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Zinc Status of Soils and Petioles of Vineyards of Peninsular India

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Abstract: *The paper presents the evaluation and classification of Zn status in soils and petioles of grapes grown in peninsular India. New norms for classification of Zn status was developed using DRIS. The optimum range of DTPA extractable soil Zn for Anab-e-Shahi was 8 to 24.9 ppm and for Thompson Seedless it was 4.5 to 8.2 ppm. The majority of Thompson Seedless vineyards were well supplied with Zn, while that of Anab-e-Shahi were deficient. The optimum range of Zn in petioles at bud differentiation stage was 25 to 94 ppm for Anab-e-Shahi, and 47 to 88 ppm for Thompson Seedless. The petiole analysis indicate majority of Thompson Seedless vineyards were well supplied with Zn while the deficiency was more frequent in the case of Anab-e-Shahi. (***Key Words****: Nutrient deficiency, DRIS)*

Zinc deficiency is being increasingly observed in many vineyards of peninsular India due to indiscriminate use of chemical fertilizers and intensive cultivation, over the years. It is therefore important to understand the status of zinc in soils and plant for taking ameliorative measures to sustain soil fertility.

Although, the zinc deficiency has been reported in wide ranges of soils and plants (Takkar *et al.* 1989, Sarosi *et al.* 1968), there is only one established standard for classification of Zn status in various soils (0.5 to 0.8 μ g/g) and crops (25 to 50 μ g/g). The establishment of specific norms for classification of nutrient status in soils of specific nature and crops are necessary to delineate the Zn deficient vineyards. The norm also helps in predicting Zn availability in soils and plant, and in turn the likelihood of Zn deficiency/toxicity in grape vineyards. In view of this the present study was undertaken.

MATERIAL AND METHODS

Nutritional survey was conducted in grape vineyards from 1977 to 1987 in the states of Karnataka, Andhra Pradesh and Maharashtra wherever Anab-e-Shahi and Thompson Seedless are grown.The soil samples were collected upto 45 cm layer at a distance of 1m from the vines. Four samples were pooled from each vineyard to make a representative

one. They were analysed for pH, EC, organic carbon, available P, K, Ca, Mg, S, Fe, Mn, Zn, and Cu by standard procedure (Page *et al.* 1982).

The petiole samples were collected both at bloom and at bud differentiation stage. Nearly 200 petioles were collected opposite to flower cluster as suggested by Cook and Wheeler (1978). The petioles collected at the 5th leaf position from the base at 45 days after back/spur pruning, as suggested by Bhargava and Summer (1987), constituted sampling at bud differentiaton stage. The sample thus collected, were immediately washed with 0.2 per cent liquid detergent followed by 0.1 N HCl solution, distilled water and finally with double distilled water, dried in oven at 70°C and analysed for N, P, K, Ca, Mg, S, Fe, Mn, Zn, and Cu (Bhargava & Raghupathi 1993). The yield data was also recorded.

Diagnosis and Recommendation Integrated System (DRIS)

DRIS developed by Beaufils (1973) and applied by Bhargava and Chadha (1988; 1993) was used. The whole population was divided into two sub-populations based on low and high yield performance. For Anab-e-Shahi yield less than 40 t/ha and for Thompson Seedless yield less than 25 t/ha were taken as low. Each parameter was expressed in as many forms as possible eg. Zn/dw, dw/Zn, N/Zn, Zn/N, etc. All the forms of expressions were takem for developing formulae for calculating the norms. Among different forms of expression the one showing highest variance ratio (variance of low yielding population/variance of high yielding population) was selected. Fromulae were developed to calculate the DRIS norms for soil, petiole and fertilizer recommendation.

The DRIS norms were calculated as follows:

$$\text{Soil Zn} = \frac{[\, f(Zn/pH) + f(Zn/EC) + f(Zn/OC) + f(Zn/P) + f(Zn/K) + f(Zn/Ca) + + (Zn/Mg) + f(Zn/S) + f(Zn/Fe) + f(Zn/Mn) + f(Zn/Cu) - f(Y/Zn)\,]}{12}$$

$$\text{where } f(Zn/K) = \left(\frac{Zn/K}{\bar{Z}n/\bar{K}} - 1\right) \frac{1000}{CV}$$

when $Zn/K > \bar{Z}n/\bar{K}$

$$\text{and} = \left(1 - \frac{\bar{Z}n/\bar{K}}{Zn/K}\right) \frac{1000}{CV}$$

when $Zn/K < \bar{Z}n/\bar{K}$

$\bar{Z}n$ = mean avail. Zn

$\bar{K}$ = mean avail. K

Zn/K = ratio of avail. Zn to avail. K in soil of a particular low yielding vineyard soil under diagnosis .

