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Preliminary DRIS Norms for Evaluating the Nutritional Status of Cantaloupe Crop

Abd El-Rheem Kh. M.[1], Shaymaa I. Shedeed[2] and Entsar M. Essa[2]

[1]Soils and Water Use Dept., [2]Plant nutrition Dept., National Research Centre, Dokki, Giza, Egypt.

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ABSTRACT

Nutritional diagnosis is an important tool for increasing quality and quantity of yield through efficient fertilization management. The Diagnosis and Recommendation Integrated System (DRIS) was developed to incorporate the importance of nutrient balance into plant analyses. Preliminary DRIS norms for cantaloupe were developed during 2013 growing season inNubaria region west of Nile Delta of Egypt. DRIS norms were established from a data bank of a leaf nutrient concentration (N, P, K, Fe, Zn,Mnand Cu) and fruit yield with 40 samples gathered from 20 commercial fields. The data were divided into high-yielding (≥ 8.0 ton ha^{-1}) and low-yielding (<8.0 ton ha^{-1}) sub-populations and norms were computed using standard DRIS procedures. The DRIS norms for N, K, Ca and Mg with high S_L/S_H ratio and low coefficient of variation (CV) found in this study probably can provide more security to evaluate the N, K, Ca and Mg status of cantaloupe plants. These norms were developed with data from only one cropping region, so they should be considered as preliminary, probably requiring some modification as more data become available.
KEY WORDS: DRIS norms, Cantaloupe, Yield, Nutrients content.

INTRODUCTION

Cucumismelo L. (Reticulatus group), commonly called as cantaloupe or muskmelon, is a member of the Cucurbitaceae family **(Bailey and Bailey, 1976)**. Consumer preference for this fruit is determined largely by its sweetness (i.e sugar content), flavor or aroma, texture and more recently as a rich source of phytonutrients **(Lester, 2008)**. Cucumismelo, in addition to its superior consumer preference, is an extremely healthful food choice as they are rich in ascorbic acid, carotene, folic acid, and potassium as well as a number of other human health-bioactive compounds **(Lester and Hodges, 2008)**.

In crop plants, the nutrient interactions are generally measured in terms of growth response and change in concentration of nutrients. Upon addition of two nutrients, an increase in crop yield that is more than adding only one, the interaction is positive (synergistic). Similarly, if adding the two nutrients together produced less yield as compared to individual ones, the interactions is negative (antagonistic).When there is no change, there is no interaction. All the three interactions among essential plant nutrients have been reported. However, most interactions are complex. A nutrient interacting simultaneously with more than one nutrient. This may induce deficiencies, toxicities, modified growth responses, and/or modified nutrient composition. Better understanding of nutrient interactions may be useful in understanding importance of balanced supply of nutrients and consequently improvement in plant growth or yields **(Fageria, 2011)**.

Diagnosis and recommendation integrated system (DRIS) is claimed to have certain advantages over other conventional interpretation tools **(Beverly, 1987; Malavolta *et al.*, 1997; Li *et al.*, 1999)**. The DRIS approach reflects the nutrient balance, identifies the order in which nutrients is responsible for limiting the fruit yield, and its ability to make diagnosis at any stage of crop development. These merits impart DRIS the ability to identify nutrient constraints early in the crop growth and allow sufficient time for remediation of identified problem right in the same season of crop **(Walworth and Sumner, 1987)**. Furthermore, DRIS norms, once developed out of a representative data bank, are by and large applicable under wide range of growing conditions **(Beaufils, 1973)**. DRIS has been used successfully to interpret the results of foliar analyses for a wide range of crops such as rubber and sugarcane **(Elwali and Gascho 1984)**, cotton **(Dagbénonbakin *et al.*, 2009)**, mango **(Hundal *et al.*, 2005)** vegetables, potatoes, wheat **(Amundson and Koehler 1987; Meldal-Johnsen and Sumner, 1980)** and even forage grass **(Bailey *et al.*, 2000).**

The objective of this work was establishment appropriate norms for the cantaloupe crop in Nubaria region west of Nile Delta of Egypt, seeking to use the DRIS method for its nutritional diagnosis.

