



## Evaluation of New Formulation of Major- and Micro-nutrient Fertilizer Mixture for Coconut

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In order to assess the efficiency of refined formulation of major and micronutrient fertilizer mixture on coconut, a field experiment was conducted at Coconut Research Station, Veppankulam between 2009 and 2011. A refined formulation of major nutrients (NPK) on ratio basis and a new formulation of micronutrient mixture was developed and evaluated on Tall and Hybrid coconut for their efficacy. The refined major nutrients formulation on coconut proved its superiority by enhancing the yield attributes viz., no. of functional leaves, no. of buttons and ultimately the mean annual nut yield (141 and 157 nuts / palm in tall and hybrid coconut respectively). The TNAU formulation of micronutrient mixture enhanced the mean annual nut yield to the tune of 23.1 and 23.5 per cent (133 and 168 nuts / palm / year) in tall and hybrid coconut respectively over control (without MN mixture). The soil nutrient availability ie., major and micronutrients and their content in index leaf tissues were also enhanced significantly to the critical level due to application of respective nutrient mixture at balanced proportion.

**Key words:** Tall and hybrid coconut, fertilizer mixture, nutrient availability, yield attributes, nut yield.

The fertilizer requirement of coconut is generally assessed through computing annual nutrient removal by the palm or by studying the yield response to graded levels of applied fertilizer at balanced proportion (Wahid, 1984). Coconut requires nutrients regularly throughout the year because of their continuous removal from the soil. In general, the major coconut soils of India are sandy or sandy loam in texture, which are poor in its inherent fertility and nutrient supplying capacity. This warrants regular fertilization to coconut for sustained productivity. The studies revealed that such soil retains nutrients for not more than 75-120 days and hence it is necessary to apply the recommended fertilizers in 2-3 splits / year (Narayanasamy *et al.*, 1988). In Sri Lanka, very high yields was obtained in coastal areas from the previously low yielding palms by applying the fertilizers once in three months. More frequent application of fertilizer was found to bring the palms bear early.

The fertilization must coincide with irrigation for better nutrient absorption. The annual nutrient removal by the coconut palms varied from 20 to 174 kg N, 2.5 to 20.0 kg P<sub>2</sub>O<sub>5</sub> and 35 to 49 kg K<sub>2</sub>O ha<sup>-1</sup> (Ouverier and Ochs, 1978). These removal are to be replenished one way or other for sustained productivity of coconut. Considering this, a major nutrient mixture (NPK) on ratio basis in split doses and a refined formulation of micronutrient mixture for coconut was developed by the TNAU and

evaluated for their efficacy on tall and hybrid coconut at Coconut Research Station, Veppankulam, Tamil Nadu.

### Materials and Methods

A field experiment was laid out between 2009 and 2011 at Coconut Research Station, Veppankulam to study the efficacy of new formulation of major nutrient (NPK) fertilizers mixture on ratio basis in split doses and a new formulation of micronutrient mixture on tall and hybrid coconut with the following treatments viz., major nutrients, T<sub>1</sub> – Farmer's practice (1.3, 2.0, 2.0 kg urea, single super phosphate, muriate of potash / palm / year as annual dose), T<sub>2</sub> – NPK mixture formulation (12:6:24 @ 2.50 kg / palm / 6 months) for tall coconut; T<sub>1</sub> – Farmer's practice (2.25, 1.50, 3.00 kg urea, single super phosphate, muriate of potash / palm / year as annual dose), T<sub>2</sub> – NPK mixture formulation (12:3:24 @ 4.00 kg / palm / 6 months) for hybrid coconut. The treatments for micronutrient mixture are T<sub>1</sub> – Control (without MN mixture), T<sub>2</sub> – TNAU MN mixture formulation @ 1 kg / palm / year and T<sub>3</sub> – Department of Agri., MN mixture @ 1 kg / palm / year for both tall and hybrid coconut. All the palms for micro nutrient experiment received the recommended dose of NPK as the case may be (tall / hybrid). The experimental site is located at 20m above MSL with average mean annual rainfall of 1,125 mm. The experimental soil belongs to Pattukkottai series and it is non-calcareous. The experimental soil of tall coconut

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was sandy loam in texture with a pH 7.0, EC 0.22 unit 2 and organic carbon 0.24 per cent. The available NPK status was low in N, medium in P and K (168, 11.2 and 138 kg ha<sup>-1</sup>, respectively). While, the micronutrient availability viz., iron, zinc, copper, manganese and boron were 3.1, 0.60, 0.40, 0.11 and 2.4 ppm respectively. In case of hybrid experiment, the soil is sandy loam in texture with a pH 7.2, EC 0.22 unit 2 and organic carbon 0.25 per cent with the NPK availability of 200, 10.0, 145 kg ha<sup>-1</sup> respectively.