CV = coef. of variation of high yield -ing population.

Petoile Zn =

$$f(Zn/DW) + f(Zn/N) + (Zn/P) + (Zn/K) + (Zn/Ca) + f(Zn/Mg) + f(Zn/S) - f(Fe/Zn) - f(Mn/Zn) - f(Cu/Zn) - f(Y/Zn)$$
$$11$$

where $f(Zn/N) = \left(\frac{Zn/N}{\bar{Z}n/\bar{N}} - 1\right) \frac{1000}{CV}$

when $Zn/N > \bar{Z}n/\bar{N}$

and $= \left(1 - \frac{\bar{Z}n/\bar{N}}{Zn/N}\right) \frac{1000}{CV}$

when $Zn/N < \bar{Z}n/\bar{N}$

in which Zn/N is the actual value of the ratios of Zn (ppm) and N(%) in the petoiles under diagnosis. The $\bar{Z}n/\bar{N}$ is the value of the norm (which is the mean value for high yielding vines) and CV is the coefficient of variation for the population of high yielding vines.

The norms for classification of Zn status in soils and plants was derived by following the procedure given below. The mean of high yielding orchards constituted the mean of optimum. The range for 'optimum' is the mean – 4/3 SD to mean + 4/3 SD. The range for 'low' was obtained by calculating mean - 8/3 SD to mean – 4/3 SD, and the value below mean – 8/3 SD was considered as deficient. The value from mean + 4/3 to + 8/3 SD was taken as high and value beyond mean + 8/3 SD was taken as excessive or toxic.

RESULTS AND DISCUSSION

General Soil Characteristics: The majority of soils (Table 1) were slightly acidic to neutral in reaction. The organic carbon content ranged from 0.92 to 2.73 per cent. The soils from Andhra Pradesh vineyards have very high carbon content. The available P content ranged from 41 to 197 ppm and was generally higher than required for optimum yield (Bhargava & Raghupati 1993). The potassium status of vineyards ranged from 461 to 668 ppm. Bhargava (1985) has reported that the K status of these vineyards is generally high. The available Ca content varied widely from 754 to 16982 ppm while available Mg from 938 to 2254 ppm. Bhargava and Wasnik (1989) have reported Mg deficiency in some vineyards of southern Karnataka. The available sulphur ranged from 34 to 188 ppm. The DTPA extractable Fe, Mn and

TABLE 1. Soil parameters and yield of vineyards

Soil Properties	Thompson Seedless		Anab-e-Shahi	
	Maharashtra	Karnataka	Andhra Pradesh	Karnataka
pH	6.6-8.6	6.2-7.4	5.74-8.0	5.5-7.6
EC(dSm^{-1})	0.1-1.5 (0.4)	0.1-0.8 (0.3)	0.12-0.67 (0.3)	0.15-0.73 (0.3)
OC (%)	0.4-2.9 (1.1)	0.1-2.3 (0.9)	1.1-5.6 (2.7)	0.2-2.2 (1.0)
Avail. P (ppm)	4-182 (41)	26-500 (183)	23-368 (142)	31-511 (197)
Avail. K (ppm)	105-1615 (668)	52-800 (428)	240-1575 (586)	94-880 (461)
Avail. Ca (ppm)	1600-50100 (16982)	360-1400 (768)	900-4800 (2316)	340-1600 (754)
Avail. S (ppm)	20-2325 (188)	15-96 (34)	13-375 (75)	8-180 (55)
Avail. Fe (ppm)	2-16 (5.48)	3-28 (14)	3-36 (12)	3-60 (194)
Avail. Mn (ppm)	3-1275 (19)	4-51 (19)	11-52 (30)	4-63 (23)
Avail. Zn (ppm)	1-11 (4)	1-12 (4)	1-122 (10)	1-2 (6)
Avail. Cu (ppm)	2-34 (13)	2-66 (13)	2-23 (11)	2-51 (14)
Yield ($t\ ha^{-1}$)	2.4-34.6 (21.0)	5.0-30.0 (14.3)	9.9-95.9 (49.6)	19.8-61.8 (37.0)

* Figures in the parenthesis indicate mean.

