and total sugar (4.87 % and 4.69 %, respectively) compared to other varieties.

Table 55 Quality parameters of sweet potato tubers during summer season

Variety	Crude fibre (%)	Reducing sugar (%)	Non reducing sugar (%)	Total sugar (%)
V_1 – Bhu Krishna	4.31	1.66	3.21	4.87
V_2 – Sree Arun	12.89	1.16	2.15	3.31
V_3 – Sree Bhadra	9.33	1.55	3.14	4.69
V_4 – Bhu Sona	6.49	0.69	2.05	2.74
V_5 – Kanjanghad local	11.46	1.52	1.11	2.64
SEm (±)	0.19	0.07	0.07	0.08
CD (0.05)	0.61	0.22	0.21	0.26

4.3.4 Cost benefit analysis

The cost of cultivation was ₹ 1,52,340/ha (Table 56). Among the varieties, the highest net return of ₹ 3,63,540/ha and BC ratio of 3.39 were realized for the variety Sree Arun.

As the tuber yield of varieties Sree Bhadra and Kanjanghad Local were poor, it resulted in net loss. Variety Bhu Krishna registered a net return of ₹ 27657/- only.

Table 56 Cost – benefit analysis of sweet potato varieties in summer season

Treatment combinations	Yield (t/ha)	Total cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B-C ratio
V_1 – Bhu Krishna	7.20	152340	179997	27657	1.18
V_2 – Sree Arun	20.63	152340	515881	363540	3.39
V_3 – Sree Bhadra	0.86	152340	21375	-130966	0.14
V_4 – Bhu Sona	11.57	152340	289329	136988	1.90
V_5 – Kanjanghad local	4.79	152340	119776	-32565	0.79

4.4 Comparison of seasonal performance of selected varieties (5 varieties x 3 seasons)

4.4.1 Growth parameters

a) Vine length at 60 DAP

The information on vine length at 60 DAP of sweet potato in all the three seasons is furnished in the Table 57. When the seasons were compared, higher vine length was produced in both *kharif* and *rabi* (182.36 cm and 176.78 cm, respectively). Variety Bhu Sona grown during *kharif* and *rabi* produced the longest vines (261 cm). Varieties Sree Bhadra and Kanjanghad Local produced shorter vines during summer season.

b) Leaf Area Index at 60 DAP

Data pertaining to leaf area index is given in Table 58. The highest leaf area index was for variety Kanjanghad Local (2.59) and LAI of all other varieties were comparable with each other.

Higher LAI (1.99) was observed in *kharif*, followed by r*abi* season (1.35). Among the combinations, variety Kanjanghad Local planted during *kharif* season produced the highest LAI of 3.46.

c) Total dry matter production per plant at harvest

The highest total dry matter production was noticed for variety Sree Arun (421.05 g/plant) (Table 59). While comparing seasons, higher total dry matter (390.34 g/plant) was in *rabi*, followed by both *kharif* and summer seasons (269.06 g/plant and 285.02 g/plant, respectively). Variety Sree Arun recorded higher total dry matter both in *rabi* and summer (485.28 g/plant and 461.20 g/plant, respectively), which was comparable with total dry matter produced by variety Sree Bhadra planted during *rabi* season (461.80 g/plant).

Table 57 Vine length of sweet potato varieties as influenced by seasons

Variety	**Vine length at 60 DAP (cm)**			
	kharif	***rabi***	**summer**	**Mean**
V_1 – Bhu Krishna	216.83	229.66	126.66	191.05
V_2 – Sree Arun	153.53	141.76	116.00	137.10
V_3 – Sree Bhadra	144.16	132.63	67.33	114.71
V_4 – Bhu Sona	261.00	261.16	112.00	211.38
V_5 – Kanjanghad local	136.30	118.66	82.66	112.54
Mean	182.36	176.78	100.93	-

Table 58 Leaf area index of sweet potato varieties as influenced by seasons

Variety	**Leaf area index at 60 DAP**			
	kharif	***rabi***	**summer**	**Mean**
V_1 – Bhu Krishna	1.08	1.18	1.02	1.09
V_2 – Sree Arun	1.65	0.78	0.94	1.12
V_3 – Sree Bhadra	1.93	0.86	0.60	1.13
V_4 – Bhu Sona	1.84	1.19	0.90	1.31
V_5 – Kanjanghad local	3.46	2.73	1.58	2.59
Mean	1.99	1.35	1.01	-

Table 59 Total dry matter at harvest of sweet potato varieties as influenced by seasons

Variety	Total dry matter at harvest (g/plant)			
	kharif	***rabi***	**summer**	**Mean**
V_1 – Bhu Krishna	265.66	381.69	274.72	307.36
V_2 – Sree Arun	316.68	485.28	461.20	421.05
V_3 – Sree Bhadra	259.65	461.80	129.33	283.59
V_4 – Bhu Sona	233.45	343.78	310.86	296.03
V_5 – Kanjanghad local	269.87	279.16	249.00	266.01
Mean	269.06	390.34	285.02	-

4.4.2 Yield and yield parameters

a) Marketable tuber yield

Marketable tuber yield also showed difference among varieties and seasons (Table 60). *Rabi* was the best season. Higher marketable tuber yield was noted for varieties Sree Arun (17.28 t/ha) and Bhu Sona (14.65 t/ha) compared to other varieties. Among different combinations, variety Sree Arun planted in *rabi* and summer produced higher marketable tuber yield (26.82 t/ha and 21.56 t/ha, respectively) which was comparable with variety Sree Bhadra in *rabi* season (21.47 t/ha). Performance of variety Bhu Sona was consistent over seasons with average yield of 14.65 t/ha.

b) Total tuber yield per ha

The trend was similar to that of marketable tuber yield (Table 61). Variety Sree Arun was superior (18.92 t/ha), followed by variety Bhu Sona (15.96 t/ha). Variety Kanjanghad Local (8.55 t/ha) produced the lowest tuber yield.

The highest tuber yield was in *rabi* season (20.17 t/ha), which was followed by the summer season (12.01 t/ha). Both in *rabi* and summer, the variety Sree Arun had the highest productivity (27.90 t/ha and 23.20 t/ha, respectively). This indicated the importance of selection of varieties according to seasons. Performance of variety Sree Bhadra in *rabi* season (23.19 t/ha) was also good.

c) Harvest Index

In general, the harvest index was high in *rabi* season due to good tuber yield and values ranged from 0.49 to 0.64 (Table 62). Whereas in *kharif*, the range in values were from 0.14 to 0.37. In summer, highest HI was for variety Sree Arun (0.60) and the lowest for variety Sree Bhadra (0.21).

Table 60 Marketable tuber yield of sweet potato varieties as influenced by seasons

Variety	**Marketable tuber yield (t/ha)**			
	kharif	***rabi***	**summer**	**Mean**
V_1 – Bhu Krishna	5.03	17.66	9.50	10.73
V_2 – Sree Arun	3.46	26.82	21.56	17.28
V_3 – Sree Bhadra	6.27	21.47	1.60	9.78
V_4 – Bhu Sona	14.33	15.82	13.80	14.65
V_5 – Kanjanghad local	4.52	11.04	5.42	6.99
Mean	6.72	18.56	10.38	-

Table 61 Total tuber yield of sweet potato varieties as influenced by seasons

Variety	**Total tuber yield (t/ha)**			
	kharif	***rabi***	**summer**	**Mean**
V_1 – Bhu Krishna	7.29	19.86	11.72	12.96
V_2 – Sree Arun	5.66	27.90	23.20	18.92
V_3 – Sree Bhadra	8.64	23.19	2.66	11.49
V_4 – Bhu Sona	15.22	17.76	14.90	15.96
V_5 – Kanjanghad local	5.95	12.14	7.55	8.55
Mean	8.55	20.17	12.01	-

Table 62 Harvest index of sweet potato varieties as influenced by seasons

Variety	**Harvest index**			
	kharif	***rabi***	**summer**	**Mean**
V_1 – Bhu Krishna	0.17	0.62	0.57	0.45
V_2 – Sree Arun	0.14	0.64	0.60	0.46
V_3 – Sree Bhadra	0.19	0.64	0.21	0.35
V_4 – Bhu Sona	0.37	0.58	0.55	0.51
V_5 – Kanjanghad local	0.16	0.49	0.52	0.39
Mean	0.21	0.59	0.49	-

4.4.3 Quality parameters

a) Crude fibre

Crude fibre content also showed difference among varieties during different seasons (Table 63). Higher crude fibre was noted for varieties Sree Arun (13.39 %) and Kanjanghad Local (13.83 %) compared to other varieties. *Rabi* registered higher crude fibre among the seasons (10.94 %). Among different combinations, variety Kanjanghad Local planted in *rabi* recorded higher crude fibre content (15.94 %).

b) Total sugar

Total sugar content also showed difference among varieties during different seasons (Table 64). Higher sugar was noted for varieties Sree Arun (5.89 %) and Bhu Krishna (5.77 %) compared to other varieties. *Rabi* registered higher sugar content among the seasons (5.86 %). Among different combinations, variety Sree Arun planted in *rabi* recorded higher total sugar content (8.55 %).

Table 63 Crude fibre content of sweet potato varieties as influenced by seasons

Variety	**Crude fibre (%)**			
	kharif	***rabi***	**summer**	**Mean**
V_1 – Bhu Krishna	5.80	4.91	4.09	4.93
V_2 – Sree Arun	14.08	13.39	12.69	13.39
V_3 – Sree Bhadra	10.93	11.59	9.14	10.55
V_4 – Bhu Sona	8.73	8.86	6.49	8.03
V_5 – Kanjanghad local	14.27	15.94	11.28	13.83
Mean	10.76	10.94	8.74	-

Table 64 Total sugar content of sweet potato varieties as influenced by seasons

Variety	**Total sugar (%)**			
	kharif	***rabi***	**summer**	**Mean**
V_1 – Bhu Krishna	5.11	7.24	4.97	5.77
V_2 – Sree Arun	5.84	8.55	3.29	5.89
V_3 – Sree Bhadra	2.49	4.49	4.72	3.90
V_4 – Bhu Sona	2.29	5.69	2.83	3.60
V_5 – Kanjanghad local	1.44	3.31	2.62	2.46
Mean	3.43	5.86	3.69	-

Discussion

5. DISCUSSION

The results of the experiment entitled 'Potassium utilization efficiency and seasonal response in photosynthates partitioning of high yielding sweet potato varieties' are discussed in this chapter with relevant scientific literature.

5.1 COMPARISON OF SEASONAL PERFORMANCE AND PHOTOSYNHATE PARTITIONING OF SWEET POTATO VARIETIES

Five varieties of sweet potato were grown in three distinct cropping seasons – *kharif*, *rabi* and summer.

The *kharif* crop was planted in July and harvested in November. The total crop duration varied from 106 days to 132 days and was raised purely as a rainfed crop.

The *rabi* crop was planted in October and harvested in February. The crop duration was shorter than *kharif* and varied from 90 days to 120 days. Supplemental irrigation was given during last phase of crop growth as there was no rainfall.

Summer crop was purely an irrigated crop and was planted in December. Total crop duration varied from 100 days to 140 days.

Five high yielding varieties included were Bhu Krishna, Sree Arun, Sree Bhadra and Bhu Sona and local variety used was Kanjanghad Local. The production potential of these varieties also varied (the details are furnished in chapter 3). It is 16 -18 t/ha in Bhu Krishna, 20 - 27 t/ha in Sree Arun and Sree Bhadra, 18 - 20 t/ha in Bhu Sona and 10 - 12 t/ha in Kanjanghad Local.

Nutrient management was followed as per POP recommendation of Kerala Agricultural University ie. 75:50:75 kg $N:P_2O_5:K_2O$/ha with organic manure dose of 10 t/ha and lime @ 600 kg/ha.

The results showed that the plant growth and tuberization of sweet potato varieties were highly influenced by seasons. Wide variability in tuber yield among sweet potato varieties has been attributed to environmental and edaphic factors. In sweet potato vegetative growth and tuber yield varies due to differences in environmental factors, especially temperature and irradiation (Sulistiani *et al*., 2020). It is also reported that the influence of light intensity and quality is also important in sweet potato production.

While comparing the weather parameters over three seasons (Fig. 1, 2 and 3) during the study, total rainfall received in *kharif* season (2303 mm) was almost six times that in r*abi* and summer. At the same time, total sunshine hours received in *kharif* was two to three times less compared to *rabi* and summer seasons. The maximum temperature was considerably higher during summer season (37.2 ^{o}C) compared to *kharif* (32.8 ^{o}C) and *rabi* (35.3 ^{o}C).

The continuous rainfall during growing period of the crop favoured vegetative growth at the expense of tuber formation during *kharif* season. The data on dry matter production by aerial part and tuber substantiate this. It is reported that 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 shoot dry matter production. Vine development took place at the expense of tuberization which led to the formation of more fibrous roots.

In sweet potato, the adventitious roots formed from planted vine cuttings, are modified into tuberous roots. Five to ten storage roots are produced per plant by the thickening of adventitious roots. Adventitious buds develop on the thin and thick roots very early in the storage root ontogeny, either individually or in groups of four. The difference between these buds and lateral root primordial buds is obvious. The plant can regenerate by forming fresh vegetative buds at the surface of the storage roots. The development of 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 (Lebot, 2009).

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 the 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.

Source strength is another factor that decides the tuber bulking (Ravi and Saravanan, 2012). In the case of sweet potato, the tuber formation depends on day light hours. Hence, even when the 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. Mishra *et al*. (2019) also reported similar findings on the effect of different planting dates on the growth and yield of various sweet potato varieties at Odisha.

Both growth and yield parameters are related to each other as photosynthesis is mainly influenced by different growth characteristics like leaf number and leaf area. Vine length was more for variety Bhu Sona during *kharif* and *rabi*. But during summer season, varieties Bhu Krishna, Bhu Sona and Sree Arun were comparable with respect to vine length. It was evident from this data that varietal responses to different climatic conditions vary. Same variety would perform differently at varying weather conditions.

Leaf area index also has an influence on yield of tuber crops and optimum LAI can result in higher yield. The tuber yield data in *rabi* season indicated that optimum LAI for sweet potato is about 0.85 to 1.32. Variety Kanjanghad Local recorded significantly higher leaf area and leaf area index irrespective of seasons. This higher LAI was due to its branching nature and production of more number of leaves. This might have resulted in mutual shading between leaves and less net assimilation rate, ultimately lead to poor tuber yield. The potential yield of this variety was only 10-12 t/ha and this yield could be attained in *rabi*. This shows the strong photosensitivity of this local variety. Kanjanghad Local has comparatively longer duration than others and response to available resources especially for applied nutrients was less.

The partitioning of photosynthetic assimilates from source to sink is crucial in deciding tuber production (Fig. 6). Varieties varied in sink capacity also. Generally, better source to sink relationship will be there for a variety having good sink capacity. Even with good source capacity, poor sink size and capacity can lead to less response to available assimilates (Zierer *et al*., 2021). In this experiment, Kanjanghad Local had good source with higher leaf area and photosynthetic activity, but production of less tuberous roots resulted in poor yield performance in all seasons. Some other factors like soil type also might have led to poor yield.

Compared to *kharif*, performance of varieties were good during *rabi* season. Favourable weather conditions especially days with long sunshine hours and cool nights favoured in the better performance of varieties during *rabi.* The lowest minimum temperature of 21 ºC was registered in *rabi* season.

While comparing the duration of varieties during different seasons, it was clear from the weather graphs (Fig.1, 2 and 3) that crop duration in general was more in *kharif* than in *rabi* and summer seasons. Varieties took lesser days for reaching maturity during *rabi.* However tuber yield was higher in this season. In *kharif*, varieties took about 22 weeks from planting to harvesting compared to *rabi* (18 weeks). This resulted in variation in vegetative growth, dry matter production and leaf area index.

Similar reports on the performance of various sweet potato varieties during different seasons were also reported by Widaryanto and Saitama (2017) Awel (2018); Bunphan and Anderson (2019).

Growth and tuberization of sweet potato varieties in *kharif* season

It was found that vegetative growth of sweet potato varieties was more during rainy season at the expense of tuberization due to excessive rainfall. The crop received a total of 2303.5 mm in 89 rainy days during *kharif.* This incessant rainfall led to vigorous vegetative growth and major share of photosynthates were utilized for canopy development. Also, total sun shine hours obtained was also very less during this season (456.4 hours), compared to 853.8 hours during *rabi* and 1081.8 hours during summer.

