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Evaluation of N, P and K Status of Wheat Using the Diagnosis and Recommendation Integrated System (DRIS) and the Physiological Diagnosis Chart

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DIAGNOSIS and Recommendation Integrated System (DRIS) is a unique approach and a comprehensive system which identifies the nutritional factors mostly limiting crop production and improving fertilizer recommendations for obtaining high crop yields. The DRIS system depends on the principle of nutrient interrelationships in determining the order of the most limiting nutrients, as well as assessing the nutritional balance in plant. The current investigation aims at (i) Developing a database from which DRIS norms and indices of wheat grown on soils of Kalubia Governorate , Egypt, could be established and (ii) Defining the order of N, P and K requirements for plant using this method.

To achieve these objectives, 1000 samples of wheat plants grown on soils of the seven Kalubia's counties were collected at shooting stage. The fresh and dry weights were recorded and samples were finely-ground and wet- ashed for N, P and K determinations. Grain yield of each field was also measured (using 1.0 m^2 plots). The 1000 observations were divided into high-yielding population (591 observations ; >2.4 Mg grains / fed., Mg = 10^6 g) and low-yielding populations (409 observations). DRIS norms were calculated for the high-yielding population because the high yield usually results from balanced nutrients in plant. DRIS norms of n/p, n/k and k/p were calculated [being Σ(N/P)/n, Σ(N/K)/n, and Σ(K/P)/n, respectively; where N, P and K are percentages of the respective nutrients in plant, and n = the number of observations].

Calculated DRIS norms were 13.93, 1.40 and 10.25 for n/p, n/k and k/p, respectively and were almost comparable with those obtained by other researchers for wheat in other countries.

The N, P and K nutritional balance of wheat plants grown in Kalubia "semiarid region" tested by the DRIS approach show that nitrogen was the most limiting nutrient indicating high increasing requirements for high-yielding populations followed, by phosphorus. A high demand of P by these populations was proven as it came in the first and second order of limitation. Both nitrogen and phosphorus should be adequately covered through a sound fertilization program.

Thus, establishing DRIS norms for wheat is of a vital importance towards obtaining high yields. The DRIS norms could be used to test the nutritional balance of nutrients in plant and diagnose nutrient requirements through calculating DRIS indices or direct application of a proposed standard physiological diagnosis (PD) chart to the low-yielding populations. Research should be directed towards establishment of database from which DRIS norms for each of the most important strategic crops could be developed to assess the elements of obtaining high crop yield production.

The Diagnosis and Recommendation Integrated System (DRIS) is a method of diagnosing nutrient deficiencies and imbalances from the mineral composition of plant tissue. DRIS often produces more accurate diagnoses than conventional system of plant analysis based on critical concentrations or normal range of tissue nutrient concentration.

Beaufils (1973) published his Diagnosis and Recommendation Integrated System (DRIS) for determining the fertilizer or other treatments required by a given crop in order to enhance the chances of obtaining a higher yield. One of the basic advantages of this system is that once a standard set of norms based on foliar composition has been developed for a given crop, they are applicable to that particular crop wherever it might be grown at any place and at any stage of its development (Beauflis, 1973 and Sumner, 1977a). The DRIS system has been proposed to diminish the effects associated with negative nutrients interaction as well as the dilution effect, or accumulation of elements in the dry matter (Walworth and Sumner, 1987). The major advantage of the “DRIS” approach is its ability to minimize the effect of leaf age (Westwood, 1978), so as to permit taking samples at a wider range of tissue age than is permissible under “the critical level” approach. It computes nutrient balance indices in the order of nutrient limitations as being negative (deficient), positive (excess) or zero (balance). It integrates interactions between nutrients and other factors. The DRIS procedure is distinguishable from other procedures of nutrient diagnosis, providing that norms for specific crops are derived from sufficiently large data base, DRIS diagnoses are applicable irrespective of varieties or geographic variables or both (Sumner, 1979).

DRIS is based upon using a large number of observations of nutrient concentrations and yield to obtain accurate estimates of means and variances of certain ratios of nutrients that discriminate between high- and low- yielding (desirable and undesirable) sub-populations.

The calibration formula calculates relative indices for nutrients that range from negative to positive values but always sum to 0. The more negative an index value for a nutrient is, the greater the need for applying that nutrient would be. When all nutrients are available at concentration ratios similar to those found in the desirable population, the DRIS index for each nutrient is 0. The use of this system proved accurate interpretations of the nutritional status of several crops (Beaufils, 1973; Beaufils & Summer, 1977; Summer, 1977, 1978 and 1979 and Raghupathi & Bhargava, 1998).

The objectives of this study were to (i) Develop database for DRIS norms and indices of wheat grown on soils of Kalubia Governorate, Egypt, (ii) Compare the locally derived norms with the existing non local norms, and (iii) Identify the order of the most limiting nutrient (or nutrients) among the tested N, P, and K nutrients and the order in which other elements would likely become limiting.

Materials and Methods

Plant sampling

To constitute a database for calculating DRIS reference norms for wheat crop *(Triticum aestivum*,) 1000 plant samples were collected at shooting stage from wheat fields distributed (different cultivars) in seven counties of Kalubia Governorate, *i.e*., Tukh, Shebien El-Kanater, Kaiuob, El-Kanater El-Khairia, El-Khanka, Benha and Kafer Shokr. The samples were collected during the wheat growing season 2002/2003. With the assistance of extension specialists in the agricultural management sector of each county, localities of wheat fields as well as wheat varieties were identified. The distribution of wheat fields and the cultivated areas in each county are shown in Table 1. The localities from which wheat samples were collected are shown in Fig. 1.

Plant samples were collected from micro-plot areas of one m^2 (1m x 1m) each in wheat fields at shooting stage. Plants were cut at 1 cm above the soil surface. Fresh plant materials were weighed and portions were taken and oven-dried at 70°C for 72 hr, weighed and ground to pass through a 0.5 mm screen. Plant samples were digested using a mixture of sulfuric and perchloric acids (Johnson and Ulrich, 1959) for N, P and K determination. Each micro-plot was harvested at maturing stage from each field and yields of straw and grains were recorded.

The 1000 observations were divided into high yielding populations (≥ 2.4 Mg grains / fed) and low yielding populations. DRIS norms were calculated for the high yield populations because the high yield usually results from a balanced nutrient in plant.

Plant analysis

Concentrations of the three macronutrients (N, P and K) in wheat plants at shooting stage were determined as follows: N by micro-kiedlahl procedure (Bremner and Mulvaney, 1982), P was calorimetrically determined according the procedure of Murphy and Riley (1962) as modified by John (1970) and Potassium was determined photometrically as described by Jackson (1967).

TABLE 1. Total area of wheat and cultivated varieties in each county on 2002/2003 season.

