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Establishing of Optimum Nutrient Ranges for Canola Leaves Affected by Compost and Zinc by DRIS Analysis

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Authors' contributions

This work was carried out in collaboration among all authors. Author SES designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors FH and HIEA managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

DRIS method is one of the important methods that reflect the status of the nutrients within the plant tissue. Field experiment were carried out at the Research and Production Station of the National Research Centre, Nubaria region, Beheira Governorate, Egypt during 2019/2020 to evaluate leaf nutrient optimum ranges of canola affected by compost addition (0, 2, 4 and 6 ton fed^{-1}) to the soil and foliar application of zinc (0, 50 and 100 ppm) under water regimes at 75 and 40% water holding capacity. A remarkable increase the macronutrient contents due to the addition of compost and had a positive effect, especially with the rates 4 and 6 ton fed^{-1} + zinc sulfate foliar spraying at a rate of 100 ppm under sufficient and deficit irrigation treatments. Under water stress, in the control treatment as compared to the treatment combination (4 ton/fed compost + 100 ppm Zn), the N index was decreased from (-143.2) to (-76.1) in this time the nitrogen a negative DRIS index indicates that the nutrient level is below the optimum. Phosphorus index was recorded (-98) reduced to (-39.4) and a negative DRIS index indicates that the phosphorus level is below optimum in these treatment combinations. Also, the DRIS index for potassium was recorded (241.2) decrease up to (115.5) and the potassium has a positive DRIS index indicates that the nutrient level is above or near to the

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optimum. 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 physiological diagnosis (PD) chart.

Objective: The objectives this study to evaluation of canola leaf nutrient optimum ranges affected by organic compost addition to the soil and micronutrient such as of zinc foliar application.

Keywords: Canola; nutrient content; compost; zinc; DRIS.

1. INTRODUCTION

Canola (*Brassica napus* L.) has been an important crop for many decades. Canola is a specific type of rape seed associated with high quality oil and meal. Canola is one of the most important oilseed plants that have high compatibility in resistance to drought and salinity stresses. After soybean, the largest cultivation area of oilseed plants is accounted to canola, and in terms of oil providing, after soybean and oil palm it is in third place [1]. Like many of the oilseed plants, canola is effected stress caused by the water deficits. Studies have shown that the incidence of water deficit at different growth stages, especially reproductive growth, is the effect of quantity and quality of oil [2].

Compost represents the most utilized form of stabilized recycled biomass as an efficient soil amendment [3,4]. Furthermore, compost made of animal manure is an inexpensive source of bioavailable nutrient for plants and it is progressively used in substitution of or in combination with inorganic fertilizers [5,4]. Composting organic wastes and their enrichment with suitable amount of chemical fertilizer could enhance fertilizer use efficiency and recycle organic waste materials and organic matter into soil, restoring soil health and improving crop yield on sustainable basis. In another study, it was shown that application of 100 kg N/ha with 50 ton/ha compost was adequate of optimum seed yield of canola [6].

Zinc is essential plant micronutrient which is involved in many physiological functions, protein and carbohydrate synthesis [7]. The decrease of zinc on plant have been associated with the drought stress caused by decreases in soil water and consequently, restriction of root growth [8]. The application of zinc (Zn) under drought conditions would influence crop yield and quality. Zinc sulfate has an important role in the plant system to decrease water stress, such that any secondary factor leading to the inaccessibility of this element for the plant, affects the yield and concentration of this element in various tissues [9].

Foliar nutrient sufficiency guidelines have often been developed from limited numbers of fertilization trials in which typically only one or two nutrients have been manipulated. That approach may not adequately reflect the influences of the wide range in soil characteristics and environmental conditions that characterize regional industry. Furthermore, the interaction among the various macro- and micronutrients is not easily captured by traditional fertilizer trials. An alternative approach to the development of foliar nutrient sufficiency guidelines is the Diagnosis and Recommendation Integrated System (DRIS); [10]. In the DRIS approach, differences in nutrient concentrations and nutrient ratios between high- and low-yielding populations are used to estimate the degree to which various nutrients may limit yield either by deficiency or excess [11].