* **Corresponding Author:** Abd El-Rheem Kh. M., Soils and Water Use Dept., National Research Centre, Dokki, Giza, Egypt.

MATERIAL & METHODS

A total of 20cantaloupe fields were sampled during the 2013 season from Nubaria region west of Nile Delta of Egypt. To identify the initial characteristics of the experimental soil, a surface soil sample (0-30 cm depth) was collected before the beginning of the experiment and subjected to some physical and chemical analyses according to **Jackson (1973)**, **Page *et al.* (1982) and Gee and Bauder (1986)** as well as some soil essential nutrients status **(Follett and Lindsay, 1971; Soltanpour and Schwab, 1977; and Lindsay and Norvell, 1978)**. The obtained results are presented in Table 1.

Table 1: Some physical, chemical and fertility characteristics of the experimental soil.

Soil characteristics	**Value**	**Soil characteristics.**	**Value**
Particle size distribution(%):	**Soil paste extract:**		
Sand	78.76	EC (dS/m)	0.74
Silt	15.32	*Soluble cations (mmolc L^{-1}):*	
Clay	5.92	Ca^{++}	1.80
Texture class	Loamy sand	Mg^{++}	1.60
Infiltration rate (cm h^{-1})	7.15	Na^{+}	3.10
$CaCO_3$ %	3.40	K^{+}	0.90
Available nutrients (mg kg^{-1} soil)		*Soluble anions (m molc L^{-1}):*	
		CO_3^{-}	nd.*
N (potassium sulphate)	18.0	HCO_3 -	1.65
P (sodium bicarbonate)	4.00	Cl^{-}	3.90
Ca (ammonium acetate)	280.5	SO_4^{--}	1.85
Mg (ammonium acetate)	199.4	pH (1:2.5 soil water suspension)	8.38
K (ammonium acetate)	32.00	Organic matter %	0.20
Fe (DTPA)	4.85	CEC (c molc kg^{-1})	12.5
Mn (DTPA)	0.90	Soil total N %	0.02
Zn (DTPA)	0.82	Soil organic carbon %	0.12
Cu (DTPA)	0.44	Soil C/N ratio	6.00

Cantaloupe yield data and 40 leaf samples were collected in commercial cantaloupe fields. Yield and nutrient concentrations established a databank, which was divided into high- (≥8.0 ton ha^{-1}) and low- yield (<8.0 ton ha^{-1}) populations. Plant samples of leaf tissue were digested with sulfuric acid in the presence of H_2O_2 and digests were analyzed for N, P, K, Ca, Mg, Fe, Zn, Mn, and Cu content. Where, Mg, Fe, Mn, Zn, and Cu were determined by atomic absorption spectroscopy. While, K and Ca by flame emission **(Jackson, 1973)** and P by ascorbic acid-reduced molybdophosphoric blue colourimetry, **Page *et al.* (1982).** Total nitrogen in plant was determined by the Kjeldahl method, **Jackson (1973).**

In order to establish the DRIS norms, it is necessary to use a representative value of leaf nutrient concentrations and respective yields to obtain accurate estimates of means and variances of certain nutrient ratios that discriminate between high- and low yielding groups. Pair of nutrient ratios is calculated from the data bank of nutrient concentrations and then, the mean, the variance and the coefficient of variation of each ratio are calculated. There are two forms of expression for a pair of nutrients, although in DRIS calculations only one form is used. The way to select the form of ratio for a pair of nutrients to be used in DRIS calculation is described by **(Walworth and Sumner (1987) and Hartz *et al.*, 1998).**

RESULTS AND DISCUSSION

Cantaloupe yields were subdivided into two groups. The first is representing the high yielding population (H) having not less than 80% from the obtained relative yield. The second, however, is representing the low yielding population (L) having less than 80% from the obtained relative yield. Mean values of each nutrient expression together with their associated CVs and variances (S_H and S_L) were then calculated for the two populations. The average yield in the high-yielding population was 9.796ton ha^{-1}, while the average yield in the low-yielding population was 6.714ton ha^{-1}. This difference was statistically significant ($P < 0.05$). Although the absolute average foliar N, P, K, Fe, Zn and Mn concentrations were higher in the high-yielding population than in low-yielding population, only the mean foliar N, P and K concentrations were significantly higher ($P < 0.05$) in the high-yielding population than in the low-yielding population (Table, 2).