The micronutrient availability viz., iron, zinc, copper, manganese and boron were 3.0, 0.55, 0.60, 0.17 and 2.5 ppm respectively. The experiment was conducted in RBD replicated five times @ 3 palms / treatment. The treatments in respect of major nutrients were imposed in two equal splits, i.e., first half during February and second half during September of every year. The yield attributes viz., number of functional leaves, number of bunches

produced, no. of buttons produced and nut yield for every treatment were recorded at the end of every year. Treatment-wise representative soil samples from each palm were collected annually upto 1 feet depth from 1.8 metre radius circle of each palm and index leaf (14<sup>th</sup> leaf from the top) samples were collected for analysis. The soil available nutrients viz., NPK and Fe, Zn, Mn, Cu and B and their content in index leaf tissues were estimated at the end of every year. The data were subjected to statistical scrutiny adopting standard procedures and the results are discussed hereunder.

## Results and Discussion

### Effect of nutrient mixture on yield attributes (Table 1)

Application of NPK fertilizer mixture on ratio basis in split doses at balanced proportion and a refined MN mixture (TNAU MN mixture) formulation to

**Table 1. Effect of designer fertilizer mixture on yield attributes and nut yield of coconut**

Treatment	No. functional leaves/palm			No. of bunches/palm			No. of buttons/Bunch			Mean annual nut yield / palm					% improve ment over farmers practice / over control	
	2009	2010	2011	2009	2010	2011	2009	2010	2011	Base yield (2003-08) 5 years mean				% increase over base yield		
										2009	2010	2011	Mean			
Macronutrient mixture for tall coconut																
T <sub>1</sub> – Farmer's practice	30.2	30.2	28.5	11.5	11.8	11.2	21.5	32.0	31.1	120	128	125	120	124	3.3	-
T <sub>2</sub> –NPK mixture formulation (12 : 6 : 24 @ 2.50 kg / palm / 6 months)	31.6	34.5	33.1	12.2	12.6	12.4	24.4	35.2	34.6	118	136	146	142	141	19.5	13.7
Macronutrient mixture for hybrid coconut (Tall x Dwarf)																
T <sub>1</sub> – Farmer's practice	30.5	32.1	32.0	11.6	11.6	11.0	22.8	32.1	32.5	121	121	130	131	127	5.0	-
T <sub>2</sub> –NPK mixtures formulation (12: 3: 24 @ 4.00 kg / palm / 6 months)	32.1	35.1	34.2	12.7	11.8	11.6	25.6	36.2	35.5	122	131	172	165	157	28.7	23.6
Micronutrient mixture for tall coconut																
T <sub>1</sub> –Control (without MN mixture)	29.2	28.5	26.2	11.0	11.1	11.0	30.1	28.1	27.1	112	120	117	110	116	3.6	-
T <sub>2</sub> – TNAU MN mixture formulation @1 kg /palm / year	31.5	32.1	31.5	12.2	12.7	12.2	33.2	34.1	33.2	108	126	138	136	133	23.1	14.7
T <sub>3</sub> – Department of Agri., MN mixture @1 kg / palm / year	30.5	30.2	30.0	11.5	11.8	11.1	30.8	31.1	30.5	113	125	126	128	126	11.5	8.6
Micronutrient mixture for hybrid coconut (Tall x Dwarf)																
T <sub>1</sub> –Control (without MN mixture)	30.3	29.0	28.1	11.2	11.0	11.2	32.5	31.3	30.1	145	150	142	136	143	-1.4	-
T <sub>2</sub> - TNAU MN mixture formulation @ 1 kg / palm / year	33.8	34.1	34.0	12.9	12.7	12.5	35.8	36.5	35.2	136	161	172	170	168	23.5	17.5
T <sub>3</sub> - Department of Agri., MN mixture @ 1 kg / palm / year	31.9	32.1	31.0	11.8	11.6	12.0	33.8	33.6	31.1	138	163	160	158	160	15.9	11.9
SEd	1	1.1	1.0	0.6	0.6	0.7	1.5	1.5	1.4	4.3	4.6	4.0	5.0			
CD (p=0.05)	NS	2.1	2.0	NS	NS	NS	NS	3.0	2.8	NS	NS	8	9			

