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THE IMPACT OF ORGANIC N FERTILIZER AND *TRICHODERMA* SP ON THE GROWTH AND YIELD OF TWO SWEET PEPPER VARIETIES UNDER THE GREENHOUSE

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Abstract

This experiment was conducted at Horticulture college (USAMV Bucharest) during the summer season of the year 2017 to investigate the growth and yield of sweet pepper varieties (‘Dinamica’ F1, ‘Abadia’ F1 and ‘Abadia’ F1-grafted on Emperador) planted under the greenhouse as influenced by DIX 10N (organic fertilizer) with dose (300 g/m^2 DIX 10 N) and soil contaminated with Trichoderma sp fungus. The results of the experiment demonstrated that the majority of growth parameters and yield components were significantly increased with all treatments of all varieties. Results indicated that there is difference in pattern of plant speed and length growth effected by varieties and treatments. Results showed (‘Abadia’ F1-grafted) with (DIX 10N+Trichoderma sp) gave the strongly positive effect in all characters studied gave (1285.99 g, 8.36 µmol m^{-2} s^{-1}, 22.96 , 24.90%) for (yield\plant, photosynthesis, plant and root dry matter %) respectively while the highest content of chlorophyll and (N,P,K) in leaves were recorded in ‘Dinamica’ F1 with (DIX 10N+Trichoderma sp) gave (134.73 µmol m^{-2}) and (230.30ppm , 198.01ppm, 4773.32ppm) respectively. ‘Abadia’ F1-grafted variety had superior results between the other varieties with all properties evaluated.

***Key words**: fertilizer, fruit yield, greenhouse, plant growth, sweet pepper varieties, Trichoderma sp.*

INTRODUCTION

Sweet pepper (*Capsicum annuum* L.), belongs to the *Solanaceae* family, is one of the most varied and widely used foods in the world; it was originated in Mexico and Central America regions and Christopher Columbus encountered it in 1493. Pepper is grown as an annual crop due to its sensitivity to frost and is actually a herbaceous perennial and will survive and yield for several years in tropical climates (Kelley and Boyhan, 2009; Vasile et al., 2010). Green peppers are contains three to six times as much vitamin C as orange (Bosland and Votava, 2007). One medium green bell pepper can provide up to 8 percent of the recommended daily allowance of Vitamin A, 180 percent of Vitamin C, 2 percent of calcium and 2 percent of iron (Kelley and Boyhan, 2009). Its fruits are harvested and consumed at different maturity stages: green, red and not fully ripe (Leja et al., 2008). Vegetable grafting is an innovative technique with an increasing demand by farmers. Grafting consists of association between two fragments of plants: a rootstock and a scion. By its root system, the rootstock provides the necessary food to the growth and engenders an additional strength to the new plant. The scion corresponds to the aerial part of the new plant, it will bring the productive characters preferred (Zijlstra et al., 1994). This technique was adopted in the Mediterranean area when the grafting was proposed as like as an alternative to the applications of methyl bromide to control the soil-borne diseases and to increase the productivity of cultures (Ioannou, 2001; Rouphael et al., 2010). The grafting is a major base of agricultural practices because of the advantages which it brings, of which resistance to the root diseases, improvement of the productivity of the cultures and for its requirement for the biological and durable production of tomato (Lee and Oda, 2003;Rivard, 2006). The nutritional quality of the fruits, especially as an excellent source of antioxidants- ascorbic acid, carotenoids and phenolic compounds - makes the daily intake of pepper a health protecting factor in the prevention of chronic human degenerative and systemic sicknesses including cancer, diabetes, liver cirrhosis and cardio-vascular diseases (Navarro et al., 2006; Nwose, 2009). Thus, pepper has attained the status of a high-value crop as the fruits are in high demand because of the pungency and pleasant flavour (Umesh, 2008).

