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Tuber quality of cassava (*Manihot esculenta* Crantz) as influenced by consortium biofertilizers and nutrient levels

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Abstract
The field experiment to assess the influence of consortium biofertilizer PGPR Mix –I and nutrient levels on the quality characters in cassava (*Manihot esculenta* Crantz) was conducted at College of Agriculture Vellayani, Thiruvananthapuram, Kerala. The treatments involved four levels of biofertilizer (PGPR Mix-I) and three levels of nutrients (SDN - standard dose of NPK, 50: 50: 100 kg ha-1). The individual effect of the biofertilizer revealed the highest nutrient, starch and protein contents and the lowest HCN content in tubers of plants fertilized with PGPR Mix - I (5% and 2%). Among the different levels of nutrients, 100 per cent SDN produced maximum starch content (27.81%). Highest protein (2.63%) and lowest HCN (49.10 mg kg-1) content were registered in 75 and 50 per cent of SDN respectively, the latter being on par with 75 per cent SDN. Neither the starch nor the protein was affected by the interaction, whereas the treatment combination PGPR Mix - I liquid (5%) + SDN (75%) recorded the lowest HCN. Thus it can be concluded that the quality of cassava tubers were positively influenced by the biofertilizer consortium and NPK levels and better tuber quality was realised with liquid PGPR Mix-I application at 5% and NPK dose of 37.5: 37.5: 75 kg ha-1.

Keywords: Liquid biofertilizer PGPR Mix-I, nutrient content, starch, protein and HCN

Introduction

Cassava (*Manihot esculenta* Crantz) commonly known as tapioca, assures food security for millions of people, especially in the developing countries of the globe. It is an important alternate source of energy and plays an important role in mitigating hidden hunger through diet diversification. Today, apart from its importance as a food crop, cassava is a source of raw material for many diversified products such as starch, sago, alcohol, liquid glucose, medications and animal feed. The economic importance for the starch industry has led to the commercialisation of the crop in many southern states of the country. In Kerala, the crop is an integral component of cropping systems, especially the homesteads and a food crop that finds a prominent place in the balanced diet. However, the crop is reported to be a heavy feeder [8] often leading to nutrient depletion in soil which calls for adoption of proper nutrient management practices. In this context, the use of biofertilizers has assumed prime importance in the integrated nutrient management strategy for cassava [15]. Biofertilizers help in replenishing the soil nutrient pool from fixed forms, especially nitrogen (N) and phosphorus (P), thus enhancing the scope for reducing chemical fertilizer use in the cultivation. Consortium biofertilizers have the advantages of a mixed population of plant growth promoting rhizobacteria in a single inoculum, ensuring mineralisation and solubilisation of different nutrients with a single application, unlike the earlier practise of using separate biofertilizers for each nutrient. Keeping this in view, a carrier based consortium biofertilizer, Plant Growth Promoting Rhizobacteria (PGPR) Mix-I was developed by the Department of Agricultural Microbiology, College of Agriculture, Vellayani under Kerala Agricultural University which contains nitrogen (N) fixers (*Azospirillum lipoferum*, *Azotobacter chroococcum*), phosphorus (P) solubiliser (*Bacillus megaterium*) and potassium (K) solubiliser (*Bacillus sporothermodurans*). Apart from the conventional carrier (talc) based formulation, a liquid formulation was also developed. The suitability of the liquid formulation in the leafy vegetable, amaranthus was examined and saving of 25 per cent chemical fertilizers with its application was observed [4]. Cassava being a long duration crop (6-10 months depending upon the variety) can significantly benefit from the use of the liquid PGPR. In this backdrop, the response of cassava to the different formulations of PGPR Mix -I in combination with different levels of nutrients (N, P and K) was evaluated with emphasis on the quality characters of tuber which decide the nutritional and industrial value of the produce

Materials and Methods

The field experiment was conducted in the Instructional Farm of College of Agriculture, Vellayani from June to December 2019. The site located was at 8°30'N latitude, 76°54'E longitude and at an altitude of 29 m above mean sea level. The soil texture was sandy clay loam with strongly acidic pH (5.23), high organic carbon %), medium N (294.37 kg ha-1), high P (42.63 kg ha-1) and medium K (138.32 kg ha-1) status. The experiment was laid out in Randomised Block Design with four levels of biofertilizers (PGPR Mix -I liquid (@ 2% and 5% concentrations), PGPR Mix -I powder @ 10 g of 2% mixture per plant and without biofertilizer) and three levels of nutrients, the standard dose (SDN) taken was 50:50:100 kg NPK ha-1 (50%, 75% and 100% SDN). Cassava setts of short duration variety, Vellayani Hraswa were planted on mounds at a spacing of 90 cm × 90 cm. Farm yard manure was applied uniformly at the time of planting @ 1 kg per mound. The biofertilizer consortium was applied thrice (basal, 60 and 120 DAP) as soil drench. The inorganic fertilizers, urea (46% N), rajphos (20% P2O5) and muriate of potash (60% K2O) were used to supply the nutrients as per treatments fixed. Full dose of P was applied basally, N and K in three equal splits (basal, 30 and 60 DAP). The crop was harvested at six months after planting by uprooting. After harvest, the tubers from the observation plants were cleaned and samples prepared for nutrient analysis, *viz*., N, P, K, starch, protein and hydrocyanic acid (HCN) content. Starch content of the tuber flesh was estimated by titrimetric method [1] and expressed as percentage on fresh weight basis. The N content of dried samples were estimated by modified micro kjeldahl method [6], P by colorimetrically [6] and K by flame photometry method [9]. Crude protein content was computed by multiplying the N content by the factor 6.25 [14] and HCN content in fresh tuber sample was estimated colorimetrically by sodium picrate method [5].