Variety Bhu Sona showed the longest vines throughout the growing period with vine length of 249.55 cm at 60 DAP (Fig. 7). Vine length of variety Bhu Sona was 90 per cent and 80 per cent higher than vine length of varieties Kanjanghad Local and Sree Bhadra. Compared to other varieties, internodal length of variety Bhu Sona was more and due to good canopy coverage, entire interspaces were covered. Variety Kanjanghad Local showed good branching without much vine elongation and gave a thicket appearance. Varieties Sree Arun and Sree Bhadra showed comparatively less branching of vines due to its inherent nature.

Leaf area and canopy development also differed among varieties (Fig. 8) and this was influenced by several characteristics like number of leaves, presence of lobes, leaf size and shape *etc*. Variety Kanjanghad Local had dense foliage; number of leaves produced by this variety was more due to lower internodal distance. Leaf length and width was also more compared to other varieties. Due to this, leaf area of Kanjanghad

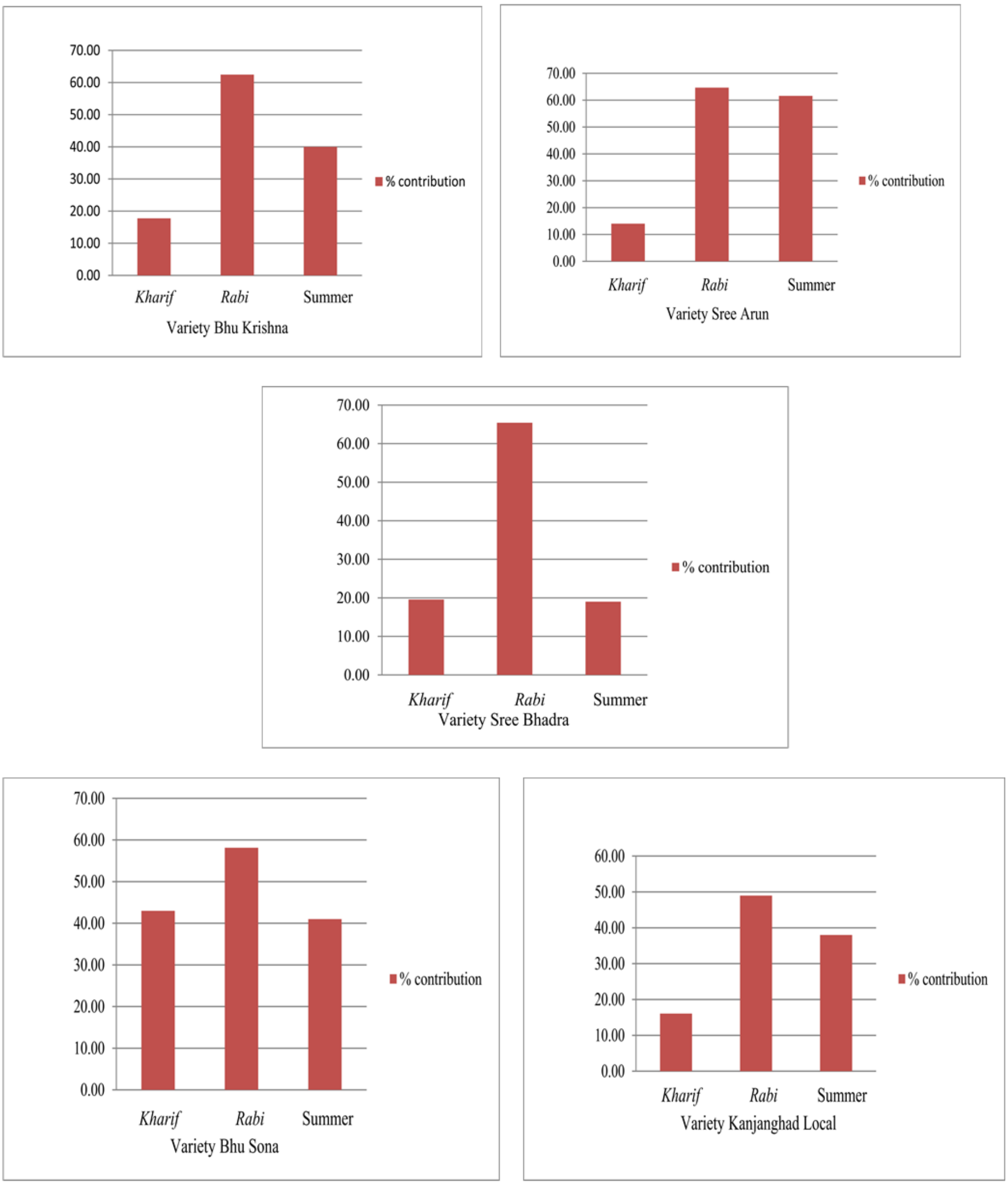


Fig. 6. Varietal variations in source – sink partitioning in sweet potato

Local was higher than other varieties which led to the highest LAI of 3.46 at 60 DAP. This was three times higher than LAI of variety Bhu Krishna which registered the lowest LAI.

Leaves of varieties showed different shades of green because of differences in chlorophyll content in their leaves as well as other pigments like anthocyanin (Plate 1 and Fig. 9). Sree Bhadra had more chlorophyll content (chlorophyll a, b and total chlorophyll) and had comparatively darker leaves than other varieties due to its varietal character. Per cent increase in total chlorophyll content for variety Sree Bhadra was 32 per cent during *kharif* over *rabi* season. In general, chlorophyll content of sweet potato varieties during *kharif* season was more due to lower sunshine hours and more moisture availability during the growing period. This increase in chlorophyll content might have increased the amount of light absorbed by the leaves, which in turn increased the rate of photosynthesis. This also resulted in more contribution of photosynthate to vegetative production and canopy development was higher during this season. Changes in chlorophyll content in plants during various sunlight conditions and its contribution to vegetative growth was also reported by Li *et al*. (2018). Influence of varying environmental conditions on chlorophyll content of sweet potato cultivars was reported by Motsa *et al*. (2015).

Dry matter production at different growth stages also varied with varietal characters and climatic conditions. It is established that in sweet potato, the relation between assimilate source and sink organs are very important and the source potential and sink capacity will vary with varieties (Lewthwaite and Triggs, 2000). Here, all varieties varied in their growth parameters, chlorophyll content and also dry matter allocation by aerial parts.

Dry matter accumulation by aerial/shoot portion was more for all the varieties during *kharif* season compared to *rabi* and summer. Per cent contribution or partitioning of total dry matter for storage in roots also differed considerably among varieties (Fig. 6). A close look on data on dry matter production of variety Bhu Sona at different growth stages revealed that its aerial dry matter was less during initial growth phase, but it increased from 60 days to 80 days due to tuber bulking. This is supported by the data on corresponding increase in tuber dry matter production. Aerial dry matter production decreased due to contribution of assimilates for tuber development. Also some leaf shedding was exhibited by this variety unlike others; probably due to translocation of assimilates from older leaves to sink organs. Contrary to this, in the case of other varieties, accumulation of aerial dry matter production continued up to harvest stage. It could be seen that the dry matter partitioning towards tuber bulking of other varieties was negligible compared to variety Bhu Sona. In variety Bhu Sona, 36 to 40 per cent of total dry matter contributed to tuber dry matter and while in the case of other varieties, it was in the range of 14 to 19 per cent only. Variety Bhu Krishna produced lower total dry matter compared to all other varieties because of poor vine growth as well as poor tuber production. This again confirmed the influence of climatic conditions on the performance of sweet potato varieties. The fresh herbage yield followed same trend as aerial dry matter production. As in the case of total dry matter production, fresh herbage yield was also more for variety Sree Arun and this was 2.3 times higher than fresh herbage yield of variety Bhu Sona.

An assessment of the performance of different varieties of sweet potato during *kharif* season showed that though assimilate synthesis in photosynthetic organs was significant, efficiency with which it could be transferred to tuber was poor. This shows the effect of season or climatic parameters in tuber initiation. It is reported that in tuber crops, the relative importance of source potential to sink capacity varies during plant growth phases because the early formation of a robust storage root competes with the development of additional source leaves. Bhagsari (1990) also found that to maximise storage root growth, a reasonably powerful root sink is needed in the later phases of plant growth. But, the root formation as well as tuberization was very slow during *kharif* season which probably led to less sink capacity. Therefore, a major share of photo assimilates produced was allocated to vegetative parts and a small share for root development. For all the varieties except Bhu Sona, shoot dry matter was more compared to tuber dry matter. The performance of variety Bhu Sona was comparatively better than other varieties, indicating its adaptability to *kharif* season probably due to photo insensitive nature. .

Yield is also a function of varietal characteristics and environmental conditions. Parameters like total tuber yield, marketable tuber yield, number of tubers per plant and average weight of tuber differed with nutrient dose and variety (Fig. 10). In general, the sink capacity of varieties was poor during *kharif* season; even though the source activity was higher. Though tuber forming roots were present at earlier stages and accelerated source development was there which is evident from data on vine growth, translocation to tuber did not take place for tuber bulking. It is clear from the graph (Fig. 1) that crop

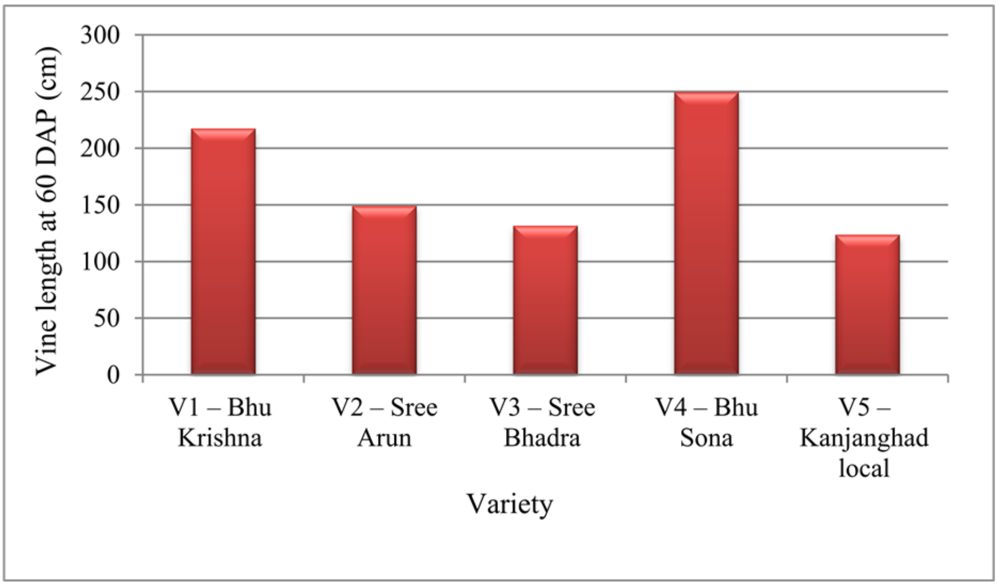


Fig. 7. Vine length of sweet potato varieties at 60 DAP in *kharif* season

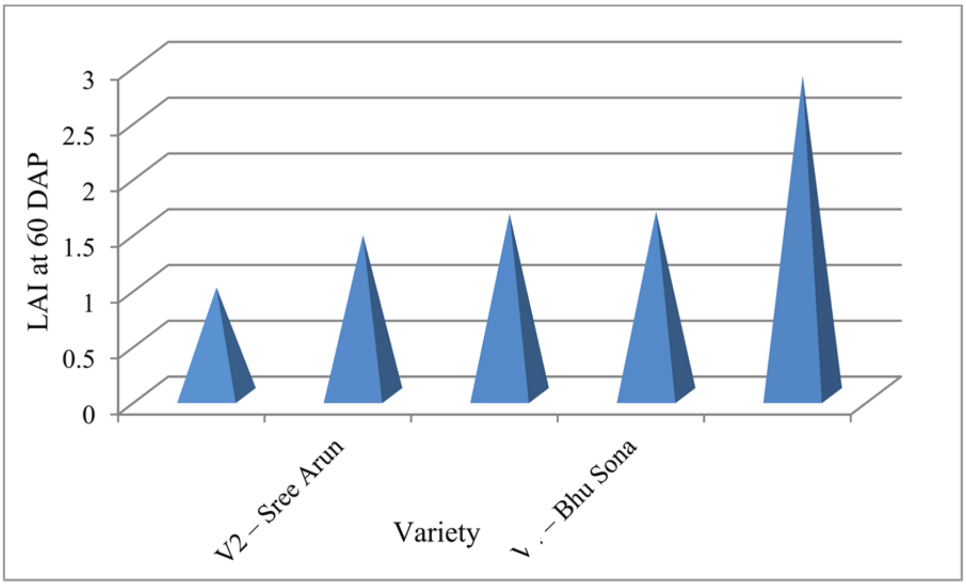


Fig. 8. Leaf area index of sweet potato varieties at 60 DAP in *kharif* season

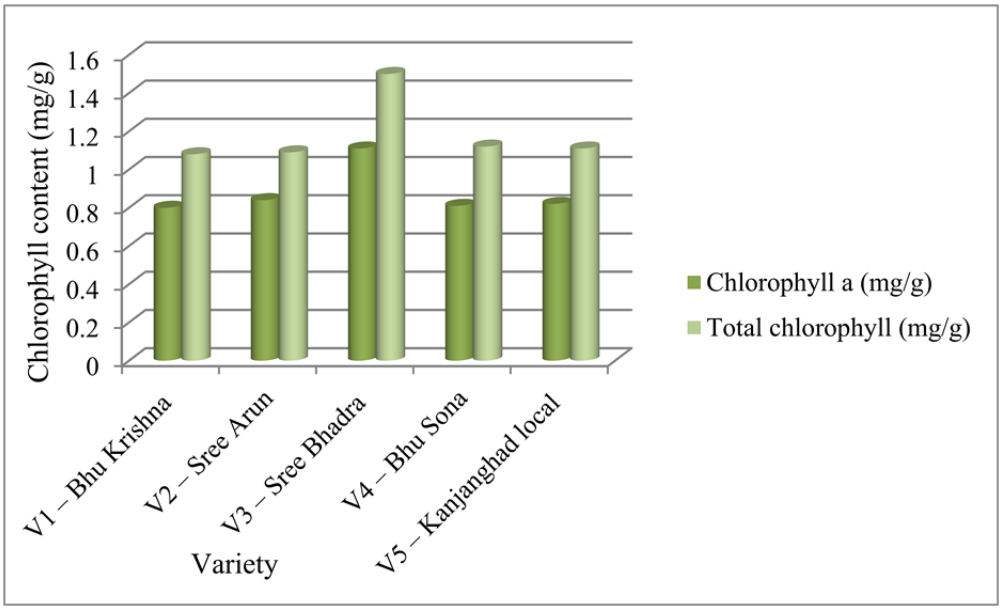


Fig. 9. Chlorophyll a and total chlorophyll content of sweet potato varieties in *kharif* season

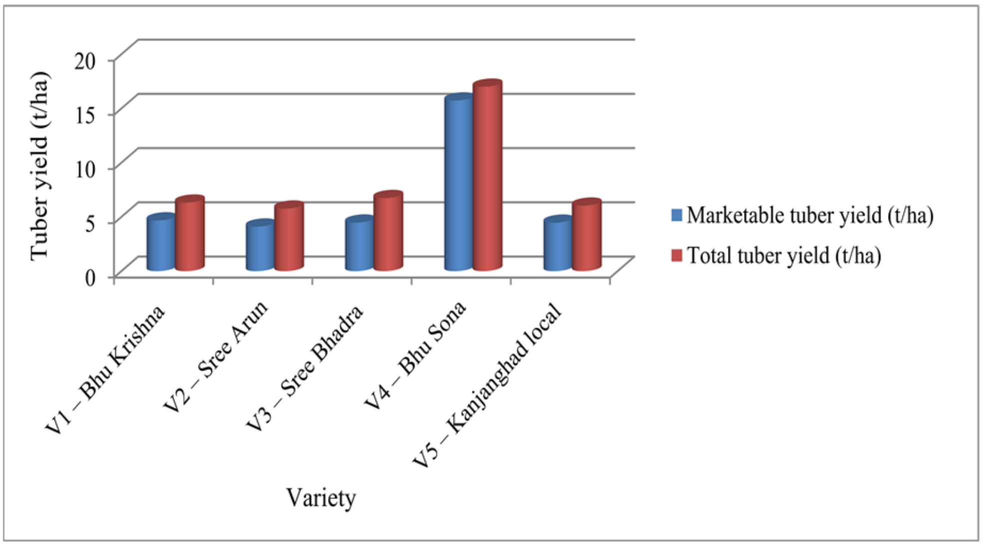


Fig. 10. Marketable and total tuber yield of sweet potato varieties in *kharif* season

received heavy rainfall distributed over entire crop period which might have adversely affected storage. It is reported that weaker storage root formation is related to both excess water and lack of oxygen in the soil (Haynes *et al*., 1967). Day length is also an important factor affecting tuberization. Sweet potato is a short day plant and day length requirements are critical for tuberization (Posthumus, 1973). The total bright sunshine hours received during the crop period was 456.4 hours.

