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Use of Perlite for Improving Some Physical Properties of Soils and Macronutrients Quantity of Multiply Onion

Abstract

Some physical properties of soils and quantity of macronutrient in multiply onion were studied. The Randomized Complete Block Design experiments were carried out in 4 treatments with 4 replications. The soil of Ban Wang Chuem near Sublungka Wildlife Sanctuary in Lop Buri Province, Thailand, mixed with perlite was used as growth material. The soil physical properties of growth material before the culture period and in the harvest period were analysed. The culture period was 2 months.

The soil physical properties of growth material studied included soil texture, soil moisture, hydraulic conductivity, density and porosity. Treatment 1 was the control made up only of the soil whereas in the treatments 2-4 perlite of 15, 22.5 and 30 kg were mixed with the soil of 150 kg each, respectively. The results showed that soil texture in all treatments become sandy clay loam with higher proportion of sand particles. The soil moisture parameters i.e. the highest field capacity and the highest available water capacity in Treatment 2 are 18.88 and 8.75% by volume, respectively. The hydraulic conductivity in all treatments ranges within the moderate standard conductivity of 28.35-45.17 cm/hr. The value of 28.35 cm/hr in Treatment 2 shows the better storage condition of the plant nutrients. Considering both soil moisture and hydraulic conductivity, Treat-

ment 2 could contain more micropores than the others; therefore it is the most effective condition for the multiply onion. The bulk density value of all treatments range between 1.42-1.49 g/cm^3, the particle density ranges from 2.50-2.59 g/cm^3 and the total porosity ranges from 40.20-44.00% by volume. These indicate that the density and porosity of all treatments are suitable for plants in general.

The multiply onion tends to have good responses to the changes of the soil physical properties. Specifically, Treatments 2 and 4 showed significant changes in the total phosphorus and total potassium contents from Treatment 1 (the control) at 95% confidential limit averaging 0.108, 0.090 and 0.386, 0.348%, respectively. Treatment 2 are therefore considered to have the best conditions of the soil moisture and hydraulic conductivity for the multiply onion.

Introduction

It has been indicated that the scientific experiments and analysis on the effect of using perlite in agriculture are very important (Akcay and Kylync, 1999; American Perlite Company, 2004). There have been research results on distribution and use of perlite in agriculture. Both fine perlite and expanded perlite have been used in pot experiment and in growth block. Reports indicated that it can improve physical properties of soils as well as of agricultural products (American Perlite Company, 2004; World Trade Organization, 2004).

This research is an analysis on properties of fine perlite and its effect on soil and growth material particularly relating to the improvement on physical properties of soils and trend on supplying macronutrients for the multiply onion.

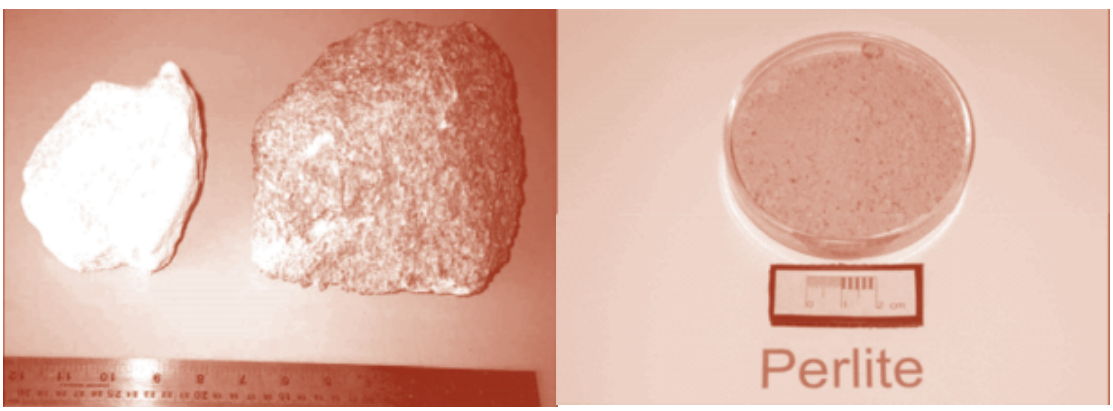

Figure 1 Perlite samples and ground perlite.

Figure 2 Growth blocks of 1.0 x 1.0 x 0.15 meter each were employed in perlite experiment for growing the multiply onion.

Methods

1. Perlite and soils samples

Perlite used was from Srabote and Khokcharoen Districts in Lop-buri Province. The soil samples were from the site of the experiment. The soil samples were collected from surface down to 30 cm depth. Nature of perlite samples and ground perlite used are shown in Figure 1.

