J. Hortl. Sci.
Vol. 9(2):166-171, 2014

Evaluating direct feeding of de-navelled banana bunch with nutrients for enhancing fruit quality, yield and nutrient content

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ABSTRACT

Direct feeding of nutrients to bunch after de-navelling was evaluated in seven varieties of banana (*Musa* sp.) cvs. 'Grand Naine' (GN), 'Robusta'(R), 'Dwarf Cavendish'(DC), 'Ney Poovan'(NP), 'Nanjangud Rasabale'(NR), 'Nendran' (N) and 'Red banana' (RB) using 500g fresh cow-dung, 100ml water, and 2.5 - 10g each of urea and SOP in combinations. Across varieties, fruit and bunch weight increased by 41.5-104.0% and 44.5-97.3%, respectively, compared to 'control'. Maximum increase in fruit weight was observed with a blend of urea + SOP each at 10g in 'GN', 7.5g in 'R', 'DC', 'N' and 'RB', while, the level of urea + SOP was best at 2.5g for 'NP' and 5.0g for 'NR'. Magnitude of increase in fruit and bunch weight was higher in the cut-end (distal end) of the bunch compared to the leaf-end (proximal end). Improvement in pulp:peel ratio was best in 'NP' (4.29-5.91) and 'NR' (2.99-4.32), while, it was lowest in 'GN' (2.69-2.72). Total soluble solids (TSS) in the pulp decreased with increasing fruit/bunch yield. 'N' showed an increase in TSS from 23.9-24.8°Brix in 'control', to 27.1-27.2° at 7.5g each combined urea and SOP application. Benefit: cost increased from 0.35 to 1.20 in 'GN', 0.79 to 1.62 in 'R', 0.60 to 1.43 in 'DC', 3.01 to 5.22 in 'NP', 2.16 to 3.41 in 'NR', 1.37 to 3.67 in 'N' and from 2.82 to 4.96 in 'RB', indicating obvious profitability of the technique. Nutrient composition in respect of N, K and S showed a general increase consequent to direct nutrient feeding. Differences in fruit quality and nutrient composition between the top and the bottom portion of the bunch differed with variety.

Key words: Direct nutrient feeding, nitrogen, potassium, sulphur, *Musa* sp., Grand Naine, Robusta, Dwarf Cavendish, *Ney Poovan*, *Nanjangud Rasabale*, *Nendran*, Red banana, banana varieties

INTRODUCTION

Manipulation of fruit size in a banana bunch to meet market demands is very important for realizing maximum profitability. Sometimes, bunch trimming is done by farmers in South East Asian countries to increase fruit size and advance fruit maturity, albeit at a small loss in bunch weight (Mustaffa and Kumar, 2012). However, without resorting to such drastic measures, enhanced bunch weight, with concomitant improvement in growth of fruits at the stalk end (i.e. leaf end) of the bunch besides improved fruit nutrient content, was successfully achieved in 'Robusta' and 'Ney Poovan' banana by direct nutrient feeding at the de-navelled distal end of the rachis or stalk, using cow-dung slurry enriched with appropriate amounts of urea and sulphate of potash (SOP) (Fig. 1) (Kotur and Keshavamurthy, 2008; Kotur and Keshavamurthy, 2010). Therefore, an attempt was made to evaluate the technique further in seven popular cultivars of banana (*Musa* sp.) in terms of yield, fruit quality and nutrient content in pulp.