Performance of variety Bhu Sona was good and registered 3 times more average weight of tuber (251.72 g) compared to all other varieties. However the number of tubers per plant was less and it produced a single large tuber probably due to some factors which adversely affected initiation of more number of tuber forming roots. Contrary to this, variety Bhu Krishna produced more number of tubers per plant, but tuber bulking was affected due to some unfavourable factors. Tuber yield per plant (291.17 g/plant) as well as total tuber yield (17.01 t/ha) were also higher for variety Bhu Sona which was on an average 2.48 times and 2.73 times higher than other varieties.

Marketable tuber yield and harvest index were also significantly higher for variety Bhu Sona. In the case of Bhu Sona, spreading was more as evident in the higher vine length of 330.45 cm. Also it was observed that adventitious roots developed from each node due to which this variety might have absorbed more nutrients from the soil leading to more photosynthates production for tuber bulking. The performance of other varieties was very poor and not able to produce substantial yield. Such differences among sweet potato varieties in terms of tuberization was earlier reported by many workers, Uwah *et al.* (2013); Dong-Wang *et al.* (2015) and Van Vugt and Franke (2018).

Growth and tuberization of sweet potato varieties in *rabi* season

Seasonal changes in rainfall, temperature and day length also affected the growth parameters of the crop. Compared to *kharif* season, rainfall was received only during early stages of crop growth (till 40 DAP) and total sunshine hours were more in *rabi* (853.8 hours compared to 456.4 hours in *kharif*). The ideal growing conditions for sweet potatoes in the tropics would include ample sunlight when the storage roots are developing and rain during establishment and planting. It is clear from the graph (Fig. 2) that the rainfall received during establishment period and total sunshine hours were higher during tuber development period. Therefore, due to these favourable weather conditions, growth and tuberization of sweet potato varieties were better and dry matter partitioning for tuber development was more in this season. Flowering was also observed during this season and variety Bhu sona showed more flowering. Flower production among varieties can be arranged as Bhu Sona > Sree Arun > Sree Bhadra > Kanjanghad Local > Bhu Krishna.

Better vine growth was observed in variety Bhu Sona throughout the growing season (Fig. 13). The increased vine length of variety Bhu Sona was due to rapid growth and also more internodal distance. Similar to *kharif* season, number of branches as well as LAI was more for variety Kanjanghad Local (Fig.14). This was mainly due to lower internodal distance, presence of more number of leaves and higher leaf length and width. Chlorophyll content also showed a similar trend as in *kharif* season. Due to dark green leaves, Sree Bhadra registered higher total chlorophyll content which was comparable with variety Bhu Krishna and variety Kanjanghad Local. Varietal differences in chlorophyll content and other pigments are reported in sweet potato due to wide genetic diversity.

Dry matter partitioning is the flow of photo assimilates from source organs to sink. It also varied with varieties (Fig. 6). In this study, the total dry matter production was significantly higher for the variety Sree Arun and it was 23 per cent higher than variety Sree Bhadra in *rabi*.

Tuber dry matter production was also higher during *rabi* compared to *kharif* season and per cent contribution of total dry matter to tuber dry matter production was also higher. For variety Sree Arun, tuber dry matter was 63 per cent of total dry matter and it was far more than the share during *kharif* season which again indicate strong influence of climatic factors in source – sink relation. Tuber dry matter production for the variety Kanjanghad Local was only 46 per cent of total dry matter produced.

Fresh herbage yield was also varied significantly among varieties and variety Sree Arun and Bhu Sona registered comparable values. Root – shoot ratio also varied significantly among varieties. The dry matter partitioning between root and shoot was dependent on functional equilibrium between root activity and shoot activity (Monk, 1966 and Marcelis, 1996). Here, root – shoot ratio of variety Sree Arun was significantly higher and comparable with variety Bhu Sona. These varieties had comparatively shorter duration than other varieties; root formation started earlier and high tuber dry matter production resulted in higher ratio. But, variety Kanjanghad Local had longer duration than others, led to slow initial root growth and poor yield which resulted in lower ratio. In short, root-shoot ratio as well as dry matter partitioning differed with variety.

Because of the favourable weather conditions during *rabi* season (Fig. 2), sink capacity was probably higher compared to *kharif* season. Therefore, assimilates produced during the growing period were partitioned for tuber bulking. High storage capacity of the roots together with assimilate flow guaranteed higher tuber yield. Considerable intervarietal variations in sweet potato in tuber growth are earlier reported by Lowe and Wilson (1975) and other workers also.

There were variabilities in total yield, marketable tuber yield, yield parameters such as number of tubers and average weight of a tuber (Fig. 15). Among the varieties, variety Sree Arun registered higher average tuber weight of 262.62 g. Tuber initiation and bulking in variety Sree Arun might have started earlier and bigger sized tubers were produced which led to higher tuber yield. Variety Sree Arun produced higher tuber yield per plant as well as total tuber yield which were 2.4 times higher than the yield produced by variety Kanjanghad Local. Both marketable tuber yield as well as harvest index was also more for variety Sree Arun. Variety Bhu Krishna produced more number of tubers, but tuber bulking was poor compared to variety Sree Arun. Performance of variety Kanjanghad Local was not good during *rabi* season also. Varietal influence of sweet potato on tuber yield at different weather conditions was also given by Manrique and Hermann, 2000; Ali *et al*., 2009; Mwololo *et al*., 2012.

The shape of tubers varied among varieties and for the same variety, different shaped tubers could be observed. This was probably dependent on compactness of soil. Variety Sree Arun showed a large variation in tuber shapes such as round, cylindrical, oblong, elliptic *etc*. During *rabi* season due to the absence of heavy rainfall, the roots could able to penetrate deeper soil layers which might have favoured tuber development. Soil moisture conditions were also favourable in *rabi* season. Variety Kanjanghad Local had deeper root system and hence harvesting was difficult. The effect of different soil factors in determining final shape of sweet potato tubers is also reported by Kisitu (2021).

Growth and tuberization of sweet potato varieties in summer season

Despite the fact that there have been many sweet potato varieties released to date, suitability of these varieties in different seasons are unknown. If irrigation is not available, growing sweet potatoes in the summer is challenging. In this season, vine establishment and sprouting are quite difficult. However with sufficient irrigation facilities, cultivation is possible, if some adaptable varieties are available. Also, sweet potato is considered as a drought resistant crop due to its deep roots which can absorb moisture from deeper soil layers. Only the variety Sree Arun sprouted quickly out of the five chosen varieties. But, other four varieties especially Bhu Krishna and Sree Bhadra established slowly and establishment rate was low. Generally, duration of all the varieties except Sree Arun was longer in this season and Sree Arun had a short duration of 90-95 days. This was probably due to slow establishment and tuberization of these varieties.

Similar to *kharif* and *rabi* seasons, in summer season also variety Bhu Sona showed longer vine length during all growth stages (Fig. 16). Variety Bhu Krishna also showed a longer vine length compared to other three varieties. The shortest vine length was seen in Sree Bhadra. Varietal characteristics had a significant influence on the spreading behaviour along with climatic conditions (Mbah and Okoro, 2015).

In the case of LAI, trend was similar to that of *rabi* and *kharif* seasons (Fig. 17). Variety Kanjanghad Local registered higher LAI than variety Sree Bhadra at 60 DAP and at harvest. This was mainly due to the presence of more number of leaves.

After establishment, initial growth was more for variety Sree Bhadra at 20 DAP and variety Kanjanghad Local at 40 and 60 DAP as evidenced by the longer vines and more leaf area. But, consistently higher dry matter was noticed for the variety Sree Arun at all stages. Total dry matter of variety Sree Arun was 3.60 times higher than variety Sree Bhadra whereas in the case of tuber dry matter it was 12 times. Fresh herbage yield was comparable for all varieties except Sree Bhadra which registered significantly lower value probably due to poor adaptability to high temperature and other parameters. Compared to Bhu Krishna, Sree Arun and Bhu Sona, the spreading growth habit and branching were also less for Sree Bhadra. The significant varietal differences noticed throughout the growing season can be attributed to the genetic diversity of the crop and plasticity to adapt to stress conditions.

Responses of sweet potato varieties to available resources and environmental conditions varied, which resulted in variations in growth and yield parameters (Fig. 18). Variety Sree Arun showed earlier flowering, root initiation and bulking. Poor tuberization was noticed for variety Sree Bhadra. For variety Kanjanghad Local also, tuber formation was poor and instead of forming tuberous roots, plants formed very lengthy fibrous roots (50 to 100 cm length). Average weight of tuber was higher for variety Sree Arun and Bhu Sona which was 2.75 times and 2.08 times higher than average tuber weight of other three varieties.

Considering the number of tubers produced by different varieties, Bhu Krishna as well as Sree Arun recorded more number of tubers which were about three times higher than variety Sree Bhadra. Variety Sree Arun produced comparatively bigger sized tubers and share of unmarketable tubers was less.

Variety Sree Arun produced the highest total tuber yield which was 2.75 times higher than total tuber yield of other varieties. Marketable tuber yield and harvest index were also the highest for this variety. The size of the tubers produced by variety Bhu Krishna was very small (average weight of tuber was 174.97 g) and thus unmarketable tuber yield was more for this variety which was comparable with variety Kanjanghad Local. Hence these two varieties are not suitable for summer cultivation.

It is evident that the growing season has a significant influence on varietal performance of sweet potato. Initiation and bulking of tubers take place only if conditions are favourable. Instead of forming tuberous roots, fibrous/hard roots are developed leading to poor economic yield. At similar weather conditions, performance of five varieties was different. Longer fibrous and hard roots were produced by variety Kanjanghad Local which was twice or thrice longer that reached deeper soil layers and gave ability to extract more moisture. Harvesting was also very difficult because of deeper roots. Though higher leaf area and canopy coverage were there, tuber yield was less probably due to above optimum LAI as well as unfavourable factors which affected tuber formation. Tuber yield was very less for variety Sree Bhadra than Kanjanghad Local. Here, adventitious root formation from nodes was very less unlike other varieties. Because of less number of roots, sink capacity was very small for this variety which led to poor partitioning of assimilates from source to sink. Establishment in the field was fast for variety Sree Arun and it started earlier tuberization and tuber bulking due to larger sink capacity. This was the major advantage of variety Sree Arun compared to other varieties. Performance of variety Bhu Sona was also good and tubers were not deep. Variety Bhu Krishna produced more share of unmarketable tubers. Therefore, it can be inferred that performance of sweet potato varieties differed during summer season and varietal selection is very important for profitable cultivation.

5.2 RESPONSE OF SWEET POTATO VARIETIES TO POTASSIUM NUTRITION

Though response to K nutrition was studied in both *kharif* and *rabi* seasons due to season bound nature of varieties, four out of five varieties tried could not produce economic tuber yield in *kharif* season. But all the varieties produced good tuber yield, as per the potential yield reported for the varieties in *rabi* season. Hence it was found that the results of *rabi* season trial only can give an exact idea about the potassium utilization efficiency as well as response to applied K.

Rabi **season**

As in *kharif*, the growth parameters of sweet potato varieties were also influenced by potassium nutrition. Generally, growth parameters increased with increasing potassium doses up to 75 kg/ha and after that a decline could be observed. Vine length of sweet potato applied with K @ 75 kg/ha registered 12 per cent increase (at 60 DAP and at harvest) compared to no potassium applied plants (Fig. 19). However, LAI was comparable at 50, 75 and 100 kg/ha potassium levels. However, it was only 13 per cent higher than no potassium applied plants. Chlorophyll content also increased with increase in potassium doses and showed a remarkable increase of 64 per cent over no potassium at 75 kg K_2O/ha. Similar to the results in *kharif* season, a further increase of K to 100 kg/ha did not influence chlorophyll content in sweet potato varieties. In control plots, marginal chlorosis of leaves was observed and a reduction in LAI. This decrease might have negatively affected photosynthesis activity of sweet potato which led to lower tuber yield. This is in accordance with findings of Liu *et al*. (2017).

Dry matter production and its allocation were also influenced by varied K levels. Dry matter is an important parameter which depends on source - sink relationship and nutrient availability especially potassium that determines photosynthate partitioning. It is reported that since the source and sink organs in higher plants are physically isolated from one another, long-distance transfer of nutrients and photosynthates via the phloem from source to sink is crucial for plant development and productivity (Engels *et al*., 2012).

While comparing the dry matter production and partitioning of *rabi* season with *kharif*, dry matter accumulated in aerial portion was less, but, tuber dry matter production was significantly higher due to favourable weather conditions which ultimately favoured efficient use of applied potassium. Dry matter production was increased with increase in potassium up to 75 kg/ha and thereafter it declined. This indicated that further addition of 25 kg/ha could not be efficiently utilized for dry matter production by different varieties of sweet potato. Dry matter produced at 75 kg/ha applied potassium led to an increase of 17 per cent and 42 per cent dry matter production at 60 DAP and at harvest, respectively over no potassium applied plants.

Tuber dry matter production of different varieties during *rabi* season was more compared to *kharif* season. Per cent increase in tuber dry matter at K @ 75 kg/ha was 56 per cent compared to no potassium. It could be observed that, of the total dry matter accumulated, 61 per cent was diverted to tubers. Fresh herbage yield at harvest was also significantly higher and comparable at 50 and 75 kg/ha K level also. Similar results were reported by Muoneke and Ukpe (2010) and Uwah *et al*. (2013) in sweet potato.

Variety x K interaction effect could be noticed for vine length and dry matter production at harvest. Tuber and total dry matter was more for the variety Sree Arun applied with 50 and 75 kg/ha potassium dose. And also all varieties responded differently to varied K levels. However, in general, all the varieties performed better during *rabi* season compared to *kharif* for the applied potassium doses with respect to tuber yield. Interaction effect was present for some growth parameters. There was intraspecific variation observed among varieties with applied K levels. Genotypic difference in utilizing the applied K levels can be attributed to differences in the transportation and redistribution of potassium at the cellular and plant level, the replacement of potassium with other ions and the allocation of resources to the economic yield (Dong-Wang *et al*., 2015).

Yield and yield parameters of sweet potato varieties were also influenced by varied K levels (Fig. 20). It is reported that tuberization behaviour is highly dependent on available potassium content in the soil. Compared to *kharif* season, effective K utilization for tuber initiation and bulking was observed during *rabi* season, which is clear from data on tuber yield.

Average weight of tuber and number of tubers per plant increased with increase in K levels up to 75 kg/ha and then a declining trend was registered. No significant variation was noticed for further addition of 25 kg/ha potassium. The per cent increase in average weight of tuber and number of tubers for 75 kg/ha added potassium was 50 per cent and 36 per cent, respectively compared to no potassium. Similarly, tuber yield per plant as well as total tuber yield was also higher for potassium application @ 75 kg/ha and it was 56 per cent as well as 50 per cent, respectively higher than that of no potassium plots. Application of 100 kg K_2O/ha did not increase tuber yield compared to 75 kg K. Harvest index also showed a similar trend. Here, it was noted that tuber yield produced by the varieties applied with 50 kg/ha was comparable with 75 kg/ha and an extra dose of 25 kg/ha helped for tuber initiation but not contributed to marketable tuber yield.

Interaction between varieties and K levels was also noticed in *rabi* season. Variety Sree Arun applied with 50, 75 and 100 kg/ha potassium registered higher tuber yield per plant and total tuber yield. Therefore, it could be noted that additional supply of 25 kg/ha potassium had no effect on the yield of variety Sree Arun. Variety Sree Bhadra also registered higher tuber yield at 75 kg/ha K, but significantly lower than variety Sree Arun. Similar trend was observed for harvest index also.

While comparing the response of different varieties to applied K levels, variety Sree Arun was more responsive to applied potassium during *rabi* season. Production of more number of nodal roots could be observed in this variety which might have helped in more potassium uptake. As in *kharif* season, in *rabi* season also, variety Bhu Sona had more roots, but tuber production was less compared to variety Sree Arun. But during *rabi* season, variety Bhu Sona was very efficient in utilizing available potassium from soil and produced comparable yield for potassium applied plots and no potassium plot. Hence with respect to tuber yield, variety Sree Arun was more suitable for *rabi* season, but, K was more efficiently utilized by variety Bhu Sona in terms of tuber initiation and bulking. Dumbuya *et al*., 2017; Putra *et al*., 2018; Sulistiani *et al*., 2020 and Lestari *et al*., 2021 have reported similar findings with respect to high yielding sweet potato lines.

