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Effect of date palm wastes and rice hull mixed with soil on growth and yield of cucumber in greenhouse culture

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Abstract

Different substrates have several materials which could have direct and/or indirect effects on plant growth and development. The use of different organic and inorganic substrates allows that plants have best nutrient uptake and sufficient growth and development to optimize water and oxygen holding. This work was carried out using a completely randomized design with six treatments and six replications. The treatments were pure palm peat, pure rice hull, soil + 5% (weight) palm peat, soil + 5% (weight) rice hull, soil + 5% (weight) palm peat + 5% (weight) rice hull and pure soil. During plant growth Papadopolus formula with fertigation method was used for nutrient solution. Selected physiochemical properties of culture media and selected growth indices of plants were measured at the end of growth period. Results showed that amount of porosity, water holding capacity (WHC) and cation exchange capacity (CEC) in date-palm peat was higher than soil and rice hull but amount of bulk density in date-Palm peat was lower than the others. Also The results showed that many growth parameters were affected by the culture media. Most amount of yield and plant height in each was related to palm waste (100%) and had significant difference at 5% level as compared with the others. Results showed that plant growing indices for cucumber plant were sufficient when cultured only in date Palm waste and rice hull substrates and when this materials were added to the soil, although it amended physiochemical properties of media but decreased the plant growing indices.

Keywords: Palm peat; Rice hull; Yield; Greenhouse cucumber; Soil

Introduction

When crop residues are returned to the soils, their decomposition can have both positive and negative effects on crop production and the environment (Kumar and Goh 1999). The use of different organic and inorganic substrates allows the plants the best nutrient uptake and sufficient growth and development to optimize water and oxygen holding (Verdonck et al. 1982). Soil organic matter is one of the most important constituents of soils due to its capacity in affecting plant growth indirectly and directly (Bongiovanni and Lobartini 2006). Indirectly, it improves the chemical and physical conditions of soils by increasing cation exchange capacity, termed buffering effect, and enhancing aggregation, aeration and water retention. Improvement of soil biological properties affects soil microbial diversity and population, thereby creating a suitable environment for root growth of plants and soil microbes (Senesi and Loffredo 1999).

Hassan dokht et al. (2001) used tea waste and bark as soil amendment and then cultured lettuce. They reported that the plants cultured in tea waste + bark + soil treatment had more yield as compared with alone soil treatment, but amount of total soluble solids (TSS) and growth indices in tea waste + soil treatment was higher than bark + soil treatment. Investigations showed that addition of rice hull to soil in rice farm caused to increase in yield in long time. The results of use of zeolite, vermiculite and some organic materials as media for hydroponic tomato production showed that the lowest yield was obtained from the rice hull and mixture of rice hull with other materials. The highest of yield, shoot dry weight and number of cluster per pot were obtained from cocopeat and perlite + mica media (Saberi et al. 2006).

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Borji et al. (2010) investigated the effect of some media include date-palm peat, perlite, cocopeat and mix of these materials on growing indices of tomato. Their results showed that fruit yield, fruit number, stem length, titrable acidity and ascorbic acid (in fruit) in different media had no significant differences. Samiei et al. (2005) investigated effect of peat moss and date-palm wastes as substrates on growing of Aglaonema and their results showed that peat moss and date-palm peat were similar in some characteristics. The effect of some culture media such as date-palm peat, cocopeat and perlite on some tomato growing indexes was studied by Mohammadi Ghehsareh et al. (2011a). The treatments were perlite, date-palm peat and different ratio of coco peat + perlite and date-palm peat + perlite. Results showed higher amount of total soluble solids (TSS) was related to Coco peat + perlite treatment that had no significant difference with date-palm peat + perlite, perlite and date-palm peat treatments.

According to present evidences original birthplace of date palm tree were in south of Iran and Iraq but today it cultivated in more areas of world. Total numbers of date palms around the world are about 100000000.

More than 50% of date palms in the world are in Iran, Iraq and Saudi Arabia (21% in Iran). Total weight of date palm wastes annually produced in the world is estimated about 4.5 million tons (Barreveld 1993; FAO 2002). Currently, appropriate management and optimized procedure is not in use for this material. It seems that residues and wastes of date palm trees could can be used as culture media for soilless systems in greenhouse or it could be applied to soil as organic fertilizer to improve soil chemical and physical conditions. Also this will decrease the adverse effect of burning these wastes to the environment, the disposal method currently is used for date palm wastes.

The objective of the present study was to compare date palm waste, rice hull, and their mixture with soil as culture media on cucumber production in greenhouse.

Methods

This work was carried out in a research greenhouse of Islamic Azad University, Khorasgan branch, using a completely randomized design with six treatments and six replications. The treatments were pure palm waste (Pa), pure rice hull (Rh), soil + 5% (weight) palm waste (S + 5%Pa), soil + 5% (weight) rice hull (S + 5% Rh), soil + 5% (weight) palm waste + 5% (weight) rice hull (S + 5%Pa + 5%Rh) and pure soil (S). *Cucumis Stativus* cultivar was used for seed.

