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Variation in the relationship of bloom time petiole nutrient contents with yield in grape cv. Thompson Seedless and its clones

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ABSTRACT

A nutritional survey was conducted to study the variation in the association of bloom-time petiole nutrient contents with yield in 'Thompson Seedless' and its clones, *viz.,* '2A', 'Manik Chaman', 'Super Sonaka' and 'SSN', the study showed that considerable variation existed in yield and nutrient contents among the cultivars/clones. Nutrients other than Mo in 'Thompson Seedless', NH_4^- N, and Cu in Clone '2A', Ca in 'Super Sonaka', and P and B in the cultivar 'SSN' were not correlated with yield. Non-significant and negative correlation is attributed to the interaction among the nutrients. Though, the correlation of individual nutrients with yield was poor, their combined effect was high. Nitrogen and Mg in 'Thompson Seedless'; NH_4^-N, P, Fe, and Zn in Clone '2A'; S and B in 'Manik Chaman'; N, NH_4^-N, K, and Zn in 'Super Sonaka'; and N, Ca, and Fe in 'SSN' were associated with reduced yields up to their respective vertex values related to minimum yields, beyond which, the relationship was positive. Such a relationship was attributed to the suppression of their positive effect at lower levels by the relative abundance of their respective antagonistic nutrients. The positive relationship of Mo in 'Thompson Seedless', Cu in Clone '2A', Ca and Mg in 'Super Sonaka', and P and B in 'SSN' indicates the sub-optimal status of these nutrients in the respective cultivars. The results showed the nutrient-specific variation of the tested genotypes.

Key words: *Vitis vinifera* L.*,* Correlations, Nutrients, Yield.

INTRODUCTION

In India, grape is cultivated in an area of 139 thousand ha with a production of 2,920 thousand MT (NHB, 7), of which 263.1 thousand MT of fresh grapes are exported, earning 305.66 million USD (APEDA, 1). Among the table grapes grown in India, 'Thompson Seedless' is the predominant cultivar. In addition, its clones, namely Clone '2A', 'Manik Chaman', 'Super Sonaka, and 'SSN', are also grown in a sizeable area. Presently, vineyard nutrient management in India for all the cultivars is based on the bloom-time petiole nutrient contents, developed by Sharma *et al*. (8) for 'Thompson Seedless' on 'Dog Ridge' rootstock. The advantage of petiole nutrient analysis is realized only when the petiole nutrient standards are used as the guidelines. The optimum levels of nutrients for 'Thompson Seedless' may not be applicable to its clones since they differ from the parent variety in vine vigour, fruitfulness, yield, and bunch and berry characters, which are influenced by nutrients. Translocation of ions (Barber and Russell, 3) and organic ions produced (Jacobson and Ordin, 6) in scions can influence the absorption of nutrients due to nutrient interactions to maintain the ionic balance in the plants. The basic requirement for determining the optimum levels of nutrients by regression analysis is the relationship of nutrients with yield. The nature and degree of correlation can be used to indicate the deficient, sufficient, or excess levels of the nutrients. Hence, the present investigations were carried out to (i) trace the relationship of nutrients with yield in different cultivars, (ii) interference of other nutrients in the yield determination of a nutrient and (iii) determine the nutrient levels associated with maximum/ minimum yield.

MATERIALS AND METHODS

Thirty vineyards each of 'Thompson Seedless', Clone '2A', 'Manik Chaman', 'Super Sonaka', and 'SSN' in the age group of 5-8 years, grafted on 'Dog Ridge' rootstock and raised on vertisols located in the districts of Nashik and Sangli of Maharashtra were surveyed during 2021 fruiting season. Eighty petioles opposite to flower clusters were collected at random from each vineyard during full bloom (Cook and Kishaba, 4). Petiole samples were analysed for nutrients as per the standard analytical procedures. Sodium and chlorides were also estimated because sodium interacts with potash varyingly in potash deficit and high sodium soils (Shikhamany and Sharma, 9), and chlorides suppress the yields (Ayers, 2)

Yield data were recorded from five vines selected at random, and yield/acre was computed based on the number of vines/acre. Correlation matrices among yield and nutrients were evolved in all cultivars. Vertex

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of each nutrient was derived by the formula Vertex = -b/2c in the quadratic function Y= a + bx + cx^2, where 'Y' is yield, 'x' is the nutrient value, 'a' is the intercept, 'b' is coefficient of 'x' and 'c' is coefficient of 'x^2'. Correlation and regression analyses were performed using the data analysis package in Microsoft Excel.