DRIS evaluation criteria have been developed for a range of agronomic and horticultural crops [12,13,14,15], including lettuce [16]. DRIS was originally conceived as a diagnostic tool with which tissue nutrient concentrations in a field of interest could be compared with a set of established standards, or ‘‘norms’’, through the calculation of nutrient indices; these indices would rank the relative degree of deficiency or excess for each nutrient.

2. MATERIALS AND METHODS

2.1 Experimental Procedures

Field experiment were carried out at the Research and Production Station of the National Research Centre, Nubaria region (30 30.054' N - 30 19.421' E), Beheira Governorate, Egypt during 2019/2020. Seeds of Canola (*Brassica napus* L.) cv. Sarw were sown on November in season. The experimental design was a split plot with four replications. The Water stress treatments (75 and 40% water holding capacity, WHC) occupied the main plots and compost treatments at the rates (0, 2, 4 and 6 ton fed^{-1}) were allocated at random in the sub-plots with the foliar application of zinc at a rate of 0, 50 and 100 ppm. The plot area was $9m^2$. Some physical and chemical properties of a representative soil sample used of the experimental site were determined before sowing according to [17] and presented in Table 1.

Calcium super-phosphate (15.50% P_2O_5) was added pre-sowing at 150 Kg/fed (ha=2.4 fed, fed= feddan) to the soil; similarly, nitrogen in the form of ammonium nitrate (33.0% N) at the rate of 20 kg N/fed as starter dose was added before first irrigation, Potassium sulphate (48% K_2O) was added at the rate of 50 kg/fed to the soil in two equal doses at 21 and 35 days after sowing. Canola plants were irrigated and maintained during the whole growth season using drip irrigation system. Foliar spray of Zinc sulphate was applied three doses to canola plants during the growth stage. The interaction of different concentrations of both compounds was also assessed in addition to untreated plants (control). Table 2 shows the components of a representative compost sample used of the experimental site.

2.2 Chemical Analysis

For mineral ions content (nitrogen, phosphorous and potassium) estimation, a known weight (0.5 g) of the dry grain of canola was digested and the obtained extract was used for the estimation of some macronutrient content according to [18].

2.2.1 Biological yield

The total biomass of the harvested plants (kg $plot^{-1}$), then it was transformed into ton per feddan.

2.2.2 Grain yield (ton ha^{-1})

It was obtained as the weight of clean grains of the plot after threshing, and then it was transformed into tone per feddan.

2.3 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:

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

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

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

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

Table 1. Some physical and chemical properties of the experimental soil

pH	EC	OM	$CaCO_3$	Particle size distribution			Texture
(1:2.5)	dSm^{-1}	%	%	Sand %	Silt %	Clay %	Class
7.76	1.26	0.84	2.98	75.7	5.3	18.28	Sandy loam
Cations (mg / 100 g soil)				Anions (mg / 100 g soil)			
Na^+	K^+	Ca^{++}	Mg^{++}	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}
3.62	1.41	3.52	1.48	0.38	3.81	1.82	3.44
Available macronutrients (mg/100 g soil)				Available micronutrients (mg/kg)			
N		P	K	Fe	Zn	Mn	Cu
15.33		3.98	16.52	11.61	0.09	5.89	0.011

Table 2. Compost manure analysis

pH	EC	Organic	Organic	C/N	Macronutrient (%)		
(1:5)	(1:5)	Matter %	Carbon %	ratio	N	P	K
7.72	2.53	25.13	14.81	23.51	0.63	0.273	0.34

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 [11].

3. RESULTS AND DISCUSSION

3.1 Macronutrient Content of Leaves in Ear Emergence

Macronutrients are essential for the plant and it's a good overall state during the growth stages. Fig. 1 showed some nutrient content of canola (nitrogen, phosphorus, potassium) as affected by compost and zinc application rates and their interaction under sufficient and deficit irrigation treatments.

Concerning the effect of organic fertilizers such as compost and mineral fertilizers like zinc sulphate on macronutrient content of canola under water stress condition, data presented that the application of compost at the rates (0, 2,4,6 ton fed^{-1}) and zinc sulphate at the rates 0, 50 and 100 ppm. Fig. 1 shows that response of canola plant for organic fertilization such as compost and foliar application of zinc sulphate.