MATERIAL AND METHODS

The study was undertaken at the farm of Krishi Vigyan Kendra, Hirehalli, Tumkur, located at latitude 13º16'20" North and longitude 77º11'11" East at an elevation of 851amsl. The crop was raised on clay loam soil with pH 7.53, electrical conductivity 0.44 dSm^{-1}, organic carbon content 0.78%, available N 126 kg ha^{-1}, available K 153 kg ha^{-1} and available S 29kgha^{-1}. Seven cultivars of banana, viz., (i) 'Grand Naine'-G (AAA) ; (ii) 'Robusta'-R (AAA); (iii) 'Dwarf Cavendish'-DC (AAA); (iv) 'Ney Poovan'-NP (AB); (v) 'Nanjangud Rasabale'-NR (AAB, silk group); (vi) 'Nendran'-N (AAB, plantain group) and (vii) 'Red Banana'-RB (AAA) were planted using suckers at a spacing of 2.1×2.1m. Fertilizer dose used was: 250:50:300g NPK / plant for the GN, R and DC, 200:50:300 for NP, NR and N, and 250:100:250 for 'Nendran'. De-navelling and direct nutrient feeding was done as per Kotur and Keshavamurthy (2008) (see Fig. 1) using 2 levels of urea + SOP, depending on expected weight of the bunch based on earlier findings

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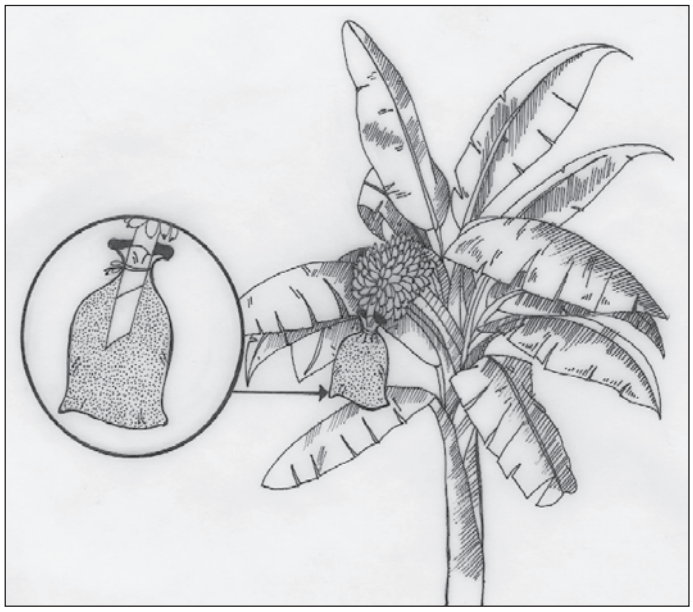

Fig. 1. Technique of direct nutrient feeding of banana bunch through the distal end

on 'Robusta' and 'Ney Poovan' (Table 1). Cow-dung contained 22.5% moisture, 1.6% N, 0.8% K and 0.5% S. In 'control', the male bud was retained until harvest. Bunches were divided into leaf-end (proximal end) and cut-end (distal end) portions, retaining the number of hands nearly equal. Bunches selected for the study were uniform in size with 135.8 ± 8.25 fingers per bunch in 'Grand Naine (n=7), 136.2 ± 9.25 in 'Robusta', 12.9 ± 7.52 in 'Dwarf Cavendish', 127.6 ± 12.34 in 'Ney Poovan', 75.6 ±9.12 in 'Nanjangud Rasabale', 55.4 ± 4.56 in 'Nendran' and 77.5 ± 7.23 in 'Red banana'. The (separated) hands were covered with brown paper and stored in cardboard boxes to ripen. The fruits were sampled at edible ripe stage for determining pulp:peel ratio, and, for total soluble solids (TSS) using a refractometer. The pulp portion was sliced, dried in an oven for 72h at 70° C, powdered and analyzed for N, K and S using standard procedures. Seven replications were made and data were analyzed in Randomized Block Design. Cost of cultivation per banana bunch was Rs. 84.54 in 'Grand Naine', Rs. 74.65 in the second and third varieties, Rs. 72.57 in 'Ney Poovan' and 'Nanjangud Rasabale', Rs. 76.17 in 'Nendran' and Rs. 84.54 in 'Red Banana' keeping in view crop duration and fertilizer dose. The cost of various levels of urea + SOP used was Rs. 0.20-0.83 per bunch, which was included in cost of production of each bunch. Prevailing wholesale price of banana fruit/kg was: Rs. 6 for the first 3 varieties, Rs. 32 for 'Ney Poovan', Rs. 28 for 'Nanjangud Rasabale', Rs. 30 for 'Nendran', and Rs. 24 for 'Red Banana'. Benefit accrued was calculated in terms of net returns computed after deducting fixed and variable costs of cultivation.