RESULTS AND DISCUSSION

Considerable variation was observed in yield and bloom-time petiole nutrient contents among the cultivars. The coefficient of variation was more than 15 per cent in yield as well as the nutrient contents. Variation in yield was less compared to nutrient contents. The coefficient of variation in yield was the least in 'Thompson Seedless', while highest in 'Super Sonaka'. Variation in the Mo content of 'Thompson Seedless' was highest, while least in 'Manik Chaman' (Table 1). The coefficient of variation was highest in NH_4^-N, P, Zn, B, Mo, Na, and Cl contents, as opposed to the least variation in yield in 'Thompson Seedless'.

On the other hand, variation in K, Mn, Cu, N, and Cl contents was less compared to the highest variation in yield in 'Super Sonaka'. Contrasting variation in yield and nutrient contents in these varieties had no bearing on the correlations of these nutrients with yield (Table 2), revealing that the variation in petiole nutrient contents was not in accordance with variation in yield. There seems to be an interference in yield determination by individual nutrients, the variation in the role of nutrients in growth and productivity in the cultivars, their inherent variation in growth and productivity, and interaction among nutrients.

Nutrients other than Mo in 'Thompson Seedless', NH_4^-N and Cu in Clone '2A', Ca in 'Super Sonaka', and P and B in 'SSN' were not correlated with yield in any of the cultivars. While Mo in 'Thompson Seedless', NH_4^-N and Cu in Clone '2A', P and B in 'SSN' were positively related to yield, with Ca negatively in 'Super Sonaka' (Table 2). Though the correlations of individual nutrients with yield were poor, their combined effect was high as indicated by the determination coefficients in the multiple regression analysis (Table 3). All the nutrients together, including Na and Cl, accounted for the highest percentage of variation (74.4%) in yield in the cultivar SSN, while least in 'Manik Chaman' (33.5%). The contribution of both major and micronutrients was highest in 'Thompson Seedless' but lowest in 'Manik Chaman' (Table 3). The sum of the percentage contribution of major and micronutrients (B+C) was higher than their combined contribution (A). So also, the sum of macro- and micro-nutrients together (A) and Na and Cl together (E) was higher than the combined contribution of macro- and micro-nutrients +Na +Cl (D) - (Table 3), which could be attributed to the interaction among nutrients. Every nutrient was correlated with other nutrients differently in different cultivars (Table 4), probably due to the overlapping relationship of nutrients with yield. Thus, it was revealed that there is no one-to-one relationship between nutrients and yield. Nutrients influence the yield directly and indirectly through other nutrients.

Among nitrogen fractions, NH_4^- N alone had a positive correlation in Clone '2A'. In quadratic analysis, the relationship of NH_4^-N was not significant, indicating the goodness of fit of a linear relationship. Yield decreased with increasing levels of NH_4^-N up to 411 ppm, beyond which the yield increased linearly (Fig.1). Linear relationship of NH_4^-N was not significant with yield in 'Super Sonaka', but the quadratic relationship was significant (Table 5). The vertex at 665 ppm of NH_4^- N was associated with the minimum yield of 9.6 t/ acre. An increase in NH_4^-N content above 665 ppm was associated with an increase in yield (Fig. 1). Phosphorus content of petioles had a positive correlation with yield in linear as well as quadratic relationships in the cultivar 'SSN'. The optimum level was 0.35 per cent, corresponding to the yield of 10.04 t/acre (Fig.1). Calcium content of

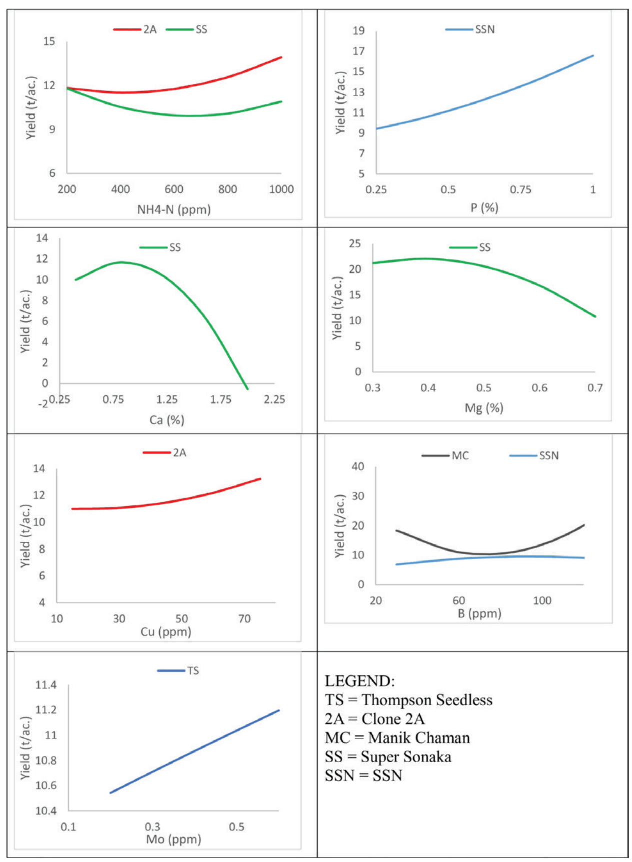

Fig. 1. Relationship of nutrients with yield in grape genotypes.

