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REGULAR ARTICLE

GROWTH AND YIELD RESPONSE OF RED ONION (*ALLIUM ASCALONICUM* L.) GROWN IN DIFFERENT POTTING MEDIA

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SUMMARY

An experiment was conducted to evaluate the growth and yield response of red onion (*Allium ascalonicum* L.) grown in different potting media. Potting materials were sandy soil, cattle manure, coir dust and paddy husk ash. The media such as medium 1 used as control (sandy soil: cattle manure at ratio (v/v) of 6:2), medium 2 (sandy soil: cattle manure: coir dust at ratio of 6:2:1), medium 3 (sandy soil: cattle manure: paddy husk ash at ratio of 6:2:1) and medium 4 (sandy soil: cattle manure: coir dust : paddy husk ash at ratio of 12:4:1:1) were prepared two weeks before planting. Bulbs were planted in each pot and other agronomic practices were done as recommended by Department of Agriculture, Sri Lanka. Plant height and number of leaves per plant were recorded at two week intervals. At the time of harvesting, fresh and air dry weights of plant, number of bulbs per plant, bulb diameter, bulb length, weight of bulbs per plant and nutrient (P and K) contents were measured and data were analyzed. The results indicated that potting materials have significant ($p<0.01$) effect on the growth, yield and nutrient contents of red onion grown in different potting media. Maximum number of leaves per plant, maximum bulb diameter, high number of bulbs per plant, high weight (50.15 g) of bulbs per plant and also high P (74 g) and K (1080 g) contents of 100 g bulbs harvested were recorded in medium 3 among tested media. It was also noted that the weight of bulbs per plant increased more than two fold in medium 3 over control (medium 1). Usage of paddy husk ash as a potting material in medium preparation would improve the growth and yield performances of red onion grown in pot culture technique.

Key words: Cattle manure, Coir dust, Nutrient contents, Onion, Paddy husk ash, Yield

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1. Introduction

Onion (*Allium cepa* L.) is an important bulb crop grown world wide. It is an important crop in all condiment and used for flavouring the food, both at mature and immature bulb stages besides being used as salad and pickles. To lesser extent, it is used by processing industry for dehydration in the form of onion flakes and powder, which are in great demand in the world market. World production was around 59.53 million mt harvested from 3.26 million ha in 2006 [1]. Red onion (*Allium ascalonicum* L.) has a vital role in the diet of Sri Lankan and has a high value cash crop of the dry and intermediate zone. In Sri Lanka, the production of red onion was around 51,200 mt harvested from 5276 ha in the year of 2008 [2]. Production level can be increased either by increasing the extent of cultivated area or by increasing yield per unit area. However, the possibility to increase the extent under cultivation is less because of limited land resource and also existing land become unsuitable to cultivation due to adverse climatic changes and natural disaster. Cultivation of crop using eco-friendly innovative techniques with sustainable use of resource is the best way to increase production level of food. On that basis several techniques are introduced for vegetable cultivation such as hanging bag, trench, pot, root dipping, aeroponic and floating techniques.

Pot technique is an open system of vegetable cultivation and crops are grown in pots or poly bags. This is a means of diversification for making agriculture more

profitable through efficient land use and maximum utilization of natural resource. Potting medium depends on the crop requirement and the medium should provide suitable condition for the crop growth. Mixture of organic manures with soil is a good medium for vegetable crops. Cattle manure, paddy husk ash, coir dust, sand or gravel, peat, vermiculite, perlite, sawdust are normally used materials for media preparation. Among these, cattle manure, coir dust and paddy husk ash are locally available organic manures and those materials contain certain amount of major nutrient (N, P and K). Onion gives good response to organic manure [3] therefore, the usage of organic manures in growing medium of onion would give better result in it's growth and yield.

