ZANCO Journal of Pure and Applied Sciences
The official scientific journal of Salahaddin University-Erbil
https://zancojournals.su.edu.krd/index.php/JPAS

ISSN (print):2218-0230, **ISSN (online):** 2412-3986, **DOI:** **http://dx.doi.org/10.21271/zjpas**

RESEARCH PAPER

A comparison between the effects of degraded and non-degraded organic matters on the suppression of chickpea fusarium wilt caused by *Fusarium oxysporum f. sp. Ciceris*

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A B S T R A C T:

A field study was conducted in Girdarasha research station, belongs to the College of Agricultural Engineering Sciences (CAES), Salahaddin University, Erbil Province, Kurdistan Region, Iraq. The objective was to investigate the effects of adding plant materials on the suppression of chickpea fusarium wilt disease caused by *Fusarium oxysporum* f. sp. *ciceris*. Two plant residues, fresh (non-degraded) and composted (degraded) from three plant sources of leaves were added to the soil. Eucalyptus (*Eucalyptus camaldulensis*), Dodonea (*Dodonaea viscosa*), and Neem (*Azadirachta indica*) were used as plant sources. Results showed the domination of composted matters over non-composted plant materials in their effects on the measured parameters (disease incidence, disease severity, plant height, and seed yield). Composted Eucalyptus leaves surpassed other composted residues in decreasing the disease severity. Nevertheless, the composted Dodonea leaves had the greatest effect in increasing both yield and plant height. The growth rate was an exception because it was not affected by the addition of these plant matters.

KEY WORDS: *Chickpea Wilt, Compost, Plant residue, Disease control.*
DOI: http://dx.doi.org/10.21271/ZJPAS.34.4.2
ZJPAS (2022) , 34(4);9-18 .

1.INTRODUCTION :

Chickpea (*Cicer arietinum* L.) is the world's third most important grain legume. Although India is the largest producer of chickpea in the world and accounts for approximately 69 % of the total world chickpea production, the origin of the crop is the so-called southeast of Turkey and north of Syria - Kurdistan (Abbo et al., 2003). However, an accurate grown area in our region is not known but it is still considered an important legume crop in Kurdistan (Salami and Ahmadi, 2010, Kanouni, 2001, Marzani, 2003). Chickpea plants are affected at various stages of development by a variety of pathogens and are generally show symptoms of a range of diseases. Chickpea diseases caused by fungi are important because they are easily propagated and are known to cause huge losses in productivity.

Fusarium oxysporum f. sp. *ciceris*, is one of the most important soil-borne, filamentous fungi, causing chickpea Fusarium wilt in which the pathogen results in massive decreases in productivity. There is a high degree of variation in disease resistance among chickpea cultivars, and, however, complete resistance to *F. oxysporum* has not been found in chickpea (Islam et al., 2012).

Chickpea wilt can be managed using several methods which include growing resistant cultivars, adjusting of sowing dates, fungicidal seed treatment, biofumigation, and use of biocontrol agents. However, the use of fungicides is not usually effective as it is used mainly for the seed-borne inoculum and has a short-term effect. On the other hand, the highly resistant varieties are neither available nor can be effective due to the presence and prevalence of a variety of

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Article History:
Received: 14/02/2022
Accepted: 26/04/2022
Published: 15/08 /2022

pathogen races (Bendre and Barhate, 1998). Biological control using microbes is becoming a critically needed component of plant disease management, particularly in reducing root diseases. The use of biocontrol agents is much safer and is presumed to be less polluting to the environment than chemical pesticides. Biocontrol agents control plant pathogens through different mechanisms of action such as competition, antibiosis, mycoparasitism, lysis, production of siderophores, and so on (Dar et al., 2013, Meki et al., 2011).

The continuous extensive use of agricultural practices that depends heavily on the application of chemical fertilizers has resulted in a loss of organic matter, an increase in acidity, and accumulation of toxic elements in fertile soils creating an environment favorable for the development of certain soil-borne diseases. Therefore, the soil-borne disease could be managed by the integration of various practices, mentioned before, like using resistant varieties, seed treatment with chemicals, seed and soil application of bioagents, and amendment of soils (Nikam et al., 2007). Successful control of soil-borne diseases by soil amendment using organic matters is well documented. In a field trial conducted by Marzani et al. (2017), the amending soil with composted plant materials at a rate of 30 t/ha was highly effective in suppressing the incidence and severity of chickpea wilt disease by 55.61%. Some growers in Australia used organic matter to control other soil-borne diseases such as root rot disease caused by *Phytophthora* on avocado (Sun and Huang, 1985). Soil amendments using plant residue will also act in reducing pesticide applications and therefore have both economic and environmental benefits (Gahukar, 2011). Another application of bio-fertilizers was conducted by Xiong et al. (2017) on *Fusarium oxysporum* in which they found a noticeable increase in the indigenous microbiota that they are showing antifungal activities against the pathogen as well as inducing disease suppression through the alteration of soil microbiome.