Nutrient supply constituted an important aspect of the improved technologies developed and whose widespread adoption continues to ensure higher fruit yields, better quality and yield stability needed for the international competitiveness of intensive vegetable production systems (Hochmuth and Hanlon, 2010). Nitrogen is an essential element required for successful plant growth and production. It's required for cellular synthesis of enzymes, proteins, chlorophyll, DNA and RNA. Inadequate supply of available N frequently results in plants that have slow growth, depressed protein levels, poor yield of low quality and inefficient water use (Hayat et al., 2010). Epstein and Bloom (2005) observed that even at low rates, fertilizer enhances fruit yields dramatically but excessive rates can give negative effects on crop nutrient use efficiency and produce diminishing financial returns. As well as organically produced crops have increased nutritional value than conventionally produced crops (Rembiałkowska, 2007; Lairon, 2010). The basic way of providing plants with essential nutrients is soil fertilization in which mineral elements are taken up by plant root system (El-Dakish, 2004). Previous studies have indicated that application of organic fertilizer fulfils the requirements of sustainable agriculture, and organic fertilizer has apparent advantages over chemical fertilizer in many aspects. For example, organic fertilizer has higher organic matter content and richer nutrient elements; it can enhance soil physical properties mainly by improving aggregate stability and decreasing soil bulk density; it can also improve soil biological and biochemical properties and optimize soil microbial community structure (Diacono and Montemurro 2010). This means that organic fertilizers have already proved ability to produce food with high quality standards. For that it's noticed that using DIX 10N treatment give highest grain of maize yield and 1.000 grain weight (Vesna et al, 2014).

Trichodermasp enriched biofertilizers are being used due to their recognized roles in growth, yield and nutritional quality of various crops. Sunautapongsuk et al., 2006) reported that *Trichoderma sp* produces large amounts of organic acids that dissolve phosphates and calcium, increasing soil fertility and positively reflecting the good growth of the plant. The increase of soft and dry weights of the plant is the result of the action of the fungus that works on the readiness of the elements and make them soluble in facilitating the plant absorption, especially the element of phosphorus, nitrogen and potassium (Diacono and Montemurro, 2010). *Trichoderma sp.* also stimulates the plant's defensive response against pathogens, which is positively reflected on plant growth indicators (Hammerschmidt et al., 2001).

The aim of experiment was to determine nutritional quality of DIX 10N (organic fertilizer) and *Trichoderma sp* to produce highest parameters growth and yield in sweet pepper varieties.

MATERIALS AND METHODS

This experiment was conducted at Horticulture Faculty (USAMV) in Bucharest during the summer season of the year 2017 to investigate the effect of providing DIX 10N (D) (organic fertilizer) at rate (300 g/m^2) and soil contaminated with*Trichoderma sp* (T) at rate (1% fungus per water) on growth and yield of sweet pepper varieties: ‘Dinamica’ F1, ‘Abadia’F1(non-grafted) and ’Abadia’ grafted (G) on ‘Emperador’ variety (tomato rootstock).All the seedlings bought from the local market and planted in 14-04-2017 under the greenhouse. The distance 0.5 m between plants in the same row and 0.8 m between rows, the Dix10N fertilizer was provided to the soil before planting and the contamination with *Trichoderma sp.* done by injected to the root system after planting by a week. The experimental soil was sandy loam in texture with pH of 6.55, E.C of 0.180 dSm^{-1}. The available N-NO$_3$ of 34.33ppm, N-NH4 of

112.54 ppm, phosphorus and potassium contents were 21.0 ppm and 177.72 ppm respectively. Randomized complete block design (factorial) consisted of 3 randomised blocks with 4 treatments of biofertilizer (Dix10 N, *Trichoderma* (*T*), Dix10 N (N)+*Trichoderma* (N+*T*) and control (C) and 3 cultivars ('Dinamica', 'Abadia' and 'Abadia' G). Each treatment consisted of 3 replicates and each replicates cultivated by 5 plants. Plants were irrigated using drip irrigation when needed depending on the moisture status of the soil and requirement of plants, also the plants were kept free from weeds, insects, and diseases using standard growing management. The results were taken after 9 weeks for each plant harvested. The data were subjected to analysis of variance (ANOVA) the statistical systems (SAS 6.12) package. Comparison of multiple means was performed using the least significant difference (LSD) test at the 5%. The following growth and yield parameters were measured:

1. Plant height (cm): measured every week.
2. Total yield (g): done by collect the fruits from each replicate then weight them and divided to get the average of plant yield.
3. Photosynthesis ($\mu mol\ m^{-2}\ s^{-1}$): estimated after 4 weeks by using a portable device LCi (ADC BioScientific Ltd.).
4. Plant&Root dry matter%: At the end of growing season, 3 plants from each replicate selected to measure plant dry weight and root dry weight. The samples kept in oven for 24 hours in 105˚C. After 24 hours the samples weighted with a digital scale then obtained the percentage of (Plant&Root dry matter%) .
5. Chlorophyll content in leaves ($\mu mol\ m^{-2}$): determinate by using Chlorophyll meter device (CCM-200 PLUS).

