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RESEARCH ARTICLE

Productivity enhancement in sweet potato (*Ipomoea batatas* L.) with PSAP and nano urea under tropical conditions

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Abstract

Nutrient management plays a crucial role in yield and productivity of sweet potato. Nutrient application as per crop requirement and proper method is very much essential to bridge the yield gap. In this background, a field experiment was conducted at the Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram to enhance the productivity of sweet potato with potassium salt of active phosphorus (PSAP) and nano urea. The experiment was laid out in factorial factorial randomised complete block design (RCBD) with 2 levels of recommended dose of nutrients (l_1: 75 % NPK and l_2: 50 % NPK) and four combinations of foliar application (FA) with PSAP and nano urea along with soil drenching (SD) of PSAP (n_1: Nano urea at 0.2 % at 30 Days after planting (DAP) and PSAP at 0.2 % at 45 DAP ; n_2: Nano urea at 0.2 % at 30 DAP and PSAP at 0.4 % at 45 DAP; n_3: Nano urea at 0.4 % at 30 DAP and PSAP at 0.2 % at 45 DAP; n_4: Nano urea at 0.4 % at 30 DAP and PSAP at 0.4 % at 45 DAP. Soil drenching was given uniformly to all treatments at the rate of 0.4 % at 15 DAP except Kerala Agricultural University package of practices (KAU POP) (control). Among the treatments, l_2n_4 recorded significantly higher average tuber weight (258 g), marketable tuber yield (17.27 t ha^{-1}) and tuber yield (19.93 t ha^{-1}). From the study it could be concluded that soil application of 50 % of recommended dose of NPK with soil drenching of PSAP at 0.4 % at 15 DAP supplemented with foliar application of nano urea at 0.4 % at 30 DAP and PSAP at 0.4 % at 45 DAP could enhance productivity by 37.64 % in sweet potato.

Keywords: nano urea; nutrient management; potassium salt of active phosphorus; sweet potato

Introduction

Sweet potato is a major tuber crop grown widely throughout the warm temperate and tropical parts of the world. This is a vegetatively propagated tuber crop with an abundant source of vitamins (A and C), carbohydrates, starch, antioxidants, minerals and amino acids. Sweet potato is cultivated in almost all parts of India and it is considered as “poor man's rich food”. Average productivity of sweet potato in India during 2023 is 11718.2 kg ha^{-1}(1). Enhanced productivity of sweet potato depends on source-sink balance, which is directly influenced by nitrogen, phosphorus, potassium and their interaction (2). Therefore, nutrient management has a crucial role in stable and high productivity of sweet potato. Nutrient application through conventional methods leads to nutrient loss through leaching, volatilisation, denitrification and fixation in soil (3). Application of nutrients as per the requirement of the crop through efficient methods of application and nutrient sources is very crucial to bridge the yield gap between potential yield and actual yield.

One of the most promising technologies developed to address the shortcomings of traditional agricultural practices is nanotechnology. The major part in nanotechnology for agricultural purposes is the development of smart fertilisers to potentially increase the nutrient use efficiency (4). Nano urea is a nano-scale variant of urea, which can enhance nitrogen use efficiency, thereby improving growth, quality and yield of the crop through controlled release of nitrogen. This will reduce the risk of runoff and leaching loss of nutrients, unlike conventional fertilisers (5).

Potassium salt of active phosphorus (PSAP) is a recently developed molecule with 180 % solubility in water with neutral pH and free from chloride and sodium. It is developed using catalytic technology, in which P is split and K is attached to it before its isotopic form is modified. This molecule is readily absorbed through foliage and is free from residual effects in the plant and soil. It has been notified as 0-40-40 grade potassium metaphosphate diamer (PMPD) by the Ministry of Agriculture and Farmers Welfare, Government of India in the September 2022 gazette (22-09-2022; page no. 16; point iv-9) (6). The high solubility and balanced phosphorus and potassium composition of PSAP enable efficient nutrient supply to sweet potato, which requires greater P and K availability during critical stages of crop growth. In this background a study was conducted to enhance the productivity of sweet potato with soil drenching of PSAP and foliar application of nano urea and PSAP.

Materials and Methods

A field experiment was conducted at the Instructional Farm attached to the College of Agriculture, Vellayani during November 2023 to February 2024. Experimental site was located at 8°25'43" N latitude, 76°59'98" E longitude and 29 m above mean sea level (MSL). Mean maximum temperature at experimental site during cropping period was between 30.17 and 31.94 °C and mean minimum temperature was 22.19 and 24.23 °C. Total rainfall recorded during the cropping period was 725.57 mm. Experiment was laid out in randomised complete block design with 3 replications. Treatments were imposed as follows.