The present study aimed to investigate the suppression influence of degraded (composted) and non-degraded (non- composted) plant materials on chickpea fusarium wilt caused by *Fusarium oxysporum* f. sp. *ciceris* under field conditions.

2.MATERIALS AND METHODS

2.1Plant materials:

Fresh leaves of Eucalyptus, Dodonea, and Neem were collected from the local parks in Erbil City. After thorough drying, leaves of each plant were divided into two halves, one kept fresh while the other part was composted according to the procedures used by (Nayeem-Shah et al., 2015, Misra et al., 2016) with few modifications in pile sizes.

2.2Field trial location:

The field trial was conducted in Girdarasha Research Station; belonging to the College of Agricultural Engineering Sciences, Salahaddin University, Erbil, Kurdistan Region, Iraq.

2.3Experimental design and treatments:

A field experiment, which was Randomized Complete Block Design (RCBD), was conducted as shown in the following diagram:

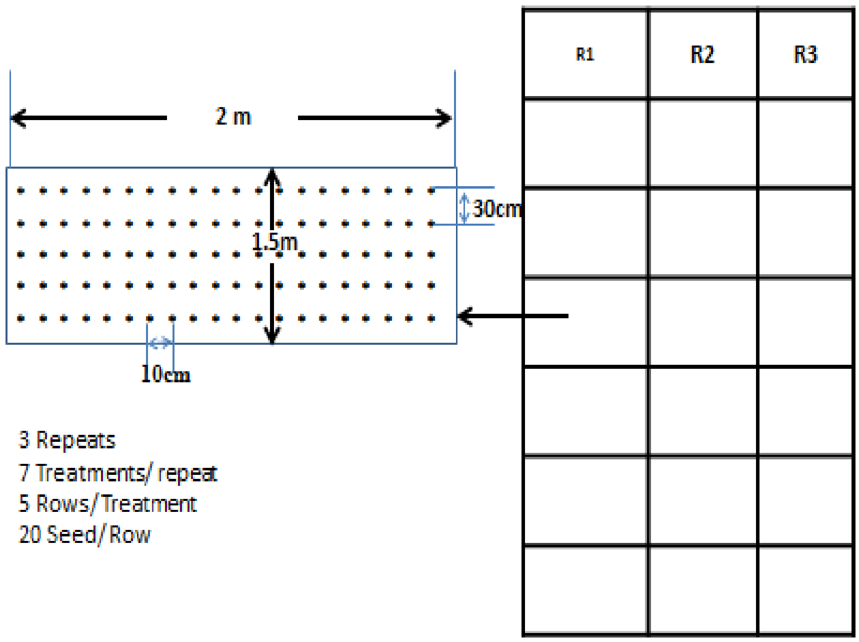

Figure (1): a diagram showing the layout of the experiment (right) and plot dimensions with the number of rows (left).

2.4Treatment preparations:

In this study, 3 kilograms of each plant material type were added to each experimental plot (at a rate of 3 kg/ $3m^2$ which is equivalent to 0.08% of organic matter to the rhizosphere soil) and mixed with soil before growing chickpea seeds. Table (1) shows the treatments used in this study.

Table (1): Treatment types and their abbreviations used in the current study.

No	Treatments/ plot	Abbreviations
1	Non-composted Neem leaves	N-NC
2	Non-composted Dodonea leaves	D-NC
3	Non-composted Eucalyptus leaves	E-NC
4	Composted Neem leaves	N-C
5	Composted Dodonea leaves	D-C
6	Composted Eucalyptus leaves	E-C
7	Untreated control	UC

2.5Soil infestation

A moderate susceptible chickpea cultivar Flip 6-15, resistant to ascochyta blight, were sown in a naturally contaminated soil with *Fusarium oxysporum*. The fungus is responsible of chickpeas wilt and has been isolated from infected plants in the previous year and soil. However, to confirm an infestation, the prepared plots were also inoculated with cultures of the pathogen grown on grain seeds at a rate of 1 kg/plot.