Variety / County	Sakha 69	Sakha 93	Gamiza 7	Gamiza 168	Giza 168	Balady	Varieties from farmers	Total								
	Fed.*	Kar.**	Fed.	Kar.	Fed.	Kar.	Fed.	Kar.	Fed.	Kar.	Fed.	Kar.	Fed.	Kar.	Fed.	Kar.
Tukh	4892	-	1097	-	1212	-	994	-	814	-	-	-	-	-	9009	-
Shebin El-Kanater	1865	-	3167	-	1185	-	495	-	240	-	-	-	1626	-	8578	-
El-Kanater El-Khiria	723	-	677	-	-	-	1250	-	400	-	-	-	-	-	3050	-
Kaliob	1874	17	383	17	880	5	247	16	333	17	-	-	-	-	3720	-
Banha	2549	-	4071	-	3031	-	-	-	1179	2	-	-	-	-	10830	2
Kafr Shokr	389	8	1129	8	370	18	-	-	-	-	-	-	156	18	2045	4
El-Khanka	-	-	790	-	90	-	85	-	-	-	1735	-	-	-	2700	-
Total	12293	1	11315	1	6768	23	3071	16	2966	19	1735	-	1782	18	39933	6

* Denotes feddan = 4200 m^2 Karat = 175 m^2

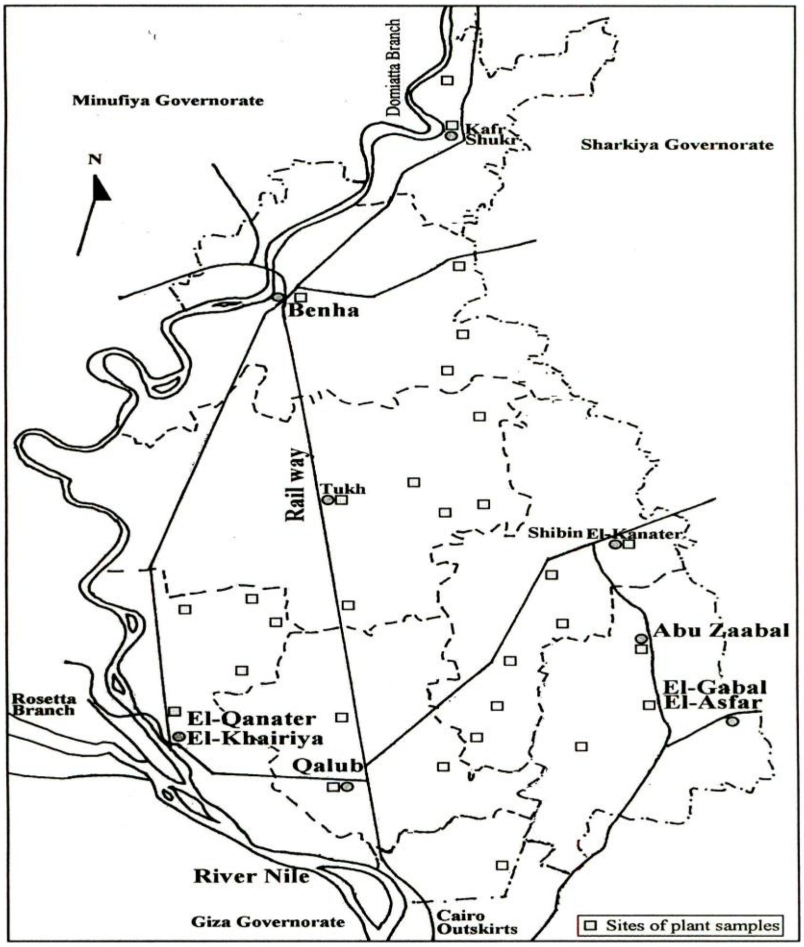

Fig.1. Different locations of wheat fields in Kalubia Governorate.

Calculating the DRIS norms and indices of N, P and K for wheat plants

DRIS norms

The DRIS reference norms were established using the criterion of significant variance at a ratio test between undesirable (low-yielding) and desirable (high-yielding) sub-populations (Beauflis, 1973). Grain yield of 2.4 tons fed^{-1} was used to separate the database of 1000 observations into low and high yielding sub-populations. The high yielding sub-populations comprised 59.1% of the total number of observations (591 of observations), while the low yielding sub-populations comprised 40.9% of the total number of observations (409 observations).

Each nutrient of the three tested ones (N, P and K) was expressed as a numerator and again as a denominator of ratios with each of the other two nutrients and the means and variances were calculated in the two sub-populations (high-yielding and low-yielding). For each nutrient the DRIS reference parameters were selected as those nutrient ratios gave the highest and significant values for the variance ratios between the two sub-populations (variance of low-yielding populations / variance of high-yielding populations). For instance, if the DRIS norms for N/P, N/K and K/P are calculated; and these expressions show the highest and significant variance ratios between the two sub-populations, the N/P or N/K or K/P must be computed for the high yielding sub-populations only and divided by the number of observations of each expression.

Thus, the norm of $n/p = \frac{\sum N/P}{n}$, the norm of

$n/k = \frac{\sum N/K}{n}$ and the norm of $k/p = \frac{\sum K/P}{n}$

where, N refers to nitrogen concentration in dry matter yield of shoots (N%), P: refers to phosphorus concentration in dry matter yield (P%), K : refers to potassium concentration in dry matter yield (K%), n : is the number of high yielding observations, n/p : is DRIS norm for nitrogen / phosphorus, n/k : is DRIS norm for nitrogen / potassium in plant and k/p is DRIS norm for potassium/ phosphorus in plant.

DRIS indices

DRIS indices which are used in the current investigation are quantitative evaluations of the relative degree of imbalance of the nutrients under study and as calculated from the following equations:

$$N, index = +\left[\frac{f(N/P) + f(N/K)}{2}\right]$$

$$P, index = -\left[\frac{f(N/P) + f(K/P)}{2}\right]$$

$$K, index = +\left[\frac{f(K/P) - f(N/K)}{2}\right]$$

where $f(N/P) = +\left(\frac{N/P}{n/p} - 1\right)\frac{1000}{C.V}$

when the actual value of N / P > n / p.

or $f(N/P) = \left(1 - \frac{n/p}{N/P}\right)\frac{1000}{C.V}$

when the actual value of N / P < n / p, n/p is the mean value for N/P, and CV is the coefficient of variation for high-yielding populations. The other terms of f (N/K) and f (K/P) are derived in a similar way using the means of n/k for N / K and k / p for K / P, respectively in place of n/p.

