EFFECT OF DIFFERENT LEVELS OF NITROGEN AND POTASSIUM FERTILIZERS APPLICATION ON NUTRIENT BALANCE AND YIELD OF BROCCOLI (*Brassica oleraceae*)

A.T. R. Dizayee **H. A. Saleh**
Assist. Prof. **Researcher**
College of Agriculture, University of Salahaddin- Erbil
Dizayee@su.edu.krd **halmatawni@yahoo.com**

ABSTRACT

A study was conducted during fall season of 2015-2016 at Qwshtapa farm village of Grdmala, Erbil to study the effect of different rates of Nitrogen and Potassium fertilizers application on nutrient balance and yield of Broccoli. Treatments included 5 levels of nitrogen (0, 60,120,180 and 240 kg N ha^{-1}), and 5 levels of potassium (0,150,300,450 and 600 kg K ha^{-1}) in factorial experiment in RCBD with three replicates. The Diagnosis and Recommendation Integrated system (DRIS) methodology was applied to study nutrient balance. Results indicated that yields were 23.916 and 11.233 Mg ha^{-1} for N_3K_1 and N_0K_0 ,respectively. Values of Absolute Total (AT)"Nutrient Balance" were 45.82 and 9.96 for N_0K_0 and N_3K_1, respectively. From DRIS and ABI values it can be concluded that N and P were the most limiting nutrients for Broccoli production in this area of Kurdistan-Iraq and soil test was good indicator for soil fertility.

Key Words: DRIS, Broccoli, NBI
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تأثير اضافة مستويات مختلفه من اسمدة النتروجين والبوتاسيوم في إتزان المغذيات وإنتاجية البروكلي (*Brassica oleraceae* var. Italica)

الوند طاهر رشيد دزه يى هلمت عوني صالح
استاذ مساعد باحث
كلية الزراعة –جامعة صلاح الدين–اربيل
Dizayee@su.edu.krd halmatawni@yahoo.com

المستخلص

اجريت هذه الدراسة في حقل (قوشتة ثة) طرد ملا –اربيل في الموسم الخريفي 2015 لدراسة تأثير المستويات المختلفة من اسمدة النتروجين والبوتاسيوم في الاتزان الغذائي وإنتاجية البروكلي بإستعمال DRIS لتحديد الاتزان .وشملت التجربة خمسة مستويات من النتروجين (0، 60، 120، 180 و 240 كغم N هـ$^{-1}$) و خمسة مستويات من البوتاسيوم (0، 150، 300، 450 و 600 كغم K هـ$^{-1}$) في تجربة عاملية وبإستعمال تصميم القطاعات الكاملة المعشاة (RCBD) و بثلاثة مكررات .وبينت اهم النتائج ان قيم الانتاج كانت 23.916 و 11.233 ميكاغرام هـ$^{-1}$ للمعاملتين N3K1 و N0K0 بالترتيب . القيم المطلقة (الاتزان الغذائي) كانت 45.82 و 9.6 للمعاملتين N_0K_0 و N_3K_1 بالترتيب . ومن قيم DRIS و NBI يمكن الاستنتاج ان عنصري النتروجين والفسفور كانت العناصر الاكثر تحديداً لنمو وإنتاجية البروكلي في هذه المنطقة من كردستان –العراق وان فحص التربة كان مؤشراً جيداً لخصوبة التربة.

الكلمات المفتاحية : نظام التشخيص والتوصية المتكامل DRIS وNBI والبروكلي.

