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RESPONSE OF NUTRIENT BALANCE INDEX IN *Triticum aestivum* L TO MYCORRHIZAL INOCULATION AND PHOSPHORUS FERTILIZER

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ABSTRACT

A pot experiment was conducted in green house of college of Science, University of Salahaddin Erbil, to study the effect of two levels (0, 20g.pot^{-1}) of mycorrhizal inoculation, four levels (0.0, 25, 50, 75kg.dounm^{-1}) of phosphorus fertilizer and their combination on nutrient balance index in *Triticum aestivum* L. Experiment was laid out in completely randomized design (CRD) with three replicates. The results indicate that the lowest nutrient balance index (0.833) was recorded from combination treatment (M_1P_2) compared to control (64.008). The DRIS index ranged from (-14.137 to +14.137) was considered adequate value without mycorrhizal inoculation. Whereas, the DRIS index with mycorrhizal inoculated treatment ranged from (-26.601 to +26.601) was considered adequate value.

KEYWORDS: *Mycorrhiza, Phosphorus, DRIS and Wheat.*

INTRODUCTION

Wheat is the main cereal crop in Iraq and constitutes the main food in the country, particularly the north region which has a total cultivation area. Itis average and total production are not consistently increasing to meet up the growing demand of Iraq population, thus a special attention should be given to produce higher yield, due to increase the population in the world on one hand and rise of price on the other hand. Mycorrhizal fungi are an important symbiotic relationship between fungi and plant roots, whereas the mycorrhazal infection enhan- ces plant growth, yield, and nutrient uptake like phosphate, especially when phosphate and other immobile nutrients are in short supply, they may also be beneficial when water in short supply. However such mycorrhizae are of a great agronomic and ecological significance (Khanam*et al.*,2006; Li,2005 and Li *et al.*,2005). In many agriculture production system, phosphorus has been identified as the most efficient essential nutrient after nitrogen, Plant analysis can be a useful tool for correcting plant nutrient deficiencies and imbalances, optimizing crop production and for evaluating fertilizer requirements(Baldock and Schulte,1996). (DRIS) is a recent approach for interpreting plant tissue analysis. The DRIS index scale that results from those calculations is continuous and easy to be understood (Walworth *et al.,*1986). This model is designed to determine when the nutrient contents of crops are excessive (positive indices), adequate (zero indices) or deficient (negative indices). The DRIS proposed by Beaufils (1973) has been used to determine the balance of N, P, K and S in wheat plant .Also many investigators has been studied DRIS approach like, Hanson, (1981); Sevenson *et al.*, (1988); Mackay et al., (1987); Al-Khafaji, (1993); Caldwell *et al.*, (1994); Soltanpour *et al.*, (1995) and Esmail*et al.*, (1999); Sultan (2005) and Darwesh, (2007). The calcareous soil are wide spread throughout the world involved Kurdistan region soils, thus the availability of phosphorus in these soil is low due to the high calcium carbonate ($CaCO_3$) content which led to chemical fixation of phosphorus. However, the studies on establishment norms of wheat crop under mycorrhiza inoculation and phosphorus fertilization in Kurdistan region are very rare , thus the objectives of this study are to evaluate norm of wheat crops in addition to determine nutrient index balance of wheat under mycorrhiza and phosphorus fertilization..

