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Soil and plant nutrient indices as tools to evaluate nitrogen management in grape production

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ABSTRACT

Survey work was carried out in Jamakhandi taluka and selected 60 grape orchards to understand nitrogen nutrition and its overall effect on grape production. Based on the quantity of nitrogen fertilizer used and manure added, the grape orchards were categorized into two categories namely, medium-N users (Category-1) and high-N users (Category-2). Contribution from fertilizers was substantially higher compared to organic sources. Nitrogen additions increased both soil available-N and petiole-N contents showing strong relationships. Both soil-N and petiole-N contents had an influence on grape yields and productivity. The results indicated that all the above soil and plant N- parameters and the grape yields were significantly higher in category-2 farmers (high-N users) than category-1 farmers (medium-N users). However, the N-productivity factor was in reverse order. The study suggested for optimization of N-applications following petiole-N and available-N contents to enhance its use efficiency.

Keywords: Nutrient, Indices, Soil, Plant, Nitrogen, Management, Grape

INTRODUCTION

Grape is one of the major cash crops in Peninsular India and it appears to be a stable and remunerative farming enterprise in Northern Karnataka. The crop management practices and use of agrochemicals are very intensive in grapes when compared to other crops. Several studies on grapes have clearly shown that the nutrition of vineyards determines the yields and quality of grapes. Therefore, the nutrient availability in soil and vine nutrient content must be monitored regularly. Imbalanced use of nutrients in terms of excess use of nitrogenous fertilizers alone can reduce yields and produce poor-quality fruits (Srivastava and Malhotra, 2014). Plants would also become very susceptible to pests and diseases with excess N nutrition (Shikamany *et al.*, 1989). Thus, a balanced supply of nutrients is important to match the physiological functions of the nutrient and get maximum yields (Ganeshamurthy *et al.*, 2010; Naraboli et al, 2019). The present survey-based study was carried out in Jamkhandi taluka of northern Karnataka to assess nitrogen management in grape orchards to understand its effect on grape yields. An attempt was made to develop soil and plant indices as tools to evaluate nitrogen management in grape production.

METHODOLOGY

Study area

Jamakhandi taluk in Bijapur district, Karnataka, is a major grape growing area as the climatic conditions are unique and provide an opportunity to cultivate grapes in black soil (Figure 1). Sixty grape orchards were chosen randomly for the collection of nutrient inputs data, soil samples, and grape petiole samples.

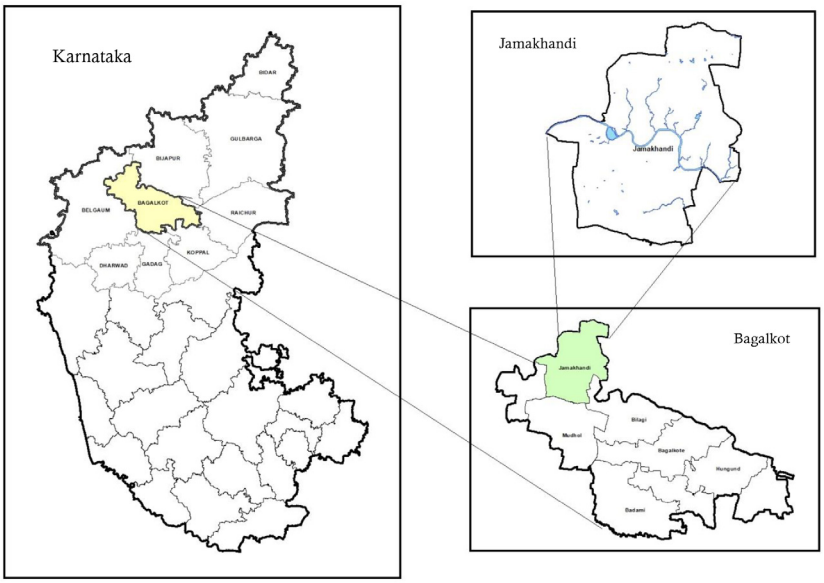

Fig. 1. Location of the study area

Data collection

The farmers were interviewed through questionnaires and collected information on nitrogen management practices. The records maintained by them were also used to quantify N-additions from different sources.

Soil sampling and available-N estimation

The soil samples were collected from February to March, after back pruning, from each orchard. The sampling was made at three representative points (45-60 cm away from the main stem and 45 cm away from the main row) and pooled into one composite sample. The samples were air-dried, sieved (2 mm), and stored in air-tight containers for nutrient analysis. Available nitrogen content was determined by the alkaline–$KMnO_4$ distillation method ((Subbaiah and Asija, 1956). Based on the available-N contents, the soils were categorized into low (<280 kg ha^{-1}), medium (280-560 kg ha^{-1}), and high (> 560 kg ha^{-1}) N-availability soils.