RESULTS AND DISCUSSION

Fruit and bunch weight: In all the varieties of banana studied, direct feeding of nutrients to the cut-end of the bunch after de-navelling significantly increased fruit and bunch weight compared to 'control'. This may be attributed to translocation of nutrients from the cow-dung slurry, mediated by added water into which distal end of the rachis at the bunch tip was dipped. The slurry contained 1.15-4.60g N, 1.125-4.5g K and 0.45-1.80g S from 2.5-10g each of urea and SOP added to enrich cow dung (in addition to 6.2g N, 2.4g K and 1.9g S present in 500g of fresh cow-dung itself). It also contained other nutrients and bio-chemicals that are helpful in enhancing fruit growth. This unorthodox movement of nutrient from the distal end into the bunch was demonstrated by Kotur and Keshavamurthy (2008) in 'Robusta' and Kotur and Keshavamurthy (2010) in 'Ney Poovan' banana using ^{15}N-enriched urea in the slurry. Over 45% of urea added to the cow dung was recovered in the bunch, indicating movement of N in both the varieties. Increase in content of other nutrients was also indicative of mobilization of nutrients from an external source into the bunch.

The optimum dose of urea + SOP translates into maximum fruit weight was 10g in 'Grand Naine', 7.5g in 'Robusta', 'Dwarf Cavendish', 'Nendran' and 'Red banana', while, it was 2.5g in 'Ney Poovan' and 5.0g in 'Nanjangud Rasabale' varieties (Table 1). At these levels of urea + SOP combination, increase in fruit weight/bunch was 61.3% in 'Grand Naine', 45.6% in 'Robusta', 51.0% in 'Dwarf Cavendish, 65.1% in 'Ney Poovan', 41.5% in 'Nanjangud Rasabale', 104.9% in Nendran and 54.8% in 'Red banana', compared to that in 'control'. Between the top and bottom halves of the bunch, it was the bottom portion that showed higher fruit weight compared to the top portion in all the varieties studied (46.4-72.6% over the 'control'). The upper half of the bunch, on the other hand, showed just 38.3-54.3% increase in all the varieties excepting 'Nendran'. In the latter variety, the top portion gained 104.5% fruit weight while the bottom portion gained 106.7% compared to 'control' owing to fewer fruits in the bunch - a characteristic of the variety. This indicated that proximity of the lower portion of bunch to the source of direct nutrient feed caused higher enhancement of the fruits relative to

Table 1. Effect of direct feeding of nutrients to bunch on fruit and bunch yield and benefit: cost ratio in seven varieties of banana