coconut significantly increased the no. of functional leaves / palm and it ranged between 28.5 and 33.1; 32.0 and 34.2 due to application of NPK mixture in tall and hybrid coconut respectively after three years of experimentation (2011). Likewise, the production of buttons increased from 31.1 to 34.6; 32.5 to 35.5 in tall and hybrid coconut respectively due to the application of NPK at balanced proportion in two equal splits. In respect of micronutrient mixture formulation, the female flower production in TNAU MN mixture (33.2 and higher than 35.2 in tall and hybrid coconut respectively), was significantly that in the existing State Department MN mixture (30.5 and 31.1 in tall and hybrid coconut respectively).

The better nutrient supply by the TNAU mixture formulation due to higher content of individual elements than State department MN mixture and it's subsequent absorption by the palms might have favoured the better yield attributes of palms. The no. of bunches / palm is not much influence by the refined formulation of NPK and TNAU MN mixture. The overall performance of palm could be improved by the application of NPK fertilizers at recommended level (Sudhakara and Nambiar, 1991).

### Effect of nutrient mixture on nut yield (Table 1)

The better yield attributes registered due to application of TNAU formulation of major and

**Table 2. Effect of designer fertilizer mixture on soil available NPK (kg ha<sup>-1</sup>)**

Treatment	Nitrogen			Phosphorus			Potassium		
	2009	2010	2011	2009	2010	2011	2009	2010	2011
Macronutrient mixture for tall coconut									
T <sub>1</sub> – Farmer's practice	210	120	210	10.0	10.2	10.0	158	166	152
T <sub>2</sub> – NPK mixture formulation (12: 6 : 24 @ 2.50 kg / palm / 6 months)	226	251	248	13.6	14.6	14.2	176	198	202
Macronutrient mixture for hybrid coconut (Tall x Dwarf)									
T <sub>1</sub> – Farmer's practice	216	214	207	11.2	9.8	10.1	160	158	150
T <sub>2</sub> – NPK mixtures formulation (12:3: 24 @ 4.00 kg / palm / 6 months)	232	256	261	14.5	15.9	14.8	181	201	211
Micronutrient mixture for tall coconut									
T <sub>1</sub> – Control (without MN mixture)	206	221	220	11.2	10.1	10.0	150	156	158
T <sub>2</sub> – TNAU MN mixture formulation @ 1 kg / palm / year	200	232	222	11.5	11.5	10.5	155	172	166
T <sub>3</sub> – Department of Agri., MN mixture @ 1 kg / palm / year	211	218	212	12.8	9.8	10.1	160	160	156
Micronutrient mixture for hybrid coconut (Tall x Dwarf)									
T <sub>1</sub> – Control (without MN mixture)	216	216	211	11.6	9.6	9.5	171	160	162
T <sub>2</sub> – TNAU MN mixture formulation @ 1 kg / palm / year	222	206	214	13.1	11.6	11.0	168	152	150
T <sub>3</sub> – Department of Agri., MN mixture @ 1 kg / palm / year	211	228	228	12.5	13.0	12.0	163	158	159
SEd	6	5	5	1.5	1.0	1.0	6	4	3
CD (p=0.05)	NS	11	10	NS	2.2	2.0	NS	8	7

micronutrient mixture resulted in better and sustained mean annual nut yield over the existing farmer's practice and State Department MN mixture both in tall and hybrid coconut. The mean annual nut yield due to NPK mixture was 141 nuts from the base yield (118 nuts) in tall coconut and 157 from the base yield (122 nuts) in hybrid coconut respectively. The corresponding per cent increase was 13.7 and 23.6 respectively over control. Similarly, the TNAU MN mixture recorded a yield increase of 14.7 and 17.5 per cent (133 and 168 nuts / palm / year in tall and hybrid coconut respectively). This obviously proved that the nut yield was appreciably increased due to refined designer fertilizer mixture for coconut. This was proved by the various

scientists at various locations (Rathinam *et al.*, 1991 and Mohandas, 2012)