The treatments were randomly distributed in the dedicated plots in each block. Tossing was used to ensure a random distribution of the treatments on the plots.

2.6Measured parameters

In this study, 6 parameters were measured and used as indicators to assess the effect of each treatment in suppressing the disease. The details of these parameters are shown in table (2):

Table (2): The parameters measured on chickpea plants during current study.

No.	Parameter	Details (time and measurement)
1	Germination rate (GR)	After 1 month from growing (cultivation)
2	Disease severity (DS)	At flowering and pod formation
3	Disease incidence (DI)	At flowering and pod formation
4	Plant height (PH)	At flowering and pod formation
5	Biological yield (BY)	Whole plot harvested and biological yield per hectare (calculated)
6	Grain yield (GY)	Whole plot harvested and yield per hectare (calculated)

2.7Disease assessment and data analysis

Disease severity (DS) was measured as a percentage (%) using the following formula:

$$\text{Disease severity (\%)} = \frac{D}{T} \times 100$$

Where:

D = Number of diseased branches.

T = Total number of branches.

Disease was scored according to the descriptive 0-3 scale, where: 0 = symptomless, stems and leaves free of any visual symptoms; 1= limited growth depression and wilting, the plant is more or less turgid; 2= mild growth depression, wilting and chlorosis of leaves; 3= severe wilting and chlorosis, a complete collapse of the plant (Lebeda and Buczkowski, 1986).

The final disease indices (DI) were calculated in percentage (0-100%) according to the formula used by Townsend (1943) as the following:

$P = \Sigma (n \times v) \times 100/x \times N$

Where: P = the total degree of infection; n = number of plants in each assessed category (infection degree); v = infection degree (0-4); x = highest scale range (in this case = 4) and N = total number of assessed plants.

The percentage of disease inhibition (PDI) was then calculated using the following formula:

PDI = (DIUC – DIIT) * 100 / DIUC,

Where:

DIUC = disease incidence in untreated control

DIIT = disease incidence in the interesting treatment

Data were analyzed using Statgraphics v.17 and means compared using Fischer's least significant difference (LSD) test at $P = 0.05$.

3.RESULTS:

3.1Germination rate:

The results in figure (2) shows that soil amendment with the composted and non-composted plant matters had no significant effects on the rate of germination rate (GR). However, non-composted Dedonea gave the highest germination rate (83.33 %) and non-composted Neem leaves gave the least germination rate (71.25 %).

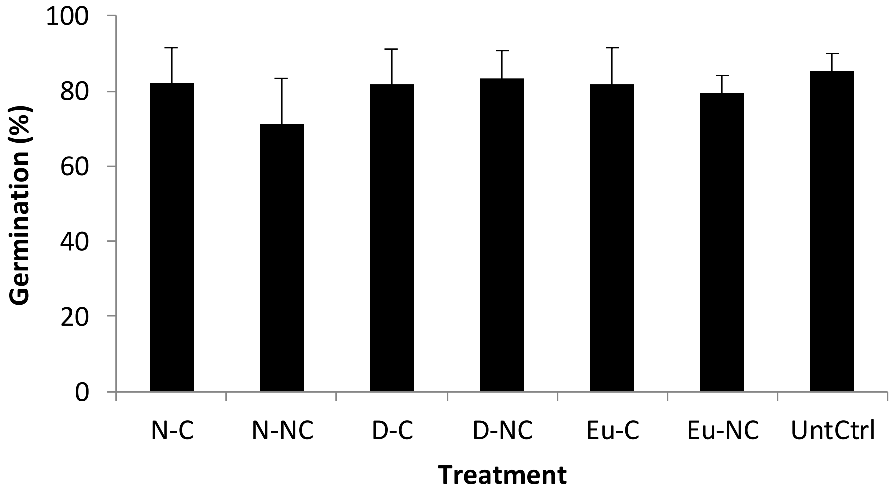

Figure (2): Effect of composted and non-composted of different plant residue on the chickpea germination rate.

3.2Disease severity:

Significant decrease in the disease severity resulted from using composted plant matters as a soil amendment. The use of composted Eucalyptus leaves showed the least disease severity (40.33 %) compared with the untreated control (91.04 %) followed by composted Dodonea leaves (42.99 %) and composted Neem leaves (45.87 %). The results of using non-composted leaves were showed less effect on disease severity with a mean severity percentage of 53.54 %, 62.45 %, and 63.64 % for Neem, Dodonea, and Eucalyptus, respectively (Figure 3).