Table 2. Mean, coefficient of variation (CV), variance and variance ratio between the low- and high yielding populations (S^2_L/S^2_H) of both yield and nutrient contents in the leaf dry matter of cantaloupe at high- and low-yielding populations[(1)].

Variable	Population	Mean	CV (%)	Variance (S^2)	S^2_L/S^2_H
Yield (ton ha^{-1})	High	9.796 **	13.17	1.664	0.201
	Low	6.714	8.624	0.335	
N (g kg^{-1})	High	2.680**	22.31	0.321	1.003
	Low	2.541	21.19	0.323	
P (g kg^{-1})	High	0.290**	18.96	0.003	0.529
	Low	0.244	16.39	0.002	
K (g kg^{-1})	High	2.013**	22.40	0.204	1.000
	Low	1.921	23.48	0.203	
Ca(g kg^{-1})	High	0.423	18.20	0.006	1.277
	Low	0.403	21.59	0.008	
Mg (g kg^{-1})	High	0.309	22.65	0.005	1.339
	Low	0.293	27.64	0.007	
Fe (mg kg^{-1})	High	0.028	17.86	25.00	2.560
	Low	0.027	29.63	64.00	
Zn (mg kg^{-1})	High	0.004	25.00	1.000	0.640
	Low	0.004	20.00	0.640	
Mn (mg kg^{-1})	High	0.020	24.00	25.00	1.538
	Low	0.017	36.47	38.44	
Cu (mg kg^{-1})	High	0.006	16.67	1.00	1.960
	Low	0.005	28.00	1.96	

[(1)] High- yield ≥8 ton ha^{-1}, low-yield <8ton ha^{-1}; mean yield and foliar nutrient contents of low- and high- yielding populations are significantly different at the 5% (**).

Mean values of nutrient expressions for both populations, together with their respective CVs and variance, were calculated and shown in (Table, 3). A total of 36 nutrient ratio expressions were finally selected. Obtained norms for cantaloupe plants were P/N, N/K, N/Ca, N/Mg, N/Fe, N/Zn, N/Mn, N/Cu, K/P, Ca/P, Mg/P, P/Fe, Zn/P, Mn/P, P/Cu, Ca/K, K/Mg, K/Fe, Zn/K, K/Mn,

Table 3.Mean, coefficient of variation (CV) and variance (S^2) of nutrient ratios of the low- and high-yielding populations, the variance ratio (S^2_L / S^2_H) and the selected ratios for cantaloupe DRIS norms

Ratios	High yield population			Low yield population			S_L/S_H	Selected ratios
	Mean	CV	S	Mean	CV	S		
N/P	8.724	10.57	0.850	10.72	23.51	6.350	7.470	
P/N	0.116	11.21	0.0002	0.097	19.59	0.0004	2.00	√
N/K	1.268	7.334	0.009	1.456	37.43	0.297	33.00	√
K/N	0.792	6.313	0.003	0.778	36.89	0.082	27.33	
N/Ca	5.954	8.666	0.266	6.708	19.14	1.649	6.199	√
Ca/N	0.169	8.876	0.0002	0.153	16.34	0.001	5.00	
N/Mg	8.300	10.57	0.771	9.860	41.88	17.05	22.11	√
Mg/N	0.122	10.66	0.0002	0.117	37.61	0.002	10.00	
N/Fe	93.61	29.08	740.9	105.9	28.14	888.0	1.199	√
Fe/N	0.012	33.33	$2*10^{-4}$	0.010	30.00	$1*10^{-4}$	0.500	
N/Zn	675.8	28.86	38025.0	782.6	24.60	37056.2	0.975	√
Zn/N	0.002	50.00	$1*10^{-5}$	0.001	30.00	$1*10^{-6}$	0.100	
N/Mn	140.2	39.40	3051.5	171.4	39.52	4588.7	1.504	√
Mn/N	0.008	37.50	$1*10^{-4}$	0.007	28.57	$4*10^{-5}$	0.400	
N/Cu	439.3	30.18	17582.8	527.6	31.13	27291.0	1.552	√
Cu/N	0.003	33.33	$1*10^{-5}$	0.002	50.00	$1*10^{-5}$	1.00	
P/K	0.147	11.56	0.0003	0.135	25.93	0.001	3.330	
K/P	6.900	11.19	0.596	7.892	26.68	4.435	7.442	√
P/Ca	0.687	10.04	0.0048	0.639	17.21	0.012	2.500	
Ca/P	1.470	10.27	0.0228	1.608	16.98	0.075	3.289	√
P/Mg	0.960	13.44	0.0166	0.904	27.88	0.064	3.855	