Levels of nutrients (L)

l_1: 50 % N, P, K; l_2: 75 % N, P, K

Soil drenching (SD) and foliar application (FA)

n_1: SD of PSAP at 0.4 % (15 DAP) + FA of nano urea at 0.2 % (30 DAP) and PSAP at 0.2 % (45 DAP)

n_2: SD of PSAP at 0.4 % (15 DAP) + FA of nano urea at 0.2 % (30 DAP) and PSAP at 0.4 % (45 DAP)

n_3: SD of PSAP at 0.4 % (15 DAP) + FA of nano urea at 0.4 % (30 DAP) and PSAP at 0.2 % (45 DAP)

n_4: SD of PSAP at 0.4 % (15 DAP) + FA of nano urea at 0.4 % (30 DAP) and PSAP at 0.4 % (45 DAP)

Control: NPK application based on Kerala Agricultural University package of practices (75:50:75 kg N: P_2O_5:K_2O ha^{-1}) (7)

Note: FA: Foliar application; SD: Soil drenching

Soil drenching with PSAP was carried out at 15 DAS using 1 g PSAP dissolved in 250 mL of water, maintaining a concentration of 0.4 %. Yield and yield attributing characters like number of tubers per vine, length and girth of tuber, average tuber weight, marketable tuber yield and tuber yield were recorded at harvest.

Number of tubers per vine

The number of tubers in five randomly selected observational plants was counted and expressed in numbers.

Length of tuber

Tuber length was measured from the base to the tip of the tuber of five randomly selected tubers of each plot and expressed in centimetre.

Girth of tuber

Tubers chosen for measuring tuber length were used for measuring tuber girth. Middle and two ends of each tuber were encircled using a measuring tape and average was taken. Mean value of each tuber was again averaged and expressed in terms of centimetre.

Average tuber weight

Five randomly selected tubers from each experimental plot were weighed individually and the mean tuber weight was calculated and expressed in gram.

Marketable tuber yield

Well developed tubers which are free from weevil infestation, disease infestation and tuber cracking were selected, weighed and expressed in terms of t ha^{-1}.

Tuber yield

Total yield from net plot area was recorded and expressed in terms of t ha^{-1}

Statistical analysis

The obtained data were statistically analysed by following standard procedure. One way ANOVA was used to find whether the treatment means are significantly different at 5 % level of significance ($\alpha = 0.05$). Upon obtaining significant ANOVA result, a multiple comparison was done using the least significant difference (LSD) test. All the statistical analysis were carried out using grapes Agri 1 software (8).

Results

Number of tubers per vine

Number of tubers per vine was not significantly influenced by levels of nutrients, soil drenching and foliar application. Interaction effect and the comparison between treatment vs control were also not significant.

Length of tuber

Length of tuber was influenced by levels of nutrients, SD and FA (Table 1). Treatment l_2 (50 % of N, P and K) recorded significantly higher tuber length (11.32 cm) among different levels of nutrients. Considering the effect of SD and FA on length of tuber, treatment n_4 recorded the highest value (14.43 cm). While considering the interaction of different levels of nutrients, SD and FA, treatment combination l_2n_4 recorded significantly higher tuber length (15.30 cm). The comparison of treatment vs control was not significant.

Girth of tuber

Girth of tuber was affected by levels of nutrients as well as SD and FA but their interaction effect was not significant (Table 1). Among different levels of nutrients, treatment l_2 (50 % of N, P and K) recorded significantly higher tuber girth (11.56 cm). Regarding SD and FA treatment n_3 (0.4 % PSAP at 15 DAP (SD) + 0.4 % nano urea at 30 DAP (FA) and 0.2 % PSAP at 45 DAP (FA) recorded superior value (13.10 cm). L × N interaction effect was not significant and the comparison between control vs treatment was also not significant.

Average tuber weight

Average tuber weight had significant effect on levels of nutrients, SD with PSAP and FA with nano urea and PSAP (Table 2). Treatment l_2 (50 % of N, P and K) recorded significantly higher average tuber weight (210.71 g) among different levels of nutrients and n_4 (0.4 % PSAP at 15 DAP (SD) + 0.4 % nano urea at 30 DAP (FA) and 0.4 % PSAP at 45 DAP (FA) recorded the highest average tuber weight (245.87 g) among SD and FA treatments. Interaction effect was also found to be significant, in which treatment combination l_2n_4 recorded significantly higher average tuber weight (258 g). Treatment vs control effect was also observed to be significant.