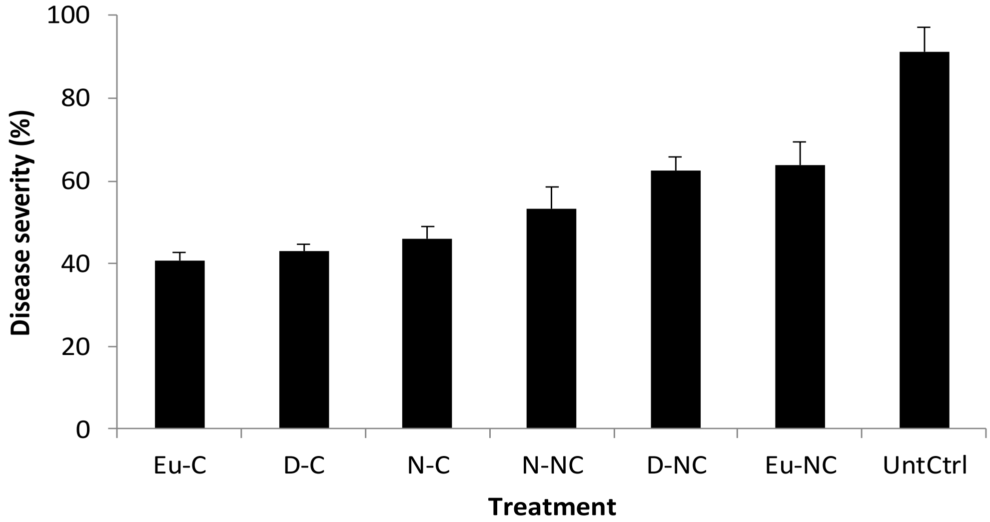

Figure (3): Effect of composted and non-composted of different plant residue on chickpea wilt severity.

3.3Disease incidence:

The results are shown in figure 4 illustrating that both composted and non-composted leaves had a significant decrease (5.97-13.84%) in disease incidence. The results show that the amendment of soil with composted plant matter causes a considerable decrease in disease incidence and surpassed the use of non-composted leaves, in which the use of non-composted Eucalyptus leaves gave the least disease protection by showing the highest disease incidence (24.06%).

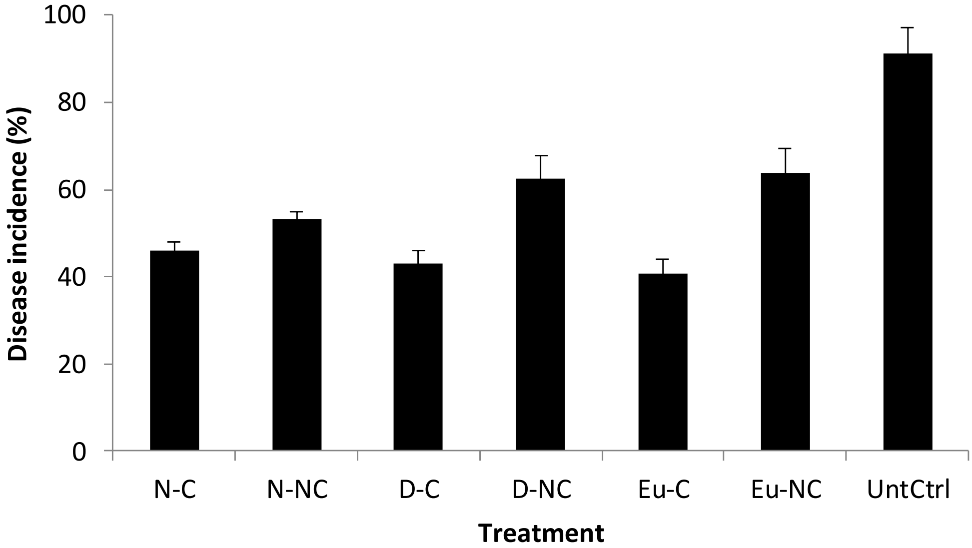

Figure (4): The effect of composted and non-composted plant residue on chickpea wilt incidence.

3.4Plant height:

According to the current study results, none of the plant materials had an effect on chickpea plant height (Figure 5). Nevertheless, the use of composted leaves of all plants had higher plant heights compared with that of non-composted leaves and the untreated control.

