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USE OF MULTINUTRIENT DIAGNOSIS UNDER DIFFERENT TILLAGE SYSTEMS ON CORN PRODUCTIVITY UNDER CALCAREOUS SOIL CONDITIONS

ABOU YUOSSEF, M. F. and A. S. El KOT
Soil Conservation Dept., Desert Research Center, Cairo, Egypt

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ABSTRACT: Diagnosis and Recommendation Integrated System (DRIS) applies nutrient ratios instead of the isolated concentration values of each nutrient in interpretation of tissue analysis. The objectives of this research were to establish adequate DRIS norms for corn grown on two rates of N, P and K under two tillage systems and correlate indices of nutrition balance with yield. The study was established on calcareous soil, Maryut soil. Two rates of N, P, and K (75 and 150 kg N/fed., 22.5 and 45 kg P_2O_4/fed., and 24 and 48 kg K_2O/fed.,respectively),were applied to plots managed with two tillage systems: chisel plow and moldboard plow. Obtained data show that corn grain yield increased with increasing N, P and K rates. The corn grain yield was affected by interaction between tillage and N- and P-rate. Maximum yield within moldboard plow system was achieved with the rate $N_2P_2K_2$ (39.16 kg grain/plot). DRIS norms for several elements (N, P, K, Fe, Mn, and Zn) calculated from the data bases were significantly different, while norms for the other nutrients (Ca, Mg, and Cu) were not. Results of this test indicate that the DRIS norms show imbalanced nutrition compared to high-yield under the two studied tillage systems. Nitrogen indices were always sub-optimal in all treatments under the two tillage systems (except, $P_2K_2N_2$ treatment). K indices were commonly sub-optimal (except, $P_2K_2N_1$ and $P_2K_2N_2$ treatments under chisel tillage). Also, P indices were commonly sub-optimal (except, $P_2K_1N_2$, $P_2K_2N_1$ and $P_2K_2N_2$ treatments under the two tillage systems, usually close to supra-optimal). The diagnosis continued in this progressive manner, yield

being increasing with each successive treatment under tillage system, until the $P_2K_2N_2$ treatment was reached. Diagnosis of this treatment under tillage system indicated that N, P, and K were most limiting. In addition, plant analysis interpreted by DRIS norms indicated the need for applying K and one or more of micronutrients to almost all studied treatments and tillage systems.

INTRODUCTION

Corn (Zea mays L.) is an important crop and one of two sources for cereal flour used in Egypt for making bread. The average area of corn on 2003 was 1.668 million feddan which produced 5.676 million tons (CAMS, 2003). This indicates that annual production per unit area is not enough for efforts consumption. Therefore, investigators frequently tried to increase the corn production with different ways. It is known that nitrogen, phosphatic and potasic fertilizer levels and tillage system exert paramount effect on the growth and yield of corn plants.

Sweeney (1993) found that the tillage primarily affected plant growth and N, P, and K nutrients uptake by grain sorghum at nine-leaf stage, with minimum effects later in the growing season. Also, Mullins, et.al. (1980) found that P concentration in lima bean petiole was higher with disk tillage than with conventional tillage.

Plant analysis can be a useful tool for correcting plant nutrient deficiencies and imbalances (Baldock & Schulte, 1996), optimizing crop production (Walworth et al., 1986), and for evaluating fertilizer requirements. The Diagnosis and Recommendation Integrated System (DRIS) is a recent approach to interpreting plant-tissue analysis (Junior and Monnerat, 2003). This methodology has received considerable attention since it was developed by Beaufils (1973).

The DRIS system makes multiple comparisons between the levels of various plant nutrients and integrates these comparisons into a series of nutrient indices (Walworth et al., 1986). The DRIS index scale that results from those calculations is continuous and easy to understand (Baldock & Schulte, 1996). This model is designed to determine when the nutrient contents of crops are excessive (positive indices), adequate (zero indices) or deficient (negative indices). Development of the DRIS for use with a crop involves compiling a database (Payne, et. al., 1990) from which optimum ratios (mean and coefficient of variance) for all nutrient combinations are determined (Snyder et al., 1989), called DRIS norms.

Several authors have affirmed that, after being developed for a plant species, the DRIS norms can be used irrespective of the cultivar grown or local conditions (Sumner, 1979; Walworth & Sumner, 1987; Payne, et. al., 1990), but others found that locally developed DRIS norms are more accurate than the broad based norms in their nutrient diagnoses (Dara et al., 1992; Jones Junior, 1993). This demonstrates that DRIS norms, calculated on the basis of finite sets of field data, must be tested to insure validity and accuracy (Walworth & Sumner, 1987). To do this, DRIS diagnosis are usually conducted on greenhouse or field-grown plants from fertilizer surveys. Caldwell et al. (1994) used NxPxKxS and NxPxK factorials to evaluate DRIS norms for onions, in which the diagnoses were considered accurate, if the next treatment containing the nutrient identified as limiting resulted in an yield increase.

The relationship between yield and plant nutrient concentration is a premise to use the plant analysis as diagnostic criterion. So, the relationship between nutrient concentration and DRIS indices may be a valuable criterion to validate the DRIS norms. If there is a relationship between plant nutrient concentration and DRIS index, this index can be used to make nutritional diagnosis. Probably, this is a new way to validate DRIS norms. This fitted model between nutrient concentration and respective DRIS index probably shows negative and positive DRIS index, it could be used to determine optimum foliar concentration. If the crop shows nutrient concentrations higher or lower than this optimum value, the crop shows positive or negative DRIS indices respectively, which indicate yield limitation by nutritional excess or deficiency.