2. Experimental design

The size of culture blocks for the multiply onion was 1.00 x 1.00 meter, and 15 centimeter deep. The Randomized Complete Block Design (RCB) was used in the experiments with 4 treatments and 4 replications. A total of 16 growth blocks were used. Some of them are shown in Figure 2.

3. Culture medium in the growth block

Each block was composed of perlite, soil and fertilizer to culture the multiply onion in each treatment. The spacing of the blocks is 15-20 centimeter apart, all in the rows.

Treatment 1 Soil without perlite + fertilizer

Treatment 2 Soil and Perlite, ratio of; 150 : 15 kg + fertilizer

Treatment 3 Soil and Perlite, ratio of; 150 : 22.5 kg + fertilizer

Treatment 4 Soil and Perlite, ratio of; 150 : 30 kg + fertilizer

A chemical compound fertilizer, formula 15-15-15, 55 g was used in each treatment.

4. Analysis

Analyses were carried out on soil and multiply onion samples. Physical properties of soils included 6 parameters. They were soil texture, soil moistures (field capacity, FC; permanent wilting point, PWP; available water capacity, AWCA), hydraulic conductivity (K_{sat}), density, total porosity (E) and micropores. The multiply onion samples were analysed for the macro-

nutrients (N, P and K). The Duncan's New Multiple Range Test (DMRT) was used for statistical analysis.

Results and Discussions

1. The physical properties of perlite, soils and growth materials.

1.1 Physical properties of perlite and soil samples.

The analysis results on physical properties of perlite and soils are shown in Table 1. The texture of perlite is sandy loam. The texture of soil is sandy clay loam. Soil moisture in perlite and soil are different. The results also show % by volume of FC, PWP and AWCA of 13.52, 8.38 and 5.14 for perlite and 17.16, 10.20, 7.56. for soil samples, respectively. The mixtures of the soil and perlite used as growth material for multiply onion in Treatments 2, 3 and 4 show an effective trend on their physical properties affecting the growth of the multiply onion. The Treatments 1-4 were then the efficient evaluation of physical properties profitable for the multiply onion.

Table 1 Some physical properties of perlite and soil samples used.

physical properties	Perlite	soils
1. Texture	sandy loam	sandy clay loam
sand (%)	72	55.2
silt (%)	18	20.7
clay (%)	10	24.1
2. Moisture		
Field Capacity (FC) (% by volume)	13.52	17.76
Permanent Wilting Point (PWP) (% by volume)	8.38	10.20
Available Water Capacity (AWCA) (% by volume)	5.14	7.56
3. Hydraulic Conductivity (cm/hr)	–	35.22
4. Density		
Bulk Density (g/cm^3)	–	1.53
Particle Density (g/cm^3)	–	2.53
5. Total Porosity (%)	–	39.5
6. Micropores	–	–

– = not analysed

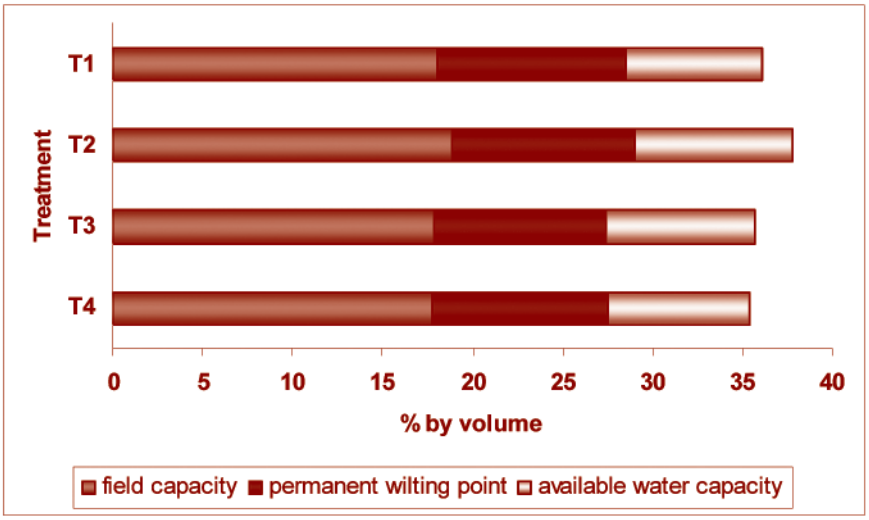

Figure 3 Field capacity, permanent wilting point and available water capacity of growth materials.

