Selection Of Suitable Particle Size And Particle Ratio For Japanese Cucumber (Cucumis Sativus L.) Plants

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Abstract: This study was conducted to select the best particle size of coco peat for cucumber nurseries as well as best particle ratio for optimum plant growth and development of cucumber. The experiment was carried out in International Foodstuff Company and Faculty of Agriculture, University of Ruhuna, Sri Lanka during 2015 to 2016. Under experiment one, three types of different particle sizes were used; namely fine (≤0.5mm) (T2), medium (3mm-0.5mm) (T3) and coarse (4mm<) (T4) with normal coco peat (T1) as treatments. Complete Randomized Design (CRD) used as experimental design with five replicates. Germination percentage, number of leaves per seedling, seedling height in frequent day intervals was taken as growth parameters. Analysis of variance procedure was applied to analyze the data at 5% probability level. The results revealed that medium size particle media (sieve size 0.5mm -3mm) of coco peat was the best particle size for cucumber nursery practice, when considered the physical and chemical properties of medium particles of coco peat. In the experiment of selecting of suitable particle ratio for cucumber plants; the compressed mixture of coco peat particles that contain 70% (w/w) unsieved coco peat, 20% (w/w) coarse particles and 10% (w/w) coconut husk chips (5 – 12mm) has given best results for growth performances compared to other treatments and cucumber grown in this mixture has shown maximum growth and yield performances.

Keywords: Coco peat pellet, Japanese cucumber, Particle ratio, Particle size

1. Introduction

The use of modern technologies with high capital investment makes a positive contribution to agriculture. Controlled Environment Agriculture (CEA) is a total concept of modifying the natural environment for optimum plant growth. Under CEA, there are various types of crops are cultivated. Among crops grown under hydroponics, salad type vegetables have increasing demand at present due to not only their high nutritive value but also attractive nature, taste and flavor. [1] In this context Japanese cucumber is highly concerned. It has a high demand from all around the world. However the success of Cucumber crop depends on the ability to keep uniform growth and development at the beginning of the nursery stage. At the initial stage of plant growth different factors are affecting plant development such as seed vigor, moisture content, substrate conditions, environmental conditions etc. Among these factors substrate condition directly affect to the plant development. [2] According to the substrate the moisture content, bulk density and porosity are being changed. Researchers have tried to provide the perfect growth media for nursery production by characterizing the physical properties of different media. The physical components that are important to quality media include: pore size, porosity, water-holding capacity, hydraulic conductivity, aeration porosity, and bulk density. [3] Bulk density is an important factor to consider in interpreting the physical and chemical properties of media on a volume basis.

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Bulk density of soilless media are low, therefore additions of sand are usually added to increase weight [4], [5], [6] Increasing bulk density provides support to the plant in lightweight containers. [5] also found that shrinkage and settling in a pot will increase bulk density. Considering these facts this experiment was done to investigate the suitable particle size, effect of pellet diameter, fertilizer type and mixing rate of fertilizer on nursery stage of Cucumber.

2. Materials and Methods

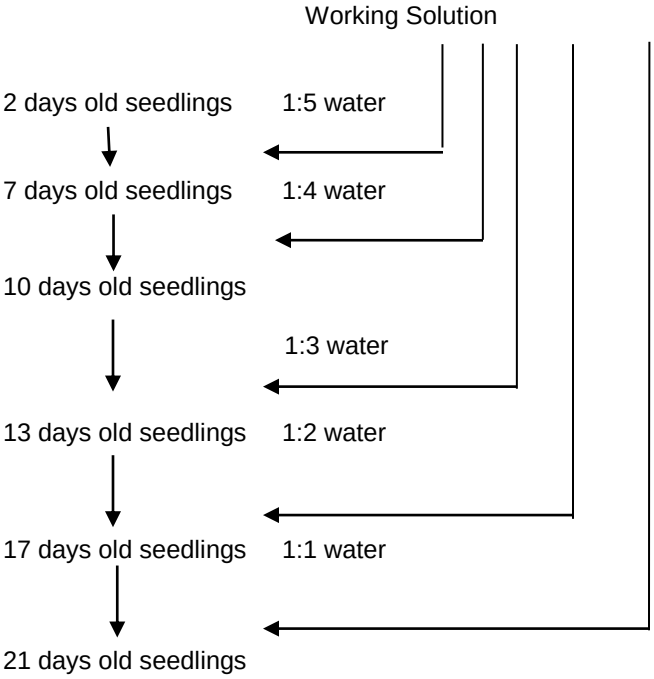
2.1 Experiment (1): Identification of suitable particle size of coco peat for tomato

The experiment was carried out in International Foodstuff Company, Embilipitiya and Faculty of Agriculture, University of Ruhuna, Sri Lanka under protected condition. Three types of different particle sizes were used with normal coco peat (control) treatment.