MATERIALS AND METHODS

This research was carried out in the glasshouse of the College of Science, University of Salahaddin-Erbil, to study the effect of mycorrhizal inoculation and different levels of phosphorus fertilizer on nutrient balance index in *Triticum aestivum* L by used modified DRIS equation. The plastic pots with diameter of 40cm and 20cmin height were used in this experiment, each pot packed with 20kg of air-dried soil. The sandy loam soil was collected from \Askikalak location, the soil sieved through 4 mm sieves, then sterilized by microwave oven in high power (1100w) which described by Razavidarbar, and Lakzain ,(2007). Some physical and chemical properties of the soil were recorded in table (1). These soil properties were determined according to methods described by Allen,(1976)and Black,(1965). Before planting, wheat grains were surface-sterilized in 3% sodium hypochlorite solution for 10 minutes and then soaked in distilled water for 12hours Li, (2005), then eleven grains were planting in each pot after germination thinned to five. For preparing the mycorrhizal inoculation the seeds of *Vicia faba* was sown in the field and irrigated four times in a week, after growing the roots of faba bean were taken for producing mycorrhizal inoculation. The roots were washed with water to remove the remaining adhering soil particles, then cut in to 1cm segments then mixed with sterilized soil after emphasized the present of mycorrhizal infection , each pot received 20 $g.pot^{-1}$ of mycorrhazal inoculation .(Mustafa, 2000).The infection of root was confirmed, by examine the root after clearing it by 10% KOH for 24 hours, then add to 10% HCl for 10 minutes after that washed it by tap water and stained with trypan blue in lacto glycerol, which described by Phillips, and Hayman (1970). The microscopic examination under (10x and 40x) explain that the mycorrhizal fungi was classified under vesicular-arbascular mycorrhizal fungi (VAMF). Fertilizers treatments consist of four levels (0, 25, 50,75 $kg.dounm^{-1}$) of super phosphate, and two level (0,20$g.pot^{-1}$) of mycorrhizal inoculation.Mycorrhizal inoculation was applied to each pot with sowing. Phosphorus fertilizer was applied ten days after germination. The fertilizer was evenly mixed with the soil. The factorial experiment was laid out in a complete randomized design (CRD) with three replicates. At harvest the plants were cut at soil surface from each pots, placing in weighted bag oven dried at $(65)^0$C for (48) hours and after that immediately the dry weight was obtained. Plant samples were taken at the tillering stage, samples were dried at 70°C for 48 h. After weighting and grinding with stainless steel mill, the samples were stored for chemical analysis. Plant samples were digested according to Schuffelen and Vanschaunou-wenburg .(1961) by using (1:1con. H_2SO_4 and H_2O_2).The N content was measured by the micro-Kjeldahl digestion method of Bremner and Mulvaney (1982). The P content was determined by the molybdenum blue colorimetric method of Black,(1965).. Calcium, Mg, Fe and Zn were determined by atomic absorption, the flame photometric method of Allen,(1976).was used to determined K and Na. Data was statistically analyzed by the computer using SPSS program. The pair comparisons were performed by least significant difference test (L.S.D) and Tukey's MSD produced at 5%and 1%level of probability (Steele and Torrie ,1969).

Table (1): Some physical and chemical properties of soil under study:-

physical properties		
Particle Size Distribution $g.kg^{-1}$	Sand	638.14
	Silt	295.18
	Clay	66.68
Soil texture	Sandy loam	
Saturation%	29.50	
Field capacity%	14.58	
Chemical properties		
pH	7.94	
ECe $dS.m^{-1}$	0.70	
Organic matter $g.kg^{-1}$	8.23	
Total $CaCO_3$ $g.kg^{-1}$	270	
Total nitrogen $g.kg^{-1}$	0.290	
Total phosphorus $g.kg^{-1}$	0.118	
Available phosphorus $mg.kg^{-1}$	2.78	
Cation $mmol.L^{-1}$		
Potassium	0.60	
Iron	0.0097	
Calcium	2.01	
Magnesium	0.76	
Sodium	0.82	

The DRIS indices were calculated by using the following index equations by Hallmark *etal.*, (1987):-

NIndex= $\frac{f(N/P)+f(N/K)+f(N/Ca)+f(N/Mg)+f(N/Fe)+f(N/DM)}{n}$

P Index= $\frac{-f(N/P)+f(P/K)+f(P/Ca)+f(P/Mg)+f(P/Fe)+f(P/DM)}{n}$

K Index= $\frac{-f(N/K)-f(P/K)+f(K/Ca)+f(K/Mg)+f(K/Fe)+f(K/DM)}{n}$

Ca Index= $\frac{-f(N/Ca)-f(P/Ca)-f(K/Ca)+f(Ca/Mg)+f(Ca/Fe)+f(Ca/DM)}{n}$

Mg Index= $\frac{-f(N/Mg)-f(P/Mg)-f(K/Mg)-f(Ca/Mg)+f(Mg/Fe)+f(Mg/DM)}{n}$

Fe Index= $\frac{-f(N/Fe)-f(P/Fe)-f(K/Fe)-f(Ca/Fe)-f(Mg/Fe)+f(Fe/DM)}{n}$

DM Index= $\frac{-f(N/DM)-f(P/DM)-f(K/DM)-f(Ca/DM)-f(Mg/DM)-f(Fe/DM)}{n}$

f(X/Y)= (X/Y / x/y -1)*100k/CVx/y if X/Y ≥ x/y

f(X/Y)= (1- x/y / X/Y)*100k/CVx/y if x/y ≥ X/Y

X and Y = nutrients, n- number of ratios, x/y- mean for X/Y, in reference population (high-yielding treatment). CV(x/y) - coefficient of variation for x/y, in reference population (high-yielding group).