### **Effect of nutrient mixture on soil fertility (Table 2 & 3)**

The split application of TNAU formulation of NPK fertilizer mixture recorded significantly higher soil available NPK over farmer's practice. After three years of experimentation, the soil available NPK enhanced *ie.*, N: 248 and 261; P: 14.2 and 14.8 ; K: 202 and 211 kg ha<sup>-1</sup> over farmer's practice (N: 210 and 207; P: 10.0 and 10.1; K: 152 and 150 kg ha<sup>-1</sup> respectively in tall and hybrid coconut field experiments. The possible reason for the enhanced NPK availability could be the split application of fertilizers at balanced proportion might have

**Table 3. Effect of designer fertilizer mixture on soil available micronutrient (mg kg<sup>-1</sup>)**

Treatment	Fe			Zn			Mn			Cu			B		
	2009	2010	2011	2009	2010	2011	2009	2010	2011	2009	2010	2011	2009	2010	2011
Macronutrient mixture for tall coconut															
T <sub>1</sub> – Farmer's practice	3.2	3.6	3.2	0.65	0.63	0.72	0.45	0.50	0.58	0.10	0.09	0.10	2.6	2.8	2.4
T <sub>2</sub> – NPK mixture formulation (12: 6 : 24 @ 2.50 kg / palm / 6 months)	3.5	3.8	3.9	0.61	0.42	0.52	0.52	0.61	0.70	0.12	0.12	1.15	2.8	3.4	2.5
Macronutrient mixture for hybrid coconut (Tall x Dwarf)															
T <sub>1</sub> – Farmer's practice	3.2	3.1	3.2	0.58	0.52	0.50	0.43	0.58	0.61	0.11	0.10	0.15	2.4	2.5	2.2
T <sub>2</sub> – NPK mixtures formulation (12:3: 24 @ 4.00 kg / palm / 6 months)	3.8	4.1	4.5	0.61	0.61	0.60	0.42	0.63	0.75	0.14	0.18	0.21	2.7	3.9	2.6
Micronutrient mixture for tall coconut															
T <sub>1</sub> – Control (without MN mixture)	3.6	3.8	3.8	0.66	0.68	0.71	0.56	0.66	0.62	0.15	0.14	0.16	2.4	2.5	2.2
T <sub>2</sub> – TNAU MN mixture formulation @ 1 kg / palm / year	6.0	6.2	6.5	1.20	1.10	1.12	1.58	1.60	1.78	0.36	0.34	0.55	3.8	4.4	4.4
T <sub>3</sub> – Department of Agri., MN mixture @ 1 kg / palm / year	5.0	5.6	5.0	0.91	0.96	1.01	0.88	1.10	1.12	0.22	0.20	0.22	3.1	3.2	3.6
Micronutrient mixture for hybrid coconut (Tall x Dwarf)															
T <sub>1</sub> – Control (without MN mixture)	3.2	3.4	3.2	0.56	0.58	0.59	0.61	0.61	1.70	0.18	0.16	0.21	2.5	2.6	2.7
T <sub>2</sub> – TNAU MN mixture formulation @ 1 kg / palm / year	6.2	6.0	6.2	1.11	1.08	1.16	1.61	1.66	1.81	0.32	0.36	0.48	3.9	4.8	4.8
T <sub>3</sub> – Department of Agri., MN mixture @ 1 kg / palm / year	4.1	4.8	5.0	0.91	0.94	0.98	0.86	1.06	1.16	0.24	0.24	0.28	2.9	3.1	3.2
SEd	0.3	1.1	1.0	0.05	0.08	0.08	0.04	0.15	0.15	0.01	0.02	0.03	0.1	0.1	0.2
CD (p=0.05)	0.5	2.2	2.1	0.10	0.17	0.18	0.08	0.30	0.32	0.03	0.04	0.05	0.2	0.2	0.4

