DEVELOPMENT OF NUTRIENT DIAGNOSTIC TECHNIQUE FOR POMEGRANATE (*Cv.*Bhagwa) GROWN IN NORTH WESTERN MAHARASHTRA

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Abstract: *Importance of optimum soil fertility and plant nutrition in sustaining the pomegranate orchard performance is well known. A survey was carried out in 150 selected orchards of hasta bahar pomegranate (cv. Bhagwa) in Nashik, Ahmednagar and Pune districts of North western Maharashtra during (2010), and the diagnostic norms for plant and soil were developed using Diagnosis and Recommendation Integrated System (DRIS). The soil and plant samples (8th leaf pair from the apex) were collected at different growth stages of pomegranate viz. at the time of bahar treatment, 50% flowering, fruit development and harvest. DRIS based analysis predicted the optimum values of available nutrients in soil as: N147.7-181.3 kgha^{-1}, P 12.7-16.2kgha^{-1}, K424.4-525.0 kgha^{-1}, Ca 22.4-27.8 cmol(p+) kg^{-1}, Mg 12.6-17.8 cmol(p+) kg^{-1}, S 6.6-9.1 mg kg^{-1}, Fe 8.2-9.9 mgkg^{-1}, Mn12.2-16.0 mgkg^{-1}, Zn 0.79-0.90 mgkg^{-1}, Cu 5.5-6.4 mgkg^{-1} in relation to fruit yield of 20.79-25.69Mg ha^{-1}. Nutrient constraints in the form of N, Zn, Mg, Fe, and Mn were identified using these diagnostics which must find a due place in a fertilizer program of pomegranate orchards in the region to obtain optimum fruit yield on sustained basis. Various nutrients in the order of decreasing influence on fruit yield were rated as: S<Ca<N<P<Mg<Kat 50% flowering, S<Ca<N<Mg<P<Kat fruit development and Ca <K<Mg<N<P<Sat harvest through leaf analysis.*

Key words: *Pomegranate, leaf analysis, nutrient diagnostics, soil analysis, optimum yield.*

Maharashtra ranks first in the country in the production of fruits whereas, the production of grapes, pomegranates and oranges are highest in Maharashtra as compared to other parts of the country.Among the various fruits grown in Maharashtra, pomegranate (*Punicagranatum*) is one of the important fruit crops commercially grown in Maharashtra having 77,716 ha area under cultivation with the production of 4.76 lakh tonnes (Mohd*et. al.* 2014). At present, an area of 1, 12,500 ha are under pomegranate cultivation in India.The pomegranate is capable of growing under semi arid conditions and marginal lands so far little attention has been paid to standardize the nutritional requirement of pomegranate in spite of fact that mineral nutrition plays an important role in influencing the yield and quality of fruits. The recommendations of the nutritional dose of pomegranate based on well laid out experiment are scanty (Singh and Patil, 1989).Crop requires substantial amount of nutrients for optimum yield and quality (Raghupati and Bhargava, 1999).High value crops like pomegranate are being cultivated without considering the crop needs and soil fertility, which is a major cause of declining yield and fertility status of soil. Hence, it is necessary to make proper fertilizer schedule, according to the need of the crop at various growth stages, by timely diagnosis of the nutrient levels in soil and plant. Some work on optimum levels of nutrients for pomegranate was carried out by Raghupati and Bhargava (1998) during recent past based on leaf and soil analysis which was particularly related with *Ganesh* variety. However, after recommendation of new promising varieties of pomegranate *viz.,* G-5, *Mrudula, Arkta, Bhagwa* by Mahatma Phule Krishi Vidyapeeth, Rahuri the separate recommendation regarding nutrition of each variety for particular ecological region is necessary for precision farming. Of the different diagnostic tools, leaf and soil-based nutrient standards have established their superiority over rest of the diagnostic methods. In the background of this information, the studies were carried out for determination of optimum limit of soil available nutrient and leaf nutrient concentration in relation to fruit yield in the pomegranate (cv. Bhagwa) orchards of North Western Maharashtra.

Materials and Methods

Extensive surveys were carried out covering as many as 150 orchards of pomegranate in Nashik, Ahmednagar and Pune districts of Maharashtra in the year 2010 on the basis of variety (Bhagwa), age of orchard (4-6 years), method of irrigation (drip) and type of bahar (hasta). The district encompasses an area of 45807 ha.

Soil and leaf sampling

Initial soil sample from each (GPS based) location of selected orchard was collected and leaf as well as soil samples were collected at three different growth stages *viz.,* 50% flowering, fruit development and harvesting stage. Pomegranate 8^{th} leaf pair from apex samples were collected from the selected orchards (Bhargava and Dhandar, 1987). The samples were oven dried at 65^{0}C.

