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INFLUENCE OF FERTILIZER LEVELS ON GROWTH, YIELD AND ECONOMICS OF NUTMEG (*MYRISTICA FRAGRANS* HOUTT)

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Abstract

A field experiment was conducted at the Department of Spices and Plantation Crops at Horticulture College and Research Institute, Tamil Nadu Agricultural University, Coimbatore (Tamil Nadu), India; during 2011-2013. Different levels of fertilizer doses *viz*., 75, 100 and 125% and recommended N, P and K through drip fertigation along with micronutrients were tried. In the control plot, the recommended dose of NPK was applied to soil with furrow irrigation. The results revealed that (tree height trunk girth) specific leaf weight yield parameters like fruit weight, nut weight, mace weight, pericarp weight, seed yield tree^{-1} and mace yield tree^{-1} were higher under the fertigation treatment with 100% water soluble fertilizer along with micronutrients. Whereas, gross return (₹ 729144 ha^{-1}, ₹ 744120 ha^{-1}) and net return (₹ 607377 ha^{-1}, ₹ 622353 ha^{-1}) benefit : cost ratio (5.98: 6.11) also were higher under the fertigation treatment with 100 % water soluble fertilizer along with micronutrients during 2011 and 2012, respectively.

Key words : Nutmeg, growth, economics, yield.

Introduction

Nutmeg is an important tree spice belongs to the family Myristicaceae. It is a native of Indonesia and distributed in areas of West Indies, Sri Lanka, India, Phillipines, Tropical America and Pacific islands (Verghese, 2000). In India, nutmeg is grown in some parts of Kerala, Tamil Nadu, Karnataka, Goa, Maharashtra, North East India and Andaman (Krishnamoorthy, 2000). In Kerala, nutmeg is mainly cultivated as a homestead crop in coconut and arecanut gardens.World average production of nutmeg is estimated between 10,000 and 12,000 tonnes per year, with annual world demand estimated at 9,000 tonnes. Indonesia and Grenada dominate in nutmeg production and export of nutmeg products *viz*., nutmeg seed and mace with world market share of 75 and 20 per cent, respectively. Therefore, proper management of nutrients is essential to realize maximum potential of the crop and to get higher economic benefit. Nutrients are important crucial elements, which are required for the plant for its growth and development. The translocation of photosynthates from source to sink is very important for the development of economic part for yield. The optimum dose of fertilizer application not only increases the yield, but also improves the quality. Dumping of huge quantity of fertilizers in the soil becomes uneconomical besides polluting the environment. Application of major nutrients in proper ratio and optimum quantity can help growers to get the maximum benefit out of these inputs. To obtain high yield of nutmeg, timely application of nutrients is a pre-requisite. Fertigation allows applying the nutrients, exactly and uniformly directly to the root volume, where the plants' active roots are concentrated. This remarkably increases the efficiency of the applied fertilizers thus economizing the quantity of fertilizers, water and the cost of labour and energy resulting in reduced cost of cultivation. Adoption of advanced and efficient methods of application of water and fertilizers will have saving upto 50% fertilizers usage. Hence, the present investigation was taken up to find out the influence of fertilizer levels on growth, yield and economics of nutmeg.

Materials and Methods

A field experiment was conducted at farmer field Devanur Pudhur 2011-2013 to study the influence of fertilizer levels on growth and economics in nutmeg under drip irrigated condition. The experiment was laid out in a randomized block design using ten treatments with three

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replications. Different levels of fertilizer doses *viz*., 75, 100 and 125% and recommended N, P and K through drip fertigation along with micronutrients. In the control plot, the recommended dose of NPK was applied to soil with furrow irrigation without micronutrients. The soil of the experimental field was sandy loam. The nutrient status of soil during the experiment was with available nitrogen (305kg N ha^{-1}), available phosphorus (26.5 kg P ha^{-1}) and available potassium (499.6 kg K ha^{-1}). The fertigation scheduling was so planned to meet the crops demand and requirement of the nutrients at different stages of crop growth.