The DRIS indices have positive and negative values which always sum to zero as they measure the relative balance among N, P and K or other elements that might be included. The order of plant nutrient requirements is affected by the value of the index, the most negative index reflects the most required nutrient (Sumner, 1976, 1977a, 1977b, 1980; Letzch & Sumner, 1984; Walworth *et al.*, 1988; Goh & Malakouit, 1992; Orlando *et al.,* 1997 , Khiari *et al.*, 2001; Abdel-Warth,2002 and Abdel-Raheem, 2003) .

Physiological diagnosis chart for N, P and K

The N/P, N/K and K/P forms of expression are interrelated in a three-coordinate DRIS chart (Fig. 2). The point of origin in the center of the chart represents the mean of each expression N/P, N/K, K/P for the populations of high yielding plants. In other words, this is the composition desired in order to increase the chances of obtaining a high yield. However, this desired composition should not be viewed as a “single inflexible point” but rather as a “range encompassed” by the inner of the two concentric circles as shown in Fig. 2. The diameter of the small circle is set at 4/3 SD from the origin, which takes account of the variability in the population. A plant composition falling within this circle would be considered to be relatively balanced, which is denoted by a horizontal arrow (→).

As one moves away from the central zone along any axis, the degree of imbalance between the two elements increases. This zone of imbalance is divided into two sub-zones, the first being a zone of slight to moderate imbalance. This depended on arrow at 45 degrees to the horizontal (↘) (↖) and is encompassed by the outer of the concentric circle which has a diameter of 8/3 SD. Beyond this circle is a zone of marked imbalance denoted by vertical arrows (↑) (↓) being either too high or too low. The reason why the two circles are set at diameters of 4/3 SD and 8/3 SD is dealt with fully by Beaufils (1971 and 1973).

Results and Discussion

N, P and K diagnostic preliminary norms for wheat (*Triticum aestivium*) were developed by using the Diagnosis and Recommendation Integrated System (DRIS) approach (Beaufils, 1973). These norms were developed from data sets of N, P and K concentrations in wheat plant samples and corresponding grain yields. The degree of nutrient imbalance in the plant was expressed in form of a DRIS index, which measures the extent to which a particular nutrient deviated from the established norms.

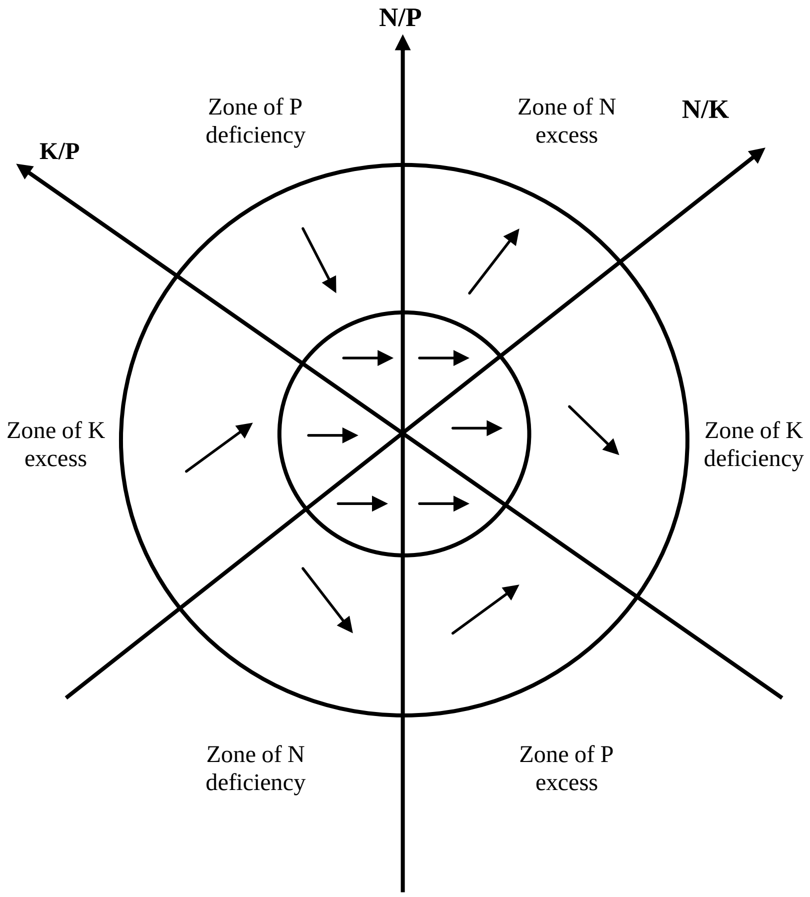

Fig. 2. Physiological diagnosis chart for direct determination of N, P and K status.

Calculation of DRIS norms for N, P and K

As described earlier, DRIS norms of N, P and K for wheat plants grown on 1000 locations in Kalubia Governorate were calculated for the low- and high – yielding populations according to the following equation :

The norm of x/y $= \Sigma (X/Y) / n$

where : x refers to the concerned nutrient (*i.e.,* nitrogen); y refers to the other nutrient (*i.e.,* phosphorus); X is the actual concentration of the nitrogen (N%) in plant tissue; Y is the actual concentration of phosphorous (P%) in plant tissue and n refers to total number of the low- or high- yielding observations.

The separation between low- and high- yielding populations was set at a yield threshold of 2.4 Mg grains / fed. (general average of the country in year 2003)

Therefore, a criterion is needed to separate a low- from a high-yield sub-population to provide an acceptable proportion of expected low yields in a population. Simply setting a yield target, as is usually done for establishing nutrient norms, does not provide a minimum yield cutoff value between the low- and high-yield sub-population. Thus, the variance ratios of nutrient expressions between the low- and high-yield sub-populations must depend on the partition between the low- and high-yield sub-populations. An optimum partition should be defined between the two sub-populations. However, there had been no formal partition proposed. An optimum partition could be determined by considering variance ratio functions for nutrient indexes along decreasing order of yield values (Khiari *et al*., 2001). The variance ratio must be high and significant when comparing the variance of nutrient expression for the lowest yields with that for the highest yields.

Mean values, standard deviations and variances for DRIS norms derived from a population of low- and high yielding plants are shown in Table 2. Significant variance ratios between low- and high- yielding sub-populations were noticed. The significance of those ratios indicates that the base on which the whole observations were divided into low- and high- yielding populations was valid.

TABLE 2. Mean values or DRIS norms, coefficients of variation "CV", standard deviation "SD" and variance "δ^2" for high-yielding population of wheat.

Ratio	Norms or mean	SD	CV%	δ^2
n/p	13.93	3.40	24.39	11.54
n/k	1.40	0.25	18.07	0.06
k/p	10.25	3.10	30.25	9.62

● 591 observations in population .

Data in Table 2 show DRIS norms for the high-yielding populations (591 observations) as follows: 13.93, 1.40 and 10.25 for n/p, n/k and k/p, respectively. Corresponding DRIS norms reported by Sumner (1981) for wheat plants derived from 1500 observations of high-yielding populations were 12.74, 1.54 and 8.08 for n/p, n/k and k/p, respectively. The calculated norms in the current study can be used with reasonable confidence because the database from which they were derived are taken from large number (591) of samples.