Normal coco peat (control) = T1
Fine particle (≤0.5mm) = (T2)
Medium particle (3mm-0.5mm) = (T3)
Coarse particle (4mm<) = (T4)

Before start the experiment, Bulk density, air filled porosity, water holding capacity, pH, Cation Exchange Capacity (CEC) and Electrical Conductivity (EC), were measured in each treatment. Then four treatments were wetted by using equal an amount of water. The cucumber nursery trays were filled by using above wetted four materials. The experimental design was arranged according to Complete Randomized Design (CRD) with five replicates. After arranging experimental units, cucumber seeds (Var. Ifdal) were sown in each replicates and covered with black polythene to control the light penetration. Daily watering was applied up to germination. Two days after germination fertilizer application schedule was started. Albert's solution was used as fertilizer; at first, stock solution was prepared. The electrical conductivity and pH of the stock solution was 60mS/cm and 5.8 respectively. Working solution was prepared from stock solution the electrical conductivity and

pH values of that solution were 1.8mS/cm and 5.8 respectively. These tomato seedlings were adapted for above working solution within 21 days. Therefore following dilution and application procedure was used.



2.2 Experiment (2): Identification of suitable particle ratio (w/w) of coco peat as growing mixture for grow bag cultivation of greenhouse vegetables

This experiment was designed to identify suitable particle ratio (w/w) of coco peat as growing mixture for grow bag cultivation of cucumber. Coco peat particles of fine (less than or equal to 0.5mm diameter), coarse (greater than 3mm diameter), chips (cut dried coconut husk, 5mm to 12mm diameter) and raw (none sieved coir peat) were used as raw materials in this experiment. Before mixing them, calcium nitrate treatment was applied to wash out excess Na^+ and K^+ from coco peat. After that above mentioned raw materials were mixed in different ratio (as weight percentage) and created following treatments.

Table 1: *Different percentages of raw material used to produce grow slab*

Raw coco peat % (w/w)	Fine particle % (w/w)	Coarse particle % (w/w)	Chip % (w/w)	Treatment code
90	0	0	10	T_1
70	0	20	10	T_2
50	20	20	10	T_3
30	20	40	10	T_4
10	40	40	10	T_5

After preparation above mixtures (T_1-T_5), grow slabs (90cmx20cm x10cm, length, width, height and 2 kg of weight) were produced as assigned in different treatments using hydraulic pressure equipment. Then the grow slabs were inserted into polythene bags (outer color is white and inner color is black , length, width and height is 112cm, 20cm and 13cm respectively) and named (T_1-T_5). After that, separate sub experiments were carried out for different greenhouse crops (tomato, bell pepper, slicing cucumber and cabbage). The grow bags that prepared as in table 1 were laid on the floor of the ploy tunnel and arrange treatments (T_1-T_5) according to the Complete Randomized Design (CRD) with five replicates. After that, measured amount of water was added separately by making three holes on the top of the bag in equal distance. After one hour, drain out holes (8mm diameter) were made on the bottom of the grow bag. The cucumber seedlings (3 per grow bag) were transplanted. Fertilizer (Albert's solution) and water were applied through drip irrigation system. In the vegetative period, EC and pH of the Albert's solution were maintained 2.0 mS/cm and 6.3 respectively. Plants were trained in vertically with the support of rope which is made by cloths and pruning and training was done as single stem plant. In the flowering stage, EC and pH of the Albert's solution were maintained 2.3mS/cm and 6.3 levels respectively. As growth parameters, plant height and number of leaves per plant were measured once in two weeks up to 12 weeks after planting and total marketable yield per bag (fresh yield in kg) was measured as yield parameter at the end of the crop (4 months after planting).

3. Results and Discussion

3.1 Effect of particle size on seed germination, number of leave per seedling and seedling height of cucumber

According to the analysis of variance of germination percentages of cucumber seeds, there was not significant ($p \leq 0.05$) difference among the mean germination percentages of three different particle sizes (fine, medium and coarse) after 5 days of seed sowing. The highest germination percentage (84.5%) was observed in medium size particle medium. Also after 7 days from seed sowing, number of leaves per seedling was same value (2 leaves) in fine, medium and coarse media. But significant ($p \leq 0.05$) variance was observed in number of leaves per seedling of cucumber at 14 and 21 days after seed sowing. Significantly highest number leaves per seedling (3.4 leaves) was recorded in medium size particle medium at 14 days after seed sowing followed by fine medium (2.8 leaves) and coarse medium (2.6 leaves) particle size (Figure 1). When 21 days after seed sowing significantly highest number of leaves/seedling (4.6 leaves) was recorded in fine media compared to seedlings in coarse particle (3.8 leaves), however leaves/seedling in medium particles (4.5 leaves) statistically same to fine media. (Figure 1)