Table 1. Range, mean and coefficient of variation in nutrient contents and yield in grape cultivars.

Cultivar		N (%)	NO_3^-N (ppm)	NH_4^-N (ppm)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Mo (ppm)	Na (%)	Cl (%)	Yield (t/acre)
Thompson Seedless	Range	0.82 - 1.88	619 -2227	89 -2113	0.23 - 0.90	1.42 - 4.62	0.52 - 2.02	0.27 - 0.66	0.1 - 0.23	34 - 324	31 - 243	45 - 232	4.0-97	42 – 132	0.03 - 3.44	0.08 - 0.74	0.06 - 1.05	8.0 - 14.50
	Mean	1.301	1208	711	0.43	2.55	0.99	0.43	0.14	112.0	87.57	85.92	32.64	68.93	0.682	0.33	0.40	12.77
	CV (%)	21.38	38.66	71.76	39.71	28.25	38.18	25.43	19.27	67.95	58.03	43.47	63.03	29.98	116.37	33.20	74.08	17.19
Clone 2A	Range	0.78 - 2.64	617 - 1763	103 - 1401	0.23 - 0.73	1.42 - 3.90	0.49 - 2.70	0.19 - 0.86	0.10 - 0.30	47 - 395	31 - 327	53 - 154	3.0 - 56	44 – 108	0.37 - 0.52	0.15 - 0.37	0.12 - 0.50	7.0 -16.0
	Mean	1.413	883	621	0.381	2.50	0.87	0.33	0.13	116.0	87.92	92.15	35.69	72.38	0.485	0.29	0.19	13.83
	CV (%)	32.55	38.88	67.73	25.59	29.87	49.89	40.09	35.03	57.55	52.30	30.05	52.76	22.34	9.07	23.26	45.95	20.21
Manik Chaman	Range	0.82 - 2.17	621 -1759	54 - 1194	0.17 -0.64	1.42 - 3.80	0.41 - 1.72	0.24 - 0.71	0.07 - 0.17	36 -182	24 - 261	41 -140	7.0 -91	44 – 103	0.37 -0.57	0.12- 0.54	0.12 -0.56	6.0 -18.0
	Mean	1.389	945	578	0.443	2.70	0.82	0.35	0.13	89.9	107.0	69.000	20.933	69.561	0.475	0.32	0.27	13.20
	CV (%)	27.61	33.31	53.70	28.74	24.54	32.70	26.02	19.79	36.39	63.98	33.17	66.15	21.43	8.83	26.51	46.93	21.01
Super Sonaka	Range	0.9 -2.03	617 -1763	55 -1201	0.21 -0.75	1.57 - 3.90	0.50 -2.89	0.25 - 0.59	0.10 - 0.17	31 - 311	25 -157	39 -149	12.0- 70	43 – 107	0.35 - 0.6	0.18 -0.49	0.10 - 0.43	6.5 -16
	Mean	1.318	1008	374	0.461	2.67	0.81	0.37	0.13	113.5	83.500	75.313	29.438	68.326	0.461	0.32	0.21	12.88
	CV (%)	27.48	34.16	60.27	29.28	23.59	49.51	25.23	13.79	60.68	39.94	41.99	47.33	23.87	12.36	19.99	42.00	23.08
SSN	Range	0.84 - 2.24	542- 1428	62 -1146	0.15- 0.61	1.45 - 3.50	0.46 -2.78	0.21 -0.47	0.10 -0.16	39 -347	40 -200	32 - 152	3 - 117	43 – 94	0.34 - 0.61	0.12 - 0.37	0.12 - 0.42	6.5 - 14
	Mean	1.347	1034	442	0.441	2.56	0.73	0.34	0.12	68.5	99.231	80.462	41.000	71.953	0.486	0.29	0.19	11.65
	CV (%)	25.27	24.79	56.68	26.28	24.31	58.52	18.82	13.52	68.41	42.08	34.28	64.33	18.56	12.74	23.83	45.79	19.02

Table 2. Correlation coefficients (r) of nutrient contents with yield.