Where the results showed that a remarkable increase the macronutrient contents due to the addition of compost and had a positive effect, especially with the rates 4 and 6 ton fed^{-1} + zinc sulfate foliar spraying at a rate of 100 ppm under sufficient and deficit irrigation treatments.

The application of compost increased microbial activity, nitrogen concentration and grain yield [19]. Use of compost in the Mediterranean semi-arid lands increased nitrogen, phosphorus, potassium and content in the rhizosphere [20]. Spraying pea and garlic plants with Zn or Fe significantly increment mineral content and uptake of N, P and K compared with the control [21].

3.2 DRIS Indices for N, P and K in Canola Plants Grown

The leaf nutrient status was interpreted using Diagnosis and Recommendation Integrated System (DRIS). Leaf samples were taken at the heading stage and analyzed for N, P and K. Nutrient indices were calculated using published standards and locally-developed indices (Nubaria region). DRIS method is one of the important methods that reflect the state of the nutrients within the plant tissue where it does not reflect the nutrients individually, but expressed in the form of ratios, and through which knowledge nutrients balance inside the plant tissues and that it was found the best ratios of different nutrients, which by finding the best nutrients balance inside the plant, through which leads to increase the efficiency of these nutrients resulting in getting the maximum crop. The Nutritional Balance Index (NBI) was calculated by summing the value in module of the index generated in sample. This NBI may be useful to indicate the nutritional status of the plant. The higher NBI is the greater the nutritional imbalance [10].

Data in Table 3 indicated that the highest absolute total of NBI (465) observed in control treatment (no compost and no Zn applied) under sufficient irrigation condition, which recorded the highest DRIS index of N, P and K (-124 and -108 and 232), the order of limitation was N>P>K respectively if compared with other treatments. The negative index values of N and P in control treatments indicated that the nutrient levels are below the optimum. Consequently, the more negative index, the more deficient the nutrient, similarly a positive index of K index indicates that the nutrient levels are above the optimum, and the more positive index the more excessive the nutrient that is relative to normal, and the DRIS index is equal to zero indicating that the nutrient is at optimum levels. However, some authors did not consider a nutrient deficiency or excessive when the DRIS indices are negative or positives and near to zero [22].

Whereas, under water deficit condition, the highest NBI (482) was found in control treatment with highest negative N index (-143.2), P index (-98) and K index (241.2) and the order of limitation was N>P>K as compared with other treatments. After addition of compost and zinc the nutrient imbalance reduced. The treatment combination (4 ton/fed compost + 100 ppm Zn) was most balanced treatment among the studied combinations, with the absolute nutrient balance index (303) which resulted from DRIS indices are (-49, -103, 151) for (N, P and K index), respectively and the order of limitation was P>N>K if compared with other treatments under sufficient irrigation system.

Whereas, under stress condition, the most balanced treatment (4 ton fed^{-1} compost + 100 ppm Zn), with the lowest nutrient balance index (231) which resulted from DRIS indices (-76.1-39.4, 115.5) for (N, P and K index), respectively and the order of limitation was N>P>K if compared with other treatments.

Under normal irrigation,the N index was decreased from (-124) in control treatment up to (-49) after application the treatment combination (4 ton/fed compost + 100 ppm Zn) indicating increase the N balance as compare to the other treatments. Phosphorus index was reduced from (-108) up to (-103) in same sequence and a negative DRIS index indicates that the nutrient level is below the optimum. Also, the DRIS index for potassium was reduced from (232) to (151), the potassium a positive DRIS index indicates that the nutrient level is above or near the optimum.