It could be concluded that establishing DRIS norms for wheat is a vital step towards high yields. DRIS norms could be used to test the nutritional balance of nutrients in plant and diagnose nutrient requirements through calculating DRIS indices or direct application of proposed standard physiological diagnosis (PD) chart to the low–yielding populations. Research should be directed towards establishment of a database from which DRIS norms for each of the most economic crops could be driven to ensure high-yield production.

The DRIS norms calculated in the current study are different from those developed by Sumner (1981), mainly in regarding of K and P levels. This situation suggests that some regionality may exist for DRIS norms dependent on soil properties at least with wheat plants (Walworth *et al.,* 1986). Diagnostic norms developed in this study were used in calculating DRIS indices for N, P and K for selected observations of low yielding plants. The selected observations representing each county have been tested by the norms and the most limiting nutrient as well as the order of nutrient limitation are diagnosed (Table 3).

Selected numbers from the total low- yielding sub-populations of the seven counties were 70 (Table 3).

Nitrogen was the most limiting nutrient as it came in the first order of limitation in 45 cases out of 70 cases (64.3 %) and was the second limiting nutrient in 15 cases out of 70 ones (21.4%). Concerning phosphorus, the current study reveals that P was the first limiting nutrient among the three tested ones in 20 out of 70 observations (28.6%) and was the second limiting nutrient in 35 ones out of 70 low-yielding observations (50%). Potassium was the first limiting nutrient in two cases only out of 70 (2.9%) ones and the second in 20 cases (28.6%).

Accordingly, it may be suggested that nitrogen was the most limiting nutrient and its requirements for the high-yielding populations are increasing. Also, there is a high demand of P by these populations as it came in the first and second order of limitation. Both nitrogen and phosphorus should be adequately covered through a sound fertilization program.

Worthy stating that sometimes low yields may frequently be obtained for an index situated in the vicinity of zero (a sufficient balance) because another factor (or factors) might limit this yield. It is excepted to obtain a relatively high yield for nutrient ratios situated either in a position of severe excess or in a position of severe deficiency (Beaufils,1971). On the other hand, although a yield may be increased by application of the deficient limiting element (or elements) the resulting indices need not necessarily be improved. If, for example, the amount of the element applied is insufficient, the index might still show a deficiency indicating that a further application is still required. In other words, the index to a certain extent, appears to be proportional to the degree of imbalance or deficiency of the element it represents. Therefore, indices can be used to determine the relative severity of deficiency or excess (Beaufils, 1971).

TABLE 3. Leaves composition, N, P and K indices and the order of limitation calculated for selected plant samples of low-yielding population grown on soils of Kalubia Governorate.

Sample code number	Leaves composition %			DRIS indices			Order
	N	P	K	N	P	K	
Tukh county							
3	1.56	0.32	3.705	-102.423	35.937	66.486	N > P > K
12	2.68	0.21	4.232	-35.403	-14.092	49.495	N > P > K
40	2.94	0.24	2.3	-5.453	3.962	1.491	N > K > P
41	2.51	0.2	1.87	-3.450	3.843	-0.393	N > K >P
47	2.91	0.26	1.91	-2.644	11.549	-8.905	K > N > P
74	2.41	0.2	1.76	-3.825	5.922	-2.097	N > K > P
75	2.33	0.19	1.81	-5.216	4.043	1.173	N > K > P
91	2.71	0.22	1.79	-0.43	6.978	-6.548	K > N > P
125	2.25	0.19	1.99	-37.113	14.373	22.74	N > P > K
134	2.21	0.21	1.81	-10.690	9.762	0.928	N > K > P
135	2.22	0.2	1.95	-11.597	4.379	7. 218	N >P > K
Al-Kanatir El-Khiria county							
223	2.5	0.19	2.2	-7.635	3.348	4.287	N > P > K
226	3.2	0.09	2.9	24.374	-67.256	42.882	P > N > K
233	2.82	0.19	2.35	-3.270	-1.501	4.771	N > P > K
235	2.75	0.15	2.22	2.884	-13.817	10.933	P > K > N
244	1.90	0.09	1.60	5.63	-22.708	17.078	P> N > K
294	2.75	0.09	2.02	23.674	-44.131	20.457	P>K>N
297	1.75	0.12	2.05	-16.730	-11.980	28.710	N > P > K
299	2.55	0.09	1.4	20.001	-38.711	18.710	P > K > N
Benha county							
302	1.95	0.24	1.95	-25.715	18.970	7.745	N > K > P
310	1.95	0.09	1.95	-0.318	-7.025	7.343	P > N > K
312	2.05	0.11	2.20	-6.969	22.648	29.617	N > P > K
321	2.85	0.09	1.75	-10.691	9.763	0.928	N > K > P
332	1.12	0.19	4.17	-144.818	9.054	135.764	N > P > K
361	2.25	0.11	1.85	5.416	-20.194	14.778	P > N > K
367	2.01	0.19	2.95	-35.708	-2.012	37.720	N >P > K
375	0.42	0.11	3.55	-300.62	18.702	281.418	N > P > K
377	1.95	0.11	2.90	-24.388	-31.573	55.961	P > N > K
430	1.95	0.11	1.90	-4.499	-16.913	21.412	P > N > K
431	2.55	0.11	1.75	14.743	-22.742	7.999	P > K > N
432	2.55	0.19	2.2	-6.531	-1.366	7.897	N > P > K
460	1.68	0.13	3.98	-65.724	31.219	95.943	N > P > K
461	2.45	0.05	2.95	32.665	-130.224	97.559	P > N > K
467	2.20	0.20	2.05	-13.893	5.461	8.432	N > P > K
487	2.01	0.24	1.85	-21598	19.049	2.549	N > K > P
517	2.40	0.19	2.28	-11.260	-0.733	11.993	N > P > K
533	1.83	0.19	3.37	-46.676	-4.782	51.458	N > P > K
537	2.2	0.24	3.53	-45.422	3.918	41.504	N > P > K
539	1.45	0.20	3.37	-81.308	8.230	73.078	N > P > K

TABLE 3. Cont.