Mg/P	1.060	12.55	0.0177	1.188	27.86	0.110	6.215	√
P/Fe	10.62	23.79	6.386	10.09	26.59	7.198	1.127	√
Fe/P	0.101	29.70	0.0009	0.106	29.24	0.001	1.111	
P/Zn	76.83	24.74	361.4	74.77	24.81	344.1	0.952	
Zn/P	0.014	28.57	$2*10^{-4}$	0.014	28.57	$2*10^{-4}$	1.00	√
P/Mn	15.78	33.05	27.21	16.17	34.29	30.74	1.130	
Mn/P	0.071	33.80	0.0006	0.069	34.78	0.001	1.667	√
P/Cu	49.68	23.77	139.5	49.84	26.28	171.6	1.230	√
Cu/P	0.022	27.27	$4*10^{-4}$	0.021	28.57	$4*10^{-4}$	1.00	
K/Ca	4.715	10.98	0.268	5.042	31.1	2.459	9.175	
Ca/K	0.215	10.69	0.0005	0.217	31.34	0.005	10.00	√
K/Mg	6.567	11.44	0.564	6.706	11.84	0.630	1.117	√
Mg/K	0.154	11.04	0.0003	0.151	11.26	0.0003	1.00	
K/Fe	73.97	29.39	472.6	77.22	25.26	380.6	0.805	√
Fe/K	0.015	33.33	$4*10^{-4}$	0.014	35.71	$3*10^{-4}$	0.750	
K/Zn	534.1	29.36	24586.2	572.2	24.34	19404.5	0.789	
Zn/K	0.002	50.00	$1*10^{-5}$	0.002	50.00	$1*10^{-5}$	1.00	√
K/Mn	111.2	40.97	2075.7	123.5	39.51	2381.4	1.147	√
Mn/K	0.011	36.36	$2*10^{-4}$	0.009	44.44	$2*10^{-4}$	1.00	
K/Cu	347.4	30.83	11470.4	380.3	23.74	8148.7	0.710	
Cu/K	0.003	33.33	$1*10^{-5}$	0.003	33.33	$1*10^{-5}$	1.00	√
Ca/Mg	1.400	9.714	0.0185	1.455	34.71	0.255	13.78	√
Mg/Ca	0.722	9.695	0.005	0.757	30.65	0.054	10.80	
Ca/Fe	15.58	25.40	15.67	15.81	22.51	12.66	0.808	√
Fe/Ca	0.069	28.99	0.0004	0.066	21.21	0.0002	0.500	
Ca/Zn	112.3	24.27	743.1	116.9	18.17	451.1	0.607	√
Zn/Ca	0.009	33.33	$1*10^{-4}$	0.009	22.22	$4*10^{-5}$	0.400	
Ca/Mn	23.31	36.89	73.96	25.32	31.19	62.36	0.847	√
Mn/Ca	0.049	34.69	0.0003	0.043	30.23	0.0002	0.667	
Ca/Cu	73.12	26.76	383.0	78.61	24.92	383.8	1.002	√
Cu/Ca	0.015	26.67	$2*10^{-4}$	0.013	23.08	$1*10^{-4}$	0.500	
Mg/Fe	11.28	26.88	9.193	11.52	22.78	6.885	0.749	
Fe/Mg	0.097	36.08	0.001	0.093	33.33	0.001	1.00	√
Mg/Zn	81.61	27.08	488.4	85.68	22.83	382.6	0.783	√
Zn/Mg	0.014	35.71	$3*10^{-4}$	0.012	33.33	$2*10^{-4}$	0.667	
Mg/Mn	16.89	37.08	39.21	18.33	29.55	29.34	0.751	√
Mn/Mg	0.069	42.03	0.0008	0.060	36.67	0.0005	0.625	
Mg/Cu	53.08	28.65	231.3	56.79	21.38	147.4	0.637	√
Cu/Mg	0.021	38.09	0.0001	0.019	31.58	$4*10^{-4}$	0.400	
Fe/Zn	7.244	7.772	0.317	7.466	7.702	0.331	1.044	√
Zn/Fe	0.139	8.633	0.0001	0.135	8.148	0.0001	1.00	
Fe/Mn	1.477	18.35	0.073	1.593	18.02	0.082	1.123	
Mn/Fe	0.697	16.64	0.013	0.648	19.14	0.015	1.154	√
Fe/Cu	4.697	8.942	0.176	4.969	8.734	0.188	1.068	√
Cu/Fe	0.215	8.837	0.0004	0.203	9.360	0.0004	1.00	
Zn/Mn	0.205	21.46	0.002	0.215	21.86	0.002	1.00	
Mn/Zn	5.053	17.93	0.821	4.854	21.36	1.075	1.309	√
Zn/Cu	0.651	9.985	0.004	0.670	12.24	0.007	1.750	√
Cu/Zn	1.551	9.994	0.024	1.514	11.89	0.032	1.333	
Mn/Cu	3.240	11.26	0.133	3.186	13.40	0.182	1.368	√
Cu/Mn	0.313	13.42	0.002	0.320	14.69	0.002	1.00	