6.Leaves content of NPK :

a. N-NO3 leaf content according to (Griess assay)

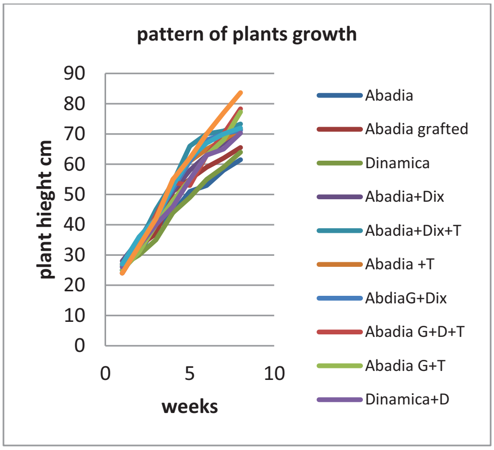
b. (P-PO4 & KO4) leaf content according to (Duval reagent and spectrophotometer)

c. KO4 leaf content according to (flame spectrophotometer)

These methods are according to the standards in Romania: ISO9001 (ICPA, 1987).

RESULTS AND DISCUSSIONS

All treatments tended to increase the yield and vegetative growth of sweet pepper compared with the control. The unfertilized plants produced the poorest plants compared with other fertilizer treatments. In Fig (1) its clearly showed difference in the growth pattern between the pepper varieties due to the effect of varieties and the biofertilizer treatments which improved nutrition of the plants. The highest plant hight between the varieties were represented by 'Abadia' G has been given 66.67cm while the maximum plant height between the combinations recorded with ('Abadia' G +T, 'Abadia' grafted + D and *T* and 'Dinamica'+ D and *T*) were (77.33, 78.33, 83.67 cm) respectively.



D = Dix 10 N,*T*=*Trichoderma*

Fig 1. The effect of treatments and varieties on pepper growth pattern

This result agrees with (Volkan and Hakan, 2018) found plants of pepper height was slightly influenced by grafted. In addition to the effect of organic fertilizer Dix10 N (D) contains a large percentage of organic elements that are essential for maintaining soil fertility, eases up the gradual absorption of the nutrients from the soil, improves soil structure and increases water retention capacity (Nicolae et al., 2014). For that it's noticed that using DIX 10N treatment give highest grain of maize yield and 1.000 grain weight (Vesna et al., 2014).

Effect of the D and *T* on some plant growth and yield parameters

Results in (Table 1) showed high effect for all parameters are the highest (except root dry matter) was obtained by the combination in ('Abadia' G+D, *T*) the maximum data for plant yield, chlorophyll content in leaves and photo-synthesis were recorded (19.56 %, 1227.56 g, 128.70 μmol m^{-2} and 7.63 μmol $m^{-2}s^{-1}$) respectively. While the control treatment showed minimum values were (16.36%, 1174.26 g, 120.7 μmol m^{-2} and 5.65 μmol m^{-2} s^{-1}) respectively.

Table 1. Effect of (D and *T*) on growth properties and yield of sweet pepper varieties

Treat-ments	Plant dry matter %	Root dry matter %	Yield/ plant g	Chloro-phyll *μmol m^{-2}*	Photo-synthesis *μmolCO_2 m^{-2} s^{-1}*
N	18.54ab	21.40	1203.62b	127.52a	7.38a
T	17.79b	20.56	1210.25b	125.87b	6.43b
N +*T*	19.56a	21.83	1227.56a	128.70a	7.63a
C	16.36c	18.03	1174.26c	120.7c	5.65b
	1.26	NS	11.67	1.63	0.82

Means in a column followed by the same letters are not significantly different at 5% level of probability

D = Dix 10 N,*T*=*Trichoderma* ,C= control

This result may due to the direct effect of *Trichoderma* in addition to the abundance of organic (D). (Bhuvaneswari et al., 2014) found that the *Trichoderma* effect chilli pepper plants and increased significantly in all plant growth parameters. And also itwas demonstrated that grafting directly affects plant yield (Nielsen and Kappel, 1996). Its influence can be exerted by the interaction of some or all of the following processes: increase of water and nutrient uptake due to the rootstocks vigorous root system (Lee, 1994), enhanced production of endogenous-hormones (Zijlstra et al., 1994), and enhancement of scion vigour (Leoni et al., 1990).