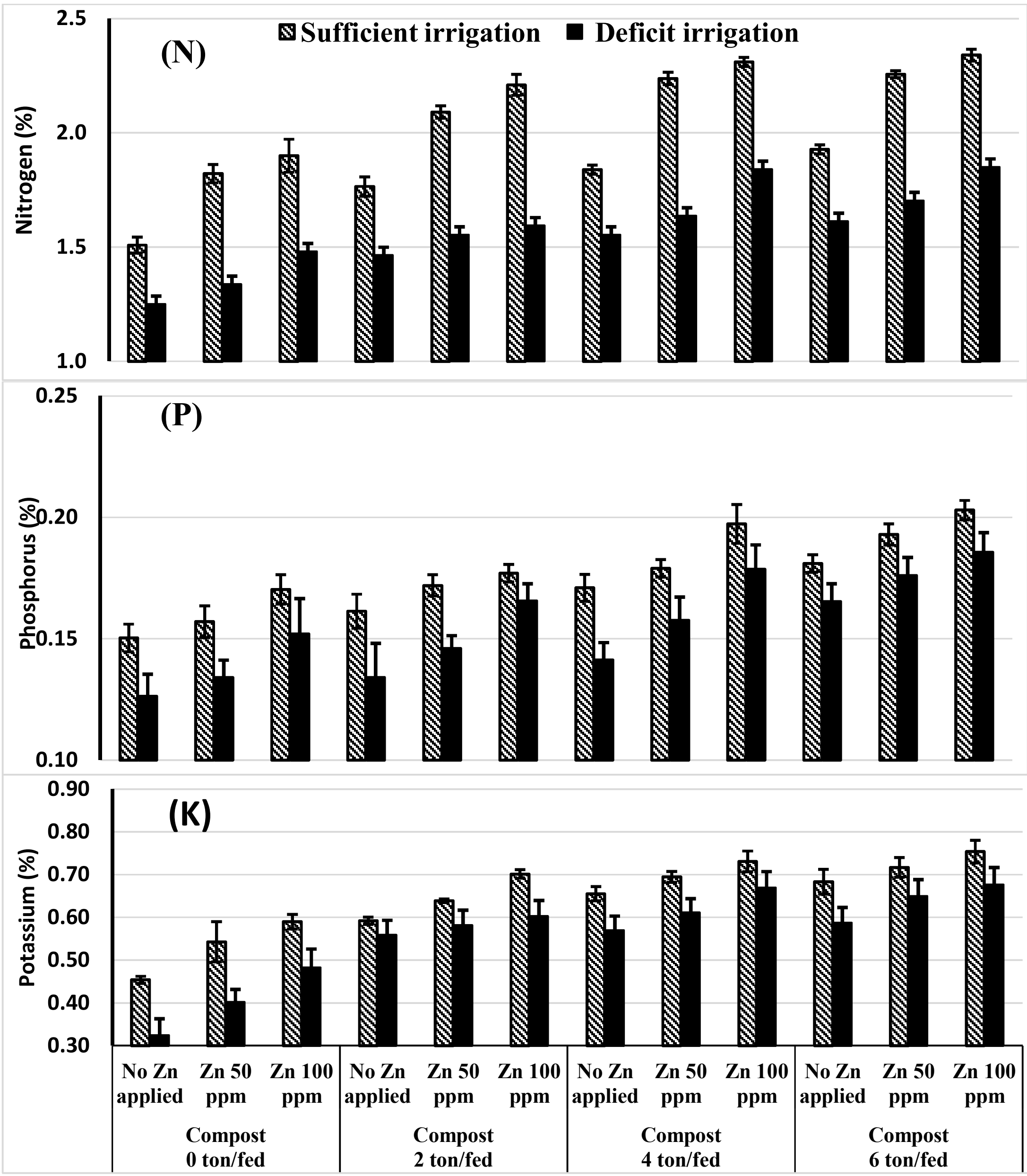

Fig. 1. Effect of compost and zinc sulphate on Nitrogen (N), Phosphorus (P) and Potassium (K) contents of canola plant during growth stage