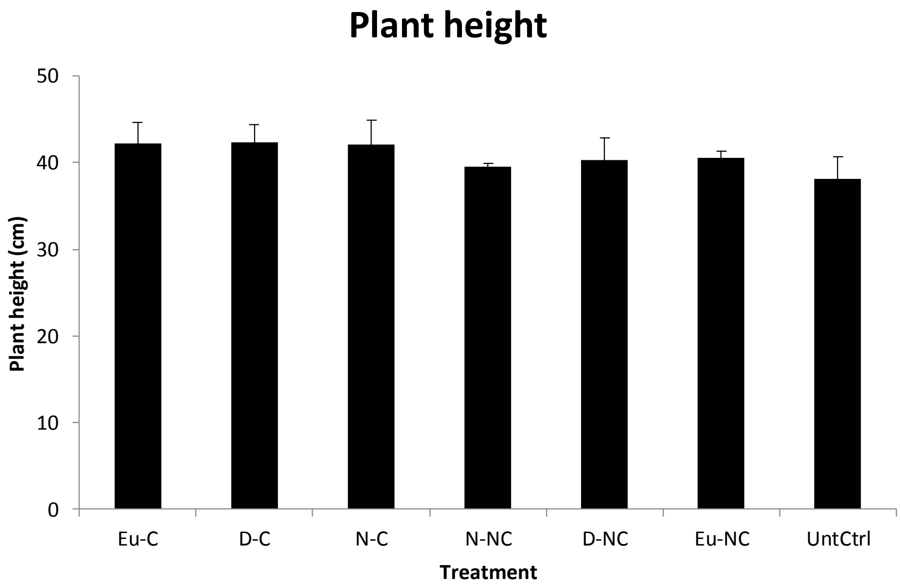

Figure (5): The influence of composted and non-composted plant residues on chickpea plant height.

3.5Biological yield:

The results showed a significant difference in the biological yield between composted and non-composted plant substances. The composted Dodonea leaves caused the highest increase in the biological yield by 84.82% followed by composted Neem and composted Eucalyptus leaves with increase rates of 60.12 % and 47.62 %, respectively. However, the non- composted plant matters were less effective and caused less increase of biological yield (ranged from 34.82 - 45.54 %) (figure 6).

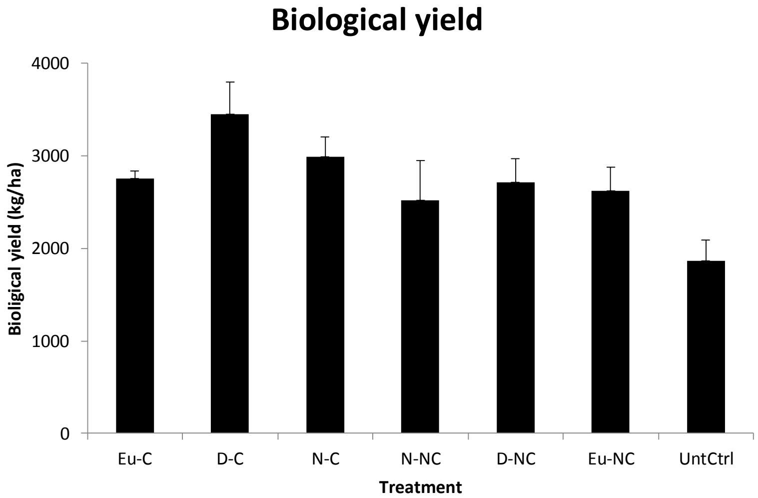

Figure (6): The effect of composted and non-composted plant residues on chickpea biological yield.

3.6Grain yield:

Soil amendment with composted and non-composted leaves of all three plant sources caused a significant increase in the number of produced seeds compared with the seed yield produced by untreated control (877.78 kg ha^{-1}) (figure 7). The most effective plant residue was the use of composted Dodonea leaves which resulted in the highest seed yield (1866.67 kg ha^{-1}) followed by composted Neem leaves (1575.56 kg ha^{-1}) while the lowest increase in seed production was induced by using non- composted Dodonea leaves (1194.44 kg ha^{-1}).