Petiole collection and N- analysis

Petiole collection was done after 40 - 45 days of 2nd pruning (October). The leaves present on the opposite of the first inflorescence were chosen for petiole sampling (Patel and Chada, 2002). About 40 - 50 leaves were picked in the morning hours at the rate of 3 - 4 leaves per plant and petioles were retained while the leaf portion was discarded. This procedure was adopted to collect 3 replicates of petioles from each grape orchard. The fresh petioles were washed for 30 seconds in solutions of 0.1 N HCl, 1 percent detergent, and in pure water (2 times) separately. These washed petioles were dried for a day in the shade and then oven-dried at 65°C for 48 hrs. The dried petioles samples were powdered separately and kept in air-tight containers for further analysis. Petiole-N was determined by the Kjeldahl digestion and distillation method. The distilled ammonia was trapped in a boric acid solution and then titrated against standard acid for N-estimations (Piper, 1966).

Grape yield and N- productivity

The individual farmers were contacted for information on total grape production. Yields obtained in terms of raisins and table grapes were translated into fresh table grape yields (t ha^{-1}) and used to derive productivity factor using the formula

$$\text{N-Productivity} = \frac{\text{Grape yields (kg/ha)}}{\text{Total N added (kg N / ha)}}$$

Data analysis

Based on the amounts of nitrogen applied, available soil N, petiole N content, yield, and productivity factors, the orchards were categorized into two groups namely Category-1 (medium N users) and Category-2 (high N users) using K-means

Table 1. Comparison of growth and yield responses of grapes to nitrogen applications among two category of farmers

Parameters	Category-1(n =22)	Category-2(n =38)
Fert. N added (kg ha^{-1})	263.2 ± 29.9^{a}	328.4 ± 31.03^{b}
Org. N added (kg ha^{-1})	77.3 ± 19.9^{a}	109.2 ± 27.4^{b}
Total N added (kg ha^{-1})	340.5 ± 38.7^{a}	437.6 ± 41.6^{b}
Soil Av. – N (kg ha^{-1})	258.8 ± 34.2^{a}	299.38 ± 36.68^{b}
Petiole- N (%)	1.14 ± 0.18^{a}	1.33 ± 0.14^{b}
Grape yield (tonnes ha^{-1})	23.15 ± 1.74^{a}	25.81 ± 1.78^{b}
Productivity (kg grapes/kg N)	88.59 ± 7.40^{a}	78.97 ± 5.94^{b}

clustering technique. The levels of significant differences among the two in soil-N, petiole-N, yield, and productivity were tested using standard data analysis tools of Microsoft-excel.

RESULTS AND DISCUSSION

The quantity of nitrogen added in the form of fertilizers and organic manures differed to a greater extent between the categories (Table 1). Application of nitrogen fertilizers was significantly higher in category-2 (328.4 ± 29.9 kg N ha^{-1}) than category-1 (263.2 ± 29.9 kg N ha^{-1}). Similarly, the amount of nitrogen added through organic manure also varied significantly with respective values of 77.3 ± 19.9 kg N ha^{-1} in category-2 and 109.2 ± 27.4 kg N ha^{-1} in category-1 grape growers.

This suggests that fertilizers are the major N-sources in grape nutrition. In terms of total nitrogen additions, category-1 grape orchards recorded significantly lesser amounts (340.5 ± 38.7 kg ha^{-1}) compared to category-2 (437.6 ± 41.6 kg ha^{-1}). The contribution of fertilizer was substantially higher compared to the organic manure in both categories of grape growers. Similar reports on the role and high use of fertilizers by grape growers have been made by Yogeeshappa, (2007) and Anita *et al*, (2019).

The available-N content in the majority of soils was in the low to medium range. Among different grape orchards, the available-N was found significantly higher in category-2 (299.4 ± 36.7 kg N ha^{-1}) than in the category-1 (258.8 ± 34.2 kg N ha^{-1}) group of grape growers (Table 2). The higher availability of nitrogen in grape soils may be due to the high application of N-fertilizers (Punit Raj *et al*, 2012; Anita, 2016). These observations were also evident in the positive relationship between available-N and total added-N (r = 0.764**; Table 2) (Fig. 2).