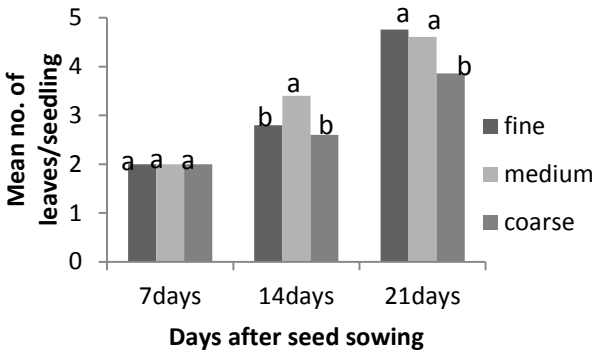


***Figure 1**: Changes of mean no. of leaves/seedling of cucumber seedling in three different particle sizes within 21 days after seed sowing*

Bars represented by the same letter are not significantly different at α ≤ 0.05 The water holding capacity is depended on the particle size of coco peat. Coco peats in fine particle have higher water holding capacity while coco peats in coarse particles have low water holding capacity. Hence, cucumber should be grown in coco peat media with fine particles to ensure better growth (i.e high no. leaves/seedling) (Table 2)

***Table 2:** Physical and chemical properties of coarse, medium and fine particle sizes of coco peat*

Particle type	Bulk density (g/l)	Water holding capacity (ml/l)	Air filled porosity (% v/v)	Electrical conductivity (µS/cm)	pH	CEC meq/100 g
Fine	164.30^{a}	830^{a}	12^{c}	600^{a}	6.2^{a}	130^{a}
Medium	108.29^{b}	550^{b}	25^{b}	325^{b}	6.1^{a}	86^{b}
Coarse	53.82^{c}	250^{c}	68^{a}	80^{c}	6.5^{a}	36^{c}

The different particle size of coco peat had a significant (p≤0.05) impact on seedling height of cucumber at 14 and 21 days after seed sowing. The seedlings in medium size particles had significantly (p≤0.05) highest mean heights (8.19cm at 14 days and 14.3cm at 21days) at 14 and 21 days after seed sowing. Approximately same and lower mean seedling heights recorded in fine and coarse, media at 14 and 21 days after seed sowing (Figure 2).

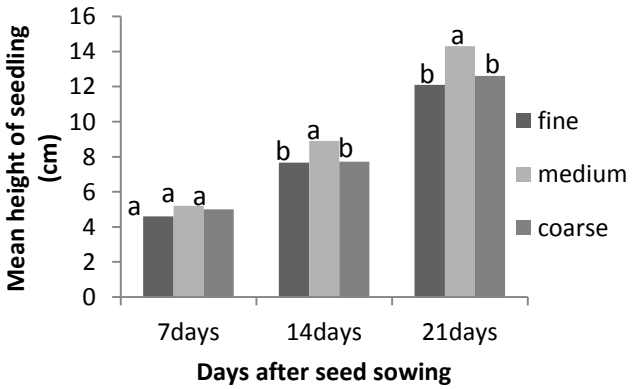


***Figure 2**: Changes of mean height (cm) of seedling of cucumber in three different particle sizes of coco peat 21 days after seed sowing*

Bars represented by the same letters are not significantly different at α ≤ 0.05 Considering to results revealed from above experiment indicate medium size particles provide better plant growth because of that medium sized media maintains moderate bulk density (108.29g/l) and moderate water holding capacity (550ml/l), good air filled porosity (25%) and best pH 6.1. When increase the bulk densities of substrates reduce the pore spaces for air [7]as a result, retain higher moisture content and low Oxygen (O_2) for root growth hence, nutrient absorption is low [8] Also significantly higher EC and CEC was observed in fine particle media, when increase the EC, soluble salt content in the media is increase [9] it makes the stress on vegetative growth of seedlings, this effect can be seen in fine particle media, this may be the reason for lower number of leaves per seedling and low seedling height in fine media. Also in opposite way, coarse particles contain lowest bulk density hence it maintains more spores for air and low water and contains low CEC. It reduces the growth performances (no leaves/seedling and height of seedling).

3.2 Experiment 2: Effect of different grow slab mixtures on growth and yield parameters of cucumber

In the mixture of grow slab had a significantly impact on vine height of cucumber. The highest vine height was recorded in T2 mixture during whole growing season with compared to other treatments. T1 particle mixture was the second best mixture (Table 2). The significantly highest number of leaves/vine was also recorded in T2 mixture (Table 3) with compared to other mixtures (T1, T3, T4 and T5). When compared to fruit yield of cucumber T2 mixture recorded the significantly highest fruit yield (5.18 kg/vine). The lowest yield was recorded in T5 mixture (figure 3).