Table 3. DRIS indices of NP K in canola leaves under water stress condition

Compost	Zn Levels	Sufficient irrigation					Deficit irrigation				
		DRIS indices			NBI	Order	DRIS indices			NBI	Order
		N	P	K			N	P	K		
0 ton/fed	No Zn	-124	-108	232	465	N>P>K	-143.2	-98.0	241.2	482	N>P>K
	Zn 50 ppm	-114	-98	212	425	N>P>K	-116.5	-104.4	221.0	442	N>P>K
	Zn 100 ppm	-82	-119	201	401	P>N>K	-68.6	-133.7	202.3	405	P>N>K
2 ton/fed	No Zn	-125	-100	224	449	N>P>K	-75.6	-127.8	203.4	407	P>N>K
	Zn 50 ppm	-82	-133	216	432	P>N>K	-101.7	-127.1	228.8	458	P>N>K
	Zn 100 ppm	-72	-133	205	410	P>N>K	-64.5	-121.3	185.8	372	P>N>K
4 ton/fed	No Zn	-119	-107	226	452	N>P>K	-73.4	-122.7	196.1	392	P>N>K
	Zn 50 ppm	-59	-128	187	374	P>N>K	-86.4	-126.1	212.5	425	P>N>K
	Zn 100 ppm	-49	-103	151	303	P>N>K	-76.1	-39.4	115.5	231	N>P>K
6 ton/fed	No Zn	-68	-131	198	397	P>N>K	-66.5	-115.8	182.2	364	P>N>K
	Zn 50 ppm	-69	-116	185	371	P>N>K	-52.4	-79.4	131.9	264	P>N>K
	Zn 100 ppm	-66	-121	187	374	P>N>K	-44.6	-86.2	130.8	262	P>N>K

Under water stress, in the control treatment as compared to the treatment combination (4 ton/fed compost + 100 ppm Zn), the N index was decreased from (-143.2) to (-76.1) in this time the nitrogen a negative DRIS index indicates that the nutrient level is below the optimum. Phosphorus index was recorded (-98) reduced to (-39.4) and a negative DRIS index indicates that the phosphorus level is below optimum in these treatment combinations. Also, the DRIS index for potassium was recorded (241.2) decrease up to (115.5) and the potassium has a positive DRIS index indicates that the nutrient level is above or near to the optimum. This outcome is to be coupled with higher yield with the smaller absolute total for value nutrient index elements agree with [23] on corn and [24] on soybean. From the DRIS index calculation proved that after addition of compost and zinc the nutrient imbalance reduced and application of 4 ton/fed compost + 100 ppm Zn, was most nutrient balanced treatments which may produce a higher yield.

3.3 Direct Reading of N, P and K Indices for Canola on Physiological Diagnosis (PD) Chart

Table 4 shows the direct reading of nutrient requirements by canola plant in terms of comparable functions of field as a reflection of the interaction within the plant which was first established by [25] for rubber trees. This reading was achieved by the means of tri-linear coordinate chart identical to the one reproduced in Fig. 2. The direct reading of N, P and K indices for canola on the PD (physiological diagnosis) chart was performed as affected by the combined application of compost and zinc for canola grown under water stress. 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.

The treatment received 4 ton/fed compost + 100 ppm Zinc has nutrient ratio in dried plant material were ratio. The selected DRIS norms were, N/P = 69.5, N/K = -202 and P/K= 172 under sufficient irrigation whereas under deficit irrigation the N/P = 70.9, N/K = -200 and P/K= 172 and the order of limitation is: P > N > K under both conditions. The same order was obtained when calculated from the equations of DRIS indices (Table 4). The obtained results are in a good agreement with those of [26,27], in which there was a correspondence between the DRIS indices and the PD chart.