***مستل من رسالة ماجستير للباحث الثاني.**

INTRODUCTION

Broccoli (*Brassica oleracea* var. italica L.) one of the family of Cruciferae is a delicious vegetable and have a very good nutrition value,(16). This vegetable crop is very rich in vitamins A and C and Calcium, Phosphorus and Iron minerals (21). Broccoli can be grown on a wide range of soil types, ranging from coarse to fine soil especially when supplied with good level of organic matter (13). Fertilizer management (especially N,P, and K) can be consider as one of the most important factors for Broccoli production (15,21). Haque *et al.,* (10), found marked increase in growth and yield of Broccoli in response to N application . Ying *et. al*,(25) observed that potassium was one of the most important element for yield of Broccoli. Cai *et al*, (7) and Brahma *et al*, (6) indicated that applying N and K produced the earliest curds of high quality and high yields. Pardeep- Kumar *et al.* (14) conducted an experiment on performance of different broccoli cultivars under different N, P and K rates. The maximum values for growth, yield and quality characteristics were obtained at the highest N, P and K levels (150, 90 and 60 kg. ha^{-1}, respectively). One of the methods for studying nutrient balance (NB) in plants is diagnosis and recommendation integrated system (DRIS) (5,23). The DRIS is a diagnostic approach that uses nutrient concentration ratios rather than concentration themselves, to interpret tissue analyses was developed to make an interpretation from the results of plant tissue chemical analyses for an accurate fertilizer recommendation (5).Another criteria is nutrient balance index (NBI) provides information about environmental stress (19) . A nutrient deficit (negative value) indicates declining soil fertility, while nutrient surplus (positive data) can indicates a risk of polluting soil, water and air. Dizayee, (8) applied different rates of nitrogen phosphors and potassium fertilizer for soybean plant using DRIS methodology, showed that the maximum yield was obtain from the combination treatments of (N_{240} P_{60} K_{50}). Therefore, this study aimed to investigate the effect of different levels of N and K on nutrient balance in plant using DRIS and yield of broccoli.

MATERIAL AND METHODS

This experiment was conducted during winter growing of season of 2015-2016 at Qwshtapa farm, village of Grdmala, with GPS reading of latitude 36^0 06.9 N, and longitude 44 03^0 E, 413.8 meter above sea level to study effects of different rates of N and K on nutrient balance and productivity of Broccoli . After land preparations 25 plots, with 2m² (2×1m) were established leaving 2m between blocks and plots. Treatments included 5 levels of nitrogen (0, 60, 120, 180 and 240 kg N ha^{-1}) using Urea (46%N) as source of nitrogen, 5 levels of potassium (0, 150, 300, 450 and 600 kg K ha^{-1}) using potassium Sulfate (42 %K) as source of potassium and their combinations ,using factorial with RCBD in three replicates.

Table 1. some physical and chemical properties of soil

Physical properties		Value	Unite
	Sand	184	
	Silt	450	g kg^{-1}soil
	Clay	366	
Texture name	Silt clay loam		
Bulk density	1.31		*M*g m^{-3}
Chemical properties			
pH	7.5		
EC	0.8		dS m^{-1}
O.M	14		g kg^{-1}soil
Available N	25		
Available P	7.5		*mg* kg^{1}soil
Available K	340		
Equivalent $CaCO_3$	330		g kg^{-1}soil
Active $CaCO_3$	15.2		
CEC	29.3		$Cmol_c kg^{-1}$soil

Constant level of phosphorus (130 kg P ha^{-1}) was applied using TSP (21%P) as source of phosphorus. Soil Samples were taken at depth of 0-30 cm before transplanting and passed through 2mm sieve for soil analysis (Table 1) . The source of irrigation water was a well at the field experiment with pH =7.63 and EC = 0.5 dS m^{-1} using drip irrigation method and watermark for irrigation. Plant samples were taken at flowering stage for leaf and head analyses (21). Calculation of DRIS indices and norms were estimated according to Abd EI-Rheem, (1) and explained in Saleh(18). Statistical parameters were evaluated

according to Esmail *et al*, (9) and the comparisons among values according to Turkey's multiple range test at (P<= 0.05).Relative yield% was obtained by dividing treatment yield on maximum yield ×100.