Cu was also in optimum range in majority of soils.

Soil Zn status: The DTPA extractable Zn status of soils ranged from 4 to 10 ppm. Soils from Andhra Pradesh have higher value as compared to the soils of Karnataka and Maharashtra. In order to asses the individual vineyards, the norms were developed for different ranges of nutrient status using DRIS (Table 2). The examination of these norms indicated that Anab-e-Shahi require higher available Zn in soil compared to Thompson Seedless. The optimum Zn requirement of Anab-e-Shahi was 8 to 24.9 ppm while that of Thompson Seedless was 4.5 to 8.2 ppm. This indicated that the normal value of Zn

TABLE 2. Norms for classification of soil Zn (ppm).

Cultivar	Range				
	Very low	low	normal	High	Very high
Anab-e-Shahi	0.8	0.8-8	8-24.9	25-41	41
Thompson Seedless	0.6	0.6-4.5	4.5-8.2	8.3-12.0	12

TABLE 3. Evaluation and classification of zinc status of vineyard soils.

State	Cultivar	< Status (%) >				
		Very low	low	Normal	High	Very high
Maharashtra	Thompson Seedless	-	7	89	4	-
Karnataka	Thompson Seedless	-	-	89	11	-
Andhra Pradesh	Anab-e-Shahi	-	73	24	3	-
Karnataka	Anab-e-Shahi	-	80	17	-	3

for Thompson Seedless is low for Anab-e-Shahi. Further, it is seen that the Maharashtra and Karnataka had normal range while of Andhra Pradesh and Karnataka had low range of zinc supply (Table 3).

Zinc Status of Plant: The mean Zn concentration of Anab-e-Shahi was much higher compared to that of Thompson Seedless (Table 4). At bloom time the mean Zn concentration of Anab-e-Shahi was about 44 to 46 ppm while in Thompson Seedless it was 90 to 104 ppm. At bud differentiation stage Anab-e-Shahi, had 60 ppm and Thompson Seedless had 71 ppm Zn (Table 5).

The evaluation and classification of zinc status of grape petioles was carried out by comparing the petiole Zn content of the individual vineyard with the standard norm. The norms were developed for each stage of sampling seperately (Table 6).The petiole Zn indicated that optimum Zn concentration for Anab-e-Shahi is much higher as compared to Thompson Seedless. The pronounced effect of deficiency is at 6 ppm Zn for Anab-e-Shahi and 26 ppm Thompson Seedless.

In Andhra Pradesh nearly 34 per cent of vineyards were deficient. The diagnosis is quite close with the soil test analysis. In Karnataka 34 per cent

Table 4. Grape petiole nutrient status in different states (Bloom time).

Nutrient	Anab-e-Shahi		Thompson Seedless	
	Karnataka	Andhra Pradesh	Maharashtra	Karnataka
N (%)	1.2 (0.8-1.9)	1.0 (0.4-2.1)	1.6 (1.0-2.4)	1.5 (1.2-2.2)
P (%)	0.5 (0.2-0.8)	0.7 (0.3-1.0)	0.5 (0.2-1.1)	0.5 (1.2-0.8)
K (%)	2.5 (1.0-4.5)	4.3 (2.0-5.4)	1.8 (0.6-3.5)	3.0 (1.7-5.1)
C (%)	0.5 (0.3-0.9)	1.2 (0.5-2.6)	1.0 (0.6-4.0)	0.6 (0.5-1.0)
Mg (%)	0.2 (0.10-0.4)	0.3 (0.10-0.95)	0.7 (0.3-2.0)	0.7 (0.40-0.9)
S (%)	0.4 (0.2-0.6)	0.1 (0.1-0.2)	0.2 (0.1-0.4)	0.3 (0.1-0.4)
Fe (ppm)	33 (15-95)	123 (14-540)	358 (23-60)	29.6 (10-75)
Mn (ppm)	122 (22-315)	48 (10-192)	142 (58-753)	207 (46-4
Zn (ppm)	46 (23-96)	44 (6-97)	104 (46-325)	90 (51-147)
Cu (ppm)	147 (10-446)	26 (2-143)	233 (15-1200)	238 (54-429)
Yield ($t\ ha^{-1}$)	37.3 (19.8-61.8)	50.29 (9.9-95.8)	20.2 (2.4-34.6)	14.3 (4.9-29.6)