Nutrient	Cultivar				
	Thompson Seedless	Clone 2A	Mank Chaman	Super Sonaka	SSN
N	0.062	0.147	-0.070	0.004	-0.054
NO_3^-N	0.164	-0.189	0.024	-0.036	0.101
NH_4^-N	0.075	**0.369***	-0.039	-0.110	0.101
P	-0.269	-0.105	-0.024	0.228	**0.382***
K	0.014	0.060	0.201	0.151	0.051
Ca	0.220	-0.229	-0.096	**-0.369***	-0.136
Mg	0.268	-0.275	0.006	-0.208	-0.076
S	-0.033	-0.196	-0.001	0.035	0.127
Fe	0.143	0.054	-0.063	0.289	-0.359
Mn	-0.106	-0.168	0.161	0.218	0.275
Zn	-0.283	-0.117	0.076	0.039	0.068
Cu	-0.214	**0.392***	-0.162	-0.070	0.305
B	-0.020	-0.009	-0.021	-0.191	**0.464***
Mo	**0.405***	0.062	0.034	-0.082	-0.012
Na	0.169	0.282	0.048	-0.020	-0.012
Cl	0.225	-0.103	0.347	-0.165	0.243

r significant at p = 0.05: 0.361 r significant at p = 0.01: 0.463

petioles in 'Super Sonaka' was associated negatively with yield but positively in the quadratic relationship. The vertex at 0.83 per cent Ca was associated with the maximum yield of 11.67 t/acre (Fig.1). Magnesium content was not significantly related to yield in any of the cultivars in a linear relationship. Still, in a quadratic relationship, it was positively correlated in 'Super Sonaka'. The vertex at 0.39 per cent Mg was associated with the maximum yield of 22.08 t/acre .

Among the micronutrients, Cu content was positively related to yield in Clone '2A', B in 'SSN' and Mo in 'Thompson Seedless'. Cu content of 19 ppm was associated with the maximum yield of 10.98 t/acre in Clone '2A', while B content of 94 ppm in 'SSN' and 0.67 ppm Mo in 'Thompson Seedless' were associated respectively with the maximum yield of 9.2 and 11.31 t/acre . Though the linear relationship of B content with yield was not significant in 'Manik Chaman', the quadratic relationship was significant but negative. The vertex at 73 ppm of B corresponded to the minimum yield of 10.24 t/acre (Fig.1).

A non-significant relationship of nutrients with yield implies that they are inadequate or more than adequate range. Increasing levels of N and Mg in 'Thompson Seedless'; P, Fe and Zn in Clone '2A'; B in 'Manik Chaman'; N, NH_4-N, K and Zn in 'Super Sonaka'; and N, Ca and Fe in 'SSN' were associated with reduced yields up to their respective vertex values but increased yields after that (Fig. 1). This can be attributed to the masking effect of the interrelationship among nutrients. The positive impact of any nutrient at its lower level seems to have been masked by its positive relationship or suppression by the negative relationship with other nutrients. Thus, the non-significant relationship of N with yield in 'Thompson Seedless' can be attributed to its positive relationship with NO_3^-N, NH_4^-N, Mg and Cu, while with NH_4^-N and P in 'Super Sonaka' and Cu in the cultivar 'SSN'. Similarly, the non-significant relationship of NH_4^-N with yield in 'Super Sonaka' was masked by its positive relationship with P and Mo. The phosphorus-yield relationship in Clone '2A' was suppressed by its antagonism with Zn. The relationship of K with yield was masked by its positive relationship with S and Zn in 'Super Sonaka'. Calcium-yield relationship in 'SSN' was masked by Mg but suppressed by Na. The non-significant relationship of Mg in 'Thompson Seedless' could be due to its positive relationship with S and Cl (Table 4). Physiological bases for the interaction among nutrients are (i) the relative abundance of nutrients in the root media, (ii) the relative rate of adsorption of nutrients onto the root surface, (iii) antagonism among similarly charged nutrient ions due to substitution and (iv) synergism between differently charged ions for maintaining ionic equilibrium in plant tissues (Fagaria, 5). The reason for the differences

Table 3. Yield determination (R^2) by petiole nutrient contents in grape cultivars.

Nutrient	Cultivar				
	Thompson Seedless	Clone 2A	Manik Chaman	Super Sonaka	SSN
A. Major and micro nutrients	0.474	0.628	0.182	0.517	0.68
B. Major nutrients	0.257	0.293	0.077	0.219	0.278
C. Micro nutrients	0.246	0.195	0.085	0.141	0.365
D. Major and micro nutrients + Na + Cl	0.476	0.642	0.335	0.522	0.744
E. Na + Cl	0.061	0.011	0.121	0.028	0.061

Table 4. Interrelationships among nutrients in different cultivars.