Cattle manure is the most common organic manure used in agriculture. Addition of cattle manure to potting medium improves the physical properties of soil, microbial activity and nutrient availability in growing medium especially nitrogen to the crop because it contains 0.35% N, 0.12% P_2O_5 and 0.17% K_2O [4]. Coir dust is the spongy, peat like residue from the processing of coconut husks for coir fiber. Nowadays coir dust is used in growing medium for many crops such as fruits tree, vegetable and cut flowers. When applied to agricultural soil, coir dust can improve moisture retention capacity, increase nutrient content, infiltration rate, total porosity and hydraulic conductivity of that soil [5]. They are able to increase aeration in the basal mixture and reduce drying of the surface by lifting moisture higher in the pot. Coir dust contains 0.2% of N, 0.18% of P_2O_5 and 0.96% of K_2O [4]. The water holding capacity of the soil was increased in direct proportion to the amount of coir dust incorporated [6]. In sandy soil of Sri Lanka where clay content ranges from 3% to 5% the cation exchange capacity is low as 4 meq/100 g soil [7]. This shows the ability of coir dust retain more plant nutrient, reducing leaching and show response to applied fertilizer when incorporated to soils in growing medium.

Paddy husk is major byproduct obtained from paddy. For every 4 ton of paddy 1 ton of husk is produced. The husk is disposed off either by dumping in an open heap near the mills side or on the road side to be burnt later. Burning of husk generates about 15-20% of its weight as ash [8]. The ash being very light is easily carried by wind and water thus contributing to air and water pollution. The huge quantity of ash generated requires large area disposal. Its effective utilization by exploiting its inherent properties is the only way to solve the environmental and disposal problem of the ash. When burned, paddy husk help to build up of soil structure and aeration as they hold shape for a long time, have good water holding capacity, and are bacteria and fungus – free making them a good potting material [9]. Paddy husk ash contains high percentage of potassium and phosphorus than nitrogen. Potassium and phosphorus contents of paddy husk were 0.01- 2.69% P_2O_5 and 0.1 – 2.54% K_2O respectively [10]. Decomposition of materials would provide additional nutrients to the growing medium which may lead to higher uptake of nutrient by the crop and subsequently high yield. Therefore, this study was carried out to evaluate the effect of potting materials on the growth and bulb yield of red onion grown in different potting media using pot culture technique and also select a best potting medium for red cultivation of onion in pots.

2. Materials and Methods

This experiment was carried out in 2008/2009 at the Agronomy farm of the Eastern University, Sri Lanka. The mean annual rainfall of the Batticaloa district ranges from 1800 to 2100 mm, annual mean temperature is between from 28 °C and 32 °C and humidity ranges from 60% to 90%. Red onion cv '*vethalam*' was used in this study. The design of the experiment was Complete Randomized Design with four treatments (Table 1). This experiment was repeated once.

Table 1: Treatments used in this study

Treatments	Potting mixture	Ratio (v/v)
T_1 (Medium-1)	Sandy soil + Cattle manure	6:2
T_2 (Medium-2)	Sandy soil + Cattle manure + Coir dust	6:2:1
T_3 (Medium-3)	Sandy soil + Cattle manure + Paddy husk ash (PHA)	6:2:1
T_4 (Medium-4)	Sandy soil + Cattle manure + Coir dust + Paddy husk ash	12:4:1:1

In this study, sandy soil, cattle manure, coir dust and paddy husk ash were used as potting materials. Before the media preparation, some selected physical properties such as water holding capacity, particle density, bulk density and porosity and chemical properties such as pH, nutrient contents (P and K), organic matter content and electrical conductivity of soil were measured and presented in Table 2. Different types of potting media were prepared two weeks before planting to allow decomposition by mixing of materials at different ratio (v/v) as shown in Table 1 and it was filled into each poly bag (50 cm diameter and 25 kg capacity) used as pot upto a height of 30 cm leaving 10 cm from the top. All the treatments were assigned randomly. Nine fungicide treated bulbs were planted at the spacing of 10 cm ×10 cm in each bag and all other cultural practices were done as recommended by Department of Agriculture, Sri Lanka.