favoured slow release and substantial built-up over the years. Similarly, TNAU formulation of micronutrient mixture was found superior in enhancing the availability of micronutrients in soil viz., Fe, Zn, Mn, Cu and B due to its considerable addition and subsequent built-up in soil over the existing State Department MN mixture by virtue of its higher content in TNAU formulation. The Fe, Zn, Mn, Cu and B content due to TNAU MN mixture was Fe: 6.5 and 6.2; Zn: 1.12 and 1.16; Mn: 1.78 and 1.81; Cu: 0.55 and 0.48; B: 4.4 and 4.8 ppm respectively.

The effect of nutrient mixture (both macro and micronutrients) on soil fertility status was almost similar in all the years of experimentation. Integrated nutrient management lays emphasis on improving and maintaining soil fertility for sustained coconut productivity Mohandas, (2012).

**Effect of nutrient mixture on index leaf nutrient content (Table 4 & 5)**

The nutrient (NPK) content of index leaf tissues was raised to the critical level due to split application

**Table 4. Effect of Designer fertilizer mixture on NPK content of index leaf in coconut**

Treatment	Nitrogen (%)			Phosphorus (%)			Potassium (%)		
	2009	2010	2011	2009	2010	2011	2009	2010	2011
Macronutrient mixture for tall coconut									
T <sub>1</sub> – Farmer's practice	1.41	1.54	1.50	0.09	0.10	0.11	0.58	0.46	1.40
T <sub>2</sub> -NPK mixture formulation (12: 6 : 24 @ 2.50 kg / palm / 6 months)	1.70	1.71	1.80	0.21	0.18	0.21	1.12	1.04	1.25
Macronutrient mixture for hybrid coconut (Tall x Dwarf)									
T <sub>1</sub> – Farmer's practice	1.45	1.50	1.40	0.11	0.09	0.10	0.51	0.52	1.40
T <sub>2</sub> .NPK mixtures formulation (12:3: 24 @ 4.00 kg / palm / 6 months)	1.68	1.74	1.81	0.22	0.19	0.22	1.21	1.12	1.52
Micronutrient mixture for tall coconut									
T <sub>1</sub> _Control (without MN mixture)	1.15	1.48	1.42	0.11	0.10	0.11	0.61	0.41	0.40
T <sub>2</sub> _ TNAU MN mixture formulation @ 1 kg / palm / year	1.58	1.52	1.56	0.18	0.12	0.18	0.81	0.46	0.51
T <sub>3</sub> _ Department of Agri., MN mixture @ 1 kg / palm / year	1.48	1.51	1.51	0.16	0.11	0.11	0.78	0.48	0.50
Micronutrient mixture for hybrid coconut (Tall x Dwarf)									
T <sub>1</sub> _Control (without MN mixture)	1.41	1.43	1.41	0.15	0.12	0.11	0.65	0.42	1.38
T <sub>2</sub> . TNAU MN mixture formulation @ 1 kg / palm / year	1.56	1.48	1.51	0.20	0.10	0.16	0.72	0.48	0.49
T <sub>3</sub> . Department of Agri., MN mixture @ 1 kg / palm / year	1.44	1.53	1.50	0.16	0.14	0.12	0.65	0.41	1.42
SEd	0.07	0.02	0.03	0.02	0.005	0.005	0.03	0.11	0.12
CD (p=0.05)	NS	0.04	0.06	NS	0.01	0.01	NS	0.22	0.24

of NPK at balanced proportion. The NPK content of index leaf was the highest by the application of TNAU formulation of major nutrient (NPK) mixture at 6 months interval over the existing farmer's practice (annual application) . The index leaf NPK content ranged from N: 1.80 and 1.81; P: 1.21 and 1.22; K: 1.25 and 1.52 per cent in tall and hybrid coconut

respectively. The staggered, continuous supply and subsequent absorption by the palm resulted in better index leaf NPK content under this treatment. As in the case of NPK mixture, the highest concentration of micronutrient viz., Fe, Zn, Mn, Cu and B in index leaf tissues (Fe: 98 and 90; Zn: 8.5 and 8.2; Mn: 31 and 35; Cu:6.8 and 7.4 and B: 142 and 145 mg kg<sup>-1</sup>)