Marketable tuber yield

Data on effect of different levels of nutrients, SD and FA on marketable tuber yield (Table 2) revealed that significantly higher marketable tuber yield could be obtained for treatment l_2 (12.02 t ha^{-1}) and n_4 (15.27 t ha^{-1}). While considering the interaction effect, superior value of marketable tuber yield (17.27 t ha^{-1}) was recorded in the treatment combination l_2n_4. Comparison between control and treatments was also noted to be significant.

Tuber yield

Results on effect of different levels of nutrients, SD and FA on tuber yield (Table 3) showed that treatments significantly influenced the tuber yield of sweet potato. Among the different levels of nutrients,

Table 1. Effect of different levels of nutrients and combination of soil drenching and foliar application on length of tuber and girth of tuber

Treatment	Length of tuber (cm)	Girth of tuber (cm)
Levels of nutrients (L)		
l_1 : 75 % N, P and K	10.02 ± 2.32^{b}	9.56 ± 1.41^{b}
l_2 : 50 % N, P and K	11.32±2.57^{a}	11.45 ± 2.46^{a}
SEm (±)	0.22	0.30
CD (0.05)	0.67	0.892
Soil drenching and foliar application (N)		
n_1: SD of PSAP at 0.4 % (15 DAP) + FA of nano urea at 0.2 % (30 DAP) and PSAP at 0.2 % (45 DAP)	9.27 ± 0.49^{b}	10.10 ± 1.70^{b}
n_2: SD of PSAP at 0.4 % (15 DAP) + FA of nano urea at 0.2 % (30 DAP) and PSAP at 0.4 % (45 DAP)	9.14 ± 1.69^{b}	10.28 ± 1.42^{b}
n_3: SD of PSAP at 0.4 % (15 DAP) + FA of nano urea at 0.4 % (30 DAP) and PSAP at 0.2 % (45 DAP)	9.82 ± 1.09^{b}	8.54 ± 0.62^{c}
n_4: SD of PSAP 0.4 % (15 DAP) + FA of nano urea at 0.4 % (30DAP) and PSAP at 0.4 % (45 DAP)	14.43 ± 1.05^{a}	13.10 ± 1.90^{a}
SEm (±)	0.31	0.41
CD (0.05)	0.94	1.269
L × N Interaction		
l_1n_1	9.44 ± 0.69^{cd}	9.29 ± 0.67
l_1n_2	7.92 ± 0.87^{e}	9.24 ± 0.85
l_1n_3	9.13 ± 0.90^{de}	8.22 ± 0.79
l_1n_4	13.57 ± 0.60^{b}	11.49 ± 0.75
l_2n_1	9.10 ± 0.20^{de}	10.90 ± 2.19
l_2n_2	10.36 ± 1.38^{cd}	11.32 ± 1.04
l_2n_3	10.50 ± 0.87^{c}	8.86 ± 0.18
l_2n_4	15.30 ± 0.34^{a}	14.71 ± 0.86
SEm (±)	0.44	0.59
CD (0.05)	1.33	NS
Control (KAU POP)	10.40 ± 0.96	10.40 ± 0.96
Treatments vs Control	NS	NS

Treatments with same letters as superscript are not significantly different. S: Significant; NS: non significant; SD: Soil drenching; FA: Foliar application; PSAP: Potassium salt of active phosphorus; DAP: Days after planting; KAU POP: Kerala Agricultural University package of practices.

Table 2. Effect of different levels of nutrients and combination of soil drenching and foliar application on average tuber weight and marketable tuber yield