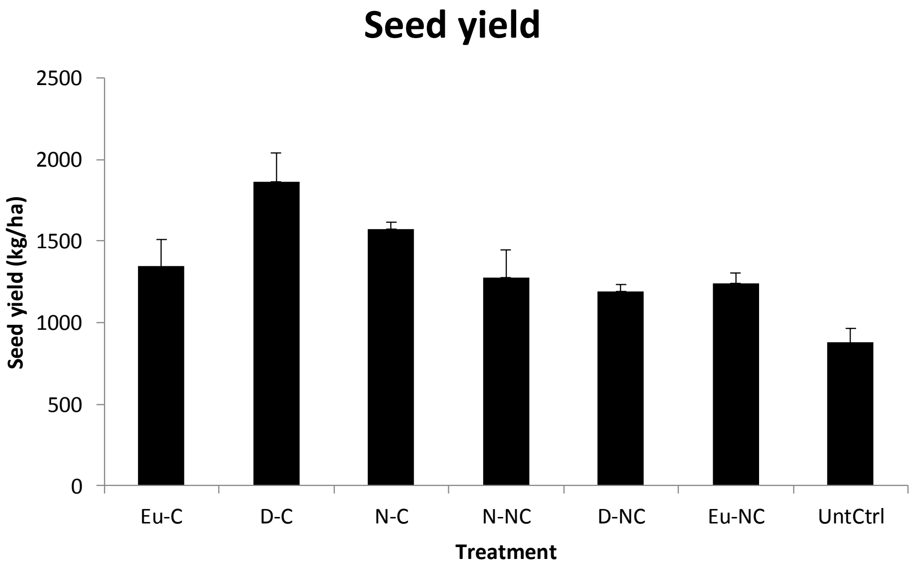

Figure (7): The efficacy of composted and non-composted plant residues on chickpea grain yield.

4.DISCUSSIONS

The results of the current study (table 3) show that the use of composted and non- composted leaves of Neem, Dodonea, and Eucalyptus as an amendment of the soil generally have a substantial effect on suppressing and controlling chickpea fusarium wilt caused by *Fusarium oxysporum* f. sp. *ciceris*. The effects are evident by showing a significant decrease in the rate of disease severity (30.10 - 55.26 %), disease incidence (19.88 - 46.09 %), a significant increase in the biological yield (34.82 - 175.89 %), and grain yield (53.04 - 165.63 %). Plant heights, although didn't display a significant increase but they increased at a rate of 3.86 - 11.20%. Following our results, the study conducted by (Madhumita et al., 2014) confirmed that the fields of chickpeas amended with Neem cake, farmyard manure, vermicompost, and green manure were decreased disease incidences by 46.7 %, 39.9 %, 39.3 %, and 26.2 %, respectively. In another similar work achieved by (Ha and Huang, 2007), in which soil was amended with 10 organic materials, the population of *Fusarium oxysporum* f. sp. *tracheiphilum*, the cause of asparagus bean wilt, was reduced significantly by some of the organic materials used in the study. In the current study, the disease was reduced by up to 56 % compared to the untreated control. Both Eucalyptus and Neem plants were also used by (Shafique et al., 2015) and resulted in reducing the number of soilborne diseases of chickpea and for other plants which were caused by *Fusarium* spp., *Macrophomina phaseolina*, and *Rhizoctonia solani*. The wilt of tomato caused by *Fusarium oxysporum* f. sp. *lycopersici* was suppressed by a compost prepared from vegetable and animal market wastes (Cotxarrera, et al., 2002). Chickpea yield was also minimized with the use of compost used in an integrated program at a rate of 5 tonnes/ha (Chaturvedi et al., 2018).

Different plant residues act differently according to the composting process, Physico-chemical properties, and bio-oxidative process, and these affect plant response characteristics (Zmora-Nahum et al., 2007). One factor that might have participated in lowering disease occurrences is inducing systemic resistance in plants. Several reports indicate that composts act in this way in host plants. (Zhang et al., 1996) found that soils amended with composted spruce and pine bark have enhanced resistance of cucumber plants against Pythium root rot and anthracnose caused by *Colletotrichum orbiculare* . Another explanation for suppressing soilborne pathogens by using soil amendments is that organic matters function in several ways. For example, they may change the pH of the soil or change the environment of nutrient supply. Low pH (less than 4.6), besides limiting some micronutrients, it is also causing some toxicity problems and poor nodulation. Reports also state the increase of the incidence of Fusarium wilt at such levels of pH (Ahlawat et al., 2007).

The use of soil amendments alone, without fumigation, proved its efficacy in lessening wilt incidences, especially those amendments that raise soil pH, which make soils more easily crumbled and support the native competitiflora. Researchers also stated that soil amendments would not only control the disease but also enhance plant growth. Under soil acidities near to 7, phosphorus, iron, and zinc become available to plants and thus make plants vigorous and more resistant (Sun and Huang, 1985). Another evidence of the effect of organic matters on protecting plant roots from soilborne diseases is the one stated by (Nautiyal et al., 2013) where they worked on the organic matters surrounding the roots that are acting to reduce cell wall degrading enzymes produced by plant roots in response to pathogens.