Treatment	Fruit weight (kg)			Bunch weight (kg)			Benefit: cost ratio
	Top	Bottom	Total	Top	Bottom	Total	
Grand Naine (GN)							
Control	11.423	7.037	18.460	11.795	7.169	18.964	0.35
7.5g	16.903	10.741	27.644	17.750	11.099	28.849	1.05
10.0g	17.631	12.143	29.774	18.443	12.533	30.976	1.20
SEm (±)	0.5660	0.5563	0.9092	0.6004	0.560	0.9510	0.067
CD *(P=0.05)*	1.7438	1.7141	2.8014	1.8498	1.728	2.9301	0.208
Robusta (R)							
Control	13.414	7.896	21.310	14.049	8.127	22.176	0.79
7.5g	18.470	12.549	31.019	19.181	12.867	32.048	1.62
10.0g	17.611	9.757	27.368	18.381	9.977	28.319	1.28
SEm (±)	0.6518	0.7814	0.7179	0.6569	0.7872	0.7471	0.055
CD(*(P=0.05)*	2.0082	2.4077	2.2121	2.0241	2.4255	2.3017	0.168
Dwarf Cavendish (DC)							
Control	12.480	6.814	19.294	13.046	6.971	20.017	0.61
7.5g	18.349	10.793	29.142	19.076	11.056	30.132	1.43
10.0g	17.173	11.507	28.680	17.823	11.731	29.554	1.38
SEm (±)	0.6313	0.3513	0.6937	0.6380	0.3545	0.7073	0.057
CD *(P=0.05)*	1.9451	1.0861	2.1373	1.9656	1.0922	2.1795	0.175
Ney Poovan (NP)							
Control	5.351	2.973	8.324	5.980	3.126	9.106	3.01
2.5g	7.690	5.549	13.739	8.397	5.967	14.094	5.22
5.0g	6.807	5.344	12.151	7.556	5.614	13.170	4.81
SEm (±)	0.3228	0.2567	0.542	0.3149	0.2559	0.5336	0.236
CD *(P=0.05)*	0.9947	0.7912	1.671	0.9702	0.7884	16.440	0.726
Nanjangud Rasabale (NR)							
Control	5.243	3.500	8.743	5.501	3.663	9.164	2.16
2.5g	5.496	4.041	9.537	5.751	4.174	9.925	2.42
5.0g	7.251	5.124	12.375	7.537	5.756	13.293	3.41
SEm (±)	0.178	0.2481	0.3344	0.1797	0.2477	0.2496	0.118
CD *(P=0.05)*	0.5489	0.7645	1.0303	0.5536	0.7632	0.7690	0.363
Nendran (N)							
Control	4.224	2.521	6.745	4.821	2.669	7.490	1.37
5.0g	7.721	4.239	11.960	8.464	4.454	12.918	3.08
7.5g	8.637	5.186	13.823	9.379	5.401	14.780	3.67
SEm (±)	0.2453	0.1861	0.3588	0.2546	0.3742	0.3638	0.115
CD *(P=0.05)*	0.7559	0.5234	1.1055	0.7844	1.1531	1.1210	0.354
Red banana (RB)							
Control	8.094	4.256	12.350	8.494	4.429	12.923	2.82
7.5g	9.089	5.219	14.408	9.573	5.389	14.962	3.43
10.0g	12.143	6.980	19.123	12.801	7.341	20.142	4.96
SEm (±)	0.3497	0.3232	0.6210	0.3621	0.3271	0.6345	0.188
CD *(P=0.05)*	1.0774	0.9958	1.9135	1.1156	1.0079	1.9549	0.578
	17.173	11.507	28.680	17.823	11.731	29.554	1.38

that of the top portion that was farther away in location. Improvement in bunch weight was in close conformity with that in fruit weight. Profitability, as reflected by benefit:cost ratio, showed that cultivation of all the varieties of banana studied is a profitable enterprise. However, significant and substantial increase in benefit:cost ratio from 0.35 to 1.20 in 'Grand Naine', 0.79 to 1.62 in 'Robusta', 0.61 to 1.43 in 'Dwarf Cavendish', 3.01 to 5.22 in 'Ney Poovan', 2.16 to 3.41 in 'Nanjangud Rasabale', 1.37 to 3.67 in 'Nendran' and 2.82 to 4.96 in 'Red Banana' shows the superior cost:effectiveness of the technique over 'control' (Table 1).

Fruit quality: Total soluble solids in the pulp, in general, showed a reduction with increasing fruit weight and bunch weight due to dilution by the enhanced biomass of pulp (Table 2). However, 'Nendran' was exceptional, in that, TSS increased from 23.9-24.8°Brix in 'control' to 27.1-27.2°Brix at 7.5g each of urea + SOP which registered maximum enhancement in fruit yield from direct nutrient feeding. The difference in TSS of pulp between the top and

Table 2. Effect of direct feeding of nutrients to bunch on quality parameters and nutrient content of pulp in seven varieties of banana