Sample code number	Leaves composition %			DRIS indices			Order
	N	P	K	N	P	K	
Kafr Sokr county							
563	2.01	0.15	2.82	-27.472	-12.972	40.444	N > P > K
583	2.95	0.2	2.106	1.227	-1.659	0.432	P > K > N
593	1.96	0.19	1.79	14.889	8.637	6.252	K > P > N
599	2.75	0.20	2.4	-6402	-2.553	8.955	N > P > K
Qaliob county							
623	2.38	0.22	2.00	-10.781	8.005	2.776	N > K > P
658	2.2	0.29	2.79	-38.572	16.047	22.525	N > P > K
662	2.65	0.17	1.85	3.502	-3.889	0.387	P > K > N
702	2.99	0.15	2.11	9.230	-14.946	5.716	P > K > N
707	2.6	0.092	1.46	28.621	-30.153	1.532	P > K > N
724	2.49	0.32	2.93	-34.105	18.176	15.929	N > K > P
725	3.84	0.31	3.81	12.209	-53.702	41.493	P > N > K
727	2.28	0.09	1.85	-20.555	0.164	20.391	N > p >K
736	2.41	0.04	2.25	59.667	-142.346	82.679	P > N > K
Al-Khanka county							
760	2.95	0.11	2.73	10.801	-42.459	31.658	P > N > K
775	1.45	0.11	1.50	-13.561	-4.296	17.857	N > p >K
787	2.42	0.22	1.83	-7.093	9.300	-2.207	N > K > P
788	1.82	0.19	1.71	-18.050	11.607	6.443	N > K > P
792	1.85	0.18	2.09	-23.386	5.09	18.296	N >P > K
793	1.54	0.2	2.73	-40.858	-5.227	35.631	N > P > K
800	1.95	0.11	1.85	-3.503	-16.172	19.675	P > N > K
802	2.1	0.17	1.82	-8.516	1.882	6.634	N > P > K
839	1.92	0.18	1.86	-16.141	6.145	9.996	N > P >K
Shibin El-Kantir county							
851	2.19	0.14	1.54	2.956	-3.731	0.775	P > K > N
866	1.91	0.17	1.91	-15.986	3.329	12.657	N > P > K
876	2.21	0.2	2.04	-13.442	5.424	8.018	N >P >K
878	2.08	0.19	1.83	-11.987	6.647	5.340	N > K > P
880	2.	0.16	2.16	-16.509	-2.896	19.405	N > P > K
887	2.25	0.2	1.69	-6.318	8.405	-2.087	N > K > P
920	2.11	0.18	1.83	-9.789	3.997	5.792	N > P > K
951	2.52	0.22	1.78	-4.114	8.840	-4.726	K > N > P
976	2.73	0.17	1.72	6.829	-2.918	-3.911	K > P > N

Direct reading of N, P and K indices for wheat on physiological diagnosis (PD) chart

Table 4 represents the basis for physiological diagnosis and established norms for interpretation of the nutrient balance in wheat leaves. In this table the limits of interpretation classes were calculated and the degrees of imbalance were identified for each nutrient ratio, *i.e.,* severe deficiency, tendency to deficiency, balanced. Also, the degrees of imbalance towards excess were set, *e.g.,* tendency to excess, severe excess, with using such interpretation classes, defining the order of limitation via applying PD chart becomes easier and helps the researchers to excute their tasks quickly and correctly.

TABLE 4. Basis for physiological diagnosis. Established norms for interpretation of the nutrient balance in wheat leaves (proposed reference data).

Symbol	Interpretation class	Mineral ratio X/Y		
		N/K	N/P	K/P
↓↓	Severe deficiency	< 0.53	< 4.54	< 3.06
↓	Deficiency	0.53-1.05	4.54-9.07	3.06-6.10
↘	Tendency (deficiency)	1.06-1.22	9.08-11.66	6.11-8.18
→	Balanced (normal)	1.23-1.57	11.66-16.20	8.18-12.32
↗	Tendency (excess)	1.58-1.79	16.21-18.78	12.33-14.39
↑	Excess	1.8-3.58	18.79-37.56	14.40-28.78
↑↑	Severe excess	> 3.58	> 37.56	> 28.78
Means for normal plants (norm)		1.40	13.93	10.25

The direct reading of nutrient requirements by a plant in terms of comparable functions of field as a reflection of the interaction within the plant was first established by Beaufils (1956) for rubber trees. This reading was achieved by means of tri-linear co-ordinate chart identical to the one reproduced in Fig.3. Readings by means of arrows, are explained in detail in a previous work by Beaufils and Sumner (1976). The direct reading of NPK indices for wheat on the PD chart was performed for selected observations of the low-yielding population in each county (Table 5) and represented by three examples as follows:

(1) Tukh : Sample code number is 3 (percentages of N, P and K in dried plant material were 1.56, 0.32 and 3.70, respectively)

N/P ratio= 4.88, N/K = 0.42 and K/P = 11.58.

Reading from NPK chart gives: N↓↓↓ P↑ K↑↑

N > P > K

The chart gives a semi-quantitative order of plant requirement for these nutrients as N > P > K. The same order is obtained when calculated from the equations of DRIS indices (Table 3). The obtained results are in a good agreement with those of Abdel-Warth (2002), in which there was a correspondence between the DRIS indices and the PD chart.

(2) Al- Kanatir El- Khiria county

Sample code number is 244 (percentages of N, P and K in in dried plant material were 1.90, 0.09 and 1.60, respectively).

N/P ratio = 21.11 N/K = 1.19 and K/P = 17.78.

Reading from the PD chart gives: N↘ P↓↓ K↑↗

P > N > K

TABLE 5. Application of PD chart to poor, low yielding plants.