RESULTS AND DISCUSSION

Application of nitrogen significantly increased yield of broccoli with N_2 giving the highest value of 20.663 *M*g ha^{1}compared to the lowest value of 15.915 *M*g ha^{1-} produced by N_0 (Table 2). These results are in agreement with Anwar *et al.* (2) who found that different levels of nitrogen increased yield of Broccoli plant and disagreed with Vagen, (22) who observed that nitrogen had no effect of on Broccoli. Application of potassium significantly increased yield of broccoli compared to control, the highest value was 19.905 *M*g ha^{-1} produced from K1 while the lowest value was 17.641 *M*g ha^{1-} produced from K_0(Table 2) .However,K_0 did not differ than K_3,which indicated that the response to K applications was not straight for word due to high level of available K in soil according to most literature (4). Comparable results were obtained by other investigators (7,17,24) Interaction between nitrogen and potassium levels had significant effect on yield of Broccoli. The highest mean value of 23.916 *M*g ha^{1-} was produced in K_1N_3 treatment, while the lowest 11.243 *M*g ha^{1-} was produced from N_0K_O treatment .These results are in agreement with Singh *et al.* (20) for Broccoli.

Table 2. Effect of levels of nitrogen, potassium and their interaction on yield of Broccoli

Treatment	Yield of plant *M*g ha^{-1}					
	N_0	N_1	N_2	N_3	N_4	Mean
K_0	11.243 ^{f}	18.700 ^{ae}	23.816 ^{a}	13.033 ^{ef}	21.416 $^{a-c}$	17.641 ^{b}
K_1	14.300^{c-f}	19.510 ^{ae}	21.500 ^{ab}	23.916 ^{a}	20.300 $^{a-d}$	19.905 ^{a}
K_2	19.200 $^{a-f}$	20.433 ^{ad}	20.850 ^{ad}	17.316^{af}	21.200 ^{ad}	19.800 ^{a}
K_3	14.250 ^{df}	15.816^{bf}	19.350 ^{ae}	18.783^{a-e}	18.983 ^{ae}	17.436 ^{b}
K_4	20.583 ^{ad}	23.800 ^{a}	17.800 ^{af}	16.250 $^{b-f}$	19.216 ^{ae}	19.530 ^{a}
Mean	15.915 ^{c}	19.651 ^{a}	20.663 ^{a}	17.859 ^{b}	20.223 ^{a}	

Table (3) shows the nutrient concentration in leaf and yield for broccoli plant. The establishment of the standard values of DRIS norms depended on concentration ratio of the treatment for the yields above 80% .These norms were established locally depending on the nutrient concentration in all plots and their ratio from the most high yielding plants treatments and also defined the nutrient ratio for all elements according to method adopted by Hassan, (11) in accordance with Walworth and Summer, (23), and Serra et al (19) using means, standard deviation (Std) and coefficient of variance(CV) for nutrient in combination treatments with 80% yield. DRIS index equal to zero indicating that the nutrient is in the optimum level while positive and negative values indicate unbalance (3).

Table 3. Percentage of nutrient concentration in leaf, yield and relative yield

treatment	N %	P %	K %	Yield. Mg. ha^{-1}	R. Y %
N_0K_0	4.15	0.18	2.25	11.233	47
N_OK_1	5.1	0.18	2.7	14.300	59.8
N_0K_2 1	5.75	0.37	2.43	19.200	80.3
N_0K_3	5.06	0.19	2.83	14.250	59.6
N_0K_4 2	5.65	0.15	2.67	20.583	86.1
N_1K_0	5.11	0.2	2.04	18.683	78.1
N_1K_1 3	6.25	0.26	2.5	19.416	81.2
N_1K_2 4	6.19	0.21	2.45	20.433	85.4
N_1K_3	4.5	0.33	2.48	15.816	66.1
N_1K_4 5	6.2	0.23	2.59	23.800	99.5
N_2K_0 6	6.1	0.221	2.29	23.816	99.6
N_2K_1 7	5.9	0.22	2.47	21.500	89.9
N_2K_2 8	5.44	0.25	2.54	20.850	87.2
N_2K_3 9	5.77	0.37	2.47	19.350	80.9
N_2K_4	6.4	0.23	2.45	17.800	74.4
N_3K_0	6.54	0.19	2.57	13.033	54.5
N_3K_1 10	5.95	0.34	2.42	23.916	100
N_3K_2	6.2	0.27	2.8	17.316	72.4
N_3K_3	6.34	0.38	2.5	18.783	78.5
N_3K_4	5.28	0.25	2.57	16.250	67.9
N_4K_0 11	5.75	0.48	2.43	21.416	89.5
N_4K_1 12	5.14	0.28	2.77	20.300	84.9
N_4K_2 13	5.76	0.45	2.72	21.200	88.6
N_4K_3	6.55	0.46	2.28	18.983	79.4
N_4K_4 14	6.11	0.75	2.61	19.216	80.3
The Norms are from 1 to 14					