It seems that the amendment of soils with plant residue is related to several mechanisms. One such mechanism is the chemical extracts present in the composted matters in amended soils found to suppress the activity of *Fusarium* species by stimulating the activity of antagonistic microbes (Kai et al., 1990, Hoitink et al., 1997). Studies also found that farmyard manures act in reducing the resistance of chlamydospores of *Fusarium* species in amended soils (Oritsejafor and Adeniji, 1990).

Table (3): The effect of different treatments on the results of measured parameters.

Treatments	Measured parameters					
	Germination rate (%) [%⇓]	Disease severity (%) [%⇓]	Disease incidence (%) [%⇓]	Plant height (cm) [%⇑]	Biological yield (kg/ha) [%⇑]	Grain yield (kg/ha) [%⇑]
N-C	82.08 [3.91]	45.87 [49.62]	16.67 [44.49]	42.00 [10.15]	2988.89 [60.12]	1575.56 [116.87]
N-NC	71.25 [16.59]	53.36 [41.39]	17.20 [42.72]	39.60 [3.86]	2516.67 [34.82]	1277.78 [67.00]
D-C	81.67 [4.39]	43.00 [52.77]	16.66 [44.52]	42.40 [11.20]	3450.00 [175.89]	1866.67 [165.63]
D-NC	83.33 [2.19]	62.45 [31.40]	19.65 [34.57]	40.27 [5.61]	2716.67 [45.54]	1194.44 [53.04]
Eu-C	81.67 [4.39]	40.73 [55.26]	16.19 [46.09]	42.20 [10.67]	2755.56 [47.62]	1344.44 [78.16]
Eu-NC	79.58 [6.84]	63.64 [30.10]	24.06 [19.88]	40.60 [6.48]	2622.22 [40.468	1244.44 [61.41]
UntCtrl	85.42	91.04	30.03	38.13	1866.67	877.78

[%⇓]: Decrease. [%⇑]: Increase, N-NC: Non-composted Neem leaves, D-NC: Non-composted Dodonea leaves, E-NC: Non-composted Eucalyptus leaves, N-C: Composted Neem leaves, D-C: Composted Dodonea leaves, E-C: Composted Eucalyptus leaves, and UC: Untreated control.

5.CONCLUSIONS

It can be concluded that the composted matters have dominated non-composted plant materials in their effects on the measured parameters (disease incidence, disease severity, plant height, and seed yield). Eucalyptus leaves when ccomposted was exceeded other composted residues in decreasing the disease severity. Nevertheless, the composted Dodonea leaves had the greatest effect in increasing both yield and plant height.

6.REFERENCES

ABBO, S., SHTIENBERG, D., LICHTENZVEIG, J., LEV-YADUN, S. & GOPHER, A. 2003. The chickpea, summer cropping, and a new model for pulse domestication in the ancient Near East. *The Quarterly Review of Biology,* 78**,** 435-448.

AHLAWAT, I., GANGAIAH, B. & ZAHID, M. A. 2007. Nutrient management in chickpea. *Chickpea breeding and management***,** 213-232.

BENDRE, N. & BARHATE, B. 1998. A souvenir on Disease Management in Chickpea. *MPKV, Rahuri during 10th Dec*.

CHATURVEDI, S., JHA, S., SINGH, N., GAUR, P. & VARSHNEY, R. 2018. Technological And Policy Intervention For Increasing Chickpea Production In India. *Pulse India,* 8**,** 7-12.

DAR, W., GANIE, S., BHAT, J. A., MIR, G. H., LAWRENCE, R., NARAYAN, S. & SINGH, P. K. 2013. Comparative efficacy of Trichoderma viride and Trichoderma harzianum against Fusarium oxysporum f sp. ciceris causing wilt of chickpea. *African Journal of Microbiology Research,* 7**,** 5731-5736.

GAHUKAR, R. 2011. Use of neem and plant-based biopesticides in floriculture: current challenges and perspectives–a review. *The Journal of*

Horticultural Science and Biotechnology, 86**,** 203-209.

HA, M. T. & HUANG, J.-W. 2007. Control of Fusarium wilt of asparagus bean by organic soil amendment and microorganisms. *Plant Pathol. Bull,* 16**,** 169-180.

HOITINK, H., STONE, A. & HAN, D. 1997. Suppression of plant diseases by composts. *HortScience,* 32**,** 184-187.