Results and Discussion

The results on the quality in terms of N, P and K content in tubers are presented in Tables 1a and 1b. Perusal of the data revealed that the contents were higher with the application of PGPR Mix-I irrespective of the formulation compared to that without biofertilizer. In addition to the nutrient solubilising and fixing abilities, the rhizobacteria present in PGPR possess growth promoting properties which would have enhanced the growth and nutrient absorption that led to the higher contents in the tubers. Among the biofertilizers, PGPR Mix-I liquid @ 5 per cent registered the highest N, P and K content (0.45, 0.29 and 0.91% respectively). The advantages of liquid formulations *viz.* higher microbial counts, near zero contamination, greater protection against environmental stresses and increased field efficacy would have impacted the uptake and nutrient content in the tubers [18]. The cassava variety used in the study took six months for maturity and hence responded better to the higher concentration of 5 percent in comparison with the 2 per cent that was proven best in the experiment in amaranthus, a 45 day old crop [4].

With respect to the levels of nutrients, significant variations were registered for P content and it was significantly the highest (0.29%) for the treatment with 75 per cent SDN. Neither N nor K varied markedly with the nutrient levels. Among the interactions, the combination of PGPR Mix- I liquid (5%) + SDN (75%) recorded the highest contents of P (0.32%) and K (0.89%), indicating the superiority over the other combinations.

Variations in the starch, protein and HCN content of tubers due to individual and interaction effects of biofertilizer and nutrient levels are depicted in Tables 2a and 2b.

Application of consortium biofertilizers exerted significant differences in the starch content in tubers. Superior values were recorded for PGPR included treatments, the maximum being with PGPR Mix-I liquid @ 5 per cent (27.81%). Significant variations in the starch content in potato tubers with organic nutrient management was recorded, the highest being in the treatment involving biofertilizers [11]. Among the levels of nutrients, 100 per cent SDN (50:50:100 kg NPK ha-1) produced maximum starch content (27.84%). This is in accordance with the results of [16] who documented the highest starch content in cassava with 100 per cent FYM + NPK on par with soil test based application of NPK. Cassava variety Vellayani Hraswa manured with the N dose of 50 kg ha-1 recorded the highest starch content (27.03%) [10].

The need for balanced NPK application in cassava was elucidated [17].

Excess N or adding N alone can favour more biomass production at the expense of tuber growth as the added N promotes vegetative growth, while simultaneously limiting carbohydrate storage in the tuber. Balanced application of NPK could increase starch content in the cassava tubers by the increased translocation of sugars [3]. Potassium being the most cardinal nutrient for translocation of sugars, it is interpreted that the higher dose of the nutrient stimulated more synthesis and allocation of starch to the storage roots. The interaction had no significant effect on the starch content in tubers.

The protein content in tubers followed a similar trend as N, with application of 5 per cent liquid PGPR Mix – I recording the highest content (2.83%) on par with 2 per cent liquid consortium (2.78%). The lowest content (2.54%) was in treatment without the biofertilizer. The effect of nutrient levels revealed 75 and 100 per cent SDN registered the higher protein content, the values being 2.63 and 2.58 per cent respectively and on par. The interaction effect was found to be non significant.

HCN content is of paramount significance with respect to the nutritional quality of cassava tubers as a higher content tends to render the crop and variety as bitter. The HCN values ranged from 47.04 mg kg-1 to 53.63 mg kg-1 (Table 2a) in accordance with the varietal character of 53 mg kg-1. HCN. The application of liquid PGPR Mix - I (2 and 5% concentrations) could reduce the HCN content in the tuber compared to that without biofertilizer. It was the lowest (49.10 mg kg-1) for 50 per cent of SDN and on par with 75 per cent of SDN (50.16 mg kg-1). The highest HCN content was observed in 100 per cent of SDN (53.63 mg kg-1). Minimal cyanogenic glucoside with the application of higher doses of K was elucidated [12]. The effect of K either individually or in conjunction with P and N in reducing HCN was attributed to the moderating effect it has in reducing the linamarin content of the tubers. Potassium in the plant is capable of regulating the linmarase enzyme responsible for starch synthesis and cyanogenic glucoside production in cassava [7]. It is interpreted that both in 50 and 75 per cent doses, K was higher compared to N and P and hence could express its regulatory effect. On the contrary, the 25 percent higher N and P in masked the effect of K. Higher doses of N contribute to a higher HCN content in the tubers [19, 13].