Treatment	Average tuber weight (g)	Marketable tuber yield (t ha^{-1})
Levels of nutrients (L)		
l_1 : 75 % N, P and K	166.48 ± 52.69^{b}	9.02 ± 2.69^{b}
l_2 : 50 % N, P and K	210.71 ± 35.97^{a}	12.02 ± 3.6^{a}
SEm (±)	3.93	0.20
CD (0.05)	11.912	0.609
Soil Drenching and foliar application (N)		
n_1: SD of PSAP at 0.4 % (15 DAP) + FA of nano urea at 0.2 % (30 DAP) and PSAP at 0.2 % (45 DAP)	177.69 ± 31.27^{c}	8.58 ± 1.40^{c}
n_2: SD of PSAP at 0.4 % (15 DAP) + FA of nano urea at 0.2 % (30 DAP) and PSAP at 0.4 % (45 DAP)	198.62 ± 19.83^{b}	10.64 ± 2.17^{b}
n_3: SD of PSAP at 0.4 % (15 DAP) + FA of nano urea at 0.4 % (30 DAP) and PSAP at 0.2 % (45 DAP)	132.19 ± 40.54^{d}	7.60 ± 1.01^{d}
n_4: SD of PSAP 0.4 % (15 DAP) + FA of nano urea at 0.4 % (30DAP) and PSAP at 0.4 % (45 DAP)	245.87 ± 16.35^{a}	15.27 ± 2.41^{a}
SEm (±)	5.54	0.28
CD (0.05)	16.846	0.862
L × N Interaction		
l_1n_1	149.57 ± 6.40^{f}	7.33 ± 0.30^{ef}
l_1n_2	184.40 ± 14.95^{de}	8.70 ± 0.50^{cd}
l_1n_3	98.21 ± 14.73^{g}	6.77 ± 0.50^{f}
l_1n_4	233.75 ± 9.92^{b}	13.27 ± 0.40^{b}
l_2n_1	205.81 ± 5.61^{cd}	9.83 ± 0.30^{c}
l_2n_2	212.84 ± 12.36^{bc}	12.57 ± 0.50^{b}
l_2n_3	166.17 ± 20.71^{ef}	8.43 ± 0.50^{de}
l_2n_4	258.00 ± 11.36^{a}	17.27 ± 1.56^{a}
SEm (±)	4.85	0.40
CD (0.05)	23.823	1.219
Control (KAU POP)	167.00 ± 8.88	11.83 ± 0.76
Treatments vs Control	S	S

Treatments with same letters as superscript are not significantly different. S: Significant; NS: non significant; SD: Soil drenching; FA: Foliar application; PSAP: Potassium salt of active phosphorus; DAP: Days after planting; KAU POP: Kerala Agricultural University package of practices.

Table 3. Effect of different levels of nutrients and combination of soil drenching and foliar application on tuber yield, t ha^{-1}

Treatment	Tuber yield
Levels of nutrients (L)	
l_1: 75 % N, P and K	166.48 ± 52.69^{b}
l_2: 50 % N, P and K	210.71 ± 35.97^{a}
SEm (±)	3.93
CD (0.05)	11.912
Soil drenching and foliar application (N)	
n_1: SD of PSAP at 0.4 % (15 DAP) + FA of nano urea at 0.2 % (30 DAP) and PSAP at 0.2 % (45 DAP)	177.69 ± 31.27^{c}
n_2: SD of PSAP at 0.4 % (15 DAP) + FA of nano urea at 0.2 % (30 DAP) and PSAP at 0.4 % (45 DAP)	198.62 ± 19.83^{b}
n_3: SD of PSAP at 0.4 % (15 DAP) + FA of nano urea at 0.4 % (30 DAP) and PSAP at 0.2 % (45 DAP)	132.19 ± 40.54^{d}
n_4: SD of PSAP 0.4 % (15 DAP) + FA of nano urea at 0.4 % (30 DAP) and PSAP at 0.4 % (45 DAP)	245.87 ± 16.35^{a}
SEm (±)	5.54
CD (0.05)	16.846
L × N Interaction	
l_1n_1	149.57 ± 6.40^{f}
l_1n_2	184.40 ± 14.95^{de}
l_1n_3	98.21 ± 14.73^{g}
l_1n_4	233.75 ± 9.92^{b}
l_2n_1	205.81 ± 5.61^{cd}
l_2n_2	212.84 ± 12.36^{bc}
l_2n_3	166.17 ± 20.71^{ef}
l_2n_4	258.00 ± 11.36^{a}
SEm (±)	4.85
CD(0.05)	23.823
Control (KAU POP)	167.00 ± 8.88
Treatments vs Control	S

Treatments with same letters as superscript are not significantly different. S: Significant; NS: non significant; SD: Soil drenching; FA: Foliar application; PSAP: Potassium salt of active phosphorus; DAP: Days after planting; KAU POP: Kerala Agricultural University package of practices.

treatment, l_2 (50 % of N, P and K) recorded significantly higher tuber yield (13.42 t ha^{-1}). Considering the effect of SD and FA, the highest tuber yield (17.63 t ha^{-1}) was recorded in the treatment n_4. Interaction between level of nutrients, SD and FA showed significant variation wherein treatment combination, l_2n_4 recorded the highest tuber yield (19.93 t ha^{-1}). Comparison of treatment vs control was also found to be significant