The grapes grown with different levels of nitrogen applications recorded variations in their petiole-N contents. It was found significantly high in category-2 orchards (1.33 ± 0.14 %) compared to category-1 orchards (1.14 ± 0.18 %) as presented in Table 1. The relationship between petiole-N and added-N (r = 0.58**) was also found significantly positive (Fig. 3) as reported earlier by Bharghava and Raghupati (2001) and Anita *et al* (2019).

The grape yields obtained in different orchards are presented in Table 2 and it ranged from 23.24 to 26.57 t ha^{-1}. The fruit yields in category-1 grape orchards were found significantly lower (23.15 ± 1.74 t ha^{-1}) compared to category-2 orchards (25.81 ± 1.78 t ha^{-1}). The relationship among different N-parameters namely, fertilizer-N added, total-N added, available-N in soil and petiole-N contents with grape yields also showed significant positive correlations (Table 2). The difference in yields could be attributed to variations in soil nutrient availability

Table 2. Correlation coefficients for different N-parameters

Parameters	Fert. N	Org. N	Total N	Avail. N	Petiole N	Yield
Fert. N	1.00					
Org. N	0.42**	1.00				
Total N	0.90**	0.77**	1.00			
Avail. N	0.54**	0.40**	0.57**	1.00		
Petiole N	0.48**	0.50**	0.58**	0.55**	1.00	
Yield	0.75**	0.13**	0.59**	0.41**	0.46**	1.00
Productivity	-0.83**	-0.50**	-0.82**	-0.44**	-0.33**	-0.27*

** Correlation is significant at P= 0.01 level

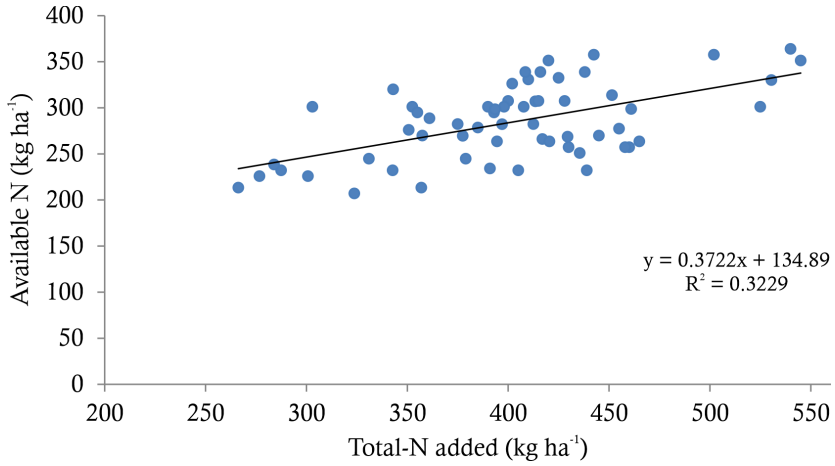

Fig. 2. Relationship between available-N in soil and total-N added

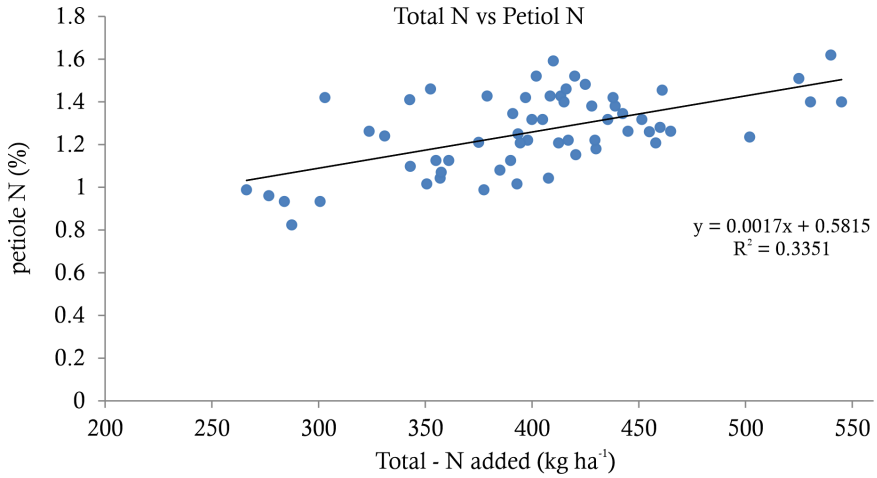

Fig. 3. Relationship between petiole N and total N fertilizers added

as determined by nutrient applications (Bhargava and Sumner, 1987; Punit Raj *et al.,* 2012). Higher amounts of nutrient applications are known to increase its availability in soil and hence, the plant uptake (Shikamany *et al.*, 1989 and Ganeshamurthy *et al.*, 2010). The diagrammatic representations of the relationships between grape yields with petiole-N content (Figure 4) and with added-N contents (Figure 5) also showed positive relationships.