RESULTS AND DISCUSSION

Table (2) shows that the combination between mycorrhizal inoculation and phosphorus fertilizer affected significantly (P≤0.01) the nitrogen, phosphorus, calcium, magnesium and potassium concentration, While affected non- significantly (P≥0.01) sodium concentration. Result showed that the highest values (27.376, 43.139 $mg.g^{-1}$), (3.717, 3.896 $mg.g^{-1}$) and (28.925, 3.842 $mg.g^{-1}$) of (nitrogen, calcium), (phosphorus, magnesium) and (potassium, sodium) were recorded in treatments (M_1P_2), (M_1P_1) and (M_1P_3) respectively. While the lowest values (11.926, 1.189 $mg.g^{-1}$),(18.796, 22.060 $mg.g^{-1}$)and(2.348, 1.595 $mg.g^{-1}$) of (nitrogen, phosphorus), (potassium, calcium) and (sodium, magnesium) were recorded in treatments (M_0P_0), (M_0P_2) and (M_0P_3, M_0P_1)respectively. The result indicated that the highest values of nutrient concentration in all phosphorus level were recorded in mycorrhizal plant. This result could be explained on the ground that the addition of mycorrhizal inoculation with convenient rates of phosphorus fertilizer increase the nutrient content of plant, via enhancing the root growth and increasing the root hair length, beside increase the root surface area, mycorrhizal hyphae may also get into smaller soil pores and compete effectively with other microorganism to obtain nutrient. This result partially agreed with that recorded by Gadd*et al*., (2006).However the present result confirm that wheat largely depending on the mycorrhizal symbiosis for uptake the nutrient particularly P, Mg and N for achievement the normal growth under normal soil nutrient condition, the increased concentration of P in plant paralleled the increase in plant dry matter production, suggesting that P was element limiting plant growth (Stewart, 2000) and Mohammad *et al.*,(2004).in addition the DRIS nutrient analysis interpretation system in figure (3) indicate clearly that the major effect of inoculation with mycorrhiza on plant growth was through an improved nutrient uptake, as well as the application of different level of phosphorus fertilizer to calcareous soil rapidly become unavailable by producing poorly soluble component, the plant root unable to absorb it, the application of mycorrhizal inoculation with phosphorus fertilizer reduced this problem by producing the symbiosis association with plant root and increase availability through solublisation of low available phosphates by lowering pH or excreting organic acid, which increase the effectiveness of exudates for nutrient mobilization not only phosphorus but also micronutrient.

Table (2): Combination effect of mycorrhizal inoculation and phosphorus fertilizer on some nutrient concentration of *Triticumaestivum* L.

Treatments	Nutrients concentration ($mg.g^{-1}$)					
	N	P	Ca	Mg	K	Na
M_0P_0	11.926	1.189	31.435	1.834	21.315	2.449
M_0P_1	15.239	2.228	24.421	1.595	21.477	3.523
M_0P_2	11.968	2.978	22.060	1.684	18.796	2.449
M_0P_3	14.883	2.973	32.870	1.755	19.717	2.348
M_1P_0	24.262	2.537	35.222	3.823	27.788	3.053
M_1P_1	26.210	3.717	32.792	3.896	28.654	3.120
M_1P_2	27.376	3.157	43.139	3.809	27.625	2.415
M_1P_3	22.399	3.139	36.681	3.774	28.925	3.824
Tukye's(0.01)	**6.172**	**1.775**	**9.319**	**0.448**	**4.2237**	**1.776**