Investigation by Filho and Azevedo (2003), in Brazil, pointed out that DRIS can be successfully applied in nutrient diagnosis of 'Valencia' sweet orange. The authors correlated yield (kg/plant) and quality (fruit mass) with DRIS indices, working in a database with more than 1,700 observations. DRIS norms were also evaluated in field fertilization trials, and successfully associated with increase in yield and fruit quality. The authors suggested that DRIS can be an economically fast and reliable alternative to nutrient diagnosis.

Coleman, et.al. (2003) reported that the DRIS analysis provides the means for diagnosing nutrient imbalance and a potential basis for prescribing corrective amendments in sweetgum plantations. Also, DRIS has successfully been used on many crops (Hockman, er.al., 1989) including corn (Zea mays L.), soybeans (Glycine max L.), wheat (Triticum aestivum L.), hybrid poplar (Populus deltoides Marsh.) and Monterey pine (Pinus radiata D. Don).

The aim of this work is to evaluate the effect of tillage on DRIS indices and nutrient concentrations, to obtain significant principal components for nutrients in the corn grain, and to diagnose nutrient imbalance in corn grain under tillage using independent data.

MATERIALS AND METHODS

The study was conducted in Maryut. The soil was a sandy clay loam. Soil analyses at initiation of the experiment are summarized in Table (1).

Table (1): Some physical and chemical properties of the studied soil.

Depth cm	Particle size distribution %			pH in paste	EC dS/cm in paste	$CaCO_3$ %	O.M %
	Sand	Silt	Clay				
0 – 30	48.16	19.99	31.85	7.98	2.80	28.23	0.42

In each experiment, there were 16 treatments representing the combination of two tillage system x two nitrogen levels x two phosphorus levels x two potassium levels.

The experimental design was a randomized complete block, treatments being replicated 3 times. Each block (2 by 20 m) was split to be randomized to tillage systems (chisel and moldboard). Also, block was randomized for N, P and K fertilizer treatments (75 and 150 kg N/fed., 22.5 and 45 kg P_2O_4/fed., and 24 and 48 kg K_2O/fed., respectively). N and K fertilizers were boradcasted by hand beside the plot 3 weeks after planting, and P fertilizer was banded adjacent to seed hills at planting.

Corn hybrid "Pioneer 30P09" was planted during the first week in May. Seeding rate was 20 kg seed fed^{-1}.

Corn was harvested in late September. Whole plants were taken at harvest from each plot to determine grain yield. Six plants were selected, at random, from each plot to determine N, P, K, Ca, Mg, Fe, Mn, Zn and Cu concentrations. Grain samples were dried and ground to pass a 0.5 mm stainless steel screen. Nitrogen was determined on 0.5 g subsamples by the macro-Kjeldahl methods (Phillips, et. al., 1980). Concentrations were determined on an oven dry basis.

One gram of grain material was digested with a mixture of concentrated HNO_3, $HClO_4$ and H_2SO_4 acids as described by Jackson (1973); Ca, Mg, Fe, Mn, Zn and Cu were then determined using a flame atomic absorption spectrophotometer (HGA-5000 graphite furnace).

Potassium was determined in plant digest using flame photometer as described by Jackson (1973). Phosphorus was assayed in plant digest using ascorbic acid method described by Fire, et. al., (1964).

Calculation of Nutrient Indices

The Diagnosis and Recommendation Integrated System (DRIS) ranks the importance of the various nutrients in limiting plant yield and estimated the degree to which each of the limiting nutrients is deficient. The DRIS indices were calculated using ratios of all 9 nutrients analyzed (N, P, K, Ca, Mg, Fe, Mn, Zn and Cu).

The general expression used to calculate DRIS indices was given by Walworth and Sumner (1987) as

$$\mathbf{AI = [+f\,(A/B) - f\,(C/A) + f\,(A/D) \ldots + f\,(A/N)]/z} \qquad \mathbf{(1)}$$

Where A….N are nutrients , AI is the DRIS index for nutrient A and when A/B > a/b,

$$f\,(A/B) = \{[\,(A/B)/\,(a/b)]\text{-}1\}\ x\ \ (1000/CV) \quad (2)$$

or, when A/B < a/b.

$$f\,(A/B) = \{1\text{-}[(a/b)/(A/B)]\}\ x\ \ (1000/CV) \quad (3)$$

in which A/B is the observed ratio of two elements in the tissue, a/b is the norm for that ratio in a large population of high-yielding plants, CV is the coefficient of variation associated with the norm, and z is the number of functions comprising the nutrient index.

RESULTS AND DISCUSSION

Corn grain yields

The data in Table (2) and Fig.(1) represent the response of corn grain yield to the tillage system and N, P, and K treatments.

Data show that the application of N_2 at the rate 150 kg N/fed. increased the corn grain production (on an average, 33.63 kg/plot) than that treatment N_1 (on an average 27.28 kg/plot) at the rate 75 kg N/fed. under the different treatments. The statistical analysis of the data in Table (2) showed that the N_1 rate (75 kg N/fed.) yielded corn grain significantly lower than that yielded with other N_2 rates (150 kg N/fed.). Similar results were reported by Sobh, et.al; (2000) and El-Bana (2001).