Sample code number	Leaves composition %			Application of PD chart								
	N%	**P%**	**K%**	**N/P**	**N/K**	**K/P**	**N/P**	**N/K**	**K/P**	**N**	**P**	**K**
Tukh County												
3	1.56	0.32	3.71	4.88	0.42	11.58	↓	↓↓	→	↓↓↓	↑	↑↑
12	2.68	0.21	4.23	12.76	0.63	20.15	→	↓	↑	↓	↓	↑↑
40	2.94	0.24	2.30	12.25	1.28	9.58	→	→	→	→	→	→
41	2.51	0.20	1.87	12.55	1.34	9.35	→	→	→	→	→	→
47	2.91	0.26	1.91	11.19	1.52	7.35	↘	→	↘	↘	↗	→
74	2.41	0.20	1.76	12.05	1.37	8.80	→	→	→	→	→	→
75	2.33	0.19	1.81	12.26	1.29	9.53	→	→	→	→	→	→
91	2.71	0.22	1.79	12.32	1.51	8.14	→	→	↘	→	↗	↘
125	2.25	0.19	1.99	8.11	0.77	10.47	↓	↓	→	↓↓	→	→
134	2.21	0.21	1.81	10.52	1.22	8.62	↘	↘	→	↘↘	↗	↗
135	2.22	0.20	1.95	11.1	1.14	9.75	↘	↘	→	↘↘	↗	↗
El-Kanater El-Khairia county												
223	2.50	0.19	2.20	13.16	1.14	11.58	→	↘	→	↘	→	→
226	3.20	0.09	2.90	35.56	1.10	32.22	↑	↘	↑↑	↘	↑↑↑	↓↓↘
233	2.82	0.19	2.35	14.84	1.20	12.37	→	↘	↗	↘	↘	→
235	2.75	0.15	2.22	18.33	1.28	14.80	↗	→	↑	→	↓↘	↑
244	1.90	0.09	1.60	21.11	1.19	17.78	↑	↘	↑	↘	↓↓	↑↗
294	2.75	0.09	2.02	30.56	1.36	22.44	↑	→	↑	↑	↓↓	↑
297	1.75	0.12	2.05	14.58	0.85	17.08	→	↓	↑	↓	↓	↑↑
299	2.55	0.09	1.40	28.33	1.82	21.11	↑	↑	↑	↑↑	↓↓	→
Benha county												
303	1.95	0.24	1.95	8.13	1.00	8.13	↓	↓	↘	↓↓	↑↗	↓↘
310	1.95	0.09	1.95	21.67	1.00	21.67	↑	↓	↑	↓	↓↓	↑↑
312	2.05	0.11	2.20	18.64	0.93	20.00	↗	↓	↑	↓	↓↘	↑↑
321	2.85	0.09	1.75	31.67	1.63	19.44	↑	→	↑	→	↓↓	↑
332	1.12	0.19	4.17	5.89	0.27	21.96	↓	↓↓	↑	↓↓↓	↓	↑↑↑
361	2.25	0.11	1.85	20.45	1.22	16.82	↑	↘	↑	↘	↓	↘
367	2.01	0.19	2.95	10.58	0.68	15.53	→	↓	↑	↓	↓	↑↑
375	.42	0.11	3.55	3.82	0.12	32.26	↓↓	↓↓	↑↑	↓↓↓↓	↓↓	↑↑↑↑
377	1.95	0.11	2.90	17.73	0.67	26.36	↗	↓	↑	↓	↓↘	↑↑
430	1.95	0.11	1.9	17.73	1.03	17.27	↗	↘	↑	↘	↓↘	↑↗
431	2.55	0.11	1.75	23.18	1.46	15.91	↑	↘	↑	↘	↓↘	↑↗
432	2.55	0.19	2.20	13.42	1.16	11.58	→	↘	↗	↘	↘	↗↗
460	1.68	0.13	3.98	12.92	0.42	30.60	→	↓↓	↑↑	↓↓	↓↓	↑↑↑↑
461	2.45	0.05	2.95	49.00	0.83	59.00	↑↑	↓	↑↑	↑	↓↓↓↓	↑↑↑
467	2.2	0.20	2.05	11.00	1.07	10.25	↘	↘	→	↘↘	↘	↗
487	2.01	0.24	1.85	8.38	1.09	7.71	↓	↘	↘	↓↘	↑↗	↘↘
517	2.40	0.19	2.28	12.63	1.05	12.01	→	↓	→	↓	→	↑
533	1.83	0.19	3.37	10.26	0.58	17.76	↘	↓	↑	↓↘	↓	↑↑
537	2.2	0.24	3.53	9.09	0.62	14.59	↘	↓	↑	↓↘	↓	↑↑
539	1.45	0.2	3.37	7.25	0.43	16.87	↓	↓↓	↑	↓↓↓	↑↑	↑↑↑

TABLE 5. Cont.

Sample code number	Leaves composition %			Application of PD chart								
	N%	**P%**	**K%**	**N/P**	**N/K**	**K/P**	**N/P**	**N/K**	**K/P**	**N**	**P**	**K**
Kafr Shokr County.												
563	2.01	0.15	2.82	13.4	0.71	18.8	→	↓	↑	↓	↓	↑↑
583	2.95	0.20	2.11	14.75	1.40	10.55	→	→	→	→	→	→
593	1.96	0.19	1.79	10.32	1.09	9.42	↘	↘	→	↘↘	↗	↗
599	2.75	0.20	2.40	13.75	1.15	12.00	→	↘	→	↘	→	↗
Qaliob County												
623	2.38	0.22	2.00	10.82	1.19	9.10	→	↘	→	↘	→	↗
658	2.2	0.29	2.789	7.59	0.79	9.62	↓	↓	→	↓↓	↑	↑
662	2.65	0.17	1.85	15.59	1.43	10.88	→	→	→	→	→	→
702	2.99	0.15	2.106	19.93	1.41	14.04	↗	→	↗	↗	↘↘	↗
707	2.6	0.092	1.46	28.26	1.78	15.86	↑	↗	↑	↑↗	↓↓	↘
724	2.49	0.32	2.93	7.78	0.85	9.16	↓	↓	→	↓↓	↑	↑
725	3.84	0.31	3.81	29.54	1.01	29.31	↑	↓	↑↑	↓	↓↓↓	↑↑↑
727	2.28	0.09	1.85	25.33	1.23	20.56	↑	→	↑	→	↓↓	↑
736	2.41	0.04	2.25	60.25	1.07	56.25	↑↑	↘	↑↑	↑	↓↓↓↓	↑↑↗
Shibin Elkanater County												
851	2.19	0.14	1.54	15.64	0.77	11.00	→	↓	→	↓	→	↑
866	1.91	0.17	1.91	11.24	1.00	11.24	↘	↓	→	↓↘	↗	↑
876	2.21	0.2	2.04	11.05	1.83	10.2	↘	↑	→	↘	↗	↓
878	2.08	0.19	1.83	10.95	1.14	9.63	↘	↘	→	↘↘	↗	↗
880	2.00	0.16	2.16	12.5	0.93	13.50	→	↓	↗	↓	↘	↑↗
887	2.25	0.2	1.69	11.25	1.33	8.45	↘	→	→	↘	↗	→
920	2.11	0.18	1.83	11.72	1.83	10.17	→	↑	→	↑	→	↓
951	2.52	0.22	1.78	11.45	1.42	8.09	↘	→	↘	↘	↗↗	↘
976	2.73	0.17	1.72	16.06	1.72	10.12	→	↗	→	↗	→	↗
Elkhanka County												
760	2.95	0.11	2.73	26.82	1.08	24.82	↑	↘	↑	↘	↓	↑↗
775	1.45	0.11	105	13.18	0.97	13.64	→	↑	↗	↑	↗	↓↘
787	2.42	0.22	1.83	11.00	1.32	8.32	↘	→	→	↘	↗	→
788	1.82	0.19	1.71	9.58	1.06	9.0	↘	↘	→	↘↘	↗	↗
792	1.85	0.18	2.09	10.28	0.89	11.61	↘	↑	→	↘	↑	↓
793	1.54	0.2	2.73	7.7	0.56	13.65	↓	↑	↗	↓	↘	↑↗
800	1.95	0.11	1.85	17.73	1.07	16.64	↗	↘	↑	↘	↓	↑↗
802	2.1	0.17	1.82	12.35	1.15	10.71	→	↘	→	↘	→	↗
839	1.92	0.18	1.86	10.67	1.03	10.33	↘	↓	→	↓↘	↗	↑