The nutrient status of plant was assessed by comparing nutrient concentration data with the nutrient indices derivate from the diagnosis and recommendation integrated system, nutrient analysis by DRIS are based on comparison of ratios of element concentration in the experimental samples with the same ratio from high yield, population. Because of it is reliance on nutrient ratios, the use of DRIS minimizes morphogenic and genotypic effects on the accuracy of deficiency diagnoses, predicts which nutrient is a limiting factor, and provides an expression for nutrient balance. The lower the sums (irrespective of sign) of the indices, mean the best nutrient balance. Plant nutrient responses to mycorrhizal fungi are evaluated to permit the selection of mycorrhizal fungi both for their effect on the alleviation of specific nutrient deficiencies and for their compatibility with a host plant species or cultivar. The combination effect of mycorrhizal inoculation and phosphorus fertilizer on nutrient indices and nutrient balance indices (NBI) of wheat *Triticum aestivum* L.were recorded in the table (3). Means value of data revealed that the lowest nutrient balance index were recorded from combination treatment (M_1P_2) and attained (0.833) compared to control (64). The nitrogen and phosphorus index increase from (-0.629and -28.882) to (-0.154 and 0.112), while calcium, magnesium, potassium and sodium index decreased from (1.742, 18.104, 9.938, and 2.220) to (-0.052, -0.053, -0.045 and 0.461) respectively. The figures (1) shows the combination effect of mycorrhizal inoculation and phosphorus fertilizer on relationship between N, P, Ca, and Mg index and their concentration in leaf, the optimum balance of nutrient (N:-0.154, P:-0.112, Ca:-0.052,and Mg:-0.053) index were produced by application of mycorrhizal inoculation with $50kg.dounm^{-1}$ of phosphorus fertililzers. This results confirm that the colonization of roots by the colonization also resulted in better balance of the nutrient of wheat, as shown by the lower sum of DRIS index values for the mycorrhizal plants.

Table (3): Combination effect of mycorrhizal inoculation and phosphorus fertilizer on some nutrient indices, nutrient balance indices (NBI) and total dry matter of *Triticum aestivum* L. .

Treatments	Nutrient Index								
	N Index	P Index	Ca Index	Mg Index	K Index	Na Index	TDW index	NBI	TDW ($g.Pot^{-1}$)
M_0P_0	-0.629	-28.882	1.742	18.104	9.938	2.220	-24.932	64.008	24.342
M_0P_1	-0.938	-8.711	-0.679	-1.019	8.330	2.429	5.865	22.692	40.527
M_0P_2	-3.680	18.006	-1.141	-18.427	2.119	1.120	20.035	46.495	39.896
M_0P_3	-2.139	0.513	0.585	-5.678	4.559	1.530	6.296	15.634	39.070
M_1P_0	0.281	-49.651	0.094	44.864	4.115	1.418	-11.210	101.544	37.227
M_1P_1	-1.214	-18.983	-1.591	18.729	0.905	2.684	-5.291	44.635	38.035
M_1P_2	-0.154	-0.112	-0.052	-0.053	-0.045	0.320	0.965	0.833	57.079
M_1P_3	-1.079	-30.460	0.225	27.740	2.173	2.763	-13.623	65.802	*35.558*