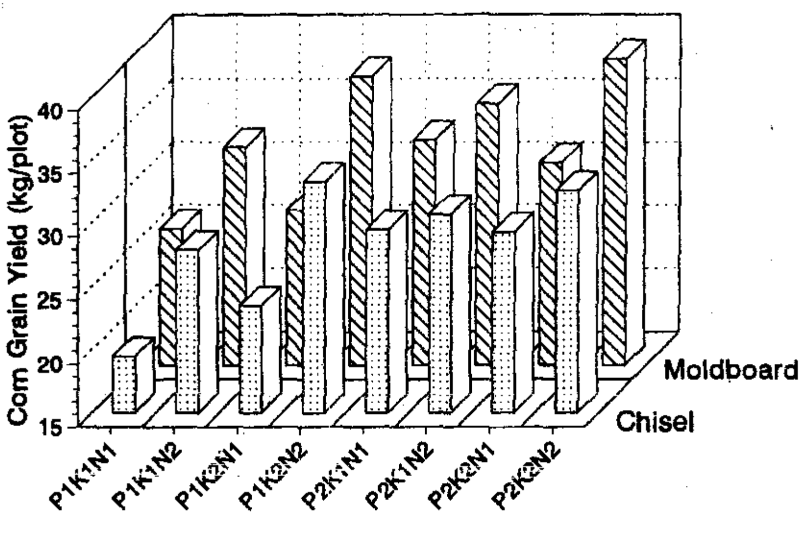


Fig. (1): Effect of N, P, K fertilizer rates and tillage system on corn grain yield.

Table (2): Corn grain yield (kg/plot) as affected by fertilizer N, P, K rates and tillage systems

Treatment		Grain Yield (kg/plot)			
		K_1		K_2	
		N_1	N_2	N_1	N_2
Chisel	P_1	19.46	27.81	23.43	32.53
	P_2	29.42	30.63	29.22	33.23
Moldboard	P_1	25.72	32.24	27.17	37.80
	P_2	32.81	35.68	31.01	39.16
	Mean of Grain Yield (kg/plot)				
Main effect of Chisel	*28.22*				
Main effect of Moldboard	*32.76*				
Main effect of N_1	*27.28*				
Main effect of N_2	*33.63*				
Main effect of P_1	*28.35*				
Main effect of P_2	*32.55*				
Main effect of K_1	*29.22*				
Main effect of K_2	*31.69*				
LSD For Main Effect	2.43				
LSD For Inter. (NxPxKx Tillage)	6.87				

Table (2): Con t.

Grain Yield (kg/plot)								
Main Effects of Two Factors								
	Tillage x P		Tillage x K		Tillage x N			
	P_1	P_2	K_1	K_2	N_1	N_2		
Chisel	25.99	30.46	26.83	29.61	25.69	30.75		
Moldboard	30.82	34.69	31.72	33.79	29.18	36.30		
	N x P		N x K		P x K			
	P_1	P_2	K_1	K_2		K_1	K_2	
N_1	23.95	30.92	27.16	27.71	P_1	26.39	30.41	
N_2	32.86	34.23	31.40	35.68	P_2	32.16	32.99	
LSD	3.43							
Main Effects of Three Factors								
	Tillage x P x N				Tillage x P x K			
	Chisel		Moldboard		Chisel		Moldboard	
	N_1	N_2	N_1	N_2	K_1	K_2	K_1	K_2
P_1	21.45	30.53	26.45	35.19	23.64	28.33	29.15	32.49
P_2	29.93	30.98	31.91	37.48	30.03	30.88	34.30	35.09
	Tillage x N x K				K x N x P			
	Chisel		Moldboard		K_1		K_2	
	K_1	K_2	K_1	K_2	P_1	P_2	P_1	P_2
N_1	25.05	26.33	29.27	29.09	22.59	31.72	25.31	35.52
N_2	28.62	32.88	34.18	38.48	30.20	32.60	30.12	35.85
LSD	4.87							

With respect to effect of phosphorus, a significant response to applied P_2 was observed up to 45 kg P_2O_4/fed. which gave on an average 32.55 Kg/plot corn grain yield. The statistical analysis of the data in Table (2) showed a high significant effect between the two rates of P on the corn grain yield. These results are in accordance with those of Raun and Barreto (1995) and Sobh, et.al. (2000).

As for the effect of potassium, data indicated (on an average) that the high corn grain yield (31.69 kg/plot) was recorded with applied K_2 (rate 48 kg K_2O /fed.); the statistical analysis of the data in Table (2) showed no significant difference in corn grain yield between K rates of 24 and 48 kg K_2O /fed..

The soil tillage main effects on yield were significant in corn grain yields (Table 2). Corn grain yield was greater in the moldboard system than in the chisel (on an average 32.76 and 28.22 kg/plot, respectively). These results are in harmony with those found by Abou Yuossef and El Kat (1999) and Abou Yuossef and El-Eweddy (2003).

Interaction effect :

The statistical analysis of the data of Table (2) showed a highly significant effect for the interaction between either N or P treatment and tillage on the corn grain yield. Such interaction was more pronounced with the moldboard tillage than the chisel tillage system at the two studied N or P rates. Results indicate that corn grain yield under moldboard tillage increased significantly with the increase of either N or P rate. The data, however, showed no significant effect for the interaction between K treatment and tillage systems on the corn grain yield.

Also, the interaction effect between N and P treatments on the corn grain yield was highly significant. Moreover, there was a high significant effect for the interaction between K treatment and either N2 or P_1 rate on the corn grain yield..

The three-way interaction involving either K, P at the two studied rates and tillage systems or between N, K at the two studied rates and tillage systems showed a highly significant effect on the corn grain yield..

Moreover, the interaction effect between N and P at the two studied rates and K_2 significant on the corn grain yield was highly.