Effect of the varities on some plant growth and yield parameters

Data in Table (2) indicated that. There was no differences determinate plant dry matter, root dry matter and photosynthesis between varieties while it was observed that there is an increase in yield per plant significantly with 'Abadia' G were obtained 1223.39g but the highest chlorophyll pigment recorded with 'Dinamica' variety at129.47μmolm^{-2}. This may due to the difference of genetic between the varieties and the activity of tomato rootstock.

Table 2. Effect of varieties on growth properties and yield of sweet pepper plants

Varieties	Plant dry matter %	Root dry matter %	Yield/ plant g	Chloro-phyll *μmol m^{-2}*	Photo-synthesis *μmolCO $_2m^{-2}$ s^{-1}*
'Dinamica'	18.65	21.22	1205.91b	129.47a	7.21
'Abadia'	17.80	20.41	1204.64b	125.28c	6.81
'Abadia'G	19.45	22.15	1223.39a	127.35b	7.41
L.S.D	NS	NS	16.67	1.63	NS

Means in a column followed by the same letters are not significantly different at 5% level of probability

Effect of the D AND *T*and varieties on some plant growth and yield parameters

Data in Table (3) showed significant effects of the combination of varieties with all properties studied. Although the different responds between varieties to the application of (D and *T*) but it's clearly showed that the treatment ('Abadia'G+D and *T*) had superior effect with all characters studied were recorded (22.96%, 24.90%, 1285.99g, 131.99 μmol m^{-2}, 8.*36 μmol m^{-2} s^{-1}*) for (plant dry matter%, root dry matter%, yield per plant, chlorophyll content, photosynthesis) respectively. Comparing with control treatments which recorded minimum values with all the characters studied.

Generally, it has been reported that grafting promotes vegetative growth at different levels dependent on rootstock.

Promoted vegetative growth (plant height) was explained by the vigorous root system of rootstocks, which are often capable of absorbing water and plant nutrients more efficiently than scion roots and serve as a good supplier of endogenous hormones (Kato and Lou, 1989; Romero et al, 1997; Cohen and Naor, 2002). In addition to the plants affected by the status of soil nutrients, especially nitrogen. Therefore, the pepper crop is expected to benefit from nitrogen fertilizer application as the adequate supply would correct nitrogen deficiency and result in rapid vegetative growth, deep green colour and higher fruit yield (Brady and Weil, 2002). Also the fungus that works on the readiness of the elements and make them soluble in facilitating the plant absorption, especially the element of phosphorus, nitrogen and potassium (Matrood, 2015).

Table 3. Effect varieties with D and *T*on yield and some growth properties of sweet pepper

Treatments	Varieties	Plant Dry matter (%)	Root dry matter (%)	Yield/ plant (g)	Chloro-Phyll *(µmol m⁻²)*	Photosynthesis *µmolCO₂ m⁻² s⁻¹*
D	'Dinamica'	18.88bc	22.36b	1221.63b	129.86c	7.70a
	'Abadia'	18.54c	20.73c	1206.36b	127.63d	7.80a
	'Abadia'G	20.11b	22.96b	1220.06b	128.06cd	8.13a
T	'Dinamica'	19.07bc	20.93c	1217.16b	128.76cd	7.16ab
	'Abadia'	18.65c	22.86b	1216.66b	126.76de	6.40b
	'Abadia'G	17.88cd	22.33b	1219.20b	129.90c	7.13ab
D+ *T*	'Dinamica'	20.01bc	22.06b	1218.40b	134.73a	8.11a
	'Abadia'	18.44c	21.96bc	1207.56b	128.64cd	8.04a
	'Abadia'G	22.96a	24.90a	1285.99a	131.99b	8.36 a
C	'Dinamica'	16.65d	19.56d	1166.45c	124.56e	5.89b
	'Abadia'	15.57d	16.12e	1188.01c	118.09f	5.03b
	'Abadia'G	16.86d	18.43d	1168.32c	119.45f	6.03b
L.S.D		1.36	1.15	22.32	2.22	1.22

Means in a column followed by the same letters are not significantly different at 5% level of probability
D = Dix 10 N,*T*=*Trichoderma* ,C= control

Effect of the D AND *T* on NPK concentration in leaves

Data in Table (4) showed significant effect of (D and *T*) on NPK content in leaves the combination of (D and *T*) recorded highest concentration of NPK were (214.98,180.11, 4728.32 ppm) comparing with control treatment given (154.66, 117.04, 3612.88ppm) respectively.

