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Plant Growth and Yield in Moni (*Morinda citrifolia* L.) as Influenced by Integrated Nutrient Management Practices

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Abstract Noni (*Morinda citrifolia* L.) well known for its vast medicinal benefits is an ever green tree of the family Rubiaceae. The tree flowers and fruits almost throughout the year and hence the continuous supply of nutrients is much essential to realize the better yields. As such the plant is hardy and grows wild in tropical forests. Systematic cultivation of noni has recently started in India and elsewhere which demands a set of cultivation guidelines. No much work has been done on standardization of agro techniques for noni. The present study was done to study the effect of applied nutrients on growth and yield of noni with seven treatments viz., T_1–Control–no fertilizer application, T_2–50 : 100 : 100 kg ha^{-1} NPK, T_3–50 : 225 : 50 kg ha^{-1} NPK, T_4–50 : 100 : 100 kg ha^{-1} NPK wherein 50% of recommended P supplied through bone meal, T_5–50 : 225 : 50 kg ha^{-1} NPK wherein 50% of recommended P supplied through bone meal, T_6–50 : 100 : 100 kg ha^{-1} NPK wherein 100% of recommended P supplied through bone meal and T_7–50 : 225 : 50 kg ha^{-1} NPK wherein 100% of recommended P supplied through bone meal. Among theses the treatments T_5 and T_7 have proven best in terms plant growth and yield.

Keywords Noni, Bone meal, Nutrient, Integrated, Phosphorus.

Introduction

Noni, nono or Indian mulberry is a tropical tree native of South East Asia and belongs to family rubiaceae. *Morinda citrifolia* L. has a long history of medicinal uses and was much used among all the botanical agents by the Polynesians for the treatment of various kinds of illness such as bowel disorders, indigestion, skin inflammation, mouth sores, fever and sprains. It has reported to be antibacterial, used against cancer, infection, arthritis, asthma, hypertension, pain [1].

Noni grows well naturally in forest lands, near the coast, in open lowlands and grasslands [2]. It is a sturdy plant and can tolerate wide range of agro-climatic conditions and grows well in wet, dry acidic, alkaline and even saline soil. The crop can also tolerate water logging and heavy winds.

Systematic cultivation of the crop in large scale is limited and the bulk of the fruit supply comes from the natural wild growth. Noni trees growing in nature usually appear healthy without the benefit of any fertilizers. This suggests that noni may require only small amounts of nutrients to grow well. However if

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Table 1. Effect of integrated nutrient management on various growth parameters of noni (*Morinda citrifolia* L.).

	Treatments	Tree height (m)	Number of branches per tree	Tree spread (m^2)
T_1	Control–no fertilizer application	2.47	5.03	3.93
T_2	50 : 100 : 100 kg ha^{-1} NPK	2.71	6.17	6.20
T_3	50 : 225 : 50 kg ha^{-1} NPK	3.43	6.33	6.45
T_4	50 : 100 : 100 kg ha^{-1} NPK-50% of recommended P through bone meal	3.01	5.73	6.27
T_5	50 : 225 : 50 kg ha^{-1} NPK-50% of recommended P through bone meal	3.61	6.70	7.50
T_6	50 : 100 : 100 kg ha^{-1} NPK-100% of recommended P through bone meal	2.91	5.50	6.39
T_7	50 : 225 : 50 kg ha^{-1} NPK-100% of recommended P through bone meal	3.67	6.23	6.54
	SEm±	0.21	0.44	0.62
	CD at 5% level	0.65	–	1.92
	CV (%)	11.65	12.87	17.44

intensive fruit production is desired in an agricultural setting, a fertilizer program is recommended to improve the production and productivity. Research is needed to develop the best fertilizer regimes for noni production as the studies on enhancing the production efficiency of noni are limited.

Materials and Methods

The study was conducted at Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bengaluru, Karnataka state, during 2013-14. The study material comprised of noni trees which were about Eight years old with seven treatments viz., T_1–Control (no fertilizer application), T_2–50 : 100 : 100 kg ha^{-1} NPK, T_3–50 : 225 : 50 kg ha^{-1} NPK, T_4–50 : 100 : 100 kg ha^{-1} NPK-50% of recommended P through bone meal, T_5–50 : 225 : 50 kg ha^{-1} –50% of recommended P through bone meal, T_6–50 : 100 : 100 kg ha^{-1} NPK-100% of recommended P through bone meal and T_7–50 : 225 : 50 kg ha^{-1} NPK-100% of recommended P through bone meal. The treatments were arranged in randomized complete block design and replicated thrice. The fertilizers were given in two equal split doses as per the treatment.The observations on growth and yield parameters were recorded at regular intervals as the tree bears fruits throughout the year.