Treatment	Total soluble solids (ºBrix)		Pulp: peel ratio		Nutrient content (%)					
					N		K		S	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
Grand Naine (GN)										
Control	22.6	22.8	2.72	2.69	1.29	1.31	1.72	1.84	0.037	0.063
7.5g	19.5	19.6	2.89	2.86	1.24	1.29	1.10	1.64	0.046	0.079
10.0g	18.6	19.5	2.92	2.84	1.38	1.32	1.26	1.90	0.067	0.063
SEm (±)	0.28	0.26	0.031	0.032	0.016	0.039	0.065	0.037	0.0019	0.0097
CD *(P=0.05)*	0.85	0.81	0.094	0.099	0.049	0119	0.202	0.114	0.0060	0.0297
Robusta (R)										
Control	23.4	23.4	2.52	2.63	1.07	1.04	1.69	1.51	0.032	0.022
7.5g	21.1	20.8	3.21	3.23	1.00	1.24	1.98	2.04	0.033	0.044
10.0g	18.3	19.0	3.10	3.18	1.25	1.64	2.05	2.16	0.037	0.036
SEm (±)	0.45	0.39	0.09	0.09	0.034	0.035	0.031	0.025	0.0011	0.0015
CD *(P=0.05)*	1.38	1.19	0.26	0.26	0.104	0.118	0.096	0.078	0.0035	0.080
Dwarf Cavendish (DC)										
Control	22.7	22.6	2.71	2.97	1.51	1.53	2.49	1.76	0.074	0.064
7.5g	17.9	19.4	3.25	3.74	2.04	1.57	2.35	2.12	0.084	0.046
10.0g	18.9	18.9	3.00	3.33	2.16	1.72	2.81	2.06	0.098	0.058
SEm (±)	0.38	0.30	0.097	0.096	0.025	0.026	0.094	0.039	0.0753	0.0018
CD *(P=0.05)*	1.17	0.92	0.299	0.297	0.078	0.082	0.289	0.121	0.2320	0.0057
Ney Poovan (NP)										
Control	25.0	23.9	4.59	4.29	1.21	1.24	1.31	1.25	0.027	0.023
2.5g	23.3	23.7	6.47	5.68	1.07	1.21	1.59	1.32	0.023	0.023
5.0g	24.0	21.8	5.91	5.89	1.27	1.28	1.34	0.92	0.028	0.019
SEm (±)	0.30	0.34	0.304	0.341	0.039	0.017	0.027	0.021	0.0015	0.0008
CD *(P=0.05)*	0.92	1.06	0.937	1.052	0.074	0.054	0.084	0.064	0.0046	0.0024
Nanjangud Rasabale (NR)										
Control	24.0	20.4	2.99	3.14	0.95	0.96	1.90	1.56	0.060	0.073
2.5g	22.6	22.4	3.34	3.63	0.91	1.12	1.97	1.98	0.072	0.066
5.0g	24.6	22.2	4.14	4.32	1.05	1.28	2.21	2.01	0.086	0.079
SEm (±)	0.31	0.16	0.122	0.090	0.026	0.044	0.046	0.022	0.0019	0.0141
CD *(P=0.05)*	0.94	0.50	0.376	0.278	0.081	0.136	0.140	0.066	0.0060	0.0433
Nendran (N)										
Control	24.8	23.9	3.30	3.30	0.97	0.84	1.33	136	0.015	0.017
5.0g	24.7	25.0	3.66	3.49	0.79	0.66	1.37	1.28	0.016	0.018
7.5g	27.2	27.1	3.89	4.08	0.96	0.76	1.29	1.35	0.026	0.022
SEm (±)	0.97	0.54	0.131	0.110	0.017	0.024	0.019	0.019	0.011	0.0007
CD *(P=0.05)*	2.98	1.65	0.403	0.339	0.051	0.076	0.058	0.059	0.0033	0.0020
Red banana (RB)										
Control	24.9	25.4	3.71	3.95	1.51	1.07	1.81	1.77	0.078	0.108
7.5g	24.1	24.8	3.76	4.02	2.04	1.00	1.58	1.53	0.093	0.078
10.0g	22.5	22.8	3.89	3.69	2.16	1.25	1.51	1.52	0.067	0.067
SEm (±)	0.21	0.15	0.039	0.238	0.025	0.033	0.026	0.028	0.003	0.005
CD *(P=0.05)*	0.65	0.47	0.121	0.733	0.078	0.104	0.080	0.087	0.009	0.0141