The shape of tubers varied among varieties and for the same variety, different shaped tubers could be observed. This was probably dependent on compactness of soil. Variety Sree Arun showed a large variation in tuber shapes such as round, cylindrical, oblong, elliptic *etc*. During *rabi* season, the roots penetrated to deeper soil layers and probably this favoured tuber development. Soil moisture conditions were also favourable in *rabi* season. Variety Kanjanghad Local had deeper root system and hence harvesting was difficult. The effect of different soil factors in determining final shape of sweet potato tubers is also reported by Kisitu (2021).

Due to the genetic variability, quality parameters varied with varieties of sweet potato. Crude fibre content was higher for variety Kanjanghad Local (14.23 %) which was more than three times of variety Bhu Krishna (4.20 %). While, crude protein was more for variety Bhu Sona (10.21 %) compared to variety Kanjanghad Local (7.33 %). Comparing the sugar content of varieties, Sree Arun registered higher sugar content (7.86 %) followed by variety Bhu Krishna. Total sugar content of variety Sree Arun was three times higher than sugar content of variety Kanjanghad Local. But starch content of variety Kanjanghad Local (32.46 %) was higher than other varieties. Tuber moisture content also varied and moisture content of variety Bhu Krishna (64 %) was higher than other varieties as in *kharif*. The quality parameters are decided by genetic factors and Ellong *et al*. (2014) and Krochmal-Marczak *et al*. (2014) have also reported varietal variability in quality parameters of sweet potato tubers.

Potassium is critical for improving quality of crops including tuber crops and hence known as 'quality nutrient'. Being a source of carbohydrates, potassium activates the enzymes responsible for starch synthesis in tuber crops. It is also reported that the addition of this nutrient helps for the synthesis of sugars, crude fibre and protein. In general, quality attributes of sweet potato tubers enhanced with increase in K levels. Crude fibre, reducing, non reducing and total sugar content, starch and moisture content of tubers were significantly higher for potassium applied @ 100 kg/ha compared to control. Crude protein content was significantly higher for 50 and 75 kg/ha potassium and showed a decline with addition of 100 kg/ha potassium. The importance of potassium fertilization on sweet potato for improving quality of tubers was also documented by El-Baky *et al*. (2010); Biswal *et al*. (2017) and Pushpalatha *et al*. (2017).

Variety x potassium interaction effect was noticed for crude fibre, crude protein, total sugars and moisture content. Variety Bhu Sona with 75 kg/ha applied potassium registered significantly higher crude protein, which was comparable with variety Bhu Krishna supplied with 50 kg/ha applied potassium. Crude fibre content was higher for variety Kanjanghad Local applied with higher doses of potassium. Whereas total sugar was higher at increased potassium doses for variety Sree Arun. But, tuber moisture content was more for variety Bhu Krishna applied with 75 and 100 kg/ha potassium. Similar conclusions were given by Sulistiani *et al*. (2020) and Gao *et al*. (2021) for various quality attributes.

Potassium content of soil showed an increase at increased K levels. Available potassium status was deficient at no potassium plots similar to initial soil K status (102 kg/ha).

Comparing the post harvest soil nutrient status, pH was increased probably due to lime application @ 600 kg/ha during land preparation. But, soil organic carbon and EC had no substantial change. While, soil available phosphorus content showed a varying trend among varieties as varietal differences were there in uptake of P at varied K levels during growing period. In general, soil available phosphorus showed a considerable decrease from 60 DAP to harvest. But, plots where variety Kanjanghad Local was planted registered higher amount of available phosphorus. This indicated that the variety did not effectively utilized soil available phosphorus and resulted in poor yield. Soil available potassium also decreased from 60 DAP to harvest and K status in the soil was increased with increase in potassium application. Potassium is a nutrient, very much important for tuberous root formation and assimilates transport and hence generally, tuber crops require higher potassium compared to other crops (Jansson, 1980).

Variation existed among varieties in K content, uptake and potassium utilization efficiency in the field. Nutrient content of index leaves at 60 DAP as well as shoot and tuber nutrient content at harvest exhibited variations. At 60 DAP, the nitrogen content in the index leaves increased with decrease in K levels and there was no significant variation noticed for 75 and 100 kg/ha potassium doses. Varieties Sree Arun and Kanjanghad Local registered higher and comparable nitrogen content in the index leaves. Phosphorus and potassium content in index leaves were also higher for the variety Sree Arun. K content also increased with increase in potassium application up to 75 kg/ha and a further addition of 25 kg/ha showed no considerable change in K content of index leaves. The nutrient content in the index leaves of varieties also varied with different K levels. This can be attributed to the genetic characteristics of varieties in nutrient absorption and accumulation.

Comparing the nutrient content of shoot and tuber at harvest, nutrient content especially nitrogen and potassium was higher for aerial parts compared to tuber. Tuber nitrogen content was higher for variety Bhu Sona (1.63 %). Tuber P and K content were higher for the variety Sree Arun (0.22 % and 1.70 %, respectively). N and P content of sweet potato varieties increased with increase in K levels up to 75 kg/ha and an additional application of 25 kg/ha did not have any substantial influence in enhancing the nutrient content in these varieties. But, potassium content of sweet potato increased with increase in K levels at harvest. Therefore, increased application of potassium beyond a particular level hence had no influence on enhancing dry matter and tuber yield due to luxury consumption of potassium. Varieties Bhu Krishna and Sree Bhadra showed luxury consumption among the varieties and this higher absorption had no influence on dry matter production. Luxury absorption of potassium by potato crop and its influence on tuber production was given by Kang *et al*. (2014).

In the case of nutrient uptake, variety Sree Arun significantly showed higher tuber nitrogen, phosphorus and potassium uptake compared to other varieties (125.73 kg/ha, 22.43 kg/ha and 147.07 kg/ha, respectively). In *rabi* season also, shoot nitrogen and potassium uptake was higher mainly due to higher dry matter production. Also, higher source activity might have helped to maintain higher nutrient content in aerial parts. Only for variety Kanjanghad Local, effective translocation of nutrients from shoot to tuber did not take place which led to lower dry matter production and ultimately lower uptake. Nitrogen and phosphorus uptake were increased up to 75 kg/ha K_2O and then declined. Potassium content also showed a similar trend and a further addition of 25 kg/ha had no influence on improving dry matter production of crop and hence uptake.

In *rabi* season, variety Sree Arun showed better utilization of available potassium from the soil up to 75 kg/ha and effectively utilized potassium for sink development and dry matter production. Further addition of potassium had no considerable influence on any of these parameters. The potassium utilization efficiency (KUE) of varieties showed a decreasing trend with increase in K level and higher KUE was at lower doses of potassium. Potassium efficient varieties were Bhu Krishna and Sree Arun. Here also, variety Bhu Sona could able to take up available potassium from the soil pool even from no potassium plots just like *kharif* season and efficiently translocate for tuber storage. Swiader *et al*. (1994) defined effective nutrient utilisation as plants' ability to produce the most dry matter possible at each increment of nutrient absorbed. George *et al*. (2002) also documented the genotypic variation for potassium uptake and utilization efficiency in sweet potato. Nutrient harvest index was also higher for variety Sree Arun indicated its effective source - sink translocation and hence, K efficiency in *rabi* season.

It can be inferred that for all the sweet potato varieties, sink size and activity were higher in *rabi* season which led to more accumulation of nutrients in the tubers and tuber development.

***Kharif* season**

Potassium nutrition profoundly influenced the growth parameters of different sweet potato varieties. The leaves, vines, stems and tubers of sweet potato typically extract significant amounts of potassium from the soil (Dumbuya *et al*., 2017). Vine length increased with increasing potassium levels up to 75 kg/ha and later it declined. Vine length for all varieties consistently increased up to 75 kg/ha potassium levels and it was 12 per cent higher than vine length at no potassium level.

Potassium had no significant influence over number of branches as it was mainly a varietal character. Just like vine length, leaf area index was also increased with increasing potassium levels up to 75 kg/ha and thereafter it declined. LAI of plants supplied with potassium @ 75 and 100 kg/ha was 44 per cent and 22 per cent higher than those with no applied potassium at 60 DAP and the same trend was registered at harvest stage also (Fig. 21 and Fig. 22).

Chlorophyll content also increased up to 75 kg/ha potassium, after which a sharp decline (14 per cent) could be observed. It was seen that a further addition of 25 kg/ha did not influence chlorophyll content in sweet potato varieties. In control plots where no K was applied, marginal chlorosis was observed and this might have led to reduction in photosynthesis activity as indicated by lower dry matter production. Importance of potassium nutrition in chlorophyll production in sweet potato is documented by Liu *et al*. (2017).

While in the case of aerial, tuber and total dry matter production, higher values were observed at increased K levels ie. 50, 75 and 100 kg/ha during all growth stages. Increase in tuber dry matter production of 50, 75 and 100 kg/ha K levels were 27 per cent, 11 per cent and 9 per cent, respectively compared to no potassium level. Also, increase in total dry matter production was 22 per cent, 21 per cent and 14 per cent, respectively for these potassium rates compared to no potassium level.

Similarly, fresh herbage yield was also increased up to 100 kg/ha (25180 kg/ha) which was 27 per cent higher than no potassium rate. But, this was comparable with 50 and 75 kg/ha potassium levels. According to the research results of Amisnaipa *et al*. (2009), the K fertilizer application at low to moderate nutrient status showed a significant increase in plant growth of sweet potato, while K fertilizer with high nutrient status did not show an increase in crop growth. Variations in the performance of sweet potato crop at different potassium levels were earlier reported by El-Baky *et al*., 2010; Cecílio Filho *et al*. (2016) and Satpathy and Singh (2021).

While studying the interaction between varieties and potassium levels, LAI showed interaction at 60, 80 DAP and at harvest. Variety Kanjanghad Local applied with 75 kg/ha recorded higher LAI than the lowest LAI produced by variety Bhu Krishna applied with no potassium level. Interaction effect was also significant with respect to chlorophyll content also. The leaf greenness varied in different varieties and it increased with increasing potassium levels up to 75 kg/ha. Eventhough the vine growth of variety Sree Bhadra was comparatively lower, its greenness was more and chlorophyll content increased up to 75 kg/ha potassium rate. The increase in chlorophyll content of sweet potato leaves with increased potassium rates was earlier reported by Byju and George (2005).

With respect to tuber dry matter production, response of varieties varied with K levels. Variety Bhu Sona registered higher tuber dry matter without K application and on an average, it was 2.4 times more than other treatment combinations. In general, for all varieties, total dry matter increased with increase in potassium application and its distribution to shoot and tuber dry matter production varied among varieties, probably due to difference in genetic makeup which decides photosensitivity and partitioning. Huai *et al*. (2022) found that low potassium fertilizer application promoted the root-shoot ratio. Similarly, Dong-Wang *et al*. (2015) also reported that genetic variation existed among sweet potato varieties in the accumulation of potassium and partitioning of assimilates from various vegetative parts to sink.

Sweet potato is a crop which produce good tuber yield within a short crop period of 3 - 4 months. Potassium is a major nutrient which plays an important role in initiation and bulking of tubers. However, intraspecific variations in potassium uptake and utilization are reported among varieties which resulted in varied varietal performance (Dong-Wang *et al*., 2015).

In general, the response to applied potassium was significant during *kharif* season and some varieties utilized even residual potassium available in the soil. The performances of some of the varieties were very poor even at higher levels of potassium. In general, no potassium or low dose of 50 kg/ha registered higher marketable and total tuber yield compared to 100 kg/ha potassium application in all varieties though soil of the experimental field was low in available K status. Huai *et al*. (2022) observed that lower doses of potassium promoted root initiation and tuberization in crops while vegetative growth enhancement took place at increased K levels. In some varieties, the shape of tubers produced also varied at different K levels and cracking was also observed which was probably due to the interaction of several factors like soil type, varietal characteristics, K uptake *etc*. Small sized tubers were produced even at higher K level of 100 kg/ha especially for varieties Sree Arun, Bhu Sona and Kanjanghad Local. Large and round shaped tubers were produced by variety Bhu Sona at low K levels and tuber developed on the soil surface layers. Variation in tuber physical appearance due to enhanced resistance during development at different soil conditions is given by Koch *et al*. (2019).

Interaction between varieties and K levels was also noticed (Fig. 23). Variety Bhu Sona registered the highest average weight of tuber (354.33 g) even without K application. Marketable tuber yield, total tuber yield and harvest index were also higher for variety Bhu Sona. Harvest index was on an average 2.65 times higher than other treatment combinations. Due to the presence of more adventitious roots in variety Bhu Sona, root surface area was increased and probably this led to greater potassium uptake from available soil resources. For all other varieties, tuberization during *kharif* season was poor and variety Bhu Sona performed comparatively better and can be recommended as a K efficient variety during *kharif* season. Different species and genotypes have various ways of successfully coping with K^+ shortage. Among which the most crucial are improved potassium uptake, the capacity to maintain a specific level of root meristem proliferation under low K^+, chemical alterations to the rhizosphere and efficient potassium translocation within the plant body. These tactics may be combined in K^+-efficient genotypes (Sustr *et al*., 2019). Some of these mechanisms might have helped variety Bhu Sona in effective K utilization.

For all other varieties, due to poor sink activity, efficient translocation did not takes place. In order to produce the highest yields, tuber crops must achieve an adequate balance between shoot, root, and tuber growth. As the photosynthates must be actively transmitted to the sink, increased production in tuber crops is attributed to the balance between shoot and root activity (Osaki *et al*., 1996). In this season, the major draw-back was the poor sink capacity and activity. Therefore, even photo assimilates produced was more as enhanced by high dry matter production, it was not actively unloaded to sink for bulking of tuber and already formed tuberous roots failed to increase its size. The photoperiod also might have negatively influenced tuber production, plant dry matter production and partitioning and long photoperiod resulting in smaller tubers and low harvest index (Assefa and Debella, 2020).

Soil type is a factor influencing tuber bulking. Variety Bhu Sona produced tubers on the surface soil layer within a depth of 15 – 20 cm. Round big sized tubers were produced rather than oblong or elliptic tubers characteristic to the variety. Unlike variety Bhu Sona, variety Kanjanghad Local developed very long fibrous roots which penetrated to deeper soil layers and no tuber formation could be observed in surface soil layers. The effect of different soil factors including soil texture and compaction in determining final shape of sweet potato tubers was given by Kisitu (2021).

The quality of tubers differed among sweet potato varieties (Fig. 24). Crude fibre content was higher for variety Kanjanghad Local (12.26 %) and crude protein was more for variety Bhu Sona (14.07 %). Variety Bhu Krishna registered the lowest crude fibre and crude protein content during *kharif* season. Variety Sree Arun registered higher sugar content followed by variety Bhu Krishna. Total sugar content of variety Sree Arun was three times higher than sugar content of variety Kanjanghad Local. But starch content of variety Kanjanghad Local was comparatively higher than other varieties. Tuber moisture content also varied and moisture content of variety Bhu Krishna (68 %) was on an average 11 per cent higher than other varieties. The genetic characteristics of sweet potato varieties significantly influenced the quality parameters of tubers and similar findings were also reported by Ellong *et al*. (2014) and Krochmal-Marczak *et al*. (2014).

Potassium is critical for improving quality of crops including tuber crops and hence known as 'quality nutrient'. Being a source of carbohydrates, potassium activates the enzymes responsible for starch synthesis in tuber crops. Also, the addition of this nutrient helps for the synthesis of sugars, crude fibre and protein. In general, quality attributes of sweet potato tubers enhanced with increase in K levels. Crude fibre (1.85 times), reducing (1.74 times), non reducing (1.46 times) and total sugar (1.56 times) content, starch (1.18 times) and moisture content (1.03 times) of tubers were significantly higher for potassium applied @ 100 kg/ha compared to control. While, crude protein content was significantly higher for 50 and 75 kg/ha potassium and then declined. Constantin *et al*. (1977) also found out that K fertilization reduced protein content of sweet potato varieties. The importance of potassium fertilization on sweet potato for improving quality of tubers was also given by El-Baky *et al*. (2010); Biswal *et al*. (2017) and Pushpalatha *et al*. (2017).

While observing the interaction between varieties and K levels, significant difference was noticed for crude protein content, total sugars and moisture content. Variety Bhu Sona with 75 kg/ha applied potassium registered significantly higher crude protein, which was double the value of the lowest crude protein content registered by variety Sree Arun with no potassium. While, total sugar of variety Sree Arun with 100 kg/ha potassium was five times more than sugar content of variety Sree Bhadra with no potassium. But, tuber moisture content was more for variety Bhu Krishna applied with 75 and 100 kg/ha potassium. Similar conclusions were given by Fujise and Tsuno, 1967; Sulistiani *et al*. (2020) and Gao *et al*. (2021) for various quality attributes of sweet potato tubers.