Treatment details

- T_1 : Control: 100% RDF* as soil application without Micronutrients
- T_2 : 100% RDF as soil application + Micronutrients
- T_3 : 75% RDF as Conventional fertilizers + Micronutrients.
- T_4 : 100% RDF as Conventional fertilizers + Micronutrients.
- T_5 : 125% RDF as Conventional fertilizers + Micronutrients
- T_6 : 100% RDF as Conventional fertilizers without Micronutrients.
- T_7 : 75% RDF as Water Soluble Fertilizers + Micronutrients.
- T_8 : 100% RDF as Water Soluble Fertilizers + Micronutrients.
- T_9 : 125%RDF as Water Soluble Fertilizers + Micronutrients.
- T_{10} : 100% RDF as Water Soluble Fertilizers without Micronutrients

*Recommended dose of fertilizers for nutmeg tree was 300: 300: 960g NPK $plant^{-1}$ $year^{-1}$. Urea, ployfeed imported grade water soluble fertilizers were used. The growth characters, yield characters was recorded for individual treatments and economics *viz*., gross return, net return, benefit : cost ratio were worked out, considering the current market price for inputs and outputs and expressed in Rs. ha^{-1}.

Results and Discussion

Tree height

The fertigation treatments significantly influenced the tree height at all stages of growth (table 1). Generally, there was a marked difference in tree height between trees which received fertigation and the trees, which received soil applied fertilizers. A remarkable increase in tree height was observed due to fertigation of water soluble fertilizers rather than straight fertilizers. Application of 100 per cent recommended dose of water soluble fertilizers along with micronutrients recorded the highest tree height of 4.75 m in 2011 and 4.88 m in 2012 during fruit maturity stages, respectively. The treatment 75 per cent recommended dose of water soluble fertilizers along with micronutrients was found on par with T_8 in both the years. The lowest tree height 3.45 m in 2011 and 3.67 m in 2012 was recorded due to soil application of recommended dose of fertilizers without micronutrient during both the years. Pooled mean values during 2011 and 2012 showed that application of 100 per cent RDF as WSF along with micronutrients through fertigation recorded the tree height of 4.82 m. Growth and development of tree is a consequence of excellent coordination of several processes during the growing stages of crop. Plant height is a phenotypic character not only decides the growth in terms of vigor, but also had direct influence on yield by increasing the number of fruits. The enhanced growth under drip might be due to better turgidity of the cells leading to cell enlargement and better cell wall development (Viers, 1972). Tree spread decides the fruiting area of nutmeg that directly influences the vigour of tree and resulted in higher yield.

Trunk girth

A gradual increase in trunk girth was observed (table 1). Significant enhancement in trunk girth was shown by fertigation treatments in 2011 and 2012. The different fertigation treatment significantly influenced the trunk girth in all the stages of growth during both the years. Among the different treatments, the plants that received 100 per cent RDF through fertigation and micronutrients registered the highest trunk girth of 63.26 cm in 2011 and 69.12 cm in 2012 during fruit maturity stages respectively. The trunk girth was lesser in the absolute control 38.42 cm in 2011and 43.26 cm in 2012. Pooled mean values showed that, the application of 100% RDF through fertigation and micronutrients recorded the highest trunk girth of 66.19 cm at fruit maturity stages, respectively in both the years. Significant increase in trunk girth observed in the present investigation might be due to the better utilization of resources like water and nutrients through fertigation (Padmavathamma, 1993; Karuthamani, 2010). Nitrogen, being an important constituent of chlorophyll, proteins and amino acids, promoted the photosynthetic efficiency of the plant system when applied in sufficient quantities(Pafli, 1965).

Specific leaf weight

The specific leaf weight was significantly influenced by fertigation at fruit maturity stages in both the years. Among the different treatments 100 per cent RDF through fertigation along with micronutrients, registered the highest specific leaf weight of 4.12g cm^{-2} in 2011 and 4.09g cm^{-2} in 2012 during fruit maturity stages. Pooled mean values showed that, the application of 100% RDF through fertigation along with micronutrients recorded the highest specific leaf weight 4.10 g cm^{-2} at fruit maturity stages respectively for both the years. The specific leaf weight is considered to be good indicator of the photosynthetic capacity of leaves (Wallace *et al*., 1972). The increase in specific leaf weight by fertigation could be directly related to better photosynthetic efficiency by stocking of more number of palisade cells (Shinde and Jadhaw, 1995) (table 1).