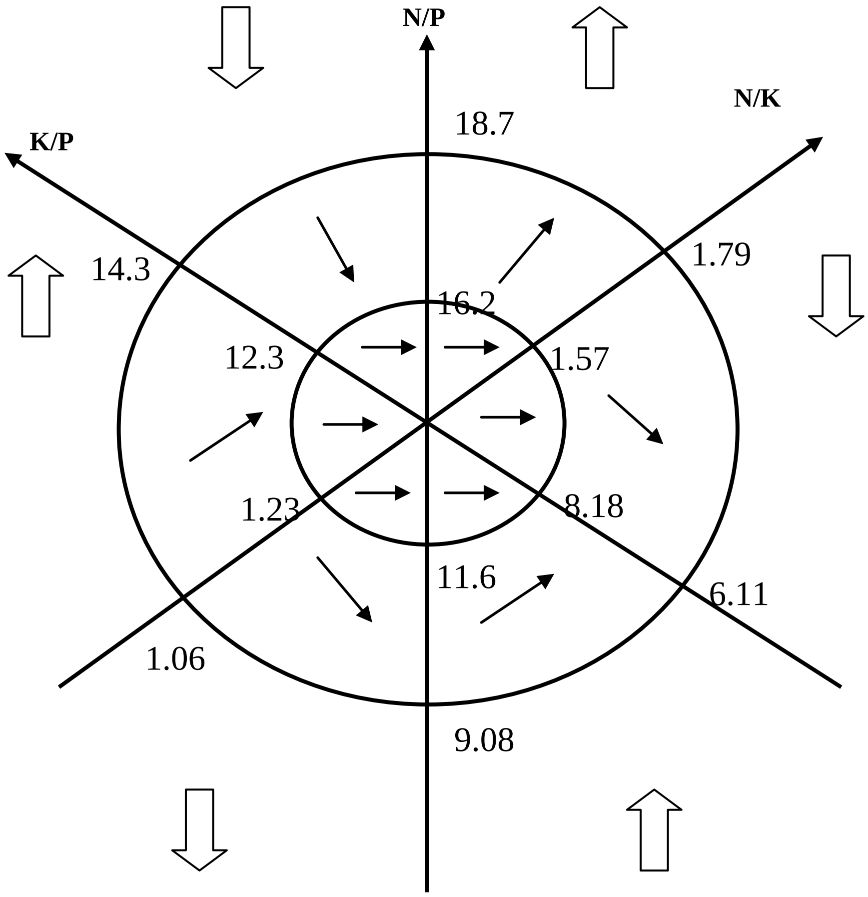

Fig. 3. Physiological Diagnosis (PD) chart and the established norms for interpretation of the nutrient balance in wheat leaves (proposed reference data).

There is a complete correspondence between the order of limitations indicated by DRIS indices and PD chart.

(3) Shibin El-Kanater county

Sample code number is 951 (N, P and K percentages in dried plant material were 2.52, 0.22 and 1.78, respectively)

N/P ratio = 11.45, N/K = 1.42, K/P = 8.1.

Reading from PD chart gives the following order of limitation:

N⭳ P⭷⭷ K⭳

K >N > P

This order is identical to that resulted from using DRIS indices. The orders of limitation calculated from the PD chart enable the imbalance phenomenon to be observed. This indicates the general validity of the chart and reference data. This validity of the chart can in no way be affected since from a PD point of view these “optimum” values are considered “favorable” imbalances. Note that all the specific advantages of the PD still apply and that a diagnosis of “favorable imbalances” could be made at any time, under any condition.

A direct application of the proposed standard physiological diagnosis chart (PD chart) for wheat to some of the low-yielding populations to test the balance of N, P and K in wheat plants, showed a relative deficiency of N followed by phosphorus. This result was similar to finding obtained with using the DRIS indices

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References

Abdel_Warth, M. (2002) Fertility status of some soils in south Sinai. *Ph.D. Thesis*, Fac, agric., Moshtohor, Zagazig Univ (Benha Branch).

Abdel-Raheem, K.M. (2003) Effect of natural soil amendments on fertilizer use efficiency as related to nutrient balance of plants grown on sandy soils. *M. Sc. Thesis, Dept., Fac. Agric.*, Ain Shams University.

Beaufils, E.R. (1957) Research for rational exploitation of *Hevea brasiliensis* using a physiological diagnosis based on the mineral analysis of various parts of the plant. *Fertile* , **3**, 27.

Beaufils, E.R. (1971) Physiological diagnosis. A guide for improving maize production based on principles developed for rubber trees. *Fert. Soc. South Africa. J.* **1**, 1-30.

Beaufils, E.R. (1973) Diagnosis and recommendation integrated system (DRIS). A general scheme of experimentation based on principles developed from research in plant nutrition. *Soil Sci. Bull*.**1**, Univ. of Natal-Pietermarmaritzburg, South Africa.

Beaufils, E.R. and Sumner, M.E. (1976) Application of the DRIS approach in calibrating soil, plant yield and quality factors of sugar cane. *Proc. South Africa. Sug. Tech. Assoc.,* **50**, pp.118-124.

Beaufils, E.R. and Sumner, M.E. (1977) Effect of time of sampling on the diagnosis of the N, P, K, Ca and Mg requirements of sugar cane by the DRIS approach. *Proc. South Africa. Sugar Technol. Assoc.,* **51,** pp.123-127.

Bremner, J.M. and Mulvaney, C.S. (1982) Nitrogen-Total. In: “*Methods of Soil Analysis*”, A. L. Page (Ed.) pp. 595-6642. 2^{nd} ed. American Society of Agronomy, Madison, Wiconson, USA.

Goh, K.M. and Malakouit, M.J. (1992) Preliminary nitrogen, phosphorus, potassium, calcium and magnesium DRIS norms and indices for apple orchards in Canterbury, New Zealand. *Commun. Soil Sci*. *Plant Anal.,* **23,** 1371-1385.

Jackson, M.I. (1967) *Soil Chemical Analysis*. Prentic- Hall Inc. Limited, New York.

John, M.K. (1970) Colorimetric determination of phosphorus in soil and plant materials with ascorbic acid. *Soil Sci.,* **109**, 214- 220.

Johnson, C.M. and Ulrich, A. (1959) Analytical method for use in plant analysis. *California Agric. Expt. Sta. Pull* . 766.

Khiari, L., Parent, L.E. and Termblay, N. (2001) Selecting the high- yield subpopulation for diagnosing nutrient imbalance in crops. *Agron. J.,* **93**, 802-808

Letzsch, W.S. and Sumner, M.E. (1984) Effect of population size and yield level in selection of Diagnosis and Recommendation Integrated System (DRIS) norms. *Commun. Soil Sci*. *Plant Anal.,* **15**, 997- 1007.