No significant difference was observed in soil available nitrogen and phosphorus at 60 DAP. But, available nitrogen showed a slight decrease from 125 kg/ha to 115 kg/ha and available phosphorus showed a considerable increase from 83 kg/ha to 121 kg/ha. Potassium content of soil showed an increase at increased K levels up to 100 kg/ha. When potassium was not applied, soil K status showed a decline to 80 kg/ha from initial status of 100 kg/ha. Soil organic carbon and EC had no substantial change. However, pH showed slight increase probably due to lime application @ 600 kg/ha during land preparation. The soil available nitrogen status generally showed a slight increase at harvest time. Cultivation of variety Kanjanghad Local resulted in decrease in soil available nitrogen content at post harvest analysis. Cultivation of variety Kanjanghad local applied with increased K levels resulted in a decrease in soil available nitrogen at harvest. Soil available phosphorus content also showed variations among varieties as nutrient uptake varied with varieties and applied K levels during growing period. Generally, soil available phosphorus showed a slight decrease from 60 DAP to harvest. Soil available potassium also decreased from 60 DAP to harvest and K status in the soil showed increase with increase in potassium application.

Varietal differences were significant with respect to potassium content and uptake. Nutrient content of index leaves at 60 DAP and also shoot and tuber nutrient content at harvest also varied. The nitrogen content in the index leaves increased with increase in K levels and there was no significant difference between 75 and 100 kg/ha potassium doses. Nitrogen content was also comparable among varieties. While, phosphorus content in index leaves of variety Bhu Sona was higher, this was 24 per cent higher than other varieties. P content in the index leaves increased up to 75 kg/ha K level and then declined. Similarly, potassium content was also higher for variety Bhu Sona which was 13 per cent higher than other varieties. K content also increased with increase in potassium application up to 75 kg/ha and a further addition of 25 kg/ha showed no considerable change in K content of index leaves.

Comparing the nutrient content of shoot and tuber at harvest, nutrient content especially nitrogen and potassium was higher for aerial parts compared to tuber. Tuber nitrogen, phosphorus and potassium were more for the variety Bhu Sona (2.33 %, 0.15 % and 1.48 %, respectively). Phosphorus content of tuber of this variety was comparable with varieties Bhu Krishna and Kanjanghad Local. N and P content of sweet potato varieties increased with increase in K levels up to 75 kg/ha and an additional application of 25 kg/ha did not have any substantial influence in enhancing the nutrient content. K content of the varieties also showed a similar trend. Increased dosage might have led to increased content up to a certain extent. The variations in nutrient content among varieties can be attributed to their genetic characteristics. Because of continuous vegetative growth and less tuber formation and bulking, shoot nutrient content did not show a reducing trend towards harvest.

While analysing the data on nutrient uptake, it can be seen that variety Bhu Sona showed significantly higher nitrogen, phosphorus and potassium uptake by tuber compared to other varieties (86.06 kg/ha, 4.02 kg/ha and 55.68 kg/ha, respectively) due to higher tuber yield.

Shoot nitrogen and potassium uptake were higher due to continuous vegetative growth during *kharif* season. Probably effective translocation of nutrients did not take place from shoot to tuber due to poor sink capacity. Therefore, whatever nutrients taken up during the growing period was utilized for the growth of aerial parts. It can be inferred that only for variety Bhu sona, effective translocation of nutrients and photosynthate from shoot to tuber took place and led to higher tuber yield and ultimately more nutrient uptake.

Nitrogen and phosphorus uptake increased up to 75 kg/ha K level and then declined. Potassium content also showed a similar trend and a further addition of 25 kg/ha had no influence on improving dry matter production of crop and hence it was reflected in uptake. While, variety Bhu Sona had the capacity to utilize available potassium content even from a deficient soil and effectively utilized this potassium for sink development, the dry matter production of this variety was higher even in plots where no K was applied. This led to higher uptake even when grown in deficient soil. Since no other varieties showed considerable tuberization during this season, the most efficient variety for K utilization was Bhu Sona. Most efficient variety could produce good tuber yield even at low soil available K. Swiader *et al*. (1994) defined effective nutrient utilisation as plants' ability to produce the most dry matter possible at each increment of nutrient absorbed. Dong-Wang *et al.* (2015) also gave a similar assumption that highly efficient cultivars have the ability to absorb K from soils to produce more tuberous dry matter than inefficient cultivars. George *et al*. (2002) also studied about the genotypic variation for potassium uptake and utilization efficiency in sweet potato.

High rainfall during *kharif* season might have lead to leaching of muriate of potash which is a highly soluble fertilizer. This also might have lead to poor response to applied potassium, even at higher doses.

In general, for all the sweet potato varieties tried, sink size and activity were poor during *kharif* which led to lower accumulation of dry matter in the tubers. However, excessive application of potassium probably leads to luxury consumption of this nutrient in sweet potato and a reduction in potassium utilization efficiency (Foloni *et al*., 2013).

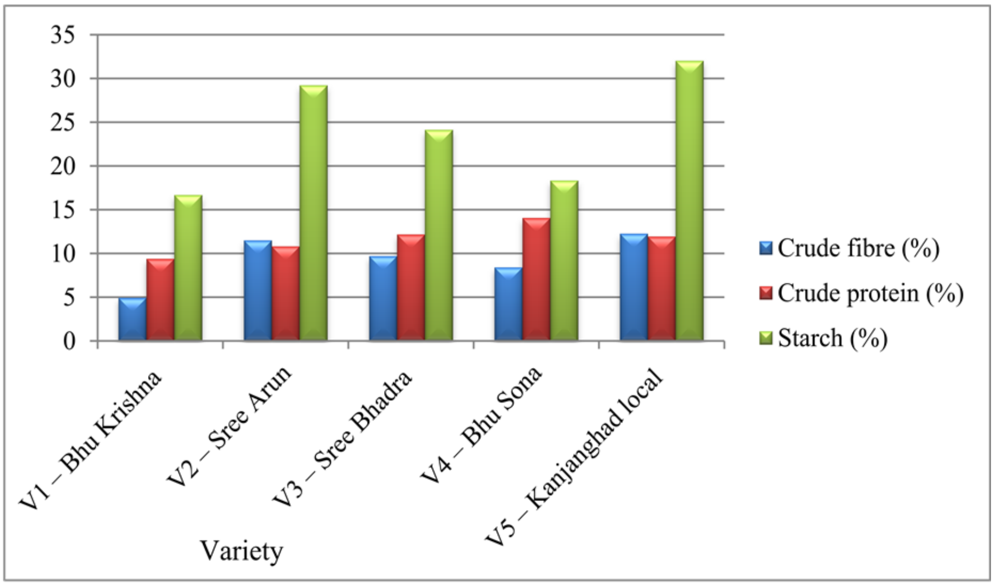


Fig. 11. Crude fibre, crude protein and starch content of sweet potato varieties in *kharif* season

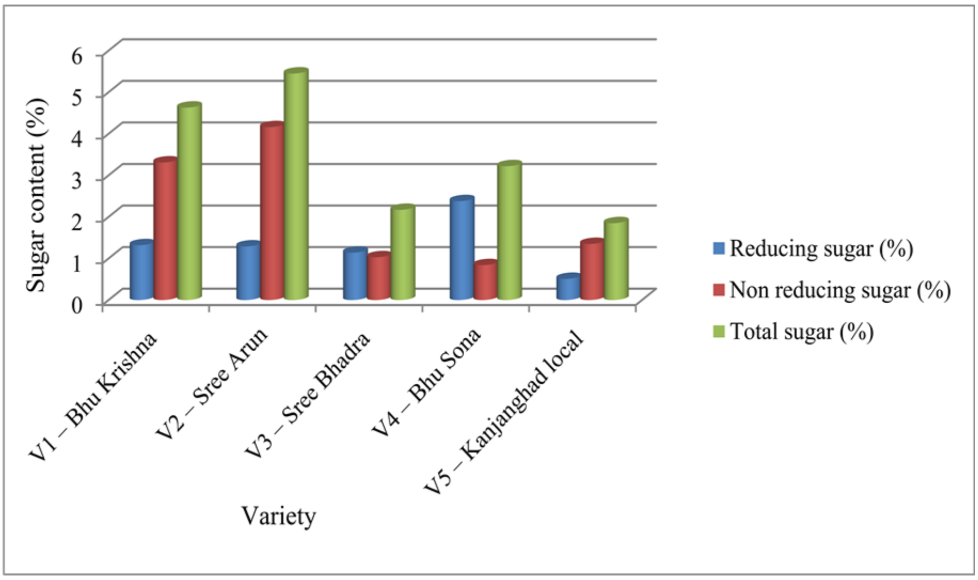


Fig. 12. Reducing, non reducing and total sugar content of sweet potato varieties in *kharif* season

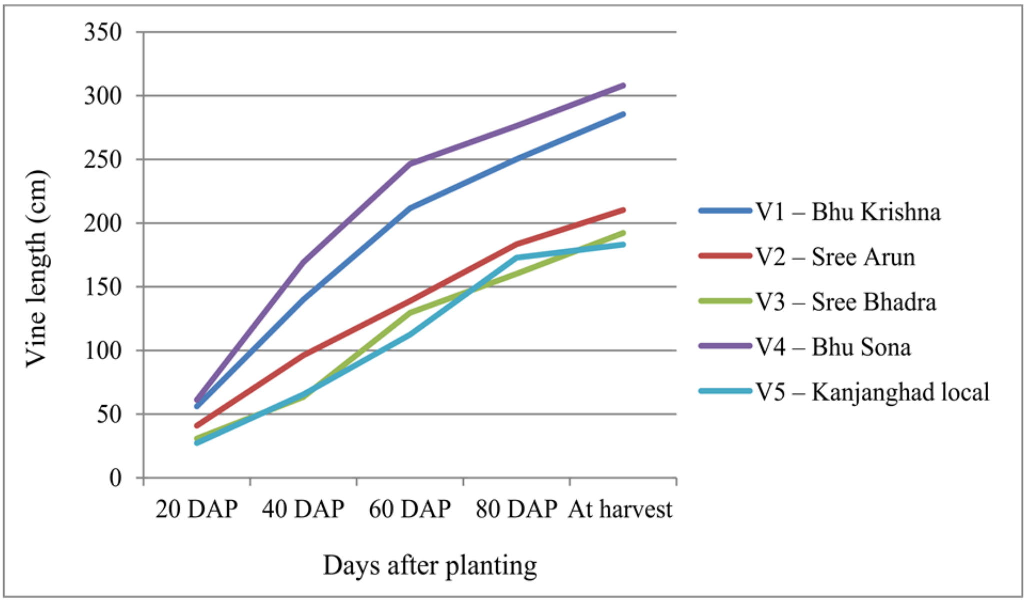


Fig. 13. Vine length of sweet potato varieties in *rabi* season

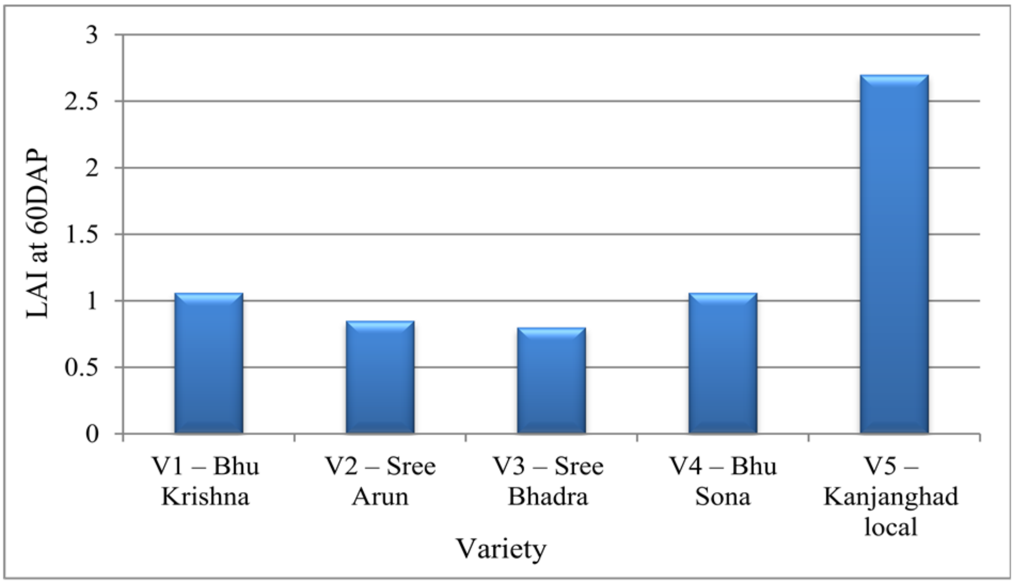


Fig. 14. Leaf area index of sweet potato varieties in *rabi* season

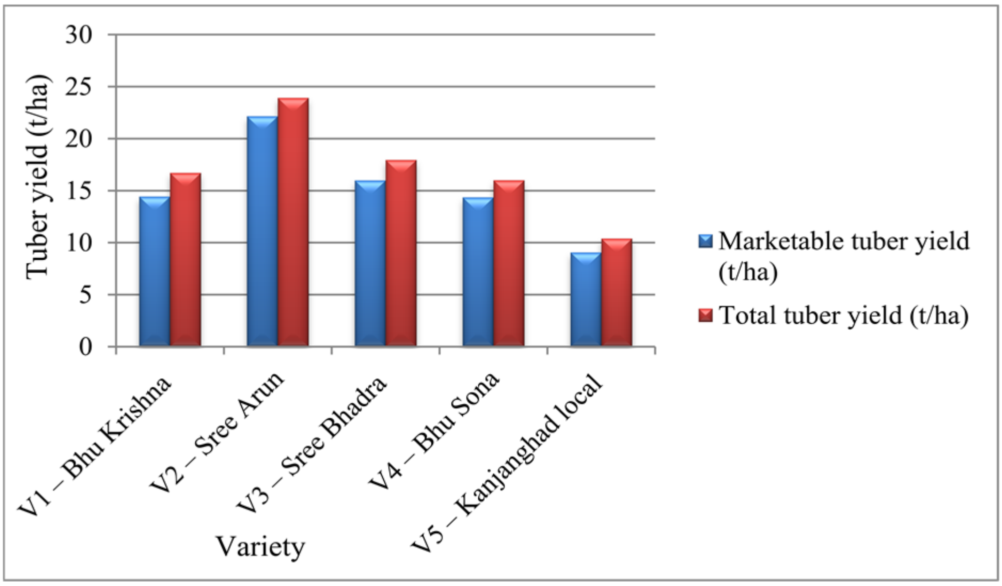


Fig. 15. Marketable and total tuber yield of sweet potato varieties in *rabi* season