Influence of fertigation on yield and yield attributes

Fruit weight

Results of the by T_7 with the fruit weight of 64.60 g and 65.59 g in 2011 and 2012, respectively. The lowest individual fruit weight indicated significant variations among the treatments. T_8 recorded the highest fruit weight of 70.13 g and 71.61g in 2011 and 2012, respectively. This treatment was followed fruit weight of 38.70 g was recorded in 2011. In 2012, the fruit was slightly increased to 40.31 g, which was also significantly lower than the other treatments. Pooled mean also indicated the significant differences among the treatments. T_8 showed its superiority with the mean fruit weight of 70.87 g followed by T_7 with the mean fruit weight of 65.09 g. The least mean fruit weight of 39.50 g was recorded in T_1 (table 2). The increase in fruit weight under drip irrigation is due to better water utilization, minimum losses of water through percolation, evaporation and excellent soil-water air relationship with higher oxygen in the root zone and higher up take of nutrients. These results are in agreement with the findings of Gornet *et al*. (1973) and Bafina *et al*. (1993). Fruit weight was increased with 100 per cent RDF through fertigation.

Table 1: Effect of fertigation on growth characters of nutmeg at fruit maturity stage.

Treatmentnts	Tree height (cm)			Trunk girth (cm)			Specific leaf weight(g cm^{-2})		
	2011	2012	Pooled mean (2011&2012)	2011	2012	Pooled mean (2011&2012)	2011	2012	Pooled mean (2011&2012)
T_1	3.45	3.67	3.56	38.42	43.26	40.84	2.59	2.62	2.60
T_2	3.73	4.03	3.88	46.11	54.16	50.14	2.83	2.85	2.84
T_3	3.82	4.05	3.94	48.13	57.21	52.67	3.29	3.31	3.30
T_4	3.84	4.09	3.97	48.19	57.26	52.73	3.35	3.33	3.34
T_5	3.87	4.12	4.00	49.32	58.22	53.77	3.42	3.43	3.42
T_6	3.89	4.15	4.02	50.37	58.25	54.31	3.49	3.51	3.50
T_7	4.71	4.85	4.78	61.25	69.09	65.17	3.73	3.78	3.75
T_8	4.75	4.88	4.82	63.26	69.12	66.19	4.12	4.09	4.10
T_9	4.13	4.27	4.20	52.57	59.44	56.00	3.55	3.56	3.55
T_{10}	4.17	4.30	4.24	51.02	59.42	55.22	3.47	3.49	3.48
SEd	**0.096**	**0.102**	**0.070**	**1.229**	**1.420**	**0.938**	**0.080**	**0.082**	**0.057**
CD (0.05)	**0.201**	**0.214**	**0.140**	**2.581**	**2.983**	**1.887**	**0.172**	**0.1721**	**0.115**

Table 2 : Influence of fertigation on yield and yield attributes.

Treatments	Fruit weight(g)		
	2011	2012	Mean
T_1	38.70	40.31	39.50
T_2	44.70	45.92	45.31
T_3	52.29	58.45	55.37
T_4	54.33	58.63	56.48
T_5	55.02	59.40	57.21
T_6	51.23	54.20	52.71
T_7	64.60	65.59	65.09
T_8	70.13	71.61	70.87
T_9	56.90	59.94	58.42
T_{10}	51.05	54.96	53.00
SEd	**1.318**	**1.398**	**0.881**
CD (0.05)	**2.769**	**2.938**	**1.771**

Nut weight

Nut weight of nutmeg was significantly influenced by fertigation levels. In 2011, a significantly high nut weight of 8.01g was recorded by T_8, which was further increased to 8.57g in 2012. The performance of T_7 also found better than the other treatments with the nut weight of 7.08g in 2011 and 7.45 g in 2012. A significantly lower seed weight of 4.69 and 4.99 g was recorded by T_1 in

Table 3 : Influence of fertigation on yield and yield attributes.