***Table 3:** The changes of no. leaves/plant of cucumber in different mixtures of grow slab during vegetative growing period*

Treatment code	2nd week	4th week	6th week	8th week	10th week	12th week
T1	7.8^{b}	12.6^{b}	16.6^{b}	22.0^{c}	24.7^{b}	27.1^{b}
T2	8.7^{a}	14.7^{a}	17.9^{a}	24.3^{a}	25.6^{a}	28.2^{a}
T3	7.6^{bc}	12.0^{b}	16.7^{b}	23.3^{b}	24.4^{b}	26.0^{c}
T4	7.4^{cd}	12.6^{b}	16.8^{b}	23.2^{b}	24.4^{b}	25.9^{c}
T5	7.2^{d}	12.3^{b}	15.8^{c}	22.6^{bc}	23.6^{c}	25.6^{c}

T1-T5 – The mixtures of different particles of coco peat used to produce grow slab Means represented by the same letter are not significantly different at α ≤ 0.05

Table 4: *The changes of height (cm) of cucumber vine in different mixtures of grow slab during vegetative growing period*

Treatment code	2nd week	4th week	6th week	8th week	10th week	12th week
T1	16.6[b]	39.8[ab]	58.5[b]	88.1[b]	122.8[b]	163.6[b]
T2	20.3[a]	45.2[ab]	65.1[a]	99.7[a]	132.0[a]	171.9[a]
T3	17.1[b]	36.4[b]	53.2[c]	84.3[bc]	120.3[b]	152.4[c]
T4	15.8[b]	35.9[b]	53.4[c]	87.3[bc]	122.8[b]	151.3[c]
T5	15.8[b]	35.5[b]	53.5[c]	80.4[c]	119.0[b]	149.0[c]

T1-T5 – The mixtures of different particles of coco peat used to produce grow slab (refer table 1) Means represented by the same letter are not significantly different at $\alpha \leq 0.05$

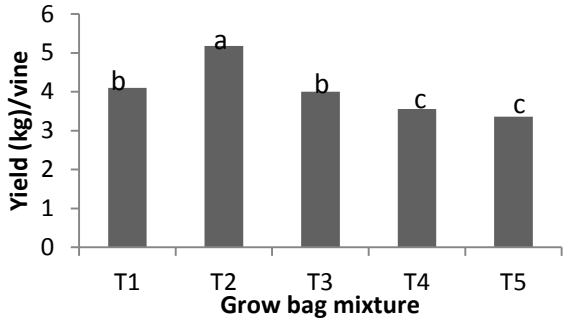


Figure 3: *Changes of mean yield of cucumber in different grow slab mixtures*

Bars represented by the same letter are not significantly different at $\alpha \leq 0.05$ When considered some physiochemical properties of substrates presented in table 2, the T4 and T5 mixtures bulk density were higher than other substrates. The amount of bulk density in T2 was 62g/l; therefore, root media aeration in this treatment is better than others. Porosity percentage that is an index for root media aeration was high for T2 substrate (70%) and it was low for T4 and T5 (56% and 51%). When root media aeration is sufficient, supply of water and nutrient elements for plants is easily [10]. The amount of EC (Electric Conductivity) in T2 was less than other substrates. As a result of that T2 substrate not badly effects on fertigation on plants and it confirms absorption optimum amount of every nutrient [11] Amount of CEC in substrates different and higher and lower amounts related to T2 and T5 respectively; therefore, the T2 media had more capacity for supplement of nutrient elements for plant. The pH of the different substrates was relatively same and it was optimum range (5.5-6.5). Also water availability of the all media was same. The physiochemical properties in T2 media were better than others that cause to increasing in growing indexes. The low amount of bulk density and the high amount of porosity related to T2 media that allowed the plant root penetrate in substrate easily and it could use more volume and space of media, thus available water and nutrient elements were sufficient for plants grow up in this media. Also the amount of CEC in T2 media was higher than others. This term related to nutrient elements buffer capacity that has an essential role in plant supplement. Therefore, physiochemical properties of substrates affected on plant growing indices and yields and tend to above results.

4. Conclusion

According to the results medium size particle media (sieve size 0.5mm -3mm) of coco peat was the best particle size for cucumber nursery practice, when considered the physical and chemical properties of medium particles of coco peat. The compressed mixture of coco peat particles that contain 70% (w/w) unsieved coco peat, 20% (w/w) coarse particles and 10% (w/w) coconut husk chips (5 – 12mm) is the best growing media for cabbage. The crops grown in this mixture are shown maximum growth and yield performances. The grow slab that produced using above ratio of coco peat particles can be used to re-cultivate the cucumber as a commercial crop to obtain maximum yield and income.

5. References

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