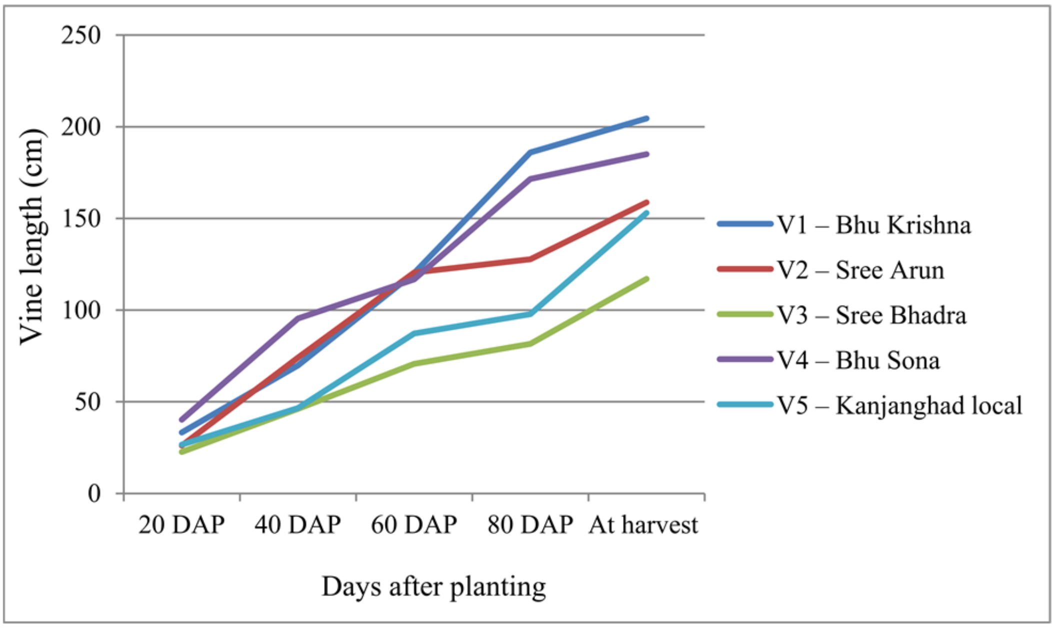


Fig. 16. Vine length of sweet potato varieties in summer season

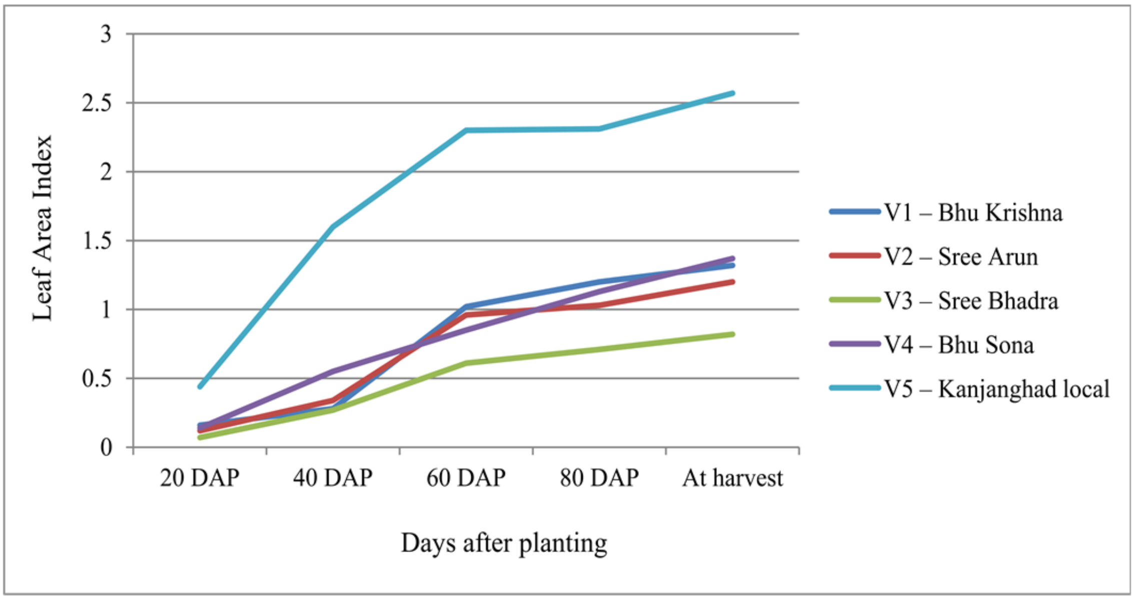


Fig. 17. Leaf area index of sweet potato varieties in summer season

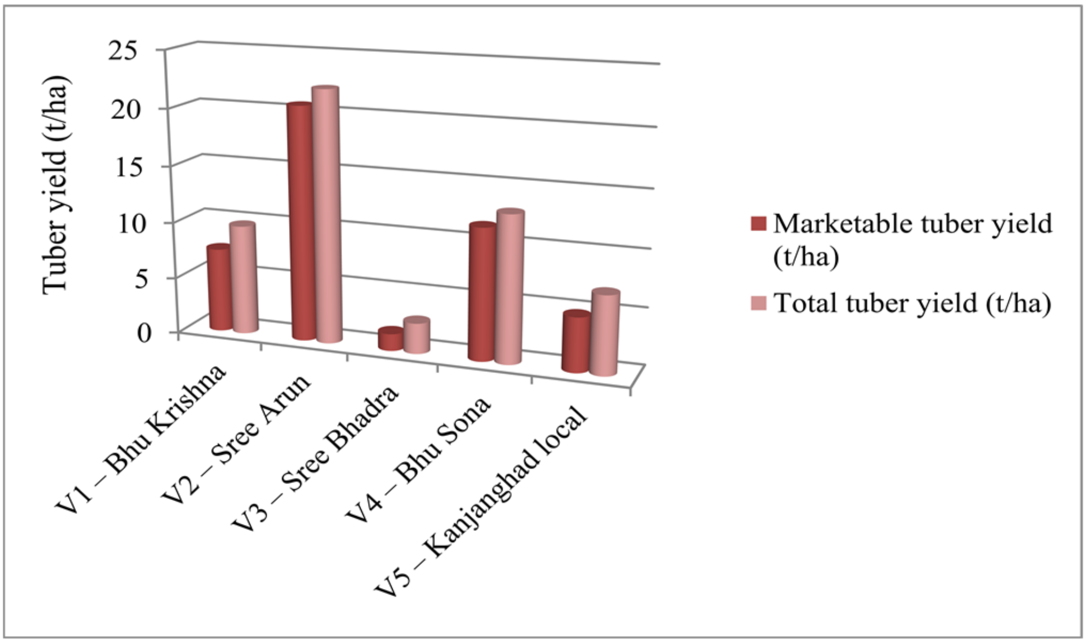


Fig. 18. Marketable and total tuber yield of sweet potato varieties in summer season

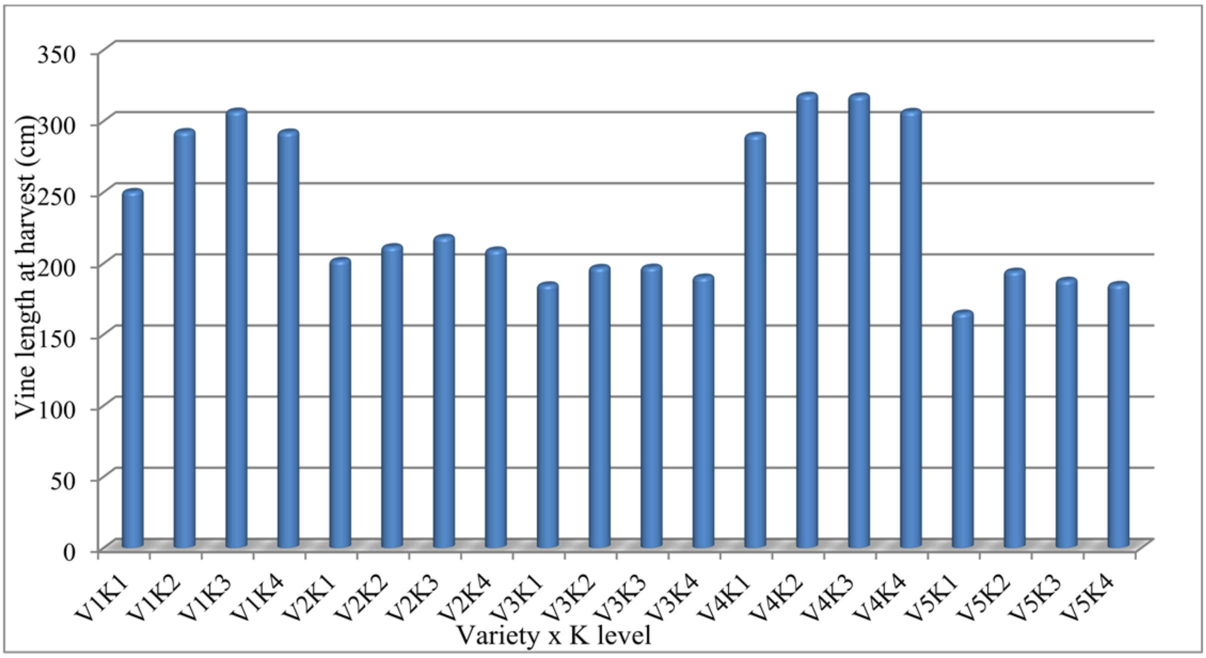


Fig. 19. Effect of varied K levels on vine length of different sweet potato varieties at harvest in *rabi* season

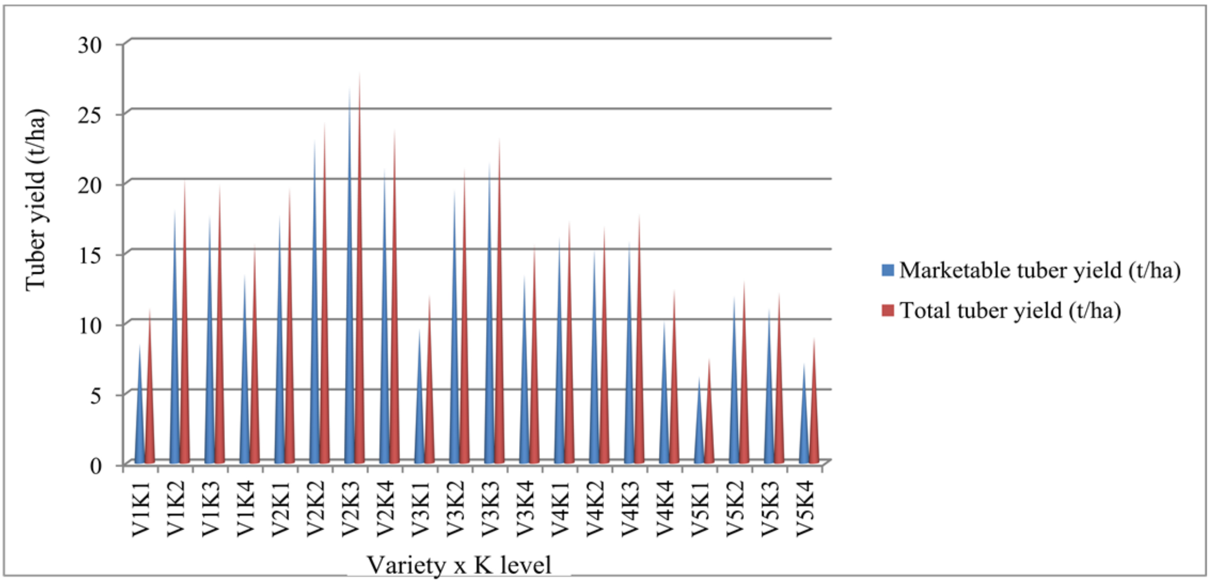


Fig. 20. Effect of varied K levels on tuber yield of different sweet potato varieties in *rabi* season

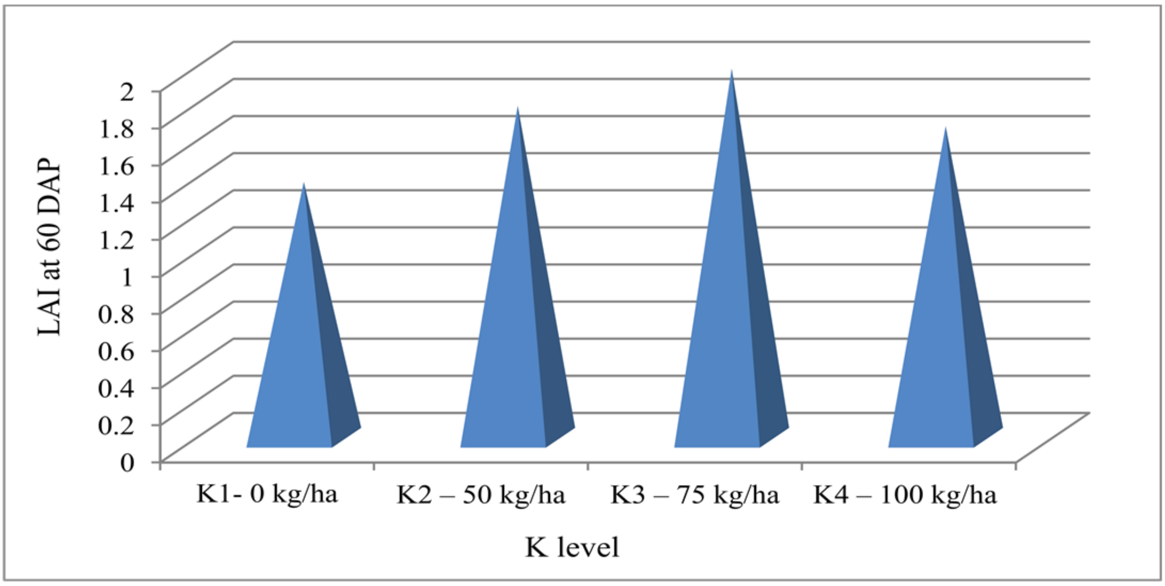


Fig. 21. Effect of varied K levels on leaf area index of sweet potato at 60 DAP in *kharif* season

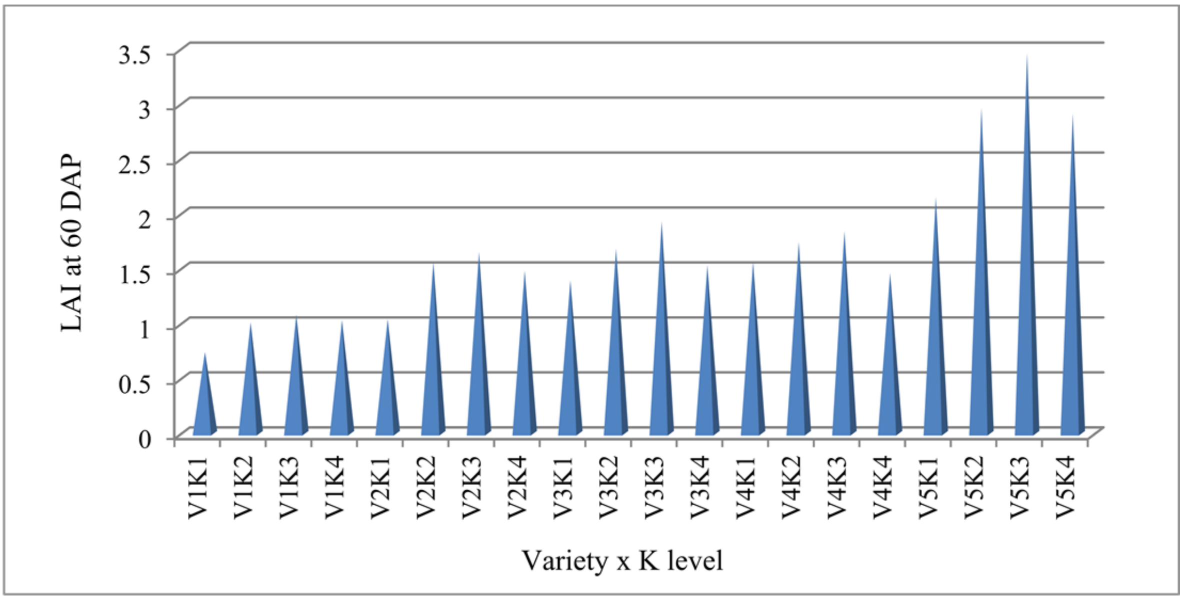


Fig. 22. Effect of varied K levels on leaf area index of different sweet potato varieties at 60 DAP in *kharif* season

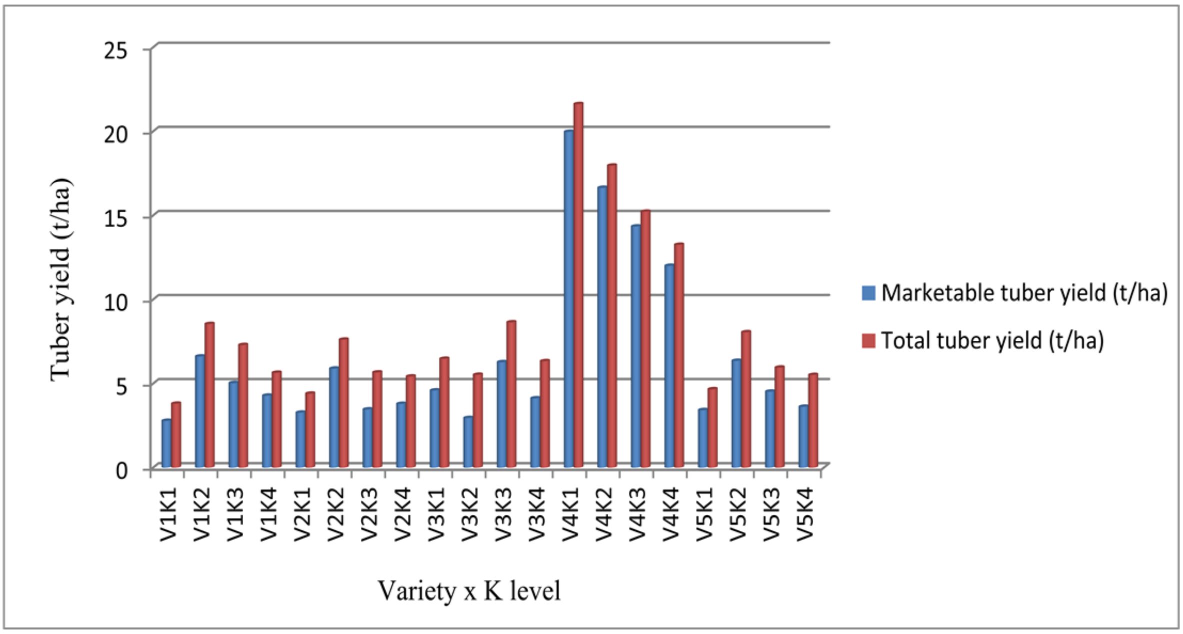


Fig. 23. Effect of varied K levels on marketable and total tuber yield of different sweet potato varieties in *kharif* season