The statistical analysis of the data of Table (2) showed the four-way interaction involving N and P and Kat the two studied rates along with tillage systems showed a high significant effect for the interaction between N_1 , K_1 and P at the two studied rates and the two investigated tillage systems on corn grain yield.

The interaction effects continued to increase corn grain yields; the best interaction was (N x P x K x tillage system) which gave a corn grain yield of (39.16 kg/plot) when treatment of 150 kg N fed. + 48 kg P_2O_4/fed. + 48 kg K_2O /fed. Was adopted under the moldboard tillage system.

Mineral Composition:

Nitrogen:

Tillage system along with N, P, and K treatments effects on corn grain-N concentration are shown in Table (3); values ranged from 1.190 to 2.201 % content in grain. In the two tillage systems grain-N concentration increased as N, P, K rates increased.

N concentration in grain was affected by N rate (Table 3). Grain-N concentration continued to increase with increasing N rate, the response to N was significant and showed that maximum grain-N concentration occurred with approximately 150 kg N/fed. under all treatments. Also, grain-N content was significantly influenced by the applied P and K rates. Moreover, grain-N content was significantly influenced by the tillage systems, the grain-N concentration was higher in the moldboard tillage. When values were averaged for N, P, and K rates, the grain-N concentration was higher in the moldboard tillage (2.201 % for the $N_2P_2K_2$ treatment)

The statistical analysis showed a significant effect for the interaction between either N, P or K treatment and tillage system on the grain-N. Such interaction was more pronounced with moldboard tillage than chisel tillage at all N, P, and K rates.

Phosphorus:

Data of phosphorus concentration for corn grain were given in Table (3). Examination of these data illustrates that N, P, and K rates were significantly favorable. Values of phosphorus concentration in grain varied between 0.4560 and 0.4196 %.

Table (3): Nutrient concentration in corn grain as affected by fertilizer N, P, K rates and tillage system.

Treatment				Nutrient concentration in grain								
Tillage	P	K	N	N %	P %	K %	Ca %	Mg %	Fe ppm	Mn ppm	Zn ppm	Cu ppm
Chisel	1	1	1	1.197	0.407	0.313	0.172	0.114	22.66	3.73	1.18	0.26
	1	1	2	1.363	0.424	0.355	0.148	0.099	25.06	5.12	1.26	0.35
	1	2	1	1.213	0.417	0.389	0.193	0.129	26.06	4.72	1.31	0.27
	1	2	2	1.575	0.428	0.391	0.166	0.110	29.20	5.17	1.40	0.30
	2	1	1	1.371	0.486	0.375	0.148	0.099	18.22	4.74	1.35	0.17
	2	1	2	1.572	0.520	0.380	0.170	0.112	26.06	5.18	1.42	0.18
	2	2	1	1.332	0.488	0.415	0.154	0.102	23.46	4.72	1.82	0.08
	2	2	2	1.613	0.534	0.422	0.160	0.106	23.80	6.54	1.91	0.18
Moldboard	1	1	1	1.491	0.420	0.321	0.182	0.121	24.13	4.03	1.27	0.09
	1	1	2	1.635	0.424	0.374	0.168	0.112	26.00	4.69	1.61	0.11
	1	2	1	1.435	0.416	0.400	0.171	0.114	19.66	5.40	1.40	0.09
	1	2	2	1.430	0.433	0.405	0.173	0.115	38.80	6.50	1.66	0.15
	2	1	1	1.587	0.478	0.369	0.171	0.114	20.26	7.40	1.70	0.19
	2	1	2	1.741	0.513	0.365	0.157	0.104	18.73	8.06	1.80	0.17
	2	2	1	1.734	0.532	0.405	0.152	0.101	22.93	7.50	1.79	0.18
	2	2	2	2.201	0.645	0.462	0.165	0110	27.44	10.34	1.97	0.13

Table (3): Cont.

	Nutrient concentration in grain								
	N %	**P %**	**K %**	**Ca %**	**Mg %**	**Fe ppm**	**Mn ppm**	**Zn ppm**	**Cu ppm**
LSD									
For one factor	0.085	22.12	0.009	0.119	0.009	2.275	0.600	0.078	0.036
For two factors Interaction	0.121	31.28	0.013	0.168	0.013	3.217	0.848	0.123	0.051
For three factors interaction	0.171	44.24	0..018	0.238	0.019	4.550	1.200	0.174	0.072
For four factors Interaction	0.242	62.56	0.026	0.337	0.027	6.434	1.697	0.246	0.102

The soil tillage main effects on phosphorus content of grains were significant (Table 3). Phosphorus concentration in grain was greater in the moldboard system than in chisel tillage. These results are in agreement with those obtained by Abou Yossef and El Kot (2000).

P concentration in grain was affected by P rate (Table 3). Grain-P concentration continued to increase with increasing P rate, the response to P was significant and showed that maximum grain-P concentration occurred with approximately 45 kg P_2O_4/fed. under all studied treatments. Also, grain-P content was influenced significantly by the applied N and K rates.

The statistical analysis showed a significant effect for the interaction between either N, P or K treatment and tillage system on the grain-P. Such interaction was more pronounced with moldboard tillage than chisel tillage at all N, P, and K rates.

Potassium:

Data in Table (3) showed clearly that grain-K was significantly affected by the N, P, and K rates. A survey of the data shows that potassium concentration ranged between 0.3735 and 0.3946 % in grains.

K concentration in grain was affected by K rate (Table 3). Grain-K concentration continued to increase with increasing K rate, the response to K was significant and showed that maximum grain-K concentration occurred with approximately 48 kg K_2O/fed under all treatments. Also, grain-K content was influenced significantly by the applied N and P rates.