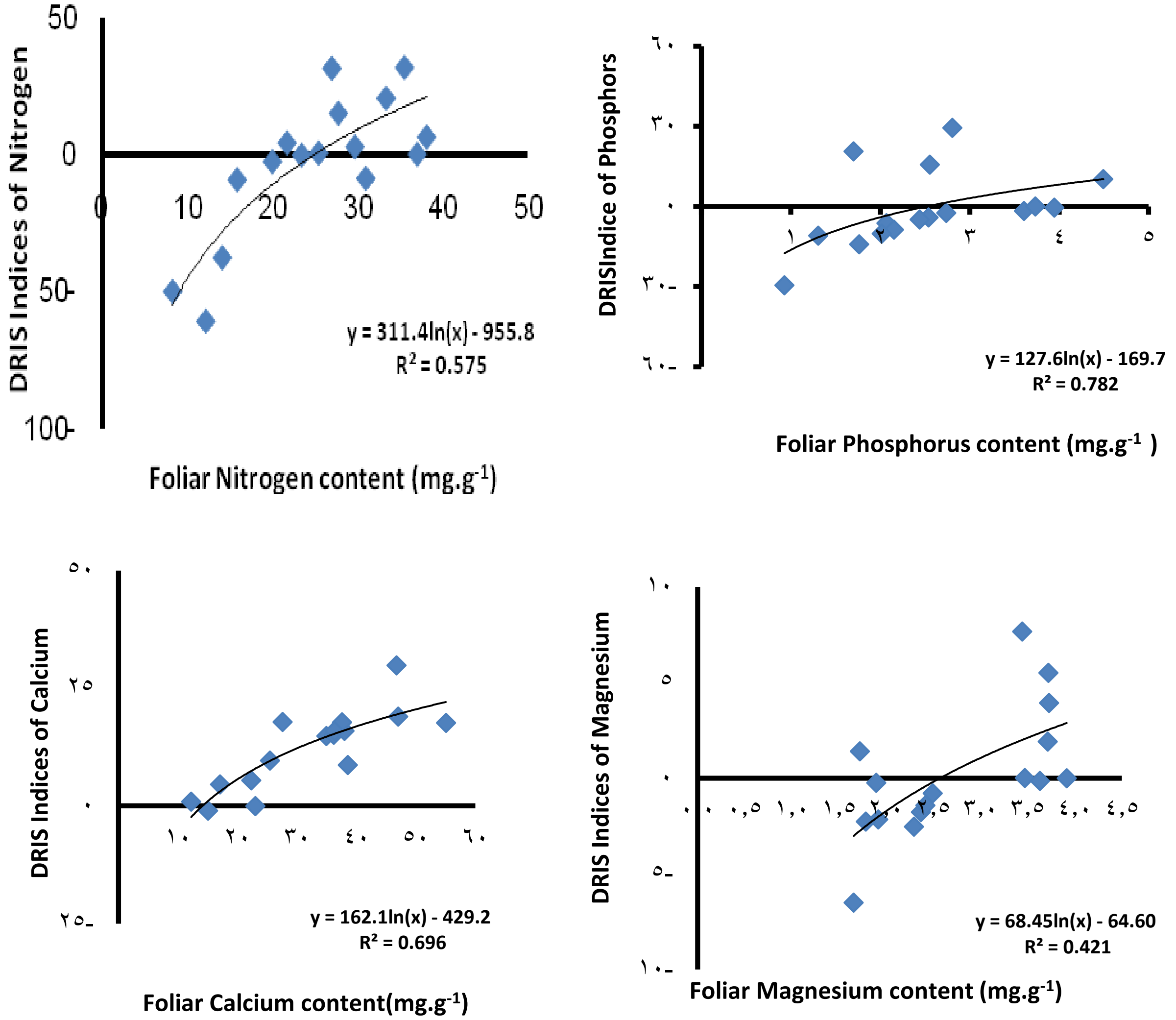

Figure (1): Relationship between DRIS indices of N, P, Ca, Mg and their foliar content (mg.g^{-1}) of *Triticumaestivum* L.

Figure (2) refers to DRIS index interpretation without mycorrhizal inoculation as affect by phosphorus fertilizer of *T. aestivum* L., the index of nutrient less than (-14.137)indicates to deficiency, but the nutrient index more than (+14.137) indicates to a luxury consumption of nutrient , while a DRIS index value from (-14.137 to +14.137) are considers adequate concentration. while figure (3) refers to DRIS index interpretation with mycorrhizal inoculation as affect of phosphorus fertilizer of *T. aestivum*L., the index of nutrient less than (-26.601) indicates to deficiency, but the nutrient index more than (+26.601) indicates to a luxury consumption of nutrient , while a DRIS index value from (-26.601 to +26.601)were considers adequate . these range of DRIS were computed by multiply the nutrients of the treatment which obtained 75%of maximum total dry matter, then the average value of nutrient balance index obtained for treatment which gave the total dry matter equal or more than this value which obtained in the high total dry matter after that this range divided by two beside adding the + and – sign to the value (Darwesh, 2007). It appears from figure (2 and 3) that the range of nutrient indices incase of the mycorrhizal inoculation more than nonmycorrhizal inoculation this may be due to the role of mycorrhizal inoculation in increasing nutrient availability for plant.

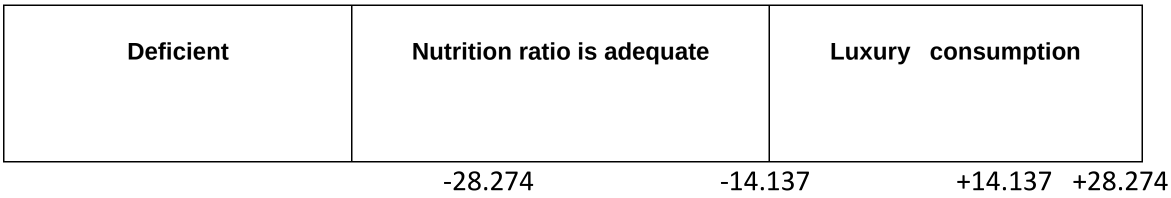

Figure (2): The DRIS indices interpretation of *Triticum aestivum* L. without mycorrhizal inoculation .