Cu/K,Ca/Mg, Ca/Fe, Ca/Zn, Ca/Mn, Ca/Cu, Fe/Mg, Mg/Zn, Mg/Mn, Mg/Cu, Fe/Zn, Mn/Fe, Fe/Cu, Mn/Zn,Zn/Cu andMn/Cu whose values were 0.116, 1.268, 5.954, 8.300, 93.61, 675.8, 140.2, 439.3, 6.900, 1.470, 1.060, 10.62, 0.014, .071, 49.68, 0.215, 6.567, 73.97, 0.002, 111.2, 0.003, 1.400, 15.58, 112.3, 23.31, 73.12, 0.097, 81.61, 16.89, 53.08, 7.244, 0.697, 4.697, 5.053, 0.651 and 3.240,respectively. The selection of a nutrient ratio as DRIS norms (i.e.: N/P or P/N) is indicated by the variance ratio **(Hartz*et al.*, 1998)**. The higher variance ratio, the more specific the nutrient ratio must be in order to obtain a high yield **(Payne *et al.*, 1990)**. Although **Beaufils (1973)** suggested that every parameter which showed a significant difference of variance ratio between the two populations under comparison (low- and high- yielding) should be used in DRIS, other researchers have adopted the ratio which maximized the variance ratio between the low- and high- yielding populations **(Payne *et al.*, 1990 and Hundal*et al.*, 2005).**

The DRIS norms for N, K, Ca and Mg with high S_L/S_H ratio and low coefficient of variation (CV) found in this study probably can provide more security to evaluate the N, K, Ca and Mg status of cantaloupe plants. These norms were developed with data from only one cropping region, so they should be considered as preliminary, probably requiring some modification as more data become available. **Roberto and Pedro (2003)** indicated that there is a speculation that the large S_L/S_H ratio and the small CV found for specific ratios between nutrients probably imply that the balance between these pairs of nutrients could be important to crop production.

Conclusion

Mean yield and foliar nutrient concentrations are not similar in low- and high yielding group. Variance of nutrient ratios of low- and high yielding groups are different.

Data from future field and surveys experiment may subsequently be used to enlarge the model database and allow the refinement of DRIS parameters and hopefully an expansion of diagnostic scope to include other nutrients. As it stands, though, this preliminary DRIS model for cantaloupe is one of the best diagnostic tools currently available for simultaneously evaluating the N, P, K, Ca, Mg, Fe, Zn, Mn and Cu status of cantaloupe.

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