Since no marked differences were observed in potassium concentration by the tillage systems, as for the effect of tillage systems the trend observed showed that was associated with a slight increase in K concentration in grain (0.380 and 0.388 % for the chisel and moldboard tillage, respectively).

The statistical analysis showed a significant effect for the interaction between either N, P or K treatment and tillage system on the grain-K. Such interaction was more pronounced with moldboard tillage than in chisel tillage at all N, P, and K rates. The best interaction effect was (moldboard tillage x P_2 x K_2 x N_2) which gave the beast K content value of 0.4630 g/kg; such value corresponded to maximum grain yield of 39.169 kg/plot.

Calcium and Magnesium:

Data in Table (3) showed no marked differences in calcium and magnesium concentrations of grains by the applied N, P, K rates and tillage system. Calcium and magnesium concentrations in grains ranged between 0.108 and 0.193 % and between 0.099 and 0.139 %, respectively.

The statistical analysis showed no significant effect for the interaction between N, P, K treatments and tillage system on the Ca and Mg content in the corn grains.

Iron, Manganese, Zinc and Copper:

Data in Table (3) revealed clearly that Fe, Mn, Zn and Cu concentration in corn grains were significantly increased by the N, P, and K rates. The range of concentration of these elements in grain were : Fe, 18.22 to 38.80; Mn, 3.73 to 10.34; Zn, 1.18 to 1.97 and Cu, 0.08 to 0.35 ppm..

Since no marked differences were observed in iron concentration in corn grain by the tillage systems, a negligible increase in Fe concentration was found in grain (24.32 and 24.74 ppm for the chisel and moldboard tillage, respectively). While, manganese and zinc concentration in grain were greater in the moldboard system than in chisel tillage (Mn, 4.99 and 6.74; and Zn, 1.46 and 1.65 ppm, for the chisel and moldboard tillage, respectively). Moreover, Copper concentration in grain was greater in the Chisel system than in moldboard tillage (0.228 and 0.145 ppm for the chisel and moldboard tillage, respectively).

The statistical analysis showed no significant effect for the interaction between N, P, K treatments and tillage systems on the Fe, Mn, Zn and Cu concentration in corn grain (except, for Fe, between treatments $P_2K_1N_1$ and $P_2K_1N_2$ with chisel tillage and between $P_1K_2N_1$ and $P_1K_2N_2$ with moldbord tillage; for Mn, between treatments $P_2K_2N_1$ and $P_2K_2N_2$ under the two studied tillage systems; for Zn, between treatment $P_1K_1N_1$ and $P_1K_1N_2$ with moldbord tillage and for Cu, between treatments of $P_2K_2N_1$ and $P_2K_2N_2$ with chisel tillage).

DRIS Comparisons Among Treatments:

DRIS analysis for the individual fertilization data with those of tillage system are summarized in Table (4). The variances of yield and nutrient concentration were not similar for both treatments (Tables 2 and 3). These differences (N, P and K) could be good indicators of the reliability of the DRIS norms in this work

Data in Table (4) and Figs. (2-5) representing the nutrient concentration in corn grain show imbalanced nutrition compared to high-yield under the two studied tillage systems. Nitrogen indices were always sub-optimal in all treatments under the two studied tillage systems (except, $P_2K_2N_2$ treatment). K indices were commonly sub-optimal (except, $P_2K_2N_1$ and $P_2K_2N_2$ treatments under chisel tillage). Also, P indices were commonly sub-optimal (except, $P_2K_1N_2$, $P_2K_2N_1$ and $P_2K_2N_2$ treatments under the two studied tillage systems, which were usually close to supra-optimal).

Iron indices were always sub-optimal in all treatments under moldboard tillage system (except, $P_1K_1N_1$ treatment); under chisel tillage, however, iron indices were commonly supra-optimal (except, $P_2K_1N_1$, $P_2K_1N_2$, $P_2K_2N_1$ and $P_2K_2N_2$ treatments were sub-optimal). Mn and Zn indices were always supra-optimal in all treatments under moldboard tillage; under chisel tillage, however, Mn and Zn indices were commonly supra-optimal (except, $P_2K_1N_1$, $P_2K_1N_2$, $P_2K_2N_1$ and $P_2K_2N_2$ treatments were sub-optimal) .

Ca, Mg and Cu indices were often supra-optimal in all treatments under the two studied tillage systems.

The N index increased to optimal as N fertilizer rate increased under tillage system. The diagnosis of lowest treatment level ($P_1K_1N_1$) under the tillage system indicated that among those nutrients included in the diagnosis, N was most limiting to yield. When N was supplied at next level ($P_1K_1N_2$), yield increased from 19.46 to 27.81 and from 25.72 to 32.27g/plot for chisel and moldboard tillage, respectively. At this treatment level ($P_1K_1N_1$), P was diagnosed as most limiting and, when supplied at the next level ($P_2K_1N_1$), yield increased

Table (4): Progressive diagnosis of grain corn from factorial Field experiment using DRIS norms form