ISLAM, M. N., NIZAM, S. & VERMA, P. K. 2012. A highly efficient Agrobacterium mediated transformation system for chickpea wilt pathogen Fusarium oxysporum f. sp. ciceri using DsRed-Express to follow root colonisation. *Microbiological research,* 167**,** 332-338.

KAI, H., UEDA, T. & SAKAGUCHI, M. 1990. Antimicrobial activity of bark-compost extracts. *Soil Biology and Biochemistry,* 22**,** 983-986.

KANOUNI, H. 2001. The yielding ability and adaptability of chickpea cultivars under rainfed conditions of Kurdistan. *Seed and Plant Improvment Journal,* 17**,** 1-11.

MADHUMITA, P., SOBITA, S. & NEELAM 2014. Effect of organic soil amendment and soil solarization on wilt of chickpea. *International Journal of Botany and Research (IJBR),* 4**,** 61-65.

MARZANI, Q. A. 2003. *Epiphytotic and control of ascochyta blight of chickpea caused by Ascochyta rabiei (pass.) Labr. in Erbil Province.* Master, Salahaddin University-Erbil.

MARZANI, Q. A., FATAH, K. M. & MUSTAFA, M. H. J. S. J. O. U. O. Z. 2017. Field efficacy of the commercial formulation of the antagonistic Trichoderma harzianum on chickpea wilt caused by Fusarium oxysporum. 5**,** 64-69.

MEKI, S., AHMED, S. & SAKHUJA, P. 2011. Control of chickpea wilt (Fusarium oxysporum f. sp. ciceris) using Trichoderma spp. in Ethiopia. *Archives of Phytopathology and Plant Protection,* 44**,** 432-440.

MISRA, R., ROY, R. & HIRAOKA, H. 2016. On-farm composting methods. Rome, Italy: UN-FAO.

NAUTIYAL, C. S., SRIVASTAVA, S., MISHRA, S., ASIF, M. H., CHAUHAN, P. S., SINGH, P. C. & NATH, P. 2013. Reduced cell wall degradation plays a role in cow dung-mediated management of wilt complex disease of chickpea. *Biology and fertility of soils,* 49**,** 881-891.

NAYEEM-SHAH, M., GAJALAKSHMI, S. & ABBASI, S. 2015. Direct, rapid and sustainable vermicomposting of the leaf litter of neem (Azadirachta indica). *Applied biochemistry and biotechnology,* 175**,** 792-801.

NIKAM, P., JAGTAP, G. & SONTAKKE, P. 2007. Management of chickpea wilt caused byFusarium oxysporium f. sp. ciceri. *African Journal of Agricultural Research,* 2**,** 692-697.

ORITSEJAFOR, J. & ADENIJI, M. 1990. Influence of host and non-host rhizospheres and organic amendments on survival of Fusarium oxysporum f. sp. elaeidis. *Mycological Research,* 94**,** 57-63.

SALAMI, P. & AHMADI, H. 2010. Energy inputs and outputs in a chickpea production system in Kurdistan, Iran. *African Crop Science Journal,* 18.

SHAFIQUE, S., ASIF, M. & SHAFIQUE, S. J. P. J. B. 2015. Management of Fusarium oxysporum f. sp. capsici by leaf extract of Eucalyptus citriodora. 47**,** 1177-1182.

SUN, S. & HUANG, J. 1985. Formulated soil amendment for controlling Fusarium wilt and other soilborne diseases. *Plant Disease,* 69**,** 917-920.

TOWNSEND, G. J. P. D. R. 1943. Methods for estimating losses caused by diseases in fungicide experiments. 27**,** 340-343.

XIONG, W., GUO, S., JOUSSET, A., ZHAO, Q., WU, H., LI, R., KOWALCHUK, G. A., SHEN, Q. J. S. B. & BIOCHEMISTRY 2017. Bio-fertilizer application induces soil suppressiveness against Fusarium wilt disease by reshaping the soil microbiome. 114**,** 238-247.

ZHANG, W., DICK, W. & HOITINK, H. 1996. Compost-induced systemic acquired resistance in cucumber to Pythium root rot and anthracnose. *Phytopathology,* 86**,** 1066-1070.

ZMORA-NAHUM, S., HADAR, Y. & CHEN, Y. 2007. Physico-chemical properties of commercial composts varying in their source materials and country of origin. *Soil Biology and Biochemistry,* 39**,** 1263-1276.