Analytical methods

Soil samples were air-dried, ground and passed through 2 mm sieve, and subjected to analysis of available nitrogen using alkaline permanganate method (Subbiah and Asija 1956), available phosphorus by using sodium bicarbonate ($NaHCO_3$ 0.5 M) extractant (Olsen *et al.,* 1965), K extraction in 1 N neutral NH4OAc in 1:2 soil : extract ant ratio after shaking for 30 min, Ca^{2+} and Mg^{2+} by saturating samples with 1 N NaCl solution and then titrating the leachate with standard EDTA solution as per the methods of Richard (1968). Erichrome Black T and calcon indicators were used for these titrations and micronutrients (Zn, Cu, Mn and Fe) in 0.05 M DTPA-Cacl2 pH 7.3 after shaking 20 g soil and 50 ml extraction together for 2 h (Lindsay and Norvell 1978).

Leaf samples were thoroughly washed (Chapman 1964) and ground using a Wiley-Grinding machine to obtain homogenous sample. Tri-acid (HNO3: HClO4: H2SO4 in 9:4:1) extracts of leaf samples (Jackson 1973) were subjected to analysis of P using vanadomolybdopophosphoric acid (ammonium molybdate + ammonium metavanadate) method; K by flame photometrically; Ca and Mg by versene titration (murexide) and eriochrome black-T(EBT) as indicators for Ca and Ca+ Mg, respectively.

Data were interpreted for diagnostic and recommendation integrated system (DRIS). The following procedure as initially developed by Beaufils (1973), modified by Bhargava (2002) and Srivastava and Singh (2008) was used through a PC based program for the development of DRIS norms:

1. Defining the parameters to be improved and the factors likely to affect them,
2. Collection of all the reliable data available from the fields and experimental plots,
3. Study the relationship between the yield and available nutrients in soil
4. Establishment of relationship between the yield and leaf nutrient composition using the following steps:
    - Each internal plant parameter is expressed in as forms as possible e.g. N/dm, n/p, p/n, n x p etc.
    - The whole population is divided into a number of sub-groups based on the economic optimum.
    - The mean of each sub-population is calculated for the various forms of expressions.
    - If necessary, class interval limits between the average and the outstanding yields were re-adjusted, so that the means of below average populations remain comparable.

- Chi-square test was performed to know that the population of orchards confirms a normal distribution.
- The variance ratios between the yield of sub-populations (using 50 kg tree^{-1} as cut-off yield level (averaged yield level usually obtained at growers' field) to separate the sub-populations) for all the forms of expressions were calculated together with the coefficient of variation.
- The forms of expressions, for which significant variance ratios (s_a for low-yielding population/s_b for high yielding population) were obtained and essentially the same mean values for the population were selected in expression with common nutrient, the mean and coefficient of variation (cv) values in the high-yield population for the selected ratios were used for calculating DRIS indices. The nutrient with the most negative index was considered the most deficient and most limiting to fruit yield and vice-versa.
- The following equations were developed for the calculation of DRIS indices based on leaf analysis:

$$N = 1/9\ [f(N/P) + f(N/K) + f(N/Ca) + f(N/Mg) + f(N/Fe) + f(N/Mn) + f(N/Cu) + f(N/Zn)]$$

where, $$f(N/P) = \left(\frac{N/P}{n/p\ \ -1}\right)\left(\frac{1000}{CV}\right) \quad \text{when } N/P > n/p$$

n/p

and $$f(N/P) = 1- \left(\frac{N/P}{n/p}\right)\left(\frac{1000}{CV}\right) \quad \text{when } N/P < n/p$$

Where N/P is the actual value of the ratio of N and P in the plant under diagnosis, n/p the value of the norm (the mean value of high yielding orchards), and CV, the coefficient of variation for population of high yielding orchards.