Treatment				DRIS Indices								
Tillage	P	K	N	**N**	**P**	**K**	**Ca**	**Mg**	**Fe**	**Mn**	**Zn**	**Cu**
Chisel	1	1	1	-4	-3	-2	2	2	1	1	3	1
	1	1	2	-1	-5	-3	2	1	2	1	1	1
	1	2	1	-6	-7	1	1	2	3	1	1	1
	1	2	2	1	-6	1	2	2	1	2	-1	1
	2	1	1	-1	2	-1	3	2	-5	-1	-1	2
	2	1	2	1	3	-4	2	1	-3	-2	-2	5
	2	2	1	-6	2	3	5	2	-1	-4	-2	1
	2	2	2	1	2	1	4	1	-3	-1	-4	1
Moldboard	1	1	1	-2	-2	-4	1	2	1	1	1	1
	1	1	2	-1	-3	-2	2	1	-1	1	2	1
	1	2	1	-3	-4	1	2	3	-2	1	1	1
	1	2	2	1	-7	-1	2	1	-4	2	2	4
	2	1	1	-2	1	-4	1	1	-7	3	3	5
	2	1	2	1	4	-5	3	2	-6	2	-1	1
	2	2	1	-2	3	-1	2	1	-3	1	1	1
	2	2	2	2	4	-3	1	1	-2	-1	-2	1

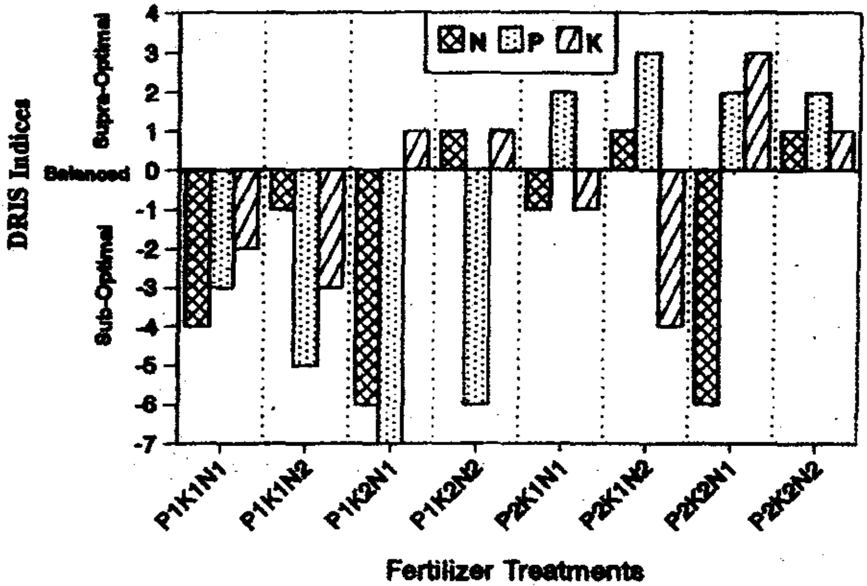


Fig.(2):Comparison of N, P, and K DRIS indices compared with those of N, P and K rates under chisel tillage.

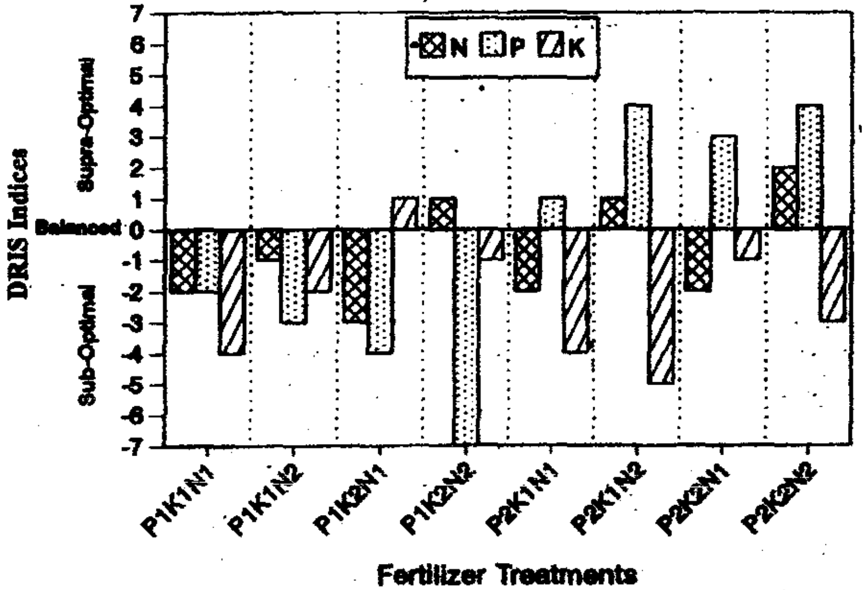


Fig.(3): Comparison of N, P, and K DRIS indices compared with those of N, P and K rates under Moldboard tillage.