Murphy, J. and Riley, J.P. (1962) A mdified single solution method for the determination of phosphate in natural waters. *Chim. Acta.* , **27**, 31-36.

Orlando Rodriuez, Eybar Rojas and Malcolm Sumner (1997) Valencia orange DRIS norms for Venezuela. *Commun. Soil Sci*. *Plant Anal.,* **28**, 1461-1468.

Raghupathi,H.B. and Bhargava (1998) Diagnopsis of nutrient imbalance in pomegranate by Diagnosis and Recommendation Integrated System and Composition Nutrient Diagnosis. *Commun. Soil Sci. and Plant Anal.,* **29**, 2881-2892.

Sumner, M.E. (1977) Preliminary N, P and K foliar diagnostic norms for soybean. *Agron. J.,* **69**, 226-230.

Sumner, M. E. (1977a) Application of Beaufils diagnosis indices to maize data published in the literature irrespective of age and conditions. *Plant and Soil,* **46**, 359-369.

Sumner, M.E. (1977b) Effect of corn leaf sampled on N, P, K, Ca and Mg content and calculated DRIS indices. *Commun, Soil Sci. Plant Anal*. **8** , 269-280.

Sumner, M.E. (1978) A new approach for predicting nutrient needs for increased crop yields. *Fert. Sol.* **22,** 68-78.

Sumner, M.E. (1979) Interpretation of foliar analysis for diagnostic purposes. *Agron. J.* **71**, 343-348.

Sumner, M.E. (1980) Diagnosing the sulfur requirementsof corn and wheat using foliar analysis. *Soil Sci. Soc. Am. J.* **45**,1881-1887.

Sumner, M.E. (1981) Diagnosis of sulfur requirements of corn and wheat using foliar analysis. *Soil Sci. Soc. Am. J.* **45**, 87-90.

Walworth, J.L. and Sumner, M.E. (1987) The diagnosis and recommendation integrated system. *Adv. Soil Sci.* **6**, 149-188.

Walworth, J.L., Woodward, H.J. and Sumner, M. E. (1988) Generation of corn tissue norms from a small, high-yielding database. *Commun. Soil Sci. Plant Anal.* **19**, 563-577.

Walworth, J.L., Sumner, M.E., Jssac, R.A. and Plank, C.O. (1986) Preliminary DRIS norms for alfalfa in southeastern United States and comparison with midwestern norms. *Agron. J.* **78**, 1046-1052.

Westwood, M.N. (1978) "*Temperate-zone Pomology*". Oregon State Univ. Press,

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تقييم حالة النيتروجين و الفوسفور والبوتاسيوم فى القمح بإستخدام نظام التشخيص و التوصيه المتكامله (DRIS) وكارت التشخيص الفسيولوجى

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تهدف هذه الدراسه إلى تطوير قاعدة بيانات يحسب منها معايير ودلائل نظام التشخيص والتوصية المتكاملة للقمح النامى في محافظة القليوبية – مصر . تحديد المغذى الأكثر تحديدا للنمو من بين العناصر الثلاثة النيتروجين والفوسفور والبوتاسيوم والترتيب الذى فيه من الممكن أن تصبح العناصر الأخرى محددة.

ولتحقيق هذه الأهداف :

- تم جمع 1000 عينة نباتية عند مرحلة طرد السنابل من حقول القمح المنتشرة فى مراكز محافظة القليوبية السبع وهى : طوخ – شبين القناطر – قليوب – القناطر الخيرية – الخانكة – بنها – وكفر شكر . وجمعت العينات فى موسم 2003/2002 . والعينات الطازجة تم وزنها وأخذت منها عينات للتجفيف على درجة حرارة 72°م لمدة 72 ساعة ثم طحنت لتمر من خلال شبكة قطرها 0.5 مم وأخذت أجزاء من العينة المطحونة وزن كل منها 0.5 جم وهضمت بخليط من حمض الكبريتيك والبركلورويك وخففت إلى 50 ملل ثم قدر محتواها من النيتروجين والفوسفور والبوتاسيوم
- تم حصاد نباتات القمح من مساحة مناظرة قدرها 1م^2 من كل حقل عند النضج وقدر وزن الحبوب الناتج .

- قسمت الألف عينة إلى مجموعات عالية الانتاج ≤ 2.4 طن حبوب / فدان وحسبت معايير الـ DRIS للمجموعات عالية الانتاج وذلك لأن المحصول العالى عادة ما ينتج من اتزان المغذيات فى النبات .
- وحسبت معايير الـ DRIS وذلك بملاحظة التباين المعنوى لاختبار النسبة بين المجموعات عالية الانتاج والأخرى قليلة الإنتاج .
- وشكلت المجموعات عالية الانتاج 59.1 ٪ (بمجموع قدره 591 عينة) بينما المجموعة منخفضة الانتاج شكلت 40.9 ٪ (مجموع عينة قدره 409)
- ولقد مثلت نسب العناصر الثلاثة (N/P N/K, K/P) على رسم ثلاثى المحاور وحسبت أيضا معايير الـ DRIS المعدلة .

<u>ويمكن تلخيص النتائج كما يلى :</u>

- تم التعبير عن درجة عدم اتزان المغذيات في النبات على صورة دلائل الـ DRIS التى تشير إلى أى مدى تشتت مغذى معين عن المعايير المقدرة .
- وتم حساب نسب مختلفة للمغذيات مثل n/p , n/k, k/p, p/n, k/n , p/k, np, nk, kp لكل من المجموعات عالية ومنخفضة الانتاج . ونسب التباين المحسوبة للنسب المختلفة المذكورة للمغذيات إلى بعضها كانت معنوية ما عدا تلك النسب الناتجة بالضرب .
- ولقد أظهرت المجموعات المنخفضة الإنتاج قيم عالية للانحراف القياسى ومعامل الاختلاف مقارنة بالمجموعات عالية الإنتاج.
- وكانت قيم معايير الـ DRIS للمجموعات عالية الإنتاج كما يلى 13.93 و 1.4 و 10.25 لـ n/p, n/k, k/p على التوالى . وكانت قيم معايير الـ DRIS المقابلة هي 12.74 و 1.45 و 8.8 لـ n/p, n/k, k/p علي التوالى .
- يمكن استخدام المعايير المحسوبة من هذه الدراسة مع ثقة عالية وذلك لأنها نتجت من قاعدة بيانات كبيرة (591 عينة) وكان الاختلاف بين المعايير المحسوبة من هذه الدراسة وتلك المقابلة بصفة أساسية فى K/P وهذا راجع جزئيا إلى تأثير المنطقة وكذلك خصائص التربة.