On the other hand, the grape productivity per unit N (kg grapes per kg of N) was in contrast to all the observed parameters. The productivity factor was significantly higher in category-1 (88.6 ± 7.40 per unit of N) compared to category-2 (79.0 ± 5.9 per unit of N) grape orchards. The decrease in grape productivity factor in contrast to soil available-N, petiole-N contents, and grape yields indicated that higher N use is reducing grape yields (Cocco *et al.*, 2021). The use of excess N is known to increase disease occurrence in many crops including grapes (Verdenal *et al.,* 2021). These results suggest that there is a need to optimize N-additions by matching grape productivity and yields with available N and petiole-N contents.

In this regard, the grape yields and productivity values were plotted against petiole-N contents (Figure 6). The yield and productivity trend curves of grapes showed an intersection at a petiole-N content of 1.30 percent suggesting optimum petiole-N value for sustainable grape yields. Similarly, the yield and productivity curves were generated with total-N additions (Figure 7) and the optimum-N dose was found at 400 kg N ha^{-1}. These observations indicate that the farmers in category-1 are applying N-fertilizers at the optimum level, whereas the farmers in category-2 are using excess N.

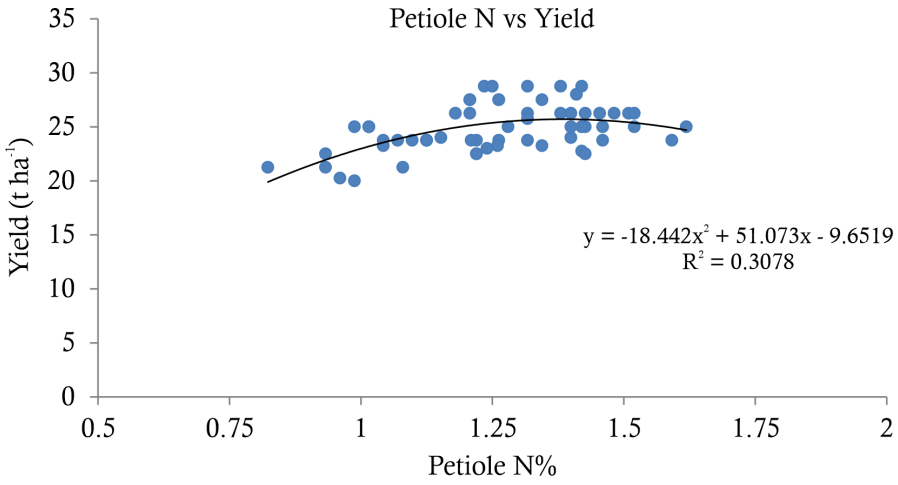

Fig. 4. Relationship between petiole N and yield

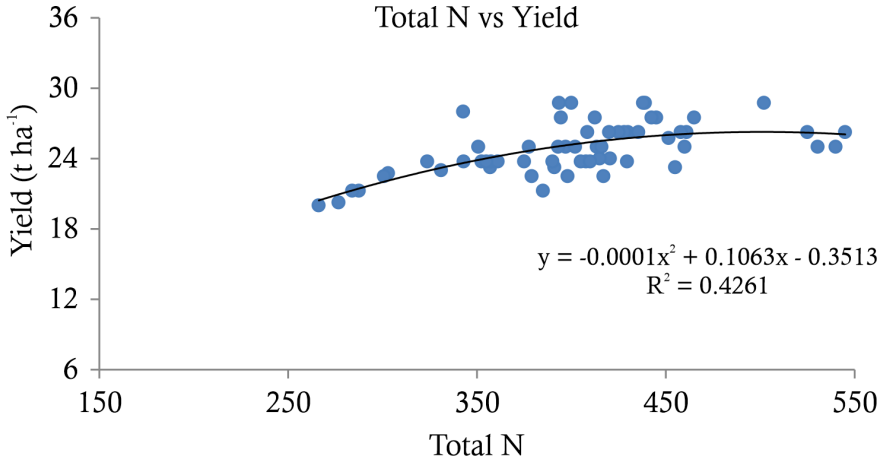

Fig. 5. Relationship between yield and total fertilizers added

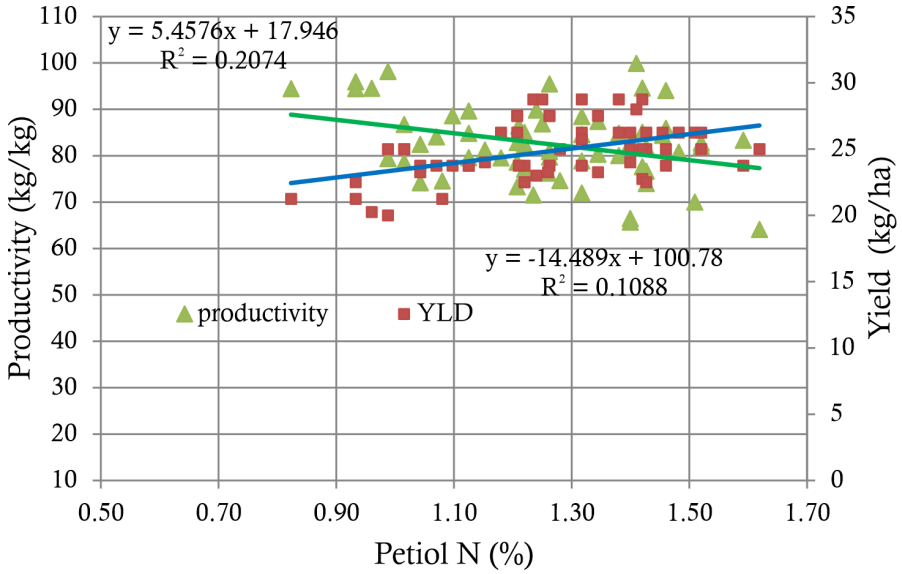