Cucumber seeds were sowed in a box of peat moss and young plants at three leaf stages were transferred in 10 liter pots filled with culture media. One cucumber plant was cultivated per pot. Heights of pots were 40 cm and distance between pots was 50 cm. Plant were grown for a period of four months (May to August). Average temperature of day and night were 30 and 18°C respectively in greenhouse. Relative humidity in greenhouse was 37.1- 61.2 percent during the growth period. Plants were fertigated with Papadopoulos nutrient solution (Papadopoulus 1991 and Papadopoulos 1994; Benton Jones 2005). pH of the nutrient solution was kept between 5.5-6. Irrigation was performed by hand, three times a day based on water and leaching requirement (20%).

Some physiochemical characteristics of the culture media including bulk density (Baruah and Barthakur 1998), organic carbon (% OC) (Walkley and Black 1934), total porosity (Baruah and Barthakur 1998), water holding capacity (WHC) (Verdonck and Gabriels 1992), cation exchange capacity (CEC) (Rhoades 1982) were measured. Electrical conductivity (EC) and pH (Asiah et al., 2004) of culture media were determined with 1:2 extraction method. Microorganisms' population in culture media were determined with counting method. Plants were grown for a period of four months (May to August) and selected growing indices including stem diameter (mm) at the plant curb location, plant height (cm), shoot dry mass (g/plant), root dry mass (g/plant), fruit length (cm), fruit number and pedicel length (cm) were measured at the end of growth period. The fruit yield (Kg/m^2) for each plant accumulated for fruitage period. Total soluble solids (TSS) of fruit (Brix%) (by Refractometer), leaf area index (LAI) (by Planimeter set), fruit firmness index (kg/cm^2) (by Penetrometer), leaf chlorophyll content (%) (by CL-10 set) were measured at the end of the growth period. Experimental data normality was verified, and then data were submitted to analysis of variance, using SPSS statistical software. Means were compared using Duncan multiple test ($P < 0.05$).

Result and discussion

Physiochemical properties of media

Some physiochemical properties of culture media are presented in Table 1. Soil texture was sandy loam and its bulk density was higher than the other media cultures. The lowest bulk density (0.04) and highest porosity was related to palm waste (86%), therefore root media aeration in this treatment was better than the other media. When root media aeration is sufficient, supplying of water and nutrient elements for plants is better. The EC of the soil treatment was higher than the other culture media and this term in palm waste was lower than the other media.

The CEC of the culture media varied between 13 and 59 Cmol/kg. Maximum and minimum amounts of CEC were related to palm waste and soil media respectively, therefore the palm waste media had more capacity to supply of nutrient elements for plant.

Table 1 Some physiochemical properties of culture media

Substrate	Porosity (%)	WHC %	Bulk density (gr/cm^3)	OM %	EC (ds/m)	pH	CEC (Cmol/kg)
Palm waste	86	92	0.04	84.48	1.28	6.7	95
Rice hull	73	88	0.09	88.52	2.24	6.2	72.6
Loamy soil	37	78	1.25	3.52	2.34	7.1	43.1

Mohammadi Ghehsareh et al. (2011b), Mohammad Khiyami et al. (2008) and Borji et al. (2010) had similar results.

Growing indices

Some growing indices of cucumber plant are presented in Table 2. Amount of cucumber yield in different culture media had significant difference at 5% level as compared with other treatments. Highest and lowest amount of fruit yield was related to palm waste and S + Pa5% + Rh5% treatments respectively. Also most amount of plant height, stem diameter and shoot dry mass was related to palm waste media that had significant differences at 5% level as compared with other treatments. Amount of bulk density, Porosity, WHC and CEC in date palm waste was maxima as compared with other media and these physiochemical properties were affected on plant growth indices and fruit yield. Sufficient conditions in the palm waste media caused to good support of water and nutrient elements for plant and leading to good growth (Olympious 1992; Kumar and Goh 1999). Results showed that the highest amount of root weight in dry condition was related to palm waste and rice hull media that had significant difference at 5% level as compared with other treatments. The roots of cucumber plant had more growth in the palm waste and rice hull media because porosity in these cultures media was higher than the others and so bulk density in these media was lower as compared with other treatments therefore resistance to root motion was minimum in these media. A good growing media would provide sufficient anchorage to the plant, serves as reservoir for nutrients and water, allow oxygen diffusion to the roots and permit gaseous exchange between the roots and atmosphere outside the root substrate (Bunt 1988). As result root growth in the date palm waste and rice hull treatments was higher than other treatments.