Treatments	Seed weight (g)			Mace weight (g)			Pericarp weight (g)		
	2011	2012	Mean	2011	2012	Mean	2011	2012	Mean
T_1	4.69	4.99	4.84	1.96	2.08	2.02	32.05	33.24	32.65
T_2	5.23	5.34	5.29	2.24	2.32	2.28	37.23	38.26	37.75
T_3	6.19	6.29	6.24	3.07	3.14	3.11	43.03	49.02	46.03
T_4	6.02	6.38	6.20	3.10	3.17	3.14	45.21	49.08	47.15
T_5	6.12	6.19	6.16	3.15	3.20	3.18	45.75	50.01	47.88
T_6	5.95	6.05	6.00	2.64	2.70	2.67	42.64	45.45	44.05
T_7	7.08	7.45	7.27	3.39	3.42	3.41	54.13	54.72	54.43
T_8	8.01	8.57	8.29	3.64	3.83	3.74	58.48	59.21	58.85
T_9	6.37	6.42	6.40	3.21	3.3	3.26	47.32	50.22	48.77
T_{10}	5.99	6.10	6.05	2.75	2.83	2.79	42.31	46.01	44.16
SEd	**0.148**	**0.153**	**0.106**	**0.072**	**0.074**	**0.051**	**1.097**	**1.168**	**0.801**
CD (0.05)	**0.312**	**0.321**	**0.214**	**0.152**	**0.155**	**0.104**	**2.304**	**2.454**	**1.611**

Table 4 : Influence of fertigation on yield and yield attributes.

Treatments	Nut yield (kg tree^{-1})			Mace yield (kg tree^{-1})		
	2011	2012	Mean	2011	2012	Mean
T_1	3.50	3.40	3.45	1.21	1.20	1.21
T_2	3.70	3.50	3.60	1.75	1.76	1.76
T_3	4.70	4.80	4.75	3.00	3.22	3.11
T_4	5.50	5.70	5.60	3.20	3.41	3.31
T_5	5.00	5.20	5.10	3.27	3.32	3.30
T_6	4.40	4.60	4.50	2.51	2.62	2.57
T_7	8.12	8.34	8.23	3.38	3.47	3.43
T_8	8.50	8.70	8.60	3.54	3.6	3.57
T_9	7.90	8.00	7.95	3.32	3.43	3.38
T_{10}	4.60	4.64	4.62	2.90	3.00	2.95
SEd	**0.155**	**0.162**	**0.100**	**0.061**	**0.063**	**0.052**
CD (0.05)	**0.327**	**0.341**	**0.201**	**0.129**	**0.132**	**0.105**

2011 and 2012, respectively. Pooled data also revealed significant variation with seed weight. **T$_8$** had shown the highest mean seed weight of 8.29 g followed by **T$_7$** with the seed weight of 7.27g. **T$_1$**, however, registered the lowest mean seed weight of 4.84g (table 3).

Mace weight

Mace weight also significantly differed among the treatments. The mace weight of the single nut was ranging from 1.96 g (**T$_1$**) to 3.64 g (**T$_8$**) in 2011 and 2.08g (**T$_1$**) to 3.83g (**T$_8$**) in 2012. Analysis of pooled mean indicated significant variations among the treatments. The treatment (**T$_8$**) recorded the highest mean mace weight of 3.74 g (table 3).

Pericarp weight

Single fruit pericarp weight of the nutmeg ranged from 32.05 to 58.48 g in 2011 and the highest weight was recorded by **T$_8$**. In 2012, also **T$_8$** recorded the highest single fruit pericarp weight of 59.21 g followed by **T$_7$** (54.72g). **T$_1$** registered significantly lower pericarp weight of 32.05g in 2011 and 33.24g in 2012. The highest pooled mean of single fruit pericarp weight of 58.85g was recorded in **T$_8$** (table 3).

Nut yield per tree

Nut yield per tree differed significantly among the treatments (table 4). Treatments involving water soluble fertilizers invariably produced higher nut yield than straight fertilizers. Application of 100 per cent recommended dose of water soluble fertilizers along with micronutrients (**T$_8$**) recorded the highest nut yield of 8.50 kg tree^{-1} in 2011 and 8.70 kg tree^{-1} in 2012. This was followed by the (Application of 75 per cent recommended dose of water soluble fertilizers along with micronutrients **T$_7$** also performed better with significantly higher nut yield of 8.12 and 8.34 kg tree^{-1} in 2011 and 2012, respectively). The recommended dose of fertilizers through soil application (**T$_1$**) registered the lowest nut yield (3.50 kg tree^{-1}) in 2011 and (3.40 kg tree^{-1}) in 2012. Pooled mean also revealed the significant variations among the treatments. The best treatment **T$_8$**, registered the highest nut yield of 8.60 kg tree^{-1}.