Results and Discussion

Optimum Soil Fertility Limit

Optimization of soil properties is an emerging field of investigation. It represents a new stage in managing soil fertility in which the transition is made from simple improvement of soil properties to regulation of these properties aimed to bring them into agreement with plant needs in order to achieve maximum yields. DRIS based analysis predicted the optimum values of nutrient availability as: available N 147.7-181.3 kg ha^{-1}, P 12.7-16.2 kg ha^{-1}, K 424.4-525.0 kg ha^{-1}, Ca 22.4-27.8 cmol (p+) kg^{-1}, Mg 12.6-17.8 cmol (p+) kg^{-1}, S 6.6-9.1 mg kg^{-1}, Fe 8.2-9.9 mg kg^{-1}, Mn 12.2-16.0 mg kg^{-1}, Zn 0.79-0.90 mg kg^{-1}, Cu 5.5-6.4 mg kg^{-1} in relation to fruit yield of 20.79-25.69Mg ha^{-1} (Table 1.) Mean DRIS indices suggested deficient to low level of N, Fe, Zn, Mn, Mg due to their negative values in decreasing order. While those of B, Ca, P, K, S, Cu and Mo on account of their increasing positive indices was found in high to excess limit. Through soil analysis, DRIS indices revealed different nutrients to be ordered as N < Fe < Zn <Mn< Mg < B < Ca < P < K < S < Cu < Mo. The work on fertility constraints diagnosis though soil test based DRIS norms is limited. The high negative index shows that the corresponding nutrient is relatively deficient. Alternatively, a large positive index indicates that the nutrient is excessive in quality. The data showed the deficiency of N, Fe, Zn, Mn, Mg due to their negative values in decreasing order. Using the progressive nutrient diagnosis, if the first limiting factor i.e. N is corrected by its supply, the next nutrient that will limit the yield is Fe. Further, if N and Fe are satisfied, the next limiting nutrient is Zn and Mn followed by Mg.

Leaf Nutrient Diagnostics

Leaf analysis as a method of assessing the crop nutrient requirements is based on the assumption that within certain limit, there exists a positive elation between doses of the nutrient supplied, leaf nutrient content, and yield (Srivastava and Singh 2003). The optimum leaf concentrations of nitrogen were 1.02-1.42, 1.12-1.48, and 1.03-1.44 per cent at 50 % flowering, fruit development and harvesting stages respectively. Raghupati and Bhargawa (1998) reported that the optimum N established using DRIS ranged from 0.91 to 1.66 per cent in pomegranate. The optimum norms of phosphorus was observed in the range of 0.07-0.48. 0.06-0.46 and 0.04-0.44 per cent at 50 % flowering, fruit development and harvesting stages respectively. Singh and Patil (1989) also reported 0.31 - 0.39 per cent P as optimum for Ganesh cultivar (Table 2).

Table 1: Soil fertility guide (derived from DRIS based analysis) for pomegranate grown in North Western Maharashtra

Nutrient	Very low	Low	Optimum	High	Very high
Fruit development					
N(kgha^{-1})	<130.3	130.3-148.6	147.7-181.3	181.4-204.3	>204.3
P(kgha^{-1})	<10.1	10.1-12.6	12.7-16.2	16.3-21.3	>21.3
K(kgha^{-1})	<308.3	308.3-424.3	424.4-525.0	524.1-622.1	>622.1
Ca(cmol(p+) kg^{-1})	<19.4	19.4-22.3	22.4-27.8	27.9-41.3	>41.3
Mg(cmol(p+) kg^{-1})	<8.1	8.1-12.5	12.6-17.8	17.9-20.2	>20.2
S(mg kg^{-1})	<2.2	2.2-6.5	6.6-9.1	9.2-12.8	>12.8
Fe (mg kg^{-1})	< 4.1	4.1-8.1	8.2-9.9	10.0-12.8	>12.8
Mn(mg kg^{-1})	<6.2	6.2-12.1	12.2-16.0	16.1-18.9	>18.9
Cu(mg kg^{-1})	<2.2	2.2-5.4	5.5-6.4	6.5-8.5	>8.5
Zn(mg kg^{-1})	<0.62	0.62-0.78	0.79-0.90	0.91-0.99	>0.99
Na(cmol(p+) kg^{-1})	<0.21	0.21-0.38	0.39-0.74	0.75-0.92	>0.92
B(mg kg^{-1})	<0.21	0.21-0.35	0.36-0.58	0.59-0.74	>0.74
Mo (mg kg^{-1})	<0.01	0.01-0.05	0.05-0.13	0.13-0.16	>0.16
Fruit yield (Mgha^{-1})	<18.33	18.33-20.78	20.79-25.69	25.70-28.14	>28.14

The optimum potassium norms ranged at 50 % flowering, fruit development and harvesting stages were 1.15 - 1.78, 1.19 - 1.82 and 1.16 - 1.70 per cent respectively. The optimum ranges for secondary nutrients *viz.,* Calcium (0.93 - 1.12, 0.99 - 1.20, 0.91 - 1.08%), Magnesium (0.77 - 0.22, 0.19 - 0.28, 0.16 - 0.21%) and sulphur (0.15-0.19, 0.14 - 0.18 and 0.16 - 0.18%) at 50 % flowering, Fruit development and harvesting stages, respectively.