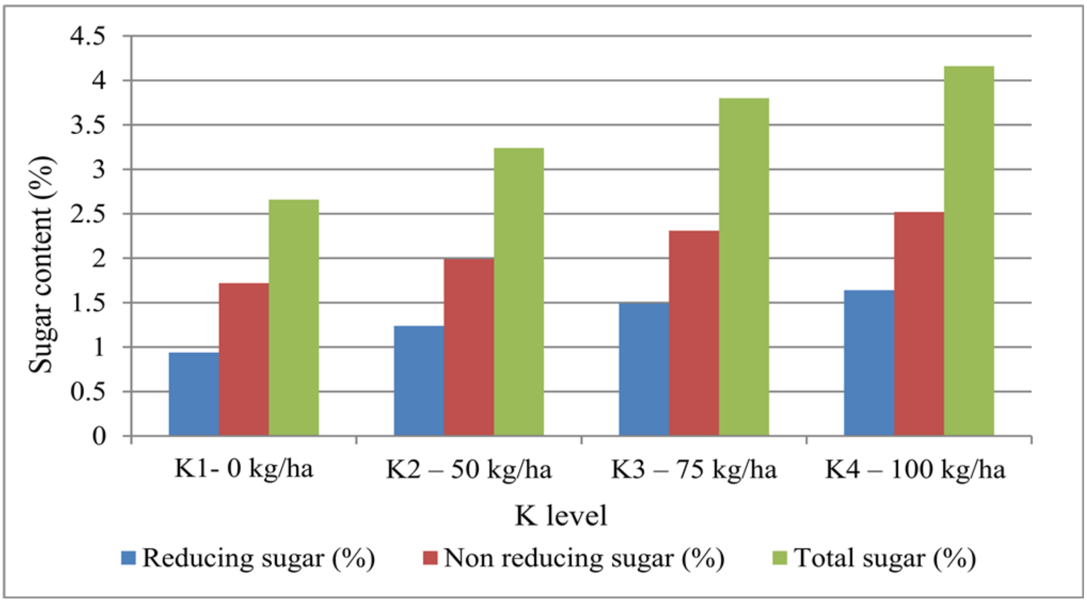


Fig. 24. Effect of varied K levels on sugar content of sweet potato in *kharif* season

5.3 ECONOMICS OF PRODUCTION IN *KHARIF* AND *RABI* SEASON

The cost of cultivation ranged from ₹ 101841 to ₹ 106961 in *kharif* season. The highest cost of cultivation was incurred when 100 kg/ha potassium was applied. The highest net return (₹ 397530) and BC ratio (4.90) was registered for variety Bhu Sona with no potassium. This variety was responsive even to the already available potassium in the soil and produced higher yield even when no potassium was applied. This resulted in more net returns compared to other varieties.

In *rabi*, cost of cultivation was higher as the crop was given intermittent irrigation during establishment and vegetative growth period. While comparing cost of cultivation during *rabi* season, it ranged from ₹ 136841 to ₹ 143161. Here also, the lowest cost was registered when no potassium was applied and the highest cost of cultivation was for 100 kg/ha potassium. The highest net return was realized for the variety Sree Arun. While comparing treatment combinations, variety Sree Arun applied with 75 kg/ha potassium registered higher net returns (₹ 528187) and BC ratio (4.71). The lowest net return was recorded when variety Kanjanghad Local was cultivated with no potassium application (₹ 17422) with a BC ratio of 1.13. However, while analysing the response of variety Bhu Sona for different doses of potassium, it can be found out that this variety can produce tubers even when soil was deficient in K and comparable with higher doses of potassium. The BC ratio for this variety at no potassium was 2.95 and was comparable with 50 and 75 kg/ha potassium doses. A further addition of 25 kg/ha had no influence on improving net returns as tuber yield was not increased.

Hence, from the current study it can be concluded that in *rabi* season, variety Sree Arun can be recommended with 50 - 75 kg/ha K_2O. It is better to go for variety Bhu Sona when no fertilizer K is applied, as in the case of organic farming. It is advisable to go for variety Bhu Sona during *kharif* season as it showed a high returns with good BC ratio.

Summary

6. SUMMARY

The research programme entitled 'Potassium utilization efficiency and seasonal response in photosynthates partitioning of high yielding sweet potato varieties' was carried out with the objectives of assessing the potassium utilization efficiency of sweet potato varieties, performance assessment of varieties under *kharif, rabi* and summer seasons and to study the seasonal changes in source-sink relationship. The studies were conducted at the Department of Agronomy, College of Agriculture, Vellanikkara, Thrissur during the period 2021-2022. The important findings from the study are summarized below.

A) Seasonal response

- Wide variation was observed in the performance of sweet potato varieties with seasons. In general, tuber yield of all varieties were good in *rabi* season, with Sree Arun registering the highest marketable tuber yield of 26.82 t/ha.
- High vegetative growth at the expense of tuber formation was observed during *kharif* season indicating poor photosynthates partitioning to sink. In summer season, tuber yield as well as vegetative growth was less.
- Seasonal response varied with varieties also. The variety Sree Arun performed better during summer season with marketable tuber yield of 21.56 t/ha whereas the variety Bhu Sona performed better in *kharif* season with a marketable tuber yield of 14.33 t/ha, compared to other varieties.
- Vine length was more for variety Bhu Sona during *kharif* and *rabi*.
- Variety Kanjanghad Local recorded significantly higher leaf area and leaf area index irrespective of seasons.
- Higher total dry matter production was noticed for variety Sree Arun in all seasons.
- Higher total dry matter production was observed in *rabi* season compared to *kharif* and summer for all varieties. Variety Sree Arun recorded higher total dry matter in *rabi* and summer (485.28 g/plant and 461.20 g/plant, respectively).
- Wide variation was noticed in quality parameters like crude fibre as well as sugar content of tubers. Higher crude fibre was noted for varieties Sree Arun and Kanjanghad Local compared to other varieties irrespective of the seasons.

- In general, higher sugar and crude fibre content was observed in tubers produced in *rabi* season. Variety Kanjanghad Local planted in *rabi* recorded higher crude fibre content compared to other varieties cultivated in different seasons. Higher sugar content was noted for varieties Sree Arun and Bhu Krishna. Variety Sree Arun planted in *rabi* recorded higher total sugar content of 8.55 per cent among different varieties.
- In general, most ideal season for all sweet potato varieties was *rabi* (September-October planting). Variety Sree Arun was found suitable for summer season and variety Bhu Sona was found suitable for *kharif* season among the five varieties. Tuber yield of variety Kanjanghad Local was found lower compared to other varieties.
- Variety Bhu Sona was found suitable for all three seasons as it can achieve average yield of 14 – 15 t/ha in all seasons compared to other varieties.

B) Response to applied K

- Growth parameters differed significantly with varied potassium levels. Growth parameters and chlorophyll content increased only up to 75 kg/ha potassium application and a further addition of 25 kg/ha had no influence on growth parameters of varieties during both seasons.
- Significant variation was noticed among varieties and potassium levels in terms of dry matter production also. In *kharif* season, shoot dry matter was higher and comparable at all K levels except at no potassium application. Significantly higher and comparable tuber dry matter production was recorded for 50 kg and 75 kg potassium levels.
- Significantly higher tuber dry matter production was noticed for variety Bhu Sona even when no K was applied.
- In *rabi* season, potassium applied @ 50, 75 and 100 kg/ha recorded significantly higher shoot dry matter, while, application of 50 and 75 kg/ha potassium recorded significantly higher tuber dry matter compared to other doses.
- Due to good tuberization and yield in *rabi* season, significant variation was noticed with respect to root-shoot ratio and significantly higher root-shoot ratio was observed for 75 and 50 kg/ha potassium doses.

- Tuber yield and yield parameters varied among varieties and was also influenced by potassium nutrition. In *kharif* season, only variety Bhu Sona could produce substantial marketable tuber yield. It performed well even without application of K and registered significantly higher average weight of tuber (251.72 g) and total tuber yield (17.01 t/ha) compared to other varieties.
- In *rabi* season, significant difference was observed for yield and yield parameters as influenced by potassium nutrition. Application of 50 kg and 75 kg/ha potassium resulted in significantly higher and comparable average weight of tuber, tuber yield per plant, marketable tuber yield, total tuber yield and harvest index compared to 100 kg/ha or no potassium.
- In *rabi* season, variety Sree Arun with 75 kg/ha potassium recorded significantly higher marketable tuber yield.
- Significantly higher unmarketable tuber yield was recorded at 100 kg/ha K application compared to lower doses. Variety Sree Arun recorded significantly higher unmarketable tuber yield when K_2O was applied @ 100 kg/ha.
- Quality parameters of sweet potato tuber increased with increase in K levels in both *kharif* and *rabi* seasons.
- In general, crude fibre and starch content were higher for variety Kanjanghad Local. Higher content of crude protein, total sugar and moisture was observed for varieties Bhu Sona, Sree Arun and Bhu Krishna, respectively at higher doses of applied potassium.
- In *rabi* season, variety Bhu Sona recorded significantly higher crude protein content at K applied @ 50 and 75 kg/ha. Higher total sugar content was observed for variety Sree Arun applied at 50, 75 and 100 kg/ha potassium doses. Significantly higher tuber moisture content was registered for variety Bhu Krishna applied with 75 and 100 kg/ha potassium.
- Primary nutrient content in the index leaf also significantly varied with K levels.
    - In *kharif* season, significantly higher phosphorus content was noticed for variety Bhu Sona, followed by the variety Bhu Krishna.
    - In the case of index leaf K content, significantly higher and comparable K content was observed for varieties Bhu Sona, Bhu Krishna and Sree Arun.
    - Potassium applied @ 50 and 75 kg/ha resulted in higher phosphorus and potassium content in index leaf compared to no K or 100 kg K.

- In *rabi* season, nitrogen content in the index leaf was significantly higher for the variety Sree Arun and variety Kanjanghad Local. While, nitrogen content showed a decreasing trend from no potassium to 100 kg/ha K application.
- Leaf phosphorus content also varied significantly and variety Kanjanghad Local registered significantly higher P content compared to other varieties.
- Leaf potassium content was significantly higher and comparable for varieties Sree Arun and Bhu Sona.
- Potassium concentration of the index leaf increased with increase in K application up to 75 kg/ha and then showed declining trend.

• In general, primary nutrient content of aerial portion was higher compared to the content in tuber.
  - With increase in potassium dose, potassium content in shoot as well as tuber increased.
  - In *kharif* season, average content of nitrogen, phosphorus and potassium of all varieties were 4.27 per cent, 0.17 per cent and 5.18 per cent, respectively and content in tuber was 1.75 per cent, 0.14 per cent and 1.06 per cent, respectively.
  - In *rabi* season, N content of tuber was significantly higher for the variety Bhu Sona, P content for varieties Sree Arun and Sree Bhadra and K content for variety Sree Arun.
  - Tuber N concentration was significantly higher and comparable for potassium applied @ 50 and 75 kg/ha.
  - Among the potassium levels, significantly higher tuber phosphorus content was noticed for 50 kg/ha potassium level compared to other doses.
  - Potassium content in shoot showed an increasing trend with increase in K application and varieties Sree Bhadra and Bhu Krishna showed luxury consumption at higher doses of potassium.
  - Application of 75 and 100 kg/ha of potassium had a significantly higher and comparable tuber K content.
  - In *rabi* season, average content of nitrogen, phosphorus and potassium of all varieties were 4.30 per cent, 0.10 per cent and 3.48 per cent, respectively and content in tuber was 1.37 per cent, 0.17 per cent and 1.31 per cent, respectively.

- While considering the uptake of primary nutrients by varieties during *kharif* season, uptake by aerial parts was more compared to tuber due to luxurious vegetative growth and poor tuberization. Among the varieties, nutrient removed by variety Bhu Sona was significantly higher.
- In *rabi* season, tuber nutrient uptake was significantly higher for the variety Sree Arun and uptake increased only up to 75 kg/ha applied potassium. But, shoot potassium uptake increased with increase in K application. While tuber K uptake was more for variety Sree Arun applied with 50 and 75 kg/ha potassium.
- In general, soil available potassium decreased from 60 DAP to harvest and K status in the soil showed increase with increase in potassium application.
- The variety Sree Arun registered higher potassium utilization efficiency, nutrient efficiency ratio and nutrient harvest index compared to other varieties. The efficiency showed decreasing trend with increase in K dose.
- The variety Bhu Sona was efficient in utilizing K and registered significantly higher potassium harvest index even when K fertilizer was not applied.
- Comparing the economics of production, variety Bhu Sona was responsive and produced higher yield even when no potassium was applied and led to more net returns compared to other varieties in *kharif* season.
- In *rabi* season, the highest net return was realized for the variety Sree Arun which was superior with respect to tuber yield.

In general, varietal selection is important in sweet potato cultivation as the partitioning of total dry matter towards tuber storage is highly influenced by seasons. Potassium dose of 50 kg/ha was found sufficient even when the status of available K in soil was low. Bhu Sona and Sree Arun were found K efficient than other varieties.

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7. REFERENCES

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Appendices

Appendix I

Weather data during the conduct of field experiment

a) Weekly weather data during *kharif* season

Standard weeks	Maximum temperature (^oC)	Minimum temperature (^oC)	Relative humidity (%)	Sunshine hours	Rainfall (mm)
27	31.8	24.5	82	33.4	35.8
28	28.7	22.5	91	6.1	331.9
29	28.8	23.1	89	10.2	156.9
30	29.5	23.8	87	11.3	95.5
31	30.6	23.3	83	18.2	39.3
32	30.2	23.4	87	20.8	122.5
33	29.7	23.4	87	7.7	62.4
34	30.9	23.6	85	26.7	55.4
35	29.7	23.2	89	16.3	156.5
36	29.3	23.6	89	7.9	131.2
37	30.4	23.9	87	22.6	94.1
38	32.7	24.4	77	43.8	1.2
39	30.3	23.6	81	36.5	44.5
40	32.1	23.9	85	26.6	113.9
41	29.7	23.6	91	20.2	192.5
42	30.5	23.5	89	18.3	216.6
43	32.8	23.5	82	38.2	61.4
44	31.5	23.5	82	16.0	121.2
45	31.2	23.5	81	18.1	35.2
46	30.3	23.4	88	13.7	160.5
47	31.6	23.1	81	25.6	44.3
48	31.3	23.8	72	18.2	30.7

b) Weekly weather data during *rabi* season

Standard weeks	Maximum temperature (°C)	Minimum temperature (°C)	Relative humidity (%)	Sunshine hours	Rainfall (mm)
43	32.8	23.5	82	38.2	61.4
44	31.5	23.5	82	16.0	121.2
45	31.2	23.5	81	18.1	35.2
46	30.3	23.4	88	13.7	160.5
47	31.6	23.1	81	25.6	44.3
48	31.3	23.8	72	18.2	30.7
49	32.8	23.6	78	49.2	0.3
50	32.6	24.9	65	60.2	0.0
51	32.2	23.0	63	59.8	0.0
52	32.4	21.8	61	72.9	0.6
1	32.4	24.0	63	63.5	0.0
2	33.4	21.9	67	61.9	0.0
3	33.9	22.3	63	65.7	0.0
4	33.2	21.3	67	61.1	0.0
5	34.7	23.7	63	60.1	0.0
6	34.0	21.8	60	58.5	0.0
7	34.4	24.2	53	48.8	0.0
8	35.3	23.8	59	62.3	0.0

c) Weekly weather data during summer season

Standard week	Maximum temperature (°C)	Minimum temperature (°C)	Relative humidity (%)	Sunshine hours	Rainfall (mm)
51	32.2	23	63	59.8	0
52	32.4	21.8	61	72.9	0.6
1	32.4	24	63	63.5	0
2	33.4	21.9	67	61.9	0
3	33.9	22.3	63	65.7	0
4	33.2	21.3	67	61.1	0
5	34.7	23.7	63	60.1	0
6	34	21.8	60	58.5	0
7	34.4	24.2	53	48.8	0
8	35.3	23.8	59	62.3	0
9	36.2	23.9	41	69.7	0
10	36.9	23.7	48	65	0
11	37.2	24.7	59	48.6	0
12	34.6	24.9	72	28.9	0.8
13	35.2	26	73	41.4	0.9
14	35.4	25.2	74	48.5	6.8
15	32.2	23.9	81	19.3	45.2
16	34.1	25.4	79	50.7	24.4
17	34.7	25.9	75	41.9	6.8
18	34.2	24.7	78	37.4	67.6
19	31.4	23.8	86	15.8	115.4
20	28	23.5	91	0	148.3

Appendix II Cost of cultivation

Cost of vine : 50 paise/vine

Cost of FYM : Rs. 1.5/kg

Cost of fertilizers : Urea – 6 Rs./kg, SSP – 9 Rs./kg, MOP – 19 Rs./kg

Cost of labour : Rs. 645/head/day

Potassium utilization efficiency and seasonal response in photosynthates partitioning of high yielding sweet potato varieties

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ABSTRACT OF THE THESIS

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ABSTRACT

A study entitled 'Potassium utilization efficiency and seasonal response in photosynthates partitioning of high yielding sweet potato varieties' was carried out with the objectives of assessing the potassium utilization efficiency of sweet potato varieties, performance assessment of varieties under *kharif, rabi* and summer seasons and to study the seasonal changes in source-sink relationship. Three experiments were carried out during the period 2021 - 22 at the Agronomy Farm, College of Agriculture, Vellanikkara, Thrissur.