1.2 Physical properties of growth materials (Treatment 1- Treatment 4).

1) Texture

The analysis showed an increasing trend of sand particle with the amount of perlite of 55.2, 56.5, 57.2 and 57.8 % by weight in Treatments 1, 2, 3 and 4, respectively i.e. and with a decreasing trend of clays. Treatment 4 has the lowest clay content (21.9%) and the texture becomes sandy clay loam.

2) Moisture

Treatment 2 shows the highest FC and AWCA (18.88 and 8.75% v) (Figure 3). Treatment 3 also shows high FC and AWCA (17.86 and 8.26 % v). These confirm that water available for plant is contained in pores with diameters of 0.2-50 μm (Foth, 1990; Department of Soil Science, 2001)

3) Hydraulic Conductivity

The analysis shows that K_{sat} (Figure 4) in Treatment 3 is the highest at 45.17 cm/hr and Treatment 2 has the lowest K_{sat} at 28.35 cm/hr. Based on standard value scale, all Treatments have the moderate K_{sat} in a range of 20-60 cm/hr (Smith and Mullins, 2000). Therefore the growth materials of all Treatments show a good range of K_{sat} and sufficient water will be available for the rate of plant growth in the experiment.

The growth material in Treatment 2 has a lower K_{sat} than that in the other Treatments. Therefore it is good for holding and supplying water and nutrients to plant. The higher K_{sat} value indicates the higher rate of leaching and nutrient loss in Treatments 3 and 4 as compared to that of Treatment 2.

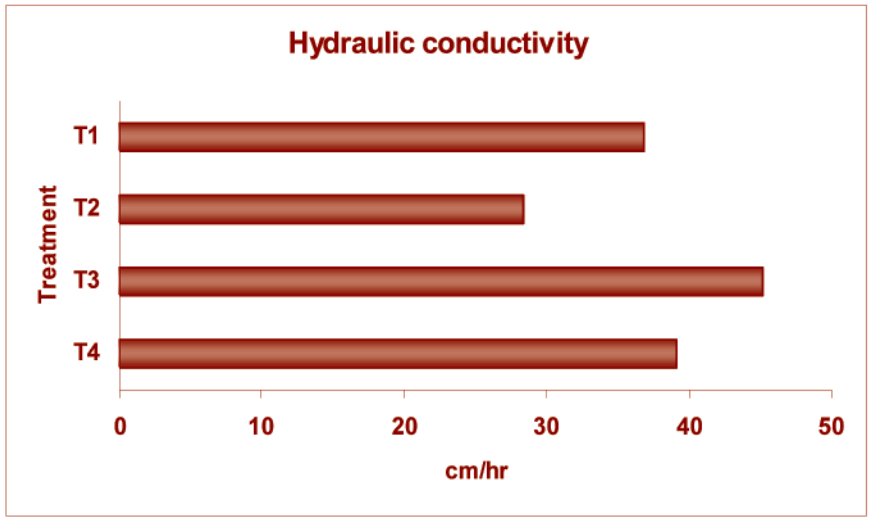

Figure 4 Hydraulic conductivity values of growth materials.

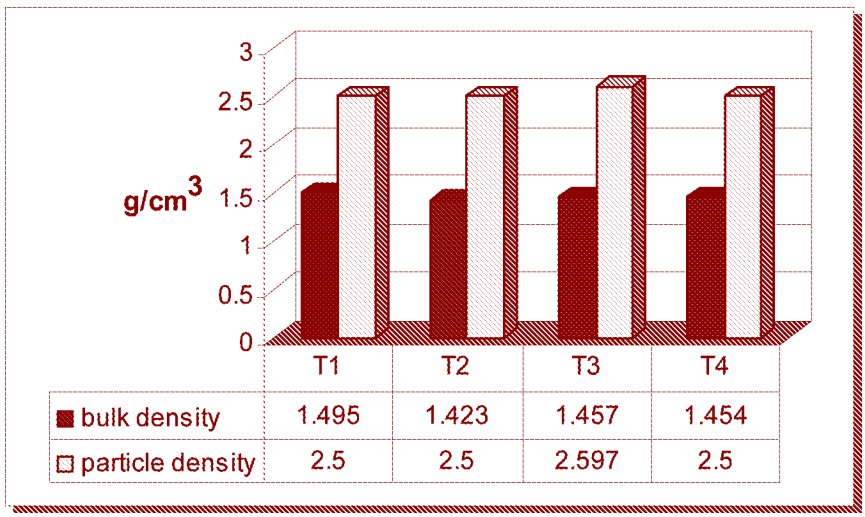

Figure 5 The bulk density and particle density of growth materials.