Discussion

The better performance of 50 % NPK combined with foliar application of 0.4 % nano urea and 0.4 % PSAP in enhancing tuber yield, average tuber weight and marketable yield can be attributed to an improved source-sink balance than increased vegetative growth. Excess nitrogen is known to promote luxury vine growth in sweet potato while suppressing storage root initiation and bulking, as the crop preferentially channels assimilates to shoot development. Excessive N application reduced storage-root formation, which was associated with increased vegetative growth (9). Similarly, it was reported that moderate NPK level (50 % of the recommended dose) prevented luxury N uptake and extended vine growth, thereby creating a medium canopy which contributed to efficient tuber bulking (10).

Foliar application of nano urea and PSAP compensated the reduced soil application of recommended dose of NPK by providing efficient, stage-synchronised nutrient supply. Nano urea could replace 25 % of the recommended nitrogen dose without yield reduction, as foliar-applied nano N is absorbed rapidly and used more efficiently than granular N (11). This is in confirmatory with the present finding that 50 % NPK plus 0.4 % nano urea out-yielded higher basal NPK levels, indicating that nano urea fulfilled the nitrogen requirement of the crop. Potassium Salt of Active Phosphorus (PSAP) supplies P and K in a highly available form that can be absorbed through both roots and foliage, promoting early root proliferation and improving P and K nutrition during the critical period of storage-root initiation. It was showed that foliar and soil-applied P and K solutions improved the root growth, nutrient uptake and yield compared with equivalent doses of conventional P and K (12). In the present treatment, soil drenching and foliar application of 0.4 % PSAP in combination with reduced NPK likely increased the efficiency of P and K use, supporting better root sink strength and translocation of assimilates to developing tubers.

The correlogram (Fig. 1.) indicated that vine yield is negatively correlated with average tube weight (-0.73) and tuber yield (-0.69) while average tuber weight is positively correlated with tuber yield (0.85).

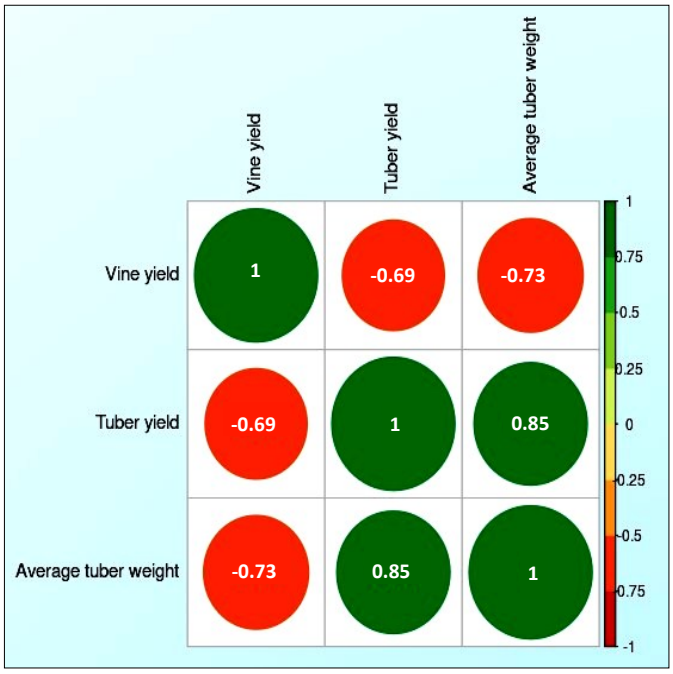


Fig. 1. Correlogram representing the relation between vine yield and tuber yield.

Conclusion

The study concluded that soil application of 37.5 kg N ha^{-1}, 25 kg P ha^{-1} and 37.5 kg K ha^{-1} (Half dose of N and full dose of P and K can be applied as basal and remaining half dose of N can be applied at 4–5 weeks after planting) with soil drenching of PSAP (0.4 %) at 15 DAP supplemented with foliar application of nano urea (0.4 %) at 30 DAP and PSAP (0.4 %) at 45 DAP could enhance productivity by 37.64 % in sweet potato.

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Authors' contributions

SGJ conceptualised and designed the research topic. DC drafted the manuscript. Proper guidance was provided by SPP, UCT, RG and MRV. All authors have read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: The authors declare that they have no conflict of interest.

Ethical issues: None

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