Nutrient	Thompson Seedless	Clone 2A	Manik Chaman	Super Sonaka	SSN	Sharad Seedless
N	NO_3-N (0.455*) NH_4-N (0.516**) Mg (0.482**) Cu (0.420*)	NO_3-N (-0.405*) K (-0.451*) Ca (-0.579**) Mg (-0.549**) S (0.712**) Zn (0.39*)	Mo (-0.386*) Cl (-0.388*)	NH_4-N (0.551**) P (0.624**)	Cu (0.418*)	P (0.381*)
NO_3-N	Mg (0.426*) Mo (0.451*) Cl (0.797**)	Ca (0.576**) Mg (0.502**) Mn (0.394*) Na (-0.374*)	------	K (0.451*) S (0.486**) Cu (0.0.378)	------	------
NH_4-N	P (0.551**) Mg (0.564**) S (0.606**)	------	Mn (0.369*) Zn (0.367*)	P (0.494**) Mo (0.384*)	------	------
P	Ca (-0.486**) S (0.695**) Fe (-0.394*) Cu (0.436*) B (-0.368*)	Zn (-0.379*)	Ca (-0.376*) Mg (-0.414*)	------	------	------
K	Mo (0.543**)	------	------	S (0.513**) Zn (0.381*)	------	------
Ca	------	Mg (0.909**) Mn (0.663**) Cl (0.584**)	Mg (0.538**)	Mg (0.576**)	Mg (0.545**) Na (-0.418*)	Mg (0.614**) Mn (-0.385*)
Mg	S (0.458*) Cl (0.411*)	S (-0.393*) Mn (0.738**) Cl (0.448*)	Mn (0.384*)	------	Zn (0.38*)	Mo (0.369*)
S	Fe (-0.396*) Cu (0.548**) Cl (0.368*)	Zn (0.463**) Cu (-0.431*)	------	------	Na (-0.402*)	------
Fe	------	------	B (-0.366*)	------	------	Mo (0.478**)
Mn	Zn (0.367*)	Cl (0.508**)	Zn (0.548**) B (-0.481**)	------	Zn (0.361*)	Zn (0.613**) Cu (0.681**)
Zn	------	------	B (-0.377*)	------	Cl (0.409)	Cu (0.51**)
Cu	------	------	Cl (-0.423*)	------	------	------
B	Cl (-0.423)	Na (0.663**)	------	------	------	------
Mo	Cl (0.518**)	------	------	------	------	Cl (0.431*)

Figures in parenthesis are the correlation coefficients

Table 5. Yield-determining functions of nutrients.

Nutrient	Cultivar	Function	R^2	X-Opt	Y-Max (t/acre)	Y-Min (t/acre)
NH_4-N	Super Sonaka	$Y= 13.75 -0.012X +8.65E\text{-}06X^2$	0.149*	665		9.60
	Clone 2A	$Y= 10.63 +0.004X -2E\text{-}06X^2$	0.043	928	12.62	
P	SSN	$Y= 8.22 +3.457X +4.921X^2$	0.147*	0.351	10.04	
Ca	Super Sonaka	$Y= 5.47 +14.9X -8.952X^2$	0.190*	0.832	11.67	
Mg	Super Sonaka	$Y= 5.06 +88.23X -114.36 X^2$	0.209*	0.386	22.08	
Cu	Clone 2A	$Y= 11.26 -0.028X +0.0007X^2$	0.178*	19	10.98	
B	Manik Chaman	$Y= 33.66 -0.642X +0.0044X^2$	0.219**	73		10.24
	SSN	$Y= 3.73 +0.124X -0.0007X^2$	0.207*	94	9.20	
Mo	Thompson Seedless	$Y= 10.2 +1.741X -0.1306X^2$	0.165*	0.67	11.31	

in the interactions among nutrients in cultivars could be due to the variation in their synthesis of organic ions, as explained earlier.

The positive relationship of P and B in 'SSN', Ca and Mg in 'Super Sonaka', Cu in Clone '2A', and Mo in 'Thompson Seedless' indicates the sub-optimal status of these nutrients in their respective cultivars. An increase in their status to optimum levels (Table 5) can help maximise yield.

AUTHORS' CONTRIBUTION

Conceptualization of research (SDS, S); Designing of the experiments (SDS, JNK, SB); Contribution of experimental materials (JNK, SB); Execution of field/ lab experiments and data collection (R, SB); Analysis of data and interpretation (S, SDS); Preparation of the manuscript (SDS, R).

DECLARATION

The authors declare that they do not have any conflict of interest.

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