Highest and lowest chlorophyll percentage was observed in rice hull and soil treatments respectively. The weight of single fruit in S + Pa5% + Rh5% treatment was highest and had significant difference as compared with other substrates. The lowest amount of TSS was observed in date palm waste that had significant difference with other substrates. The lowest fruit firmness index was related to loamy soil treatment and the highest amount of fruit firmness index was related to S + 5%Pa treatment, and it had significant difference as compared with other treatments. The fruit length in the palm waste media culture was lowest and had significant difference with other media culture

Table 2 Effect of culture media on yield and some growth indices of cucumber

Culture media	Fruit yield (Kg)	Plant height (cm)	Stem diameter (cm)	Shoot dry (g) mass	Root dry mass (g)	Chlorophyll %
Palm waste	3.67^a	328.1^a	1.8^a	88.4^a	3. 5^b	50.94^a
Rice hull	2.12^b	260^b	0.9^b	55.4^b	3.9^a	63.24^a
Loamy soil	1.82^b	258.9^b	0.9^b	41.9 ^{c}	1. 8^c	35.13^c
S + Pa5%	1.41^c	247.4 ^{b}	0.9^b	42.4^c	1.7 ^{c}	48.12^b
S + Rh5%	1.46^c	196.6^c	0.9^b	36.1^c	2.0^c	47.13^b
S + Pa5% + Rh5%	1.04^d	234^{bc}	0.9^b	40.5^c	2.7^{bc}	45.25^b
Culture media	**WSF (g)**	**TSS (brix%)**	**Fruit firmness index (Kg/cm^2)**	**Fruit length (cm)**	**Fruit diameter (cm)**	**Pedicel length (cm)**
Palm waste	85.1^b	2.67^b	1.92^{ab}	12.5^b	2.9^{ab}	3.2^{bc}
Rice hull	77.9^b	2.75^{ab}	1.83^{ab}	13.5^a	2.8^c	2.9^c
Loamy soil	82.9^b	3.58^a	1.42^b	13.6^a	2.9^{ab}	2.6^c
S + Pa5%	82.7^b	3.58^a	2.25^a	13.5^a	3^a	2.7^c
S + Rh5%	89.4^b	3.33^{ab}	1.83^{ab}	13.8^a	3^a	3.4^b
S + Pa5% + Rh5%	93.6^a	3.58^a	1.75^{ab}	13.9^a	3^a	3.9^a

* S = soil, Pa = Palm waste, Rh = Rice hull, WSF = weight of single fruit.
**Different letters in each Colum represent significant differences and same letters don't represent significant differences at level 5%.

although other treatments had no significant difference together. Highest amount of fruit diameter was related to S + 5%Pa, S + 5%Rh and S + Pa5% + Rh5% treatments and had significant difference with other media culture so most amount of pedicel length was related to S + Pa5% + Rh5% treatment. These results were similar to Olympious (1992), Kumar and Goh (1999) findings that physiochemical properties of culture media affected on plant growth and yield. Results of Mohammadi Ghehsareh et al. (2011a) on tomato plant showed that fruit yield in date palm and perlite had no significant differences at 5% level. Saberi et al. (2006) reported lowest and highest amounts of tomato yield were obtained from rice hull and perlite media cultures respectively. A lot of these results were similar to Mohammadi Ghehsareh et al. (2011b) and Borji et al. (2010) investigations. Tzortzakis and Economakis (2008) showed that highest yield, highest total number of fruits per plant, fruit weight, fruit firmness and total soluble solid of tomato were obtained from plants grown in organic media (Maize) as compared with inorganic media.

Some researchers reported that when organic wastes were added to the soil, it improved the chemical and physical conditions of soils and thereby creating a suitable environment for root growth of plants (Senesi and Loffredo, 1999; Bongiovanni and Lobartini 2006; Hassan dokht et al. 2001) but in this study some growing indices of cucumber plant were decreased when date palm waste and rice hull were mixed with soil. Addition of palm waste and rice hull to the soil improved the physiochemical properties of mix media but amount of cucumber yield in mix media (soil + 5% (weight) palm waste + 5%(weight) rice hull) was lowest and even it was lower than the soil media. These results may be related to microorganisms' population and their activity in different substrates. Micro organisms population before planting in the soil, palm waste and rice hull were $830*10^7$, $490*10^7$ and $335*10^7$ respectively. Microorganisms' population in the soil was higher and when it was mixed with organic matter (palm waste and rice hull), activity of micro organisms for organic matter mineralization were increased and caused competition between plant roots and microorganisms for nutrient elements uptake. The organic wastes that were used in this study were fresh and have not passed fermentation period therefore mineralization process maybe were lead to decreasing in fruit yield and number of fruit in the soil + 5% (weight) palm waste + 5% (weight) rice hull treatment.

Conclusion

Results of this study clearly showed that date palm waste has a great potential to be used as the culture media for plant growth in hydroponic systems. Date palm waste provided better physical and chemical condition for plants growth and plants grown in this media produced highest yield. when fresh date Palm waste and rice hull were mixed with soil, although caused the amendment of the physiochemical properties of soil but the plant growing indices decreased and were even lower than soil treatment. It seems that addition of fresh organic waste to soil caused to increase in microorganisms' activity, immobilization process in rhizosphere and affected on plant activity. Therefore in mixing process with soil, firstly, date palm waste must be fermented and composed and after the completion of the process it would be mixed with soil.

Competing interests

The authors declare that there is no conflict of interest.

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