The conjunctive use of liquid formulation of PGPR Mix -I, at 5 or 2 per cent concentration and 75 per cent of SDN significantly reduced the HCN content in tubers.

Microorganisms present in the consortium have hydrolytic enzymes with capacity to detoxify cyanide by splitting the CN¯ radical into carbon and nitrogen that cause glucoside hydrolysis [2]. It is reckoned that this coupled with the increased K content observed might have minimized the HCN content in the combination of consortium biofertilizer and 75 per cent SDN.

The study brings to light the influence of consortium biofertilizers and NPK levels on the quality characters of cassava. The individual effects registered marked variations, while the interaction effects were non significant except for P, K and HCN contents. Application of the consortium biofertilizer PGPR Mix-I significantly improved the quality parameters and among the different NPK levels, 100 per cent, 75 per cent and 50 per cent of SDN gave the best results on starch, protein and HCN content respectively. The HCN content of the tuber was significantly lowered with application of PGPR Mix – I (5%) along with 37.5: 37.5: 75 kg NPK ha-1 *ie.*, 75 per cent SDN and the combination was found to be suitable for better quality tubers in cassava.

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Table 1a: Effect of biofertilizer and levels of nutrients on NPK content in tubers

Treatments	Nutrient content (%)		
	N	P	K
Biofertilizer (B)			
b1 - PGPR (L) 2%	0.44	0.23	0.84
b2 - PGPR (L) 5%	0.45	0.29	0.91
b3 - PGPR (P)	0.42	0.20	0.80
b0 - without biofertilizer	0.40	0.17	0.73
SEm±	0.01	0.02	0.04
CD(0.05)	0.022	0.042	0.084
Levels of nutrients (N)			
n1 -50% SDN	0.41	0.24	0.64
n2 -75% SDN	0.42	0.29	0.67
n3 -100% SDN	0.41	0.22	0.69
SEm±	0.03	0.01	0.05
CD (0.05)	NS	0.023	NS

*L- Liquid P- Powder SDN- 50:50:100 kg NPK ha-1

Table 1b: Interaction effect of biofertilizer and nutrient levels on NPK content

B ×N Interaction	Nutrient content (%)		
	N	P	K
b1n1	0.44	0.29	0.73
b1n2	0.43	0.26	0.78
b1n3	0.43	0.33	0.83
b2n1	0.43	0.34	0.82
b2n2	0.44	0.38	0.89
b2n3	0.43	0.32	0.80
b3n1	0.43	0.23	0.76
b3n2	0.43	0.30	0.75
b3n3	0.44	0.25	0.81
b0n1	0.42	0.18	0.63
b0n2	0.43	0.21	0.67
b0n3	0.43	0.20	0.70
SEm±	0.001	0.05	0.02
CD (0.05)	NS	0.11	0.048

Table 2a: Effects of biofertilizer and levels of nutrients on tuber quality

Treatments	Starch (%)	Protein (%)	HCN (mg kg-1)
Biofertilizer (B)			
b1 - PGPR (L) 2%	27.59	2.78	47.04
b2 - PGPR (L) 5%	27.81	2.83	48.85
b3 - PGPR (P)	27.78	2.65	52.37
b0 - without biofertilizer	27.12	2.54	53.39
SEm±	0.19	0.02	1.48
CD (0.05)	0.568	0.054	4.381
Level of nutrients (N)			
n1-50% SDN	27.05	2.54	49.10
n2-75% SDN	27.33	2.63	50.16
n3-100% SDN	27.84	2.58	53.63
SEm±	0.16	0.01	1.28
CD (0.05)	0.492	0.046	3.294

*L- Liquid P- Powder SDN- 50:50:100 kg NPK ha-1

Table 2b: Interaction effects of biofertilizer and nutrient levels tuber quality

B×N Interaction	Starch (%)	Protein (%)	HCN (mg kg-1)
b1n1	26.85	2.73	48.95
b1n2	27.18	2.68	46.78
b1n3	26.95	2.70	48.11
b2n1	27.46	2.71	49.18
b2n2	27.33	2.76	46.12
b2n3	27.80	2.72	47.26
b3n1	27.68	2.69	48.59
b3n2	27.50	2.70	49.19
b3n3	27.36	2.75	50.33
b0n1	26.83	2.68	53.70
b0n2	27.40	2.67	52.09
b0n3	27.03	2.74	51.29
SEm±	0.23	0.51	1.07
CD (0.05)	NS	NS	2.311

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