bottom portions of the bunch varied with variety. In 'Grand Naine', 'Dwarf Cavendish' and 'Red banana', the bottom portion showed slightly higher TSS. In 'Ney Poovan' and 'Nanjangud Rasabale', the pulp from bottom portion showed slightly lower TSS. Pulp:peel ratio is indicative of relative quantity of edible part of banana fruit, a higher value indicates better quality fruit. Pulp:peel ratio improved invariably with direct nutrient feeding compared to that in 'control', since, growth in pulp was markedly higher than that in the peel. The improvement was marked is higher in 'Ney Poovan' (4.29-5.91) and 'Nanjanagud Rasabale' (2.99-4.32), while, it was lowest in 'Grand Naine' variety (2.69-2.92). In the rest of the varieties, change in TSS was moderate.

Nutrient content: Content of N, K and S was influenced significantly by direct nutrient feeding to the bunch. In fact, it was due to the combined action of (i) level of enrichment of cow-dung by urea + SOP (ii) infusion of N, K and S from the enriched slurry (iii) dilution of the nutrients gained in enhanced biomass of the pulp and (iv)

the characteristic of a variety. In the case of N in the pulp from 'control' fruits, differences between top and bottom portion of the bunch were only slight. When direct nutrient feeding was done N content generally increased with increasing level of urea + SOP, and, the pulp from bottom part of the bunch showed higher N content in 'Robusta' and 'Nanjangud Rasabale'. In the rest of the varieties, N content was lower, perhaps owing to dilution. Potassium content was higher in the pulp from bottom of the bunch in 'Dwarf Cavendish', 'Ney Poovan' and 'Nanjangud Rasabale'. Increasing levels of urea + SOP in cow-dung slurry caused an increase in K content in general, but the reverse was true in 'Nendran', 'Red banana' and 'Grand Naine'. Increasing level of urea + SOP in cow-dung slurry generally increased S content in the pulp of the banana fruit. Sulphur content in the pulp from bottom portion of bunch was higher in 'Grand Naine', while, in the rest of the varieties, it was generally lower in the bottom part of the bunch. These results suggest a general improvement in N, K and S content with direct nutrient feeding.

The unorthodox movement of nutrients from the distal stalk-end into the fruit bunch may be attributed to the fact that a developing bunch forms a strong sink for the nutrients available in the cow-dung slurry, actives as a source of nutrients. This was conclusively demonstrated by a significant movement of ^{15}N from the cow-dung slurry into the fruits (Kotur and Keshava Murthy, 2008) to an extent of 44.1% of applied N in 'Robusta', and to 41.5% in 'Ney Poovan' (Kotur and Keshava Murthy, 2010). Inclusion of urea in the slurry is reported to enhance urease activity, which may facilitate hydrolysis of urea into NH_3 and water for easy absorption and assimilation of N there by enhances bunch yield (Ancy *et al.*, 1998). De-navelling *per se* saves the plant from unnecessary expense of energy and nutrients (which the male flower does, if retained until harvest). Direct nutrient feeding through the distal end after de-navelling, additionally, helps bunch development. Improvement in the composition of fruit pulp in respect of N, K, and S may be attributed to translocation of the nutrients present in the slurry. Significance of observed variation in TSS in different varieties of banana needs to be ascertained organoleptically. Improved nutrient content in the pulp may have beneficial nutraceutical consequences in the banana fruit, in particular, and could lead to promotion of nutritional security in general. The results showed that remunerative boost in yield of high quality banana fruits can be achieved by direct nutrient feeding of the bunch with appropriate amounts of urea and SOP blended into fresh cow-dung slurry. To estimate the relation between bunch weight in banana cultivars and urea + SOP quantities used for direct nutrient feeding, correlation and regression were analyzed. A Initial and final bunch weight upon direct nutrient feeding showed that 'Nendran' did not conform with the rest of the varieties. Correlation between initial bunch weight ('control') and maximum increase in bunch weight observed (n = 42) in 6 varieties was highly significant (r = 0.944**, Fig. 2). Further, maximum bunch weight obtained and quantity of urea + SOP used also showed a high degree of correlation (r = 0.853**) and good regression (Fig. 3). From the equation obtained, each gram of urea and SOP used resulted in an increase of 3.852kg bunch weight, corrected by -1.257kg being the intercept.