Fig. 6. Petiole K vs. Yield and productivity

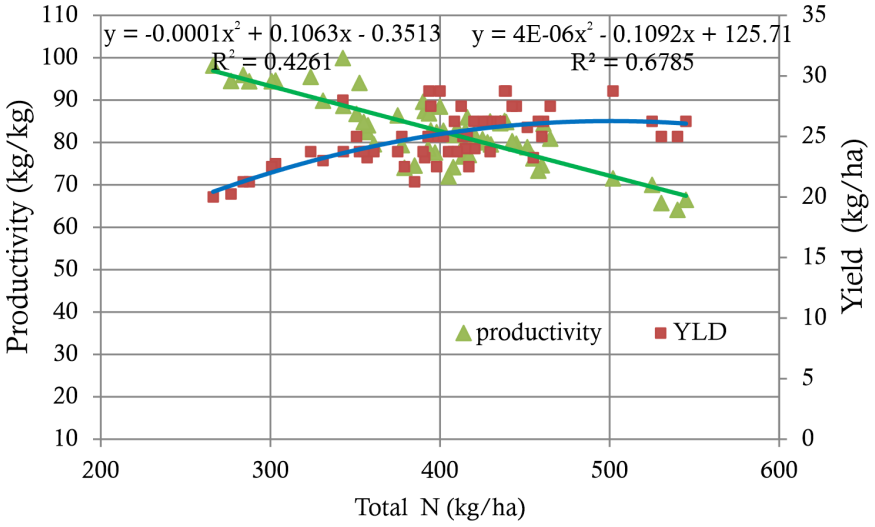

Fig. 7. Total N vs. Yield and productivity

Incidentally, the optimum-N addition value (fertilizer + FYM) in grape orchards is closer to the fertilizer recommendations of 300 kg N ha^{-1} suggest to deduct the amount of N-added from organic manures. Similarly, the optimum petiole-N value was within the optimum range of 1.20 to 1.53 percent prescribed by the Indian Institute of Horticultural Research, Bangalore. This comprehensive study on grapes in Jamakhandi suggests that the farmers need to be educated on the adoption of both soil-N and petiole-N analysis to optimize nitrogen additions through fertilizers + FYM to achieve good grape yields sustainably.

CONCLUSION

The total amount of nitrogen applied through fertilizers and organic manures was found significantly different in all three categories. All the soil samples and petiole samples from grape orchards of Jamakhandi recorded higher nitrogen contents and indicated a positive relationship with applied N. The grape yields also increased with an increase in N-additions. The grape yields showed strong correlations with fertilizer-N, total-N, available-N, and petiole-N. However, high-K applications did not contribute to productivity in terms of yield per unit-K added and it was found in the reverse order. The optimum petiole N value was found to be 1.3 percent and the optimum dose of total N was 400 kg to get a productive and sustainable grape yield.

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