4) Density, Porosity, Micropores

For the density analysis, a range of the bulk density of all Treatments between 1.42-1.49 g/cm^3 was obtained (Figure 5). It is within the standard range of bulk density (1.2-1.6 g/cm^3) for plant growth (Ocean Country Soil Conservation District (OCSCD), Schnabel Engineering Associates, Inc. and USDA Natural Resources Conservation Service (NRCS), 2001; Warrick, 2002). Therefore, all Treatments have a suitable range of bulk density and adding perlite could reflect trend on improving the bulk density of the culture media in

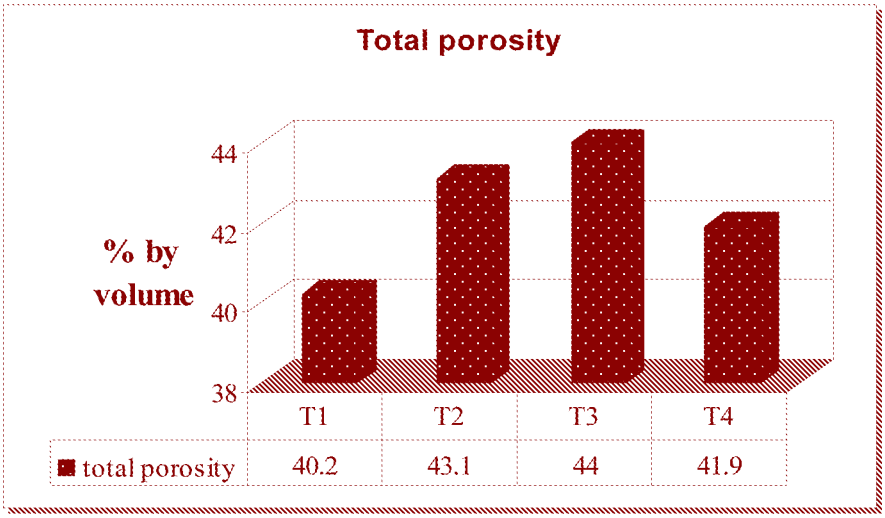

Figure 6 The total porosity of growth materials.

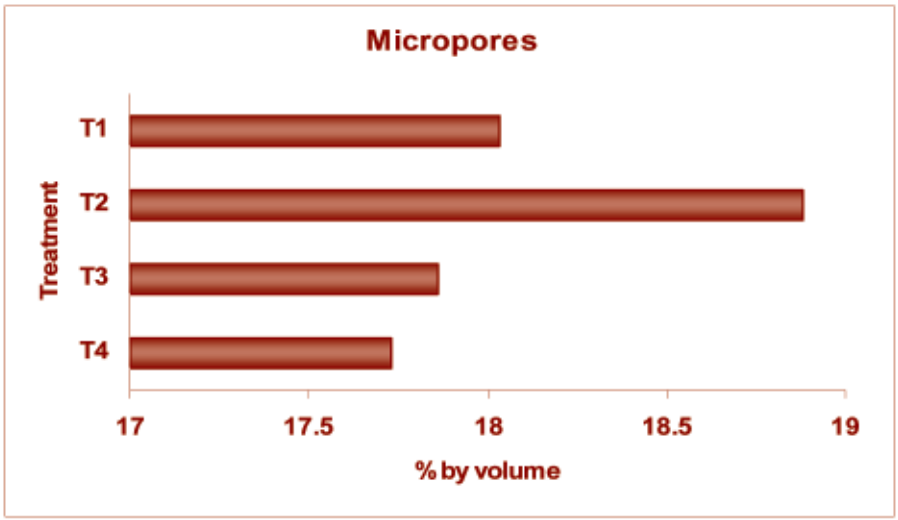

Figure 7 Micropores of growth materials.

all Treatments. The particle density values of growth materials range from 2.5-2.6 g/cm^3.

As shown in Figures 5 and 6, perlite decreases the bulk density of soils and increases the porosity in the Treatments 2 and 3, but not in a progressive trend since the total porosity of Treatment 4 is lower than that of Treatments 2 and 3. Therefore, the mixtures of soil and perlite is in an optimum limit to make growth materials high in total porosity. The porosity values are similar on the range of 40.2-44.0% by volume.

Table 2 Total nitrogen of multiply onion in each Treatment using DMRT.