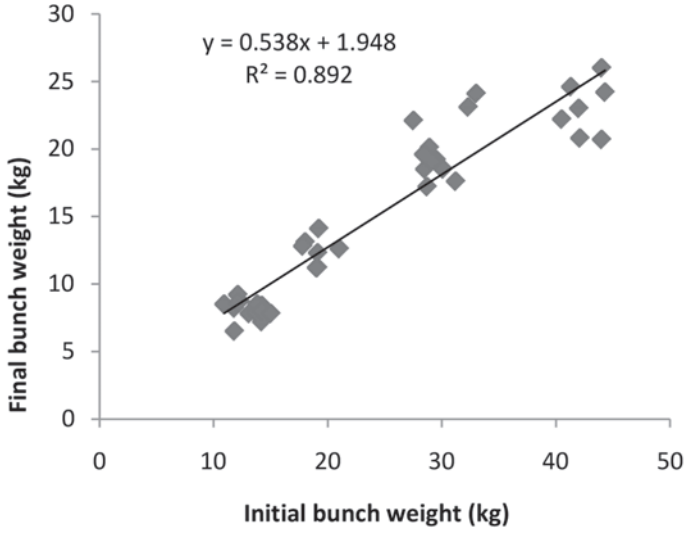

Fig. 2. Relation between initial and final bunch yield upon direct nutrient feeding in different cultivars of banana

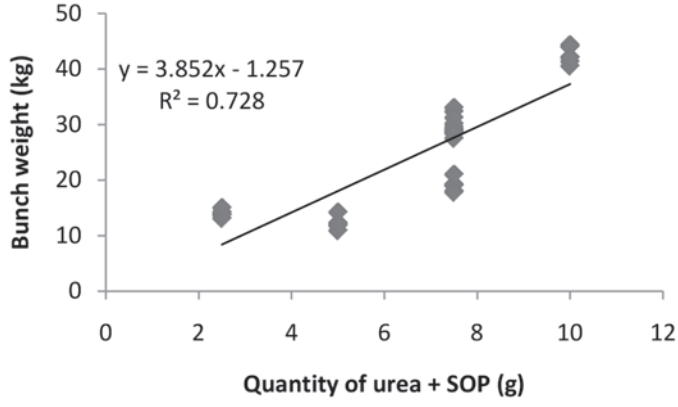

Fig. 3. Relation between quantity of urea + SOP and increase in bunch weight upon direct nutrient feeding in different varieties of banana

The analysis showed that a robust relationship exists between the quantity of urea + SOP used and the expected increase in bunch weight. This can be adopted in practice in most banana cultivars. As the composition and quality of cow-dung may vary depending upon the breed of the cow, the kind of feed and other factors, verification of the technique is advisable to maximize dividends from direct nutrient feeding of the banana bunch in different varieties.

ACKNOWLEDGEMENT

The authors are grateful to Director, Indian Institute of Horticultural Research, Bangalore, for providing facilities, to Scientist-in-Charge, KVK, Hirehalli, for providing the crop for the trial, and to Shri N.K. Kacker and Shri S. Thippeswamy, Technical Officers, for technical assistance.

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(MS Received 07 December 2013, Revised 25 May 2014, Accepted 21 June 2014)