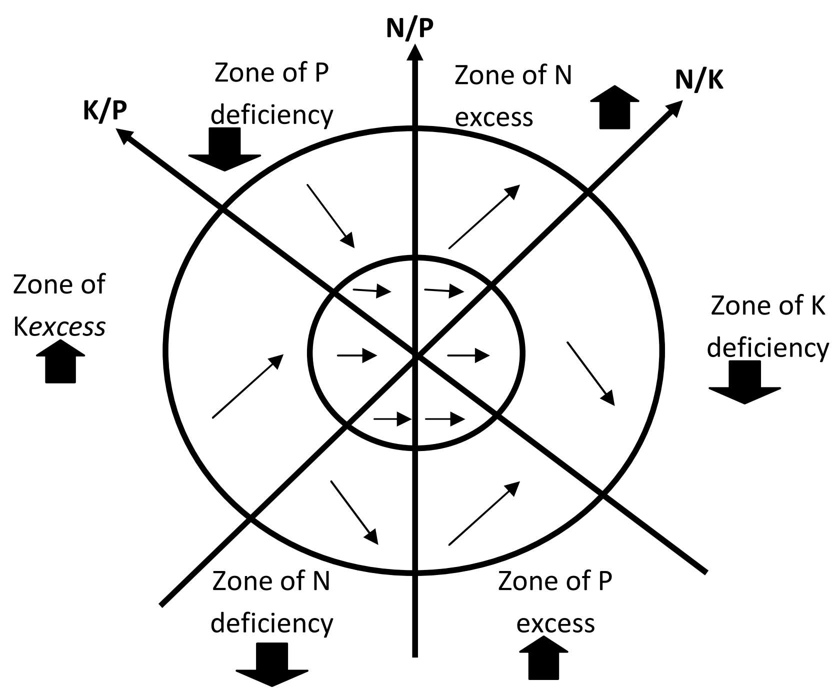

Fig. 2. Physiological diagnosis chart for direct determination of the N, P and K status

Table. 4 Application of PD chart in canola leaves under water stress condition

Compost	Zn Levels	Sufficient irrigation						Deficit irrigation					
		Application of PD Chard						Application of PD Chard					
		N/P	N/K	K/P	N/P	N/K	K/P	N/P	N/K	K/P	N/P	N/K	K/P
0 ton/fed	No Zn	24.7	-274	175	↗	↑↑	↓	-1.44	-151	80	→	↑↑	↓↓
	Zn 50 ppm	59.7	-223	178	↑	↑↑	↓	44.2	-149	115	↑	↑↑	↓↓
	Zn 100 ppm	64.9	-163	140	↑	↑↑	↓↓	54.0	-143	118	↑	↑↑	↓↓
2 ton/fed	No Zn	28.5	-257	168	↗	↑↑	↓	15.4	-302	181	↗	↑↑	↓
	Zn 50 ppm	79.3	-197	177	↑	↑↑	↓	78.0	-215	189	↑	↑↑	↓
	Zn 100 ppm	64.2	-203	168	↑	↑↑	↓	65.6	-199	166	↑	↑↑	↓
4 ton/fed	No Zn	32.7	-271	181	↗	↑↑	↓	62.8	-236	189	↑	↑↑	↓
	Zn 50 ppm	76.2	-212	185	↑	↑↑	↓	67.2	-214	178	↑	↑↑	↓
	Zn 100 ppm	69.5	-202	172	↑	↑↑	↓	70.9	-200	172	↑	↑↑	↓
6 ton/fed	No Zn	31.5	-279	185	↗	↑↑	↓	31.9	-265	177	↗	↑↑	↓
	Zn 50 ppm	70.4	-235	197	↑	↑↑	↓	69.9	-221	186	↑	↑↑	↓
	Zn 100 ppm	75.6	-220	190	↑	↑↑	↓	55.8	-259	198	↑	↑↑	↓

Table. 5 Basis for physiological diagnosis, established norms for interpretation of the nutrient balance in canola leaves (proposed reference data)

Symbol	Interpretation class	Mineral ratio		
		n/p	**n/k**	**k/p**
↓↓	Severe deficiency	<6.91	<4.86	<0.54
↓	Deficiency	6.91 - 8	4.86 - 5.97	0.54 - 0.91
↘	Tendency (Deficiency)	8.01 - 8.54	5.98 - 6.53	0.92 - 1.09
→	Balanced (normal)	8.55 - 9.65	6.54 - 7.66	1.1 - 1.48
↗	Tendency (Excess)	9.66 - 10.19	7.67 - 8.22	1.49 - 1.66
↑	Excess	10.2 - 11.29	8.23 - 9.34	1.67 - 2.04
↑↑	Severe excess	>11.29	>9.34	>2.04
Means for normal plant (norm)		9.10	7.10	1.29

A direct application of the proposed standard PD chart for canola to some of the deficit irrigation treatment to the test balance of N, P and K in plant leaves, showed a relative deficiency of N followed by P. These results are similar to the findings obtained with using the DRIS indices (Table 5).

4. CONCLUSION

It could be concluded that establishing DRIS norms for Canola is a vital step towards production of 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 physiological diagnosis (PD) chart.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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