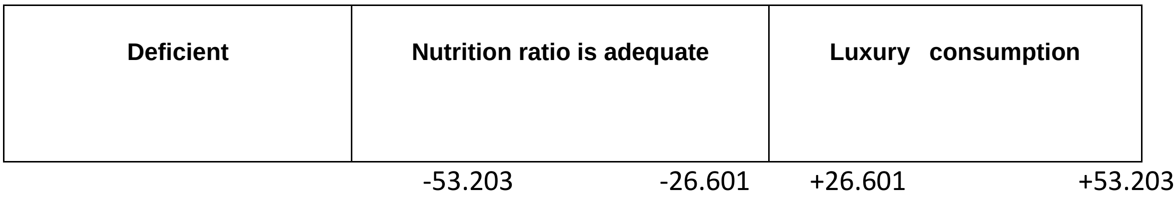

Figure (3): The DRIS indices interpretation of *Triticum aestivum* L. with mycorrhizal inoculation

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کاردانەوەی لەنگەرکرتنی توخمەخۆراکیەکانلە گەنمی *Triticumaestivum* L**بۆ کوتراوی مایکۆرایزا و پەیینی فۆسفاتی**

پوختە

ئەم تویژینەوەیە لە خانووی شووشەی کولیژی زانست،زانکۆی سەلاحەددین- هەولیر ئەنجامدرا. بۆ زانینی کاریگەری دوو ئاست (0، 20گم.ئینجانە[1-]) لە کوتراوی مایکۆرایزا و چوار ئاست (0، 25، 50، 75 کگم.دونم[1-]) لە پەیینی فۆسفاتی وە هەروەها تیکەل کردنیان لەسەر لەنگەرکرتنی توخمەخۆراکیەکان جۆری گەنم *Triticumaestivum* L. **و تاقیکردنەوەکە داریژرا بەبەکارهینانی فاکتۆریەل لە دیزاینی هەرەمەکی تەواودا ، بە سێ جار دووبارە.لە ئەنجامدا دەرکەوت کە نزمترین بری بەلگەی هاوسەنگی توخمە خۆراکی (0.833) تۆمارکرا لە مامەڵەی (M1P2) بە بەراورد بەمامەڵەی کۆنترول(64). بری بەلگەی DRIS کە دەکەویتە نیوان(-14.137- +14.137) بەبریکی گونجاو دادەنریت لە مامەڵەی بێ مایکۆرایزا، بەلام لە مامەلەی کوتراو بە مایکۆرایزا بەلگەی DRIS دەکەویتە نیوان (-26.601 - 26.601 +)ەبریکی گونجاو دادەنریت.**

أستجابة دليل الأتزان الغذائي في الحنطة ***Triticumaestivum* L** **للتلقيح بالمايكورايزا والسماد الفوسفاتي**

الخلاصة

اجريت هذه الدراسة فى البيت الزجاجى التابعة لكلية العلوم ، جامعة صلاح الدين – أربيل،لدراسة تأثير مستويين (0، 20غم.سندانة[1-])من تلقيح المايكورايزا، أربعة مستويات (0، 25، 50، 75 كغم.دونم[1-]) من السماد الفوسفاتى و التداخل بينهما في ألأتزان الغذائى في ***Triticumaestivum* L.** وذلك باستخدام تجربة عاملية فى تصميم العشوائى الكامل و بثلاثة مكررات.حيث كان ادنى دليل للأتزان الغذائي (0.833) وسجل في المعاملة (M_1P_2) مقارنة بمعاملة السيطرة (64).وقيمة الدليل DRIS تتراوح بين (-14.137 - +14.137) حيث اعتبرت قيمة ملائمة في معاملة بدون تلقيح مايكورايزا، قي حين معاملة التلقيح بالمايكورايزا كانت قيمة الدليل DRIS تتراوح بين(-26.601 - +26.601) حيث اعتبرت قيمة ملائمة