Table 4. Nutrient ratio, Function, DRIS indices, AT , yield and relative yield for broccoli plant

treatment	Nutrient ratio			Function			INDICES			A.T	Yield *Mg.* ha^{-1}	R.Y%
	N/P	N/K	P/K	F(N/P)	F(N/K)	F(P/K)	N index	P index	K index			
N_0K_0	23.06	1.85	0.08	2.63	-28.94	-16.87	-13.16	-9.75	22.91	45.82	11.233	47
N_0K_1	28.40	1.89	0.07	9.43	-25.75	-25.97	-8.16	-17.70	25.86	51.72	14.300	59.8
N_0K_2	15.70	2.37	0.15	-8.79	1.93	4.48	-3.43	6.64	-3.21	13.28	19.200	80.3
N_0K_3	27.13	1.79	0.07	7.80	-33.49	-26.45	-12.84	-17.13	29.97	59.94	14.250	59.6
N_0K_4	36.85	2.12	0.06	20.17	-11.11	-34.50	4.53	-27.33	22.80	54.68	20.583	86.1
N_1K_0	25.98	2.50	0.10	6.35	8.50	-9.34	7.42	-7.84	0.42	15.68	18.683	78.1
N_1K_1	23.70	2.50	0.11	3.45	8.26	-6.35	5.86	-4.92	-0.96	11.72	19.416	81.2
N_1K_2	29.46	2.53	0.09	10.77	9.47	-13.96	10.12	-12.37	2.25	24.74	20.433	85.4
N_1K_3	13.61	1.83	0.13	-14.48	-30.31	1.19	-22.40	7.84	14.56	44.80	15.816	66.1
N_1K_4	26.87	2.39	0.09	7.48	2.81	-12.51	5.15	-10	4.85	20	23.800	99.5
N_2K_0	27.71	2.67	0.10	8.55	16.59	-9.31	12.57	-8.93	-3.64	25.14	23.816	99.6
N_2K_1	26.71	2.35	0.09	7.28	1.19	-12.88	4.20	-10.08	5.88	20.16	21.500	89.9
N_2K_2	22.05	2.14	0.10	1.35	-9.64	-9.07	-4.15	-5.21	9.36	18.72	20.850	87.2
N_2K_3	15.59	2.33	0.15	-9.26	0.20	4.46	-4.53	6.86	-2.33	13.72	19.350	80.9
N_2K_4	27.51	2.62	0.10	8.30	14.03	-9.79	11.17	-9.05	-2.12	22.34	17.800	74.4
N_3K_0	27.25	2.52	0.09	7.96	9.00	-10.99	8.48	-9.47	0.99	18.94	13.033	54.5
N_3K_1	17.49	2.48	0.14	-5.35	7.20	2.75	0.93	4.05	-4.98	9.96	23.916	100
N_3K_2	22.98	2.22	0.10	2.52	-5.62	-9.33	-1.55	-5.88	7.48	14.96	17.316	72.4
N_3K_3	16.70	2.53	0.15	-6.85	9.92	4.92	1.53	5.88	-7.42	14.82	18.783	78.5
N_3K_4	20.83	1.95	0.09	-0.21	-21.25	-10.36	-10.73	-5.08	15.81	31.62	16.250	67.9
N_4K_0	11.93	2.40	0.20	-20.29	3.28	15.48	-8.50	17.88	-9.38	35.76	21.416	89.5
N_4K_1	18.58	1.86	0.10	-3.47	-28.31	-8.05	-15.89	-2.29	18.18	36.36	20.300	84.9
N_4K_2	12.71	2.12	0.17	-17.42	-11.02	8.13	-14.22	12.77	1.45	28.44	21.200	88.6
N_4K_3	14.24	2.86	0.20	-12.66	25.50	15.49	6.42	14.08	-20.50	41	18.983	79.4
N_4K_4	8.15	2.34	0.29	-42.07	0.72	34.09	-20.68	38.08	-17.40	76.16	19.216	80.3