Treatment	mean	difference
T_1 [soil (150 kg) + fertilizers 15-15-15 (55 g)]	3.083a	–
T_2 [soil (150 kg) : perlite (15 kg) + fertilizers (55 g)]	2.910a	-0.172 ns
T_3 [soil (150 kg) : perlite (22.5 kg) + fertilizers (55 g)]	2.788a	-0.295 ns
T_4 [soil (150 kg) : perlite (30 kg) + fertilizers (55 g)]	2.875a	-0.208 ns
Average	2.914	
CV = 13.0%		

* : significant
ns : not significant

In addition, the micropores (Figure 7) of growth material mixtures in the Treatments 1-4 were 18.0, 18.9, 17.9 and 17.7% by volume., respectively. The Treatment 2 had high volume of micropores which is good for water retention and the capacity to store and release plant nutrients. There is also a good relationship between micropores and available water capacity.

2. The response of multiply onion to changes of chemical properties of soil by perlite

1) Nitrogen

As shown in Table 2, the multiply onion does not show any response to change of soil properties by having perlite in the growth materials. There is not any significant relationship of adding perlite and the growth of multiply onion found

Table 3 Total phosphorus of multiply onion in each Treatment using DMRT.

Treatment	mean	difference
T_1 [soil (150 kg) + fertilizers 15-15-15 (55 g)]	0.226b	–
T_2 [soil (150 kg) : perlite (15 kg) + fertilizers (55 g)]	0.334a	0.108*
T_3 [soil (150 kg) : perlite (22.5 kg) + fertilizers (55 g)]	0.279ab	0.052 ns
T_4 [soil (150 kg) : perlite (30 kg) + fertilizers (55 g)]	0.317a	0.090*
Average	0.289	
CV = 17.3%		

* : significant
ns : not significant

Table 4 Total potassium of multiply onion in each Treatment using DMRT.

Treatment	mean	difference
T_1 [soil (150 kg) + fertilizers 15-15-15 (55 g)]	1.138b	–
T_2 [soil (150 kg) : perlite (15 kg) + fertilizers (55 g)]	1.524a	0.386*
T_3 [soil (150 kg) : perlite (22.5 kg) + fertilizers (55 g)]	1.243ab	0.105 ns
T_4 [soil (150 kg) : perlite (30 kg) + fertilizers (55 g)]	1.486a	0.348*
Average	1.348	
CV = 15.1%		

* : significant

ns : not significant

in the DMRT analysis. In fact, the Nitrogen means of the treatments having perlite (T2, T3 and T4) decrease slightly as compared to Treatment 1 (control). The means of the total nitrogen of multiply onion in each Treatment are not significant, the average mean is 2.914%.

2) Phosphorus

The analytical results of total phosphorus of multiply onion in the Treatments 2 and 4 are significantly higher than that of the control (Treatment 1) at 95% confidential limit. The differences are 0.108 and 0.090% increases for the Treatment 2 and Treatment 4, respectively. Treatment 2 shows the highest mean of 0.334% and Treatment 4 of 0.317%. Both Treatments show better means than that of Treatment 3. The average mean of the total phosphorus of multiply onion is 0.289%.

3) Potassium

The analytical results of total potassium of multiply onion in Treatments 2 and 4 are significantly higher than that of the control (Treatment 1) at 95% confidential limit. The differences are 0.386 and 0.348% increases for the Treatment 2 and Treatment 4., respectively. Treatment 2 shows the highest mean of 1.524% and Treatment 4 of 1.486%. Both Treatments have better means than that of the Treatment 3. These ratios of soil : perlite in Treatment 2 and Treatment 4 have a good effect on potassium of multiply onion. Treatment 2 has also shown good results on physical properties of soil, including moisture, hydraulic conductivity and volume of micropores.

Conclusions

The results of the analysis on some physical properties of soil and on macro nutrients of multiply onion response reveal two relevant important conclusions.

Firstly, the physical properties of soil such as the soil moisture and hydraulic conductivity can be improved by using perlite as indicated by the good response in Treatment 2 whereas there is the good available water and nutrient storage for plant, which shows the slow leaching.

Secondly, the response of multiply onion by adding perlite shows a significant effect on total phosphorus and total potassium in Treatment 2 and Treatment 4.

Based on those two conclusions, Treatment 2 shows a better result on the effect of micropores in the growth material promoting the suitable moisture condition and retarding the loss of nutrients from leaching.

The use of perlite can be effective on clayey soils since perlite can improve their physical properties. In an intensive agriculture the use of perlite can be considered for a more efficient practice. However, more experiments are advised to increase the confidence on its use.

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