Table 4. Effect of D and *T* on NPK concentration in leaves of sweet pepper

Treatments	N-NO_3ppm	PO_4ppm	Kppm
D	167.77bc	153.17b	4261.66c
T	182.88b	161.59b	4445.44b
D +*T*	214.98a	180.11a	4728.32a
C	154.66c	117.04c	3612.88d
L.S.D	15.32	12.23	106.43

Means in a column followed by the same letters are not significantly different at 5% level of probability
D = Dix 10 N,*T*=*Trichoderma* , C= control

Effect of the varieties on NPK concentration in leaves

Results in Table (5) clearly showed that the 'Abadia' F1 recorded the lowest concentration in NPK comparing with other varieties has been given (171.58, 139.80, 4217.91 ppm).

Table 5. Effect of varieties on NPK content in leaves of sweet pepper

Varieties	N-NO_3 ppm	PO_4 ppm	Kppm
'Dinamica'	184.90a	167.51a	4287.07a
'Abadia'	171.58b	139.80c	4217.91b
'Abadia' G	183.74a	151.62b	4281.33a
L.S.D	5.34	7.21	7.54

Means in a column followed by the same letters are not significantly different at 5% level of probability
D = Dix 10 N,*T*=*Trichoderma* ,C= control

Effect of the varieties with(D and*T*) on NPK concentration in leaves

The analysis showed superior concentration of NPK in pepper leaves with all combinations between varieties with (D and *T*).On the other hand, the variety 'Dinamica' combined with (D and T) showed higher concentration of NPK in pepper leaves was given (230.30,198.01, 4773.32ppm) but also followed by 'Abadia' G combined with (D and *T*)were given(216.33, 179.00, 4766.66ppm)respectively (Table 6).

Table 6. Effect of D and *T* on NPK content in leaves of sweet pepper varieties

Treat-ments	Varieties	N-NO_3 ppm	PO_4 ppm	K ppm
D	'Dinamica'	167.00e	176.94bc	4278.33f
	'Abadia'	165.33e	138.26d	4246.66f
	'Abadia' G	171.00e	144.33d	4260.00f
T	'Dinamica'	183.33d	178.78b	4476.66d
	'Abadia'	174.00de	149.66cd	4386.66e
	'Abadia' G	191.33cd	156.33cd	4473.33d
D + *T*	'Dinamica'	230.30a	198.01a	4773.32a
	'Abadia'	198.33c	163.33c	4645.00c
	'Abadia'G	216.33b	179.00b	4766.66b
C	'Dinamica'	159.00f	116.33e	3620.00g
	'Abadia'	148.66 f	107.96e	3593.33g
	'Abadia'G	156.33f	126.85e	3625.33g
L.S.D		10.73	15.23	68.45

Means in a column followed by the same letters are not significantly different at 5% level of probability
D = Dix 10 N, *T*=*Trichoderma* ,C= control

The maximum of the highest growth characters may be due to the better physico-chemical properties of Dix 10N (D) which contains 10% N, 3% P_2O_5 and 3 K_2O and It is a good source of organic matter 41% which would have improved the physico-chemical properties of soil. In addition to these, *Trichoderma* (*T*) produces large amounts of organic acids that dissolve phosphates and calcium, increasing soil fertility and positively reflecting the good growth of the plant (Sunautapongsuk et al., 2006). Although using organic fertilizers led to lower soil bulk density produced growth promoting hormone that causes better root network of plant and can improve plant growth development by providing better soil physical condition for root growth and development that causes higher root dry weight% this results agree with (Dynes, 2003).

CONCLUSIONS

The grafting improved the agronomic behaviour of 'Abadia' pepper and highest parameters of growth and yield recorded with 'Abadia' G combined with Dix N10 and *Trichoderma* (D and T) compared with the control and other treatment this was apparently due to improved nutrition of the fertilized plants. In addition, the treatment 'Dinamica' treated with combined with Dix N10 and *Trichoderma* (D and T) recorded highest concentration of NPK in leaves and the results declared there is difference in responding (D and *T*) as well as the varieties treatments. This was apparently due to improved nutrition of the fertilized plants and genetic factor.

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