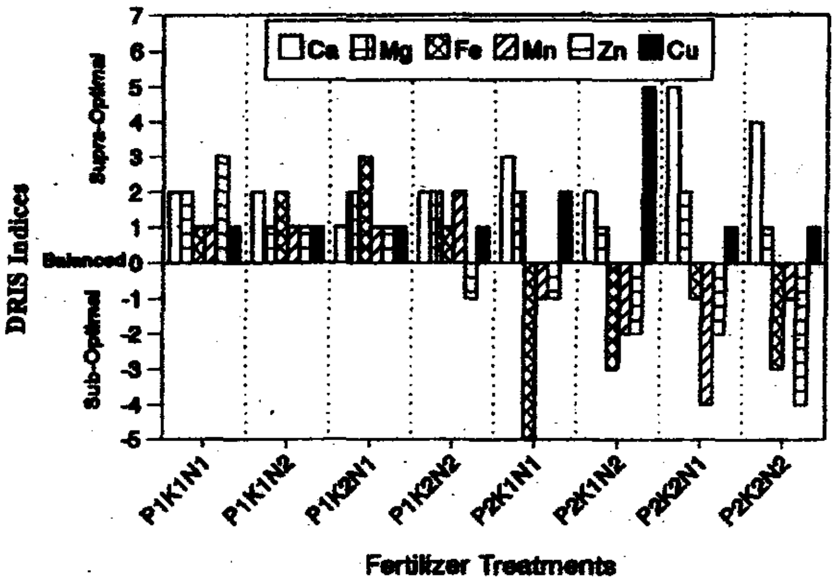
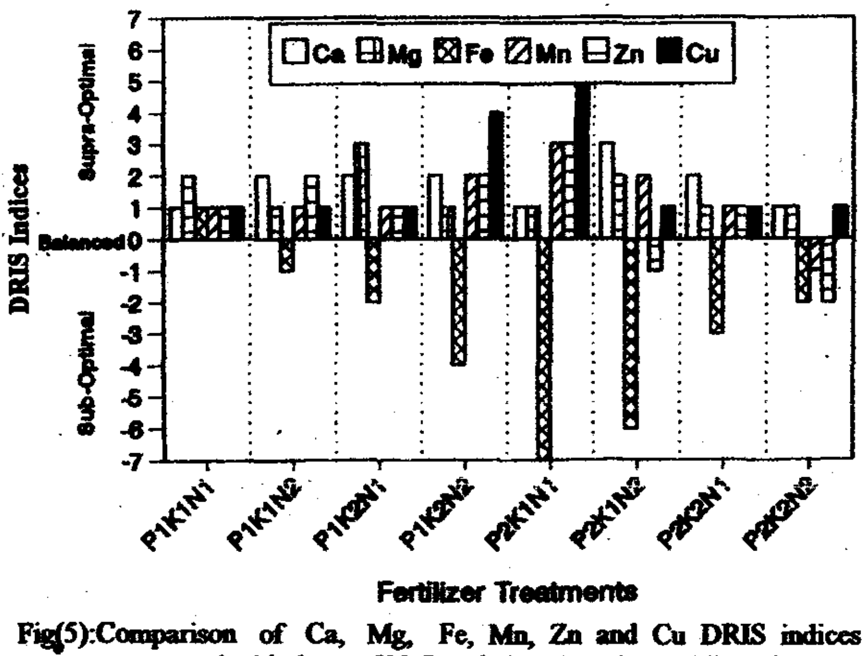


Fig.(4): Comparison of Ca, Mg, Fe, Mn, Zn and Cu DRIS indices compared with those of N, P and K rates under chisel



Fig(5):Comparison of Ca, Mg, Fe, Mn, Zn and Cu DRIS indices compared with those of N, P and K rates under moldboard tillage from 19.46 to 29.42 and from 25.72 to 32.81 g/plot for chisel and moldboard tillage, respectively.

Moreover, At the treatment level ($P_1K_1N_1$), K was diagnosed as limiting and, when supplied at next level ($P_2K_1N_1$), yield increased from 19.46 to 23.43 and from 25.72 to 27.17 g/plot for chisel and moldboard tillage, respectively.

Using the second level of each nutrient variable as the starting point for diagnoses allows further testing of these norms. When $P_1K_1N_2$, $P_1K_2N_1$ and $P_2K_1N_1$ were used as starting points, yields always increased and the diagnoses led to the top-yielding ($P_2K_2N_2$ treatment under the two studied tillage systems).

The diagnosis continued in this progressive manner, yield increasing with each successive treatment under tillage system, until the $P_2K_2N_2$ treatment was reached. Diagnosis of this treatment under tillage system indicated that N, P, and K were most limiting.

The high corn grain yield obtained by DRIS–guided fertilization were attributed to the better nutrient balance as revealed by DRIS indices under the two studied tillage systems.

The average yield recommended by diagnoses of the treatment variable recommended by diagnoses with chisel tillage was 13.07 g/plot, while that with moldboard tillage was 13.44 g/plot. These values are not significantly different.

In addition, plant analysis interpreted by DRIS norms indicated the need for applying K and one or more micronutrients to almost all treatments and tillage systems.

The relationships between yield and corn grain nutrient concentration are show in Table (5). For Ca and Mg, regressions were not significant and these two nutrients were excluded from subsequent data analysis, namely the elaboration of the final model.

Multiple regression analysis data are presented in Table (6), which show that adding successive variables, particularly micronutrients, improves the model. Apparently, the best fitted model includes N, P, K, Fe, Mn, and Zn. Ca, Mg and Cu were excluded in this variable testing due to lower correlation

Table (5): Regressions between corn grain yield (Y) and nutrient concentration in grain.

Regression Model	R^2
$Y = 26.40 + 23.56\ \ln(N)$	0.82^{**}
$Y = 52.12 - 10.05/P$	0.68^{**}
$Y = 59.90 - 11.18/K$	0.70^{**}
$Y = 0.19 - 0.01\ Ca$	0.05^{ns}
$Y = 0.13 - 0.10\ Mg$	0.04^{ns}
$Y = 21.20 + 0.37\ Fe$	0.46^{*}
$Y = 23.89 + 0.59\ Mn + 0.08\ Mn^2$	0.52^{*}
$Y = -8.40 + 31.29\ Zn^{1/2}$	0.58^{*}
$Y = 33.55 - 17.09\ Cu$	0.06^{ns}

* Significant at the 0.05 probability level
** Significant at the 0.01 probability level
ns not Significant

Table (6): Dependent variables of regression model for corn grain yield vs. nutrient concentration in corn grain.