The use of nutrient concentration of diagnosis of nutrient deficiencies is usually based on an assumed relationship between concentration and crop performance. DRIS provides a mathematical means of ordering a large number of ratios into nutrient indices that can be easily interpreted. After establishment of DRIS norms, the formulae proposed by Beaufils (1973) and modified by Bhargava (2002) were used for calculation of an index for each nutrient that ranges from negative to positive values. A nutrient index is a mean of the deviations from the optimum or norm values (Bailey *et al.* 1997). Negative DRIS index value indicated that nutrient level is below optimum. Consequently, the more negative index, the more deficient the nutrient. Similarly a positive DRIS index indicates that the nutrient level is above the optimum and the more positive the index. More the negative index, more is the imbalance of that nutrient at that crop growth stage. (Beaufils 1973; Bhargava 2002).

Table 2: Leaf analysis based - DRIS norms for pomegranate at different growth stages

Nutrients	DRIS indices				
	Very low	Low	Optimum	High	Excess
50% Flowering					
N%	<0.82	0.82-1.01	1.02 – 1.42	1.43 – 1.86	> 1.86
P%	<0.002	0.002-0.06	0.07-0.48	0.49-0.68	>0.68
K%	< 0.92	0.92 – 1.14	1.15 – 1.78	1.79 – 1.98	> 1.98
Ca%	< 0.72	0.72 – 0.92	0.93 – 1.12	1.13 – 1.72	> 1.72
Mg%	< 0.08	0.08 – 0.16	0.17 – 0.22	0.22 – 0.29	> 0.29
S%	< 0.07	0.07 – 0.14	0.15 – 0.19	0.20 – 0.28	> 0.28
Fruit development					
N%	< 0.86	0.86 – 1.11	1.12 – 1.48	1.49 – 1.92	> 1.92
P%	< 0.002	0.002 – 0.05	0.06 – 0.46	0.46-0.66	>0.66
K%	< 0.90	0.90 – 1.81	1.19 -1.82	1.83 – 2.01	> 2.01
Ca%	< 0.74	0.74 – 0.98	0.99 – 1.20	1.21 -1.79	> 1.79
Mg%	< 0.09	0.09 – 0.18	0.19 – 0.28	0.28 – 0.37	> 0.37
S%	< 0.06	0.07 – 0.13	0.14 – 0.18	0.19 – 0.26	>0.26
Harvesting					
N%	< 0.80	0.80 -1.02	1.03 – 1.44	1.45 – 1.88	> 1.88
P%	<0.001	0.001 – 0.03	0.04-0.44	0.45-0.65	>0.65
K%	< 0.90	0.90 – 1.15	1.16 – 1.70	1.71 – 1.96	> 1.96
Ca%	< 0.70	0.70 – 0.90	0.91 – 1.08	1.08 – 1.60	> 1.60
Mg%	< 0.08	0.08 – 0.15	0.16 – 0.21	0.22 – 0.27	> 0.27
S%	< 0.07	0.07 – 0.15	0.16 – 0.18	0.19 – 0.26	> 0.26
Fruit yield ($Mgha^{-1}$)	<18.33	18.33-20.78	20.79-25.69	25.70-28.14	>28.14

Table 3: Identifying nutrient constraints in pomegranate using leaf analysis based DRIS

Growth stages	Leaf Nutrients						Order of nutrient requirement
	N	P	K	Ca	Mg	S	
50% flowering	-4.24	-1.62	0.1	-7.63	-0.71	-13.25	S>Ca>N>P>Mg>K
Fruit development	-3.71	0.2	0.71	-6.58	-3.26	-13.66	S>Ca>N>Mg>P>K
Harvesting	-4.92	2.46	-5.34	-8.78	-3.46	-12.41	Ca>>K>Mg>N>P>S

As the value of each function ratio is added to one index subtotal and subtracted from another, prior to averaging, all indices are balanced around zero. Therefore, nutrient indices should sum to zero (Walworth and Sumner 1987). The more negative an index (S index -13.25), the more lacking is the nutrient (S), which represents a relatively its high requirement as compared to other nutrients used in diagnosis. The order of nutrient requirement in present study revealed that S and Ca were identified as the major yield limiting nutrients in low yielding plots at 50 % flowering and fruit development stages (Table3). The nutrients were arranged in the order of their requirement, which are based on their relative shortage or excess governed by the site specificity. Leaf Ca requirement was showed at harvesting stage also S and Ca nutrients requirement followed by Fe, N, P, K and Mg at 50 % flowering and fruit development stages, but at harvesting stage it showed higher requirement of K in leaf than N and P concentration in leaf.

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