Mace yield per tree

Variations in mace yield due to fertigation treatments were observed in both the years of the experimentation (table 4). Fertigation with water soluble fertilizers recorded more mace yield as compared to soil application of fertilizers. During 2011, fertigation with 100 per cent recommended dose of water soluble fertilizers along with micronutrients (**T$_8$**) recorded the highest mace yield of 3.54 kg tree^{-1}, which was on par with 75 per cent

Table 5 : Benefit cost ratio (BCR) influenced by different fertilizer treatments during 2011.

Treatments	Estimated seed yield (kg ha^{-1})	Estimated mace yield (kg ha^{-1})	Gross returns (Rsha^{-1})	Total cost of cultivation (Rs ha^{-1})	Net returns (RS ha^{-1})	BCR
T_1	546.00	188.76	2,77,056	84,983	1,92,073	3.26
T_2	577.20	273.00	3,36,960	85,872	2,51,088	3.92
T_3	733.20	468.00	5,00,760	1,03,852	3,96,908	4.82
T_4	858.00	499.20	5,56,920	1,06,218	4,50,702	5.24
T_5	780.00	510.12	5,40,072	1,08,591	4,31,480	4.97
T_6	686.40	391.56	4,40,856	1,05,329	3,35,527	4.18
T_7	1266.72	527.28	6,96,384	1,19,274	5,77,109	5.83
T_8	1326.00	552.24	7,29,144	1,21,766	6.07,377	5.98
T_9	1232.40	517.92	6,80,472	1,36,180	5,44,291	4.99
T_{10}	717.60	452.40	5,86,720	1,19.885	4,65,851	4.85

Table 5a : Benefit cost ratio (BCR) influenced by different fertilizer treatments during 2012**.**

Treatments	Estimated seed yield (kg ha^{-1})	Estimated mace yield (kg ha^{-1})	Gross returns (‘Rs ha^{-1})	Total cost of cultivation (‘Rsha^{-1})	Net returns (‘Rsha^{-1})	BCR
T_1	530.40	187.20	2,85,948	84,983	2,00,964	3.36
T_2	580.32	274.56	3,37,061	85,872	2,51,189	3.92
T_3	748.80	502.32	5,26,032	1,03,852	4,22,179	5.06
T_4	889.20	531.96	5,85,936	1,06,218	4,79,718	5.51
T_5	811.20	517.92	5,54,112	1,08,591	4,45,521	5.10
T_6	717.60	408.72	4,60,512	1,05,329	3,55,183	4.83
T_7	1301.04	541.32	7,15,104	1,19,274	5,95,829	5.99
T_8	1357.20	561.60	7,44,120	1,24,766	6,22,353	6.11
T_9	1248.00	535.08	6,95,448	1,36,180	5,59,268	5.51
T_{10}	733.20	468.00	5,86,572	1,19,885	4,65,703	4.85

recommended dose of water soluble fertilizers along with micronutrients (**T_7**). During both the years, soil application of fertilizers recorded the lesser mace yield as compared to all other treatments. Pooled mean analysis also indicated significant variations among the treatments. The highest pooled mean mace yield of 3.57 kg tree^{-1} was recorded in **T_8**. Increased yield under drip fertigation with water soluble fertilizers were also reported by Shiva Shankar (1999) in capsicum.

Economics

The economics worked for different treatments showed that 100% water soluble fertilizers under fertigation along with micronutrients recorded highest benefit: cost ratio for both the years respectively in Tables 5 & 5a). High net return of nutmeg could be assured by increasing the productivity by adopting judicious management practices. In the present study, application of 100% water soluble fertilizers secured the highest gross return (₹ 7,29,144 ha^{-1}, ₹ 7,44,120 ha^{-1}), net return of ₹ 6.07,377 ha^{-1}, ₹ 6,22353 ha^{-1} with highest benefit: cost ratio of (5.98, 6.11). In any investment economics, it is the B : C ratio, which is more important to compare the profitability of the treatments to identify input technologies to improve the yield. From the foregoing discussion, it could be concluded that application of 100% water soluble fertilizer along with micronutrieits showed superiority over other treatments.

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