Model	R^2
N + P	0.641^{**}
N + K	0.651^{**}
P + K	0.406^{*}
N + P + K	0.652^{**}
N + P + K + Fe	0.655^{**}
N + P + K + Mn	0.657^{**}
N + P + K + Zn	0.507^{**}
N + P + K + Fe + Mn	0.758^{**}
N + P + K + Fe + Zn	0.808^{**}
N + P + K + Mn + Zn	0.707^{**}
N + P + K + Fe + Mn + Zn	0.921^{**}

* Significant at the 0.05 probability level
** Significant at the 0.01 probability level

coefficients, as show in Table (5). The analysis of residuals (data not shown) for this model shown that the residuals are increasing as the independent variables decrease. It should be noted that the absence of N in the models largely decreases the coefficient of determination. Therefore, the final equation used for yield estimates is as following:

Corn Grain Yield = 3.73 + 12.29 N – 11.61 P + 9.09 K – 0.05 Fe – 0.04 Mn + 7.19 Zn

The best estimation indicates that 92% of yield variation may be linked to N, P, K, Fe, Mn and Zn concentration in grains values (Table 6) in spite of less clear relationships for Mn and Zn. Phosphorus is positively related with yield (Table 5), however, the sign of the model coefficient for P is negative. The independent variables often contain some redundant information and vary together, making it difficult to separate the effects of the different independent variables on the dependent variable. This multicollinearity, which was also shown by the large standard error of the P estimate (data not shown), does not affect the usefulness of a regression equation for prediction of new observation (Glantz and Slinker, 1990).

It can be concluded that The Diagnosis and Recommendation Integrated System (DRIS) and my be used to evaluation yield of the corn. According to the model (DRIS) and presented multiple regression, optimal nutrient ranges of the studied elements can be tested for different soil conditions, plant development, and cultivars.

Also, the different nutritional balance between the low- and high-yield indicates that the DRIS norms developed in this studies are reliable. Moreover, The DRIS norms for micronutrients found in this paper probably can provide more security to evaluate the micronutrient status of corn grain.

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أستخدم التشخيص متعدد العناصر تحت نظم حرث مختلفة على إنتاجية الذرة تحت ظروف الأرض الجبرية

محمد فتحي أبويوسف و أحمد سعيد القط
قسم صيانة الأراضي – مركز بحوث الصحراء -المطرية – القاهرة

في تجربة حقلية تم تقييم تأثير عمليات الحرث و التسميد بالنيتروجين و الفسفور و البوتاسيوم على إنتاجية محصول الذرة الشامية تحت ظروف الأراضي الجيرية بمنطقة مريوط وباستخدام التشخيص متعدد العناصر DRIS. تم دراسة تأثير نوعين من الحرث (محراث حفار و محراث قلاب) و كذلك مستويين من التسميد بكل من النيتروجين و الفوسفور و البوتاسيوم (٧٥ ، ١٥٠ كجم نيتروجين /فدان و ٢٢,٥ ، ٤٥ كجم P_2O_4/فدان و ٢٤ ، ٤٨ كجم K_2O/فدان ، على الترتيب). عند الحصاد تم تقدير محصول الحبوب (كجم/شريحة) ، كما تم تقدير تركيز العناصر التالية في الحبوب: N, P, K, Ca, Mg, Fe, Mn, Zn, and Cu.

أظهرت النتائج أنه بزيادة التسميد بالـ N, P, K زاد محصول الحبوب مع تأثر محصول الحبوب بالتفاعل بين التسميد بكل من النيتروجين و الفوسفور. تم الحصول على أعلى محصول عند استخدام المحراث القلاب عند التسميد بالمستوى العالي بالـ N, P, K, (٣٩,١٦ كجم حبوب/شريحة). أخيرا تم حساب DRIS norms للعناصر المقدرة في الحبوب ووجد فروق معنوية للعناصر التالية N, P, Ca, Mg, and Cu : ، بينما لم يوجد فروق معنوية للعناصر التالية K, Fe, Mn, and Zn.

أظهرت نتاج استخدام DRIS normsعدم توازن العناصر تحت نظم الحرث المستخدمة بالمقارنة بأعلى محصول. كان دليل النيتروجين للمعاملات يقع تحت المستوى الأمثل للعناصر (ماعدا معاملة $P_2K_2N_2$ التى كانت في مستوى أعلى من الأمثل) تحت نظم الحرث المختلفة. وجد أيضا آن دليل البوتاسيوم للمعاملات يقع تحت المستوى الأمثل للعناصر (ماعدا معاملتي $P_2K_1N_2$and $P_2K_2N_2$ تحت نظام المحراث الحفار فكانت أعلى من المستوى الأمثل). أخيرا، وجد آن دليل الفوسفور للمعاملات يقع تحت المستوى الأمثل للعناصر (ماعدا معاملتي $P_2K_1N_2$ and $P_2K_2N_2$ تحت نظام الحرث المختلفة فكانت أعلى من المستوى الأمثل).

اظهر التشخيص متعدد العناصر للمعاملات السمادية تحت نظم الحرث المستخدمة آن دليل النيتروجين و الفوسفور و البوتاسيوم هي العوامل المحددة لإنتاجية المحصول ،باستثناء التركيز العالي من سماد البوتاسيوم. كما اظهر التشخيص المتعدد العناصر DRIS احتياجا آلي إضافة المزيد من عنصر البوتاسيوم و العناصر الصغرى (إحداها أو كلها) للمعاملات تحت ظروف الحرث المستخدم.