There were totally twelve trees per treatment from which representative fruit samples were collected randomly from all the four directions of the tree and were used for further analysis. Cumulative yield per tree (kg) was noted down and the same was converted to per hectare yield and expressed in terms of tonnes.

Results and Discussion

All the growth parameters studied in the experiment were positively influenced by the application of nutrients (Table 1). Significantly higher plant height was recorded in T_7 (3.67 m) which was *on par* with T_5 (3.61 m) and T_3 (3.43 m). This increase in height may be attributed to the ready availability of phosphorus and immediate availability of optimum nutrients to the plants i.e. N and K which were easily dissolved and released nutrients that were quickly absorbed by the plants leading to an increased growth. Nitrogen has been reported to increase growth of various fruit plants [3]. Further nitrogen promotes the protein synthesis, whereas phosphorus is involved in the synthesis of numerous phosphorylated compounds resulting in the better growth of the plants [4]. Bone meal which is a rich source of phosphorus might have affected the protein synthesis positively leading to improved tree growth [5]. Similar findings have been reported in crops like ber [6], acid lime [7, 8], guava [9] and sweet orange [10].

Table 2. Effects of integrated nutrient management practice on physical characters of fruits in noni (*Morinda citrifolia* L.).

	Treatments	Fruit length (cm)	Fruit width (cm)	Fruit weight (g)	Fruit volume (cm^3)
T_1	Control–no fertilizer application	3.64	21.99	20.67	3.49
T_2	50 : 100 : 100 kg ha^{-1} NPK	3.75	25.52	27.07	3.63
T_3	50 : 225 : 50 kg ha^{-1} NPK	3.88	28.27	31.33	3.61
T_4	50 : 100 : 100 kg ha^{-1} NPK-50% of recommended P through bone meal	3.70	25.74	31.03	3.73
T_5	50 : 225 : 50 kg ha^{-1} NPK-50% of recommended P through bone meal	3.96	29.97	35.83	3.79
T_6	50 : 100 : 100 kg ha^{-1} NPK-100% of recommended P through bone meal	3.82	25.30	31.73	3.71
T_7	50 : 225 : 50 kg ha^{-1} NPK-100% of recommended P through bone meal	3.97	24.00	34.43	3.50
	SEm±	0.08	0.56	1.17	0.06
	CD at 5% level	–	1.73	3.61	0.20
	CV (%)	3.58	3.77	6.70	3.06

Application of 50 : 225 : 50 kg ha^{-1} NPK-50% of recommended P through bone meal (T_5) recorded maximum tree spread (7.50 m^2) and the least was in the control (3.93 m^2). This might be due to more number of branches per plant due to supply of adequate nutrients to plants in the available form. The combined action of mineral nutrients and organic sources of nutrients might have played a role in increasing the growth of the side branches and thereby contributing significantly to maximizing tree spread in noni. This is in agreement with the findings in ber [6], fig [11] and in mango [12].

Significant variations were observed for fruit width among different treatments (Table 2) and maximum fruit width was recorded in T_5 (3.79 cm) followed by T_4 (3.73 cm) and T_6 (3.71 cm) which were *on par* with each other. The least fruit width of 3.49 cm was recorded in control (T_1). Variation in fruit characters like the width might be attributed to the availability of more phosphorus which helps in efficient photosynthesis and accumulation of more carbohydrates [5]. Phosphorus exists in various forms in plant tissues and the organic P containing compounds built chiefly in leaves are transported to developing fruits [13]

Table 3. Effect of integrated nutrient management practices on fruit yield in noni (*Morinda citrifolia* L.).