* Figures in the parenthesis indicate ranges.

of vineyards of Anab-e-Shahi were low in petiole Zn whereas soil test indicated that 80 per cent of vineyards were low in available Zn. However, in case of Thompson Seedless, majority of vineyards were optimum with Zn supply (Table 7).The diagnosis of Zn deficiency using petiole analysis is found better index as it relates with vine nutrition and in turn the yield.

The soil available Zn was poorly correlated with yield. The correlation coefficient of available Zn with yield for Thompson Seedless in Maharashtra (75 vineyards) was $r = 0.089$,

TABLE 5. Grape petiole nutrient status (Bud differentiation stage).

Parameter with unit	Anab-e-Shahi Andhra Pradesh	Thompson Seedless Maharashtra
N (%)	0.9 (0.5-2.0)	1.3 (0.5-2.2)
P (%)	0.6 (0.3-0.9)	0.5 (0.2-0.8)
K (%)	1.8 (1.0-4.3)	2.6 (1.8-3.2)
C (%)	1.7 (1.3-3.0)	1.1 (0.66-1.7)
Mg (%)	0.4 (0.26-1.6)	0.8 (0.4-1.4)
S (%)	0.1 (0.1-0.3)	0.1 (0.1-0.2)
Fe (ppm)	79 (14-540)	69 (34-113)
Mn (ppm)	50 (16-370)	126 (44-289)
Zn (ppm)	60 (12-118)	71 (10-144)
Cu (ppm)	14 (4-58)	45 (12-250)
Yield ($t\ ha^{-1}$)	50.0 (17.3-86.5)	21.5 (10.0-34.5)

*Figures in the paranthesis indicate ranges

Karnataka (28 vineyards) was 0.259, and for Anab-e-Shahi in Karnataka(56 vineyards) was $r = -0.0115$ and in Andhra Pradesh (166 vineyards) was $r = 0.020$. Similarly, the correlation coefficient between petiole Zn and yield was also not significant in most of the states. The correlation coefficient values for Anab-e-Shahi in Karnataka (56 vineyards) was $r = -0.118$ and in Andhra Pradesh (164 vineyards) was $r = 0.025$. In case of Thompson Seedless of Maharashtra (76 vineyards) the correlation coefficient value was $r = 0.011$, and in Karnataka (28 vineyards) it was $r = 0.389$. This clearly indicated that simple correlation studied failed to explore the exact relationship between Zn status in soils and plant with yield in vineyards of peninsular India.

TABLE 6. Petiole norms for classifying grape vine Zn status.

Cultivar	Sampling time	Deficient	low	Optimum	High	Excessive
Anab-e-Shahi	Bud differentiation stage	<6	6-24	25-94	95-128	>120
Anab-e-Shahi	bloom time	<29	29-11	42-58	59-93	>93
Thompson seedless	Bud differentiation stage	<26	26-46	47-88	89-109	>109
Thompson seedless	bloom time	<13	13-52	53-132	133-171	>171

TABLE 7. Evaluation and classification of grape vines based on petiole analysis.

State	Cultivar	Sampling time	<----------Status (%)----------> Defi-cient	low	Opti - mum	High	Excess
Andhra Pradesh	Anab-e-Shahi	Bud differentiation stage	-	9	83	8	-
Andhra Pradesh	Anab-e-Shahi	Flowering stage	34	20	15	31	-
Karnataka	Anab-e-Shahi	Flowering stage	9	34	39	16	2
Maharashtra	Thompson Seedless	Bud differentiation stage	-	14	61	14	11
Maharashtra	Thompson Seedless	Flowering stage	-	6	67	13	5
Karnataka	Thompson Seedless	Flowering stage	-	4	93	3	-

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