Five high yielding varieties [Bhu Krishna (V_1), Sree Arun (V_2), Sree Bhadra (V_3), Bhu Sona (V_4) and Kanjanghad Local (V_5)] were raised during *kharif, rabi* as well as summer seasons with POP recommended dose of NPK (75:50:75 kg $N:P_2O_5:K_2O$/ha) to assess the seasonal variations in tuber yield and source - sink relationship. Wide variation was observed in the performance of sweet potato varieties with seasons. In general, tuber yield of all varieties were good in *rabi* season, with Sree Arun registering the highest marketable tuber yield of 26.82 t/ha. Photosynthate partitioning towards underground storage was more in *rabi* season, leading to better tuber yield in all varieties. In *kharif,* tuber yield was meagre and vegetative growth was much higher indicating poor partitioning to sink, whereas in summer season tuber yield as well as vegetative growth were less. Wide variation in varietal performance was observed in both *kharif* and summer. Variety Sree Arun performed better during summer season with marketable tuber yield of 21.56 t/ha whereas variety Bhu Sona performed better in *kharif* season with a marketable tuber yield of 14.33 t/ha, compared to other varieties

Experiment on K utilization efficiency consisted of 20 treatment combinations (with five varieties of sweet potato and four potassium levels) in Randomized Block Design, replicated thrice and was laid out both in *kharif* and *rabi*. Varieties included were Bhu Krishna (V_1), Sree Arun (V_2), Sree Bhadra (V_3), Bhu Sona (V_4) and Kanjanghad Local (V_5). Four potassium levels were 0 (K_1), 50 (K_2), 75 (K_3) and 100 kg K_2O/ha (K_4). Nitrogen and phosphorus were applied @ 75 kg and 50 kg/ha as per POP recommendation.

Growth parameters differed significantly among varieties and also with varied potassium levels. During *kharif* and *rabi* seasons, the highest vine length was observed for variety Bhu Sona, whereas number of branches and leaf area index were higher for

variety Kanjanghad Local and maximum chlorophyll content was recorded for variety Sree Bhadra. Growth parameters increased only up to 75 kg/ha potassium application and a further addition of 25 kg/ha had no influence on performance of varieties during both seasons.

Tuber yield and yield parameters also varied among varieties and were also influenced by potassium nutrition. In *kharif* season, the variety Bhu Sona only could produce substantial marketable tuber yield (15.74 t/ha). It performed well even without the application of K and registered significantly higher average weight of tuber (251.72 g), total tuber yield (17.01 t/ha) and tuber dry matter production (102.91 g/plant) compared to other varieties. The data on dry matter accumulation indicated that the photosynthates partitioning was affected during *kharif* season in the case of all other varieties ultimately leading to luxuriant vegetative growth at the expense of tuber yield. This emphasise the photoperiod sensitivity of sweet potato varieties and hence K utilization efficiency of varieties were analyzed based on data generated in *rabi* season.

In *rabi* season, the performance of all the varieties were good. Average weight of tuber, marketable tuber yield (22.15 t/ha) and tuber dry matter production were higher for variety Sree Arun. Potassium applied @ 50 kg and 75 kg/ha resulted in significantly higher and comparable marketable tuber yield compared to 100 kg or no potassium. Among the treatment combinations, variety Sree Arun with 75 kg/ha potassium registered the highest marketable tuber yield (26.82 t/ha). The highest dose of 100 kg/ha potassium led to the highest unmarketable tuber yield (62.86 g/plant). Varieties Sree Arun and Bhu Krishna had higher potassium utilization efficiency. However the variety Bhu Sona could produce substantial tuber yield even without application of potassium fertilizer and was found suitable even for low K soils. Luxury consumption was noticed for varieties Sree Bhadra and Bhu Krishna at higher doses of K with shoot K content of 5.46 per cent and 5.12 per cent, respectively at 100 kg/ha potassium application.

Quality parameters of sweet potato tuber increased with increase in K levels in both *kharif* and *rabi* seasons. Crude fibre and starch content were higher for variety Kanjanghad Local, crude protein content for variety Bhu Sona and total sugar content for variety Sree Arun. Variety Bhu Krishna had significantly higher tuber moisture content of 63- 68 per cent.

The results of the experiments indicated that varietal selection is important in sweet potato cultivation as the partitioning of total dry matter towards tuber storage is highly influenced by seasons and *rabi* is the most ideal season. The varieties Bhu Sona and Sree Arun were found suitable for *kharif* and summer seasons, respectively in the present study. In general, potassium dose of 50 kg was found sufficient even when the status of available K in soil was low. Bhu Sona and Sree Arun were found K efficient than other varieties.

സംഗ്രഹം

തൃശ്ശൂർ വെള്ളാനിക്കര കാർഷിക കോളേജിലെ അഗ്രോണോമി ഫാർമിൽ 2021 - 2022 കാലയളവിൽ 'ഉയർന്ന വിളവ് തരുന്ന വിവിധ മധുരക്കിഴങ്ങു ഇനങ്ങളുടെ പൊട്ടാസ്യം ഉപയോഗക്ഷമതയും വിവിധ കാലങ്ങളിൽ ഇവയുടെ പ്രകാശ സംശ്ലേഷണ പദാർത്ഥങ്ങളുടെ വിഭജനവും' എന്ന തലക്കെട്ടിൽ പരീക്ഷണങ്ങൾ നടത്തുകയുണ്ടായി. പൊട്ടാസ്യം മൂലകത്തിൻ്റെ ഉപയോഗക്ഷമതയും മധുരക്കിഴങ്ങ് ഇനങ്ങളുടെ വിവിധ കാലങ്ങളിലുള്ള പ്രവർത്തന ക്ഷമതയും ആയിരുന്നു ഈ പഠനത്തിൻ്റെ മുഖ്യ ലക്ഷ്യങ്ങൾ.

ഉയർന്ന വിളവ് നൽകുന്ന അഞ്ചു ഇനങ്ങളായ ഭൂ കൃഷ്ണ, ശ്രീ അരുൺ, ശ്രീ ഭദ്ര, ഭൂ സോനാ, കാഞ്ഞങ്ങാട് ലോക്കൽ മൂന്ന് കാലങ്ങളിൽ കേരള കാർഷിക സർവകലാശാലയുടെ പി ഓ പി ശുപാർശ ചെയ്യുന്ന N P K വളത്തിൻറെ അളവ് (75:50:75 കിലോ ഗ്രാം/ഹെക്ടർ) ഉപയോഗിച്ചു വളർത്തി, ഇവയുടെ വിളവിൽ വരുന്ന വ്യതിയാനങ്ങൾ വിലയിരുത്തി. ഋതുക്കൾക്കനുസരിച്ചു മധുരക്കിഴങ് ഇനങ്ങളുടെ പ്രകടനത്തിൽ വ്യാപകമായ വ്യതിയാനം നിരീക്ഷിക്കപ്പെട്ടു. പൊതുവെ, രണ്ടാം വിള കാലത്തിൽ (റാബി) എല്ലാ ഇനങ്ങളുടെയും കിഴങ്ങു വിളവ് മികച്ചതായിരുന്നു. ശ്രീ അരുൺ ഹെക്ടറിനു 26.82 ടൺ വിളവ് രേഖപ്പെടുത്തി. മധുരക്കിഴങ് ഒന്നാം വിളയായി (ഖാരിഫ്) നട്ടപ്പോൾ തുമ്പിൽ വളർച്ച കൂടുതലായി കാണുകയും ഇത് കിഴങ്ങുത്പാദനം കുറയ്ക്കുകയും ചെയ്തു. മൂന്നാം വിളയിലും (വേനൽ) കിഴങ്ങുത്പാദനവും സസ്യ വളർച്ചയും കുറവായിരുന്നു. 21.56 ടൺ/ഹെക്ടർ കിഴങ്ങു വിളവോടെ മൂന്നാം വിളയിൽ ശ്രീ അരുൺ എന്ന ഇനം മികച്ച പ്രകടനം കാഴ്ച വെച്ചു. എന്നാൽ ഒന്നാം വിള കാലത്തു മറ്റു ഇനങ്ങളെ അപേക്ഷിച്ചു ഭൂ സോനാ എന്ന ഇനം 14.33 ടൺ/ഹെക്ടർ വിപണമൂല്യമുള്ള കിഴങ്ങു വിളവു രേഖപ്പെടുത്തി.

പൊട്ടാസ്യം വിനിയോഗ കാര്യക്ഷമതയെ കുറിച്ചുള്ള പഠനം റാൻഡമൈസിഡ് ബ്ലോക്ക് ഡിസൈനിൽ 20 ട്രീറ്റ്മെന്റ് കോമ്പിനേഷനിൽ രണ്ടു വിളക്കാലത്തും നടത്തുകയുണ്ടായി. ഇതിനായി ഭൂ കൃഷ്ണ, ശ്രീ അരുൺ, ശ്രീ ഭദ്ര, ഭൂ സോനാ, കാഞ്ഞങ്ങാട് ലോക്കൽ എന്നീ ഇനങ്ങളും 0, 50, 75, 100 കിലോ ഗ്രാം/ഹെക്ടർ എന്ന അളവുകളിൽ പൊട്ടാസ്യം വളവും നൽകി. നൈട്രജൻ 75 കിലോ/ഹെക്ടർ, ഫോസ്ഫറസ് 50 കിലോ/ഹെക്ടർ എന്ന അളവിലും എല്ലാ ഇനങ്ങൾക്കും നൽകി.

കിഴങ്ങു വർഗങ്ങളുടെ വിളവും വിളവിനെ സ്വാധീനിക്കുന്ന ഘടകങ്ങളും ഇനങ്ങൾ തമ്മിലും പൊട്ടാസിയം അളവുകൾ തമ്മിലും വ്യത്യാസപ്പെട്ടിരിക്കുന്നു. ഒന്നാം വിള കാലത്തു ഭൂ സോനാ എന്ന ഇനത്തിന് മാത്രമേ വിപണന യോഗ്യമായ കിഴങ്ങു വിളവ് (15.74 ടൺ/ഹെക്ടർ) ഉത്പാദിപ്പിക്കാൻ സാധിച്ചുള്ളു. പൊട്ടാസിയം പ്രയോഗം കൂടാതെ തന്നെ ഇത് മികച്ച വിളവ് ഉത്പാദിപ്പിക്കുകയും ഒരു കിഴങ്ങിൻ്റെ ശരാശരി തൂക്കം 251.72 ഗ്രാമും മൊത്തം കിഴങ്ങു വിളവു 17.01 ടൺ/ഹെക്ടർ രേഖപ്പെടുത്തുകയും ചെയ്തു. ഒന്നാം വിള കാലത്തെ ഇനങ്ങളുടെ പ്രകടനവും വിളവും മോശമായതിനാൽ രണ്ടാം വിള കാലത്തെ വിവരങ്ങൾ അടിസ്ഥാനമാക്കി ഇനങ്ങളുടെ പൊട്ടാസ്യം ഉപയോഗക്ഷമത വിശകലനം ചെയ്യുകയുണ്ടായി.

രണ്ടാം വിള കാലത്തു എല്ലാ ഇനങ്ങളുടെയും കിഴങ്ങുത്പാദനം മികച്ചതായിരുന്നു. കിഴങ്ങിൻറെ ശരാശരി തൂക്കവും കിഴങ്ങു വിളവും ശ്രീ അരുൺ ഇനത്തിനു കൂടുതലായി രേഖപ്പെടുത്തി. വിവിധ പൊട്ടാസ്യം അളവുകളിൽ 50, 75 കിലോ ഗ്രാം /ഹെക്ടർ ഉയർന്ന കിഴങ്ങു വിളവ് രേഖപ്പെടുത്തി. വിവിധ ട്രീറ്റ്മെന്റ് കോമ്പിനേഷനുകളിൽ ശ്രീ അരുൺ ഇനം 75 കിലോ ഗ്രാം /ഹെക്ടർ പൊട്ടാസ്യം വളം ചെയ്തപ്പോൾ കൂടുതൽ കിഴങ്ങുത്പാദിപ്പിച്ചു. വിവിധ ഇനങ്ങളിൽ രണ്ടാം വിള കാലത്തു ശ്രീ അരുൺ, ഭൂ കൃഷ്ണ ഇനങ്ങൾ ഉയർന്ന പൊട്ടാസ്യം ഉപയോഗക്ഷമത

രേഖപ്പെടുത്തി. എന്നിരുന്നാലും, ഭൂ സോനാ എന്ന ഇനത്തിന് പൊട്ടാസ്യം വളപ്രയോഗം കൂടാതെ തന്നെ ഗണ്യമായി കിഴങ്ങു വിളവ് നല്കാൻ കഴിയുമെന്നു നിരീക്ഷിക്കുകയുണ്ടായി.

പൊതുവേ, കൂടിയ അളവിലുള്ള വളപ്രയോഗം വഴി മധുരക്കിഴങ്ങിൻറെ ഗുണനിലവാര ഘടകങ്ങൾ ഒന്നാം വിളക്കാലത്തും രണ്ടാം വിളക്കാലത്തും വർധിച്ചതായി കണ്ടു. കാഞ്ഞങ്ങാട് ലോക്കൽ ഇനത്തിന് അസംസ്കൃത നാരുകളുടെയും അന്നജത്തിന്റെയും അളവും ഭൂ സോനാ ഇനത്തിനു അസംസ്കൃത പ്രോട്ടീൻ അളവും ശ്രീ അരുൺ ഇനത്തിന് മൊത്ത പഞ്ചസാര അളവും കൂടുതലായി രേഖപ്പെടുത്തി. ഭൂ കൃഷ്ണ ഇനത്തിൽ 63 - 68 ശതമാനം ഈർപ്പവും രേഖപ്പെടുത്തി.

മധുരക്കിഴങ്ങ് കൃഷിയിൽ ഇനങ്ങളുടെ തിരഞ്ഞെടുപ്പ് എങ്ങനെ വിവിധ വിളക്കാലങ്ങളെ ആശ്രയിച്ചിരിക്കുന്നുവെന്നും അവ എങ്ങനെ കിഴങ്ങുത്പ്പാദനത്തിലേക്ക് നയിക്കുന്നുവെന്നും പഠന ഫലങ്ങൾ സൂചിപ്പിക്കുന്നു. വിവിധ കാലങ്ങളിലുള്ള ഇനങ്ങളുടെ ഉത്പ്പാദനം നോക്കുമ്പോൾ രണ്ടാം വിളക്കാലമാണു ഏറ്റവും അനുയോജ്യമെന്ന് കണ്ടെത്തി. നിലവിലെ പഠനത്തിൽ ശ്രീ അരുൺ, ഭൂ സോനാ എന്നീ ഇനങ്ങൾ യഥാക്രമം മൂന്നാം വിളക്കാലത്തിനും ഒന്നാം വിളക്കാലത്തിനും അനുയോജ്യമാണെന്ന് കണ്ടെത്തി. വിവിധ പൊട്ടാസ്യം അളവുകളിൽ, 50 കിലോഗ്രാം/ഹെക്ടർ മികച്ച വിളവ് തരാൻ പര്യാപ്തമാണെന്നു കണ്ടെത്തി. ഇനങ്ങളിൽ, പൊട്ടാസ്യം കാര്യക്ഷമത കൂടുതലുള്ള ഇനങ്ങളായി ഭൂ സോനയും ശ്രീ അരുണും കണ്ടെത്തി.