	Treatments	Cumulative yield per tree (kg)	Yield per hectare (tonnes)
T_1	Control–no fertilizer application	20.67	22.96
T_2	50 : 100 : 100 kg ha^{-1} NPK	27.07	30.07
T_3	50 : 225 : 50 kg ha^{-1} NPK	31.33	34.81
T_4	50 : 100 : 100 kg ha^{-1} NPK-50% of recommended P through bone meal	31.03	34.48
T_5	50 : 225 : 50 kg ha^{-1} NPK-50% of recommended P through bone meal	35.83	39.81
T_6	50 : 100 : 100 kg ha^{-1} NPK-100% of recommended P through bone meal	31.73	35.26
T_7	50 : 225 : 50 kg ha^{-1} NPK-100% of recommended P through bone meal	34.43	38.26
	SEm±	1.17	1.30
	CD at 5% level	3.61	4.01
	CV (%)	6.70	6.70

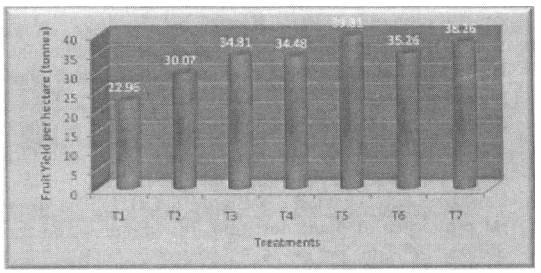

Fig. 1. Fruit yield per hectare as influenced by integrated nutrient management.T_1–Control ; T_2-50 : 100 : 100 kg ha^{-1} NPK ; T_3–50 : 225 : 50 kg ha^{-1} NPK ; T_4–50 : 100 : 100 kg ha^{-1} NPK-50% of recommended P through bone meal ; T_5–50 : 225 : 50 kg ha^{-1} NPK-50% of recommended P through bone meal ; T_6–50 : 100 : 100 kg ha^{-1} NPK-100% of recommended P through bone meal ; T_7–50 : 225 : 50 kg ha^{-1} NPK-100% of recommended P through bone meal.

thereby resulting in an increased fruit size. It is clear that the supply of nutrients to plants have an added advantage over no fertilizer application. The results are in conformity with that reported in mango [12, 14].

A significant difference in mean fruit weight was noticed among the treatment combinations (Table 2). The fruit weight was maximum (29.97 g) in T_5 followed by T_3 (28.37 g). Similarly the fruit volume was also maximum (26.23 cm^3) in T_5. The least fruit weight (21.99 g) and least volume (19.19 cm^3) among the treatments were recorded in T_1 (Control). The increase in fruit weight and volume in T_5 and T_3 could be attributed to ready availability of higher levels of phosphorus along with nitrogen and potassium. Nitrogen is an essential element in proteins and chlorophyll and promotes better growth. N also governs the utilization of P, K and other elements. Potassium also helps in formation of proteins, chlorophyll, starch and sugars. Phosphorus promotes better root development thereby making the plants absorb more nutrients leading to better growth and in turn increased photosynthetic efficiency and accumulation of more carbohydrates [15] thereby enhancing yield. The results are in conformity with that obtained sweet orange [16] and in guava [17].

Cumulative yield per tree (kg) and calculated yield per hectare (t ha^{-1}) varied significantly with different sources and levels of nutrients in noni (Table 3, Fig. 1). The treatment T_5 registered maximum fruit yield i.e. 35.83 kg/tree and 39.81 t/ha which was *on par* with T_7 (34.43 kg/tree and 38.26 t/ha), whereas, the lowest yield (20.67 kg/tree and 22.96 t/ha) was obtained in T_1 (Control).

This increase in yield with the above combination of nutrients might be due to the optimum supply of plant nutrients at desired level during the entire period of the crop growth and fruit formation, ultimately resulting in accumulation of more photosynthates leading to more length, breadth, volume and weight of the fruit. This can also be attributed to the increased production of carbohydrates, amino acids and proteins with higher doses of applied nitrogen and formation of more ATP with application of phosphorus [5] that might have helped in additional tree growth and promoted higher yield.

Inorganic fertilizers provide the nutrients quickly to plants in the available form. Whereas, organic manures which are slow releasers of nutrients [18] might have a continuous supply of nutrients to the perennial plant for a longer period promoting both vegetative and in turn the fruit growth and yield. Hence combined application of organic and inorganic sources of nutrients might have been responsible for higher yield.

The findings are in agreement with that reported in noni [2] and other crops like guava [19] ; phalsa [20] ; cape gooseberry (*Physalis peruviana* L.) [21] and sweet orange [22].

Conclusion

The treatment T_5 comprising of application of 50 : 225 : 50 kg ha^{-1} NPK wherein 50% of recommended P was supplied through bone meal has resulted better plant growth and recorded higher fruit yield. With the above results it can be concluded that there is a scope for increasing the productivity of noni in commercial cultivation with the application of organic and inorganic nutrients.

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