**Table 5. Effect of Designer fertilizer mixture on index leaf nutrient content (ppm) in coconut**

Treatment	Fe			Zn			Mn			Cu			B		
	2009	2010	2011	2009	2010	2011	2009	2010	2011	2009	2010	2011	2009	2010	2011
Macronutrient mixture for tall coconut															
T <sub>1</sub> – Farmer's practice	70	74	70	5.0	5.0	4.0	21	18	19	4.2	4.0	5.0	115	118	110
T <sub>2</sub> – NPK mixture formulation (12: 6 : 24 @ 2.50 kg / palm / 6 months)	74	80	82	5.2	4.6	5.1	24	21	28	4.8	4.8	5.1	120	124	125
Macronutrient mixture for hybrid coconut (Tall x Dwarf)															
T <sub>1</sub> – Farmer's practice	70	78	72	5.8	5.2	5.0	18	20	22	5.1	5.0	4.8	118	118	116
T <sub>2</sub> .NPK mixtures formulation (12:3: 24 @ 4.00 kg / palm / 6 months)	72	72	68	6.2	5.8	5.9	19	26	27	5.0	5.2	5.0	121	126	124
Micronutrient mixture for tall coconut															
T <sub>1</sub> _Control (without MN mixture)	70	76	78	5.2	5.1	5.2	20	23	22	5.0	4.8	4.8	117	110	110
T <sub>2</sub> _ TNAU MN mixture formulation @ 1 kg / palm / year	80	94	98	6.1	8.1	8.5	24	29	31	5.8	6.4	6.8	130	142	142
T <sub>3</sub> _ Department of Agri., MN mixture @ 1 kg / palm / year	76	80	82	6.0	7.0	7.1	22	26	25	5.1	5.8	5.2	124	122	128
Micronutrient mixture for hybrid coconut (Tall x Dwarf)															
T <sub>1</sub> _Control (without MN mixture)	72	78	80	5.4	5.3	5.6	18	21	23	1.3	4.6	4.4	118	121	116
T <sub>2</sub> . TNAU MN mixture formulation @ 1 kg / palm / year	86	96	99	6.2	8.0	8.2	24	28	33	6.0	6.9	7.2	132	145	145
T <sub>3</sub> - Department of Agri., MN mixture @ 1 kg / palm / year	80	84	85	6.0	6.8	7.2	20	26	28	5.4	6.1	6.5	126	125	130
SEd	3.0	2.5	2.6	0.3	0.7	0.7	1.0	1.5	1.5	0.3	0.6	0.6	6.0	5.0	5.0
CD (p=0.05)	6.0	5.0	5.0	0.6	1.4	1.5	2.0	3.0	3.0	0.6	1.2	1.1	12.0	10.0	10.0

was associated with TNAU formulation of MN mixture over State Department MN mixture (Fe: 82 and 85; Zn: 7.1 and 7.5; Mn: 25 and 28; Cu: 5.2 and 6.5 and B 128 and 130 mg kg<sup>-1</sup> respectively). The

higher quantities of these micronutrients supplied by the TNAU formulation might have helped in better assimilation by the palms. This proved the beneficial effect of balanced supply of nutrients in enhancing

the leaf nutrient content (Ghosh and Bandopadhyay 2009).

### Conclusion

The TNAU formulation of major nutrient mixture to tall (2:1:4 NPK @ 2.5 kg / palm / 6 months) and hybrid (4:1:8 NPK @ 4.0 kg /palm / 6 months) coconut significantly increased the mean annual nut yield (141 and 157 nuts / palm in tall and hybrid coconut respectively). Besides, the major nutrients (NPK) availability in soil and their content in index leaf tissues were significantly increased. Similarly, the new TNAU formulation of micronutrient mixture recorded the highest mean annual nut yield of 133 and 168 nuts / palm which was 14.7 and 17.5 per cent higher over control (without MN mixture) in tall and hybrid coconut respectively. The availability of micronutrients in soil (Fe, Zn, Mn, Cu, and B) and their content in index leaf tissue were also higher due to application of TNAU micronutrient mixture @ 1 kg / palm / year.

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