Table 5. the nitrogen, potassium and phosphorus status in broccoli plant depending on NBI values.

treatment	N %	P %	K %	NBIa	R. Y %
N_0K_0	Deficient	Deficient	Adequate	22.91	47
N_OK_1	Deficient	Deficient	Adequate	25.86	59.8
N_0K_2	Deficient	Adequate	Deficient	6.64	80.3
N_0K_3	Deficient	Deficient	Adequate	29.97	59.6
N_0K_4	Adequate	Deficient	Adequate	27.33	86.1
N_1K_0	Adequate	Deficient	Adequate	7.42	78.1
N_1K_1	Adequate	Deficient	Deficient	5.86	81.2
N_1K_2	Adequate	Deficient	Adequate	12.37	85.4
N_1K_3	Deficient	Adequate	Deficient	22.40	66.1
N_1K_4	Adequate	Deficient	Adequate	10.00	99.5
N_2K_0	Adequate	Deficient	Deficient	12.57	99.6
N_2K_1	Adequate	Deficient	Adequate	10.08	89.9
N_2K_2	Deficient	Deficient	Adequate	9.36	87.2
N_2K_3	Deficient	Adequate	Deficient	6.86	80.9
N_2K_4	Adequate	Deficient	Deficient	11.17	74.4
N_3K_0	Adequate	Deficient	Adequate	9.47	54.5
N_3K_1	Adequate	Adequate	Deficient	4.98	100
N_3K_2	Deficient	Deficient	Adequate	7.48	72.4
N_3K_3	Adequate	Adequate	Deficient	7.41	78.5
N_3K_4	Deficient	Deficient	Adequate	15.81	67.9
N_4K_0	Deficient	Adequate	Deficient	17.88	89.5
N_4K_1	Deficient	Deficient	Adequate	18.18	84.9
N_4K_2	Deficient	Adequate	Adequate	14.22	88.6
N_4K_3	Adequate	Adequate	Deficient	20.50	79.4
N_4K_4	Deficient	Adequate	Deficient	38.08	80.3

From Tables 3,4 and 5 it can be seen that the treatment combinations (N_3K_1) regarded as the most balance among studied interaction with (A.T) is (9.96) which produced from DRIS indices of 0.93, 4.05, - 4.98 for Nitrogen, Phosphorus and Potassium, respectively and gave yield of 23.916 *M*g ha^{-1} The nutrient balance indices in this treatment are quite close to zero and can be consider as the most optimum treatment. Values of absolute total (AT) were 45.82 and 9.96 for N_0K_0 and N_3K_1, respectively (Table 5) and these values were corresponded with 11.233 and 23.916 *M*g ha^{-1} and values of relative yield of (47% and 100%), respectively. All values between these two levels can be considered as either in excess (+ value) or in shortage (- values).According to DRIS indices and NBI values (19) it can be concluded that the most limiting nutrients in the studied area were N and P and plants will respond to their application. These results confirmed what can be expected from soil analysis (Table 1). The soil initially had very good level of K and low levels of N and P according to nutrient sufficient values mentioned by other investigators for nitrogen (12) and for phosphorus (4).

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