Table 2: Properties of sandy soil used for the experiment

Properties	Amount
Physical properties	
• Water holding capacity (%)	25.59
• True density (g/cm^3)	02.61
• Apparent density (g/cm^3)	01.45
• Porosity (%)	44.38
Chemical properties	
• pH (water : soil = 2:1)	6.40
• Electrical conductivity (µs / cm)	31.30
• Organic mater content (%)	0.60
• Total K content (%)	0.12
• Total P content (%)	0.06

During the vegetative growth period, plant height and number of leaves per plant were recorded from second week to tenth week of planting at two weeks interval. At the time of harvesting (85 days after planting), number of bulbs per plant, bulb diameter, bulb length and bulb weight per plant were measured in each treatment. The potassium and phosphorus contents were determined in bulbs using dry ashing and wet ashing method [11] respectively. All collected data were statistically analyzed by analysis of variance and the mean separation was done using Duncan's Multiple Range Test at 5% level by using Statistical Analysis System (SAS) soft ware package.

3. Results and Discussion

Plant height

There was significant difference ($P<0.05$) in plant height among the treatments upto 8th week after planting (WAP) (Table 3). The difference among the treatments would be due to the different compositions of potting mixture. At the 2nd WAP, plant height of control treatment (T_1) was significantly differed ($P<0.01$) from other treatments. But T_3 and T_4 were not showed any significant difference ($P>0.05$) in plant height. Both

media contained paddy husk ash likewise T_2 and T_4 were also not significantly differed each other, those media contained coir dust as a component in potting media. However, height of plant in T_2 and T_3 were significantly differed ($P<0.05$) at 2nd WAP. The reason may be the variation in nutrient contents of both media. T_3 contained high P and K than T_2 [12]. Coir dust in T_2 takes a certain period for fully decomposition and to release nutrient due to it's high C: N ratio (104:1). Average plant height ranges from 19.36 cm to 26.03 cm at 2nd WAP. It was further noted that from 4th to 8th WAP T_2, T_3 and T_4 did not significantly vary ($P>0.05$) each other but they all significantly varied ($P<0.05$) from T_1. At 10th WAP, there was no significant difference in plant height ($P>0.05$) among the treatments because plants in all treatments entered into bulb formation, during this period normally vegetative growth ceases.

Table 3: Plant height of onion grown in different potting media

Treatment	Canopy height (cm)				
	At 2nd week	At 4th week	At 6th week	At 8th week	At 10th week
T_1	19.36 ± 0.86 c	34.54 ± 0.25 b	40.11 ± 0.29 b	38.92 ± 0.43 b	35.27 ± 1.04
T_2	23.20 ± 0.22 b	37.64 ± 0.56 a	43.35 ± 0.17 a	43.37 ± 0.43 a	35.47 ± 0.70
T_3	26.03 ± 0.48 a	39.29 ± 0.81 a	44.41 ± 0.52 a	44.63 ± 0.60 a	38.50 ± 0.71
T_4	24.87 ± 1.45 ab	37.54 ± 1.08 a	43.35 ± 0.30 a	42.84 ± 1.32 a	38.84 ± 1.78
F test	**	*	*	*	*ns*

Value represents mean ± standard error of five replicates

F test: - **: P< 0.01; * P< 0.05; ns: not significant

Means followed by the same letter in each column are not significantly different according to Duncan's Multiple Range Test at 5% level

Relatively high levels of nutrients are required for optimum growth and development at early stage and adequate moisture supply is most suitable during the early growth [13]. Positive effect of K on growth parameter may be due to the K increased efficiency of the plant for utilization of nitrogen which essential for plant growth as well as other process related to nitrogen metabolism [14]. With respect to plant height, T_3 showed high values while T_1 showed low values among the treatments i.e. high vegetative growth was recorded with medium contained high P and K than others. The obtained results were in good accordance with El- Bassiony [15] who reported that the increases in soil and foliar application of K increases plant height of onion. Similar results were also stated by other researchers [16] [17] in onion.

Number of leaves per plant

There was highly significant difference ($P<0.01$) among the treatments in the number of leaves per plant during their vegetative growth (Table 4). Number of leaves per plant at 2nd WAP indicated that high values obtained in T_3 and T_4, those two treatments were not significantly differed ($P>0.05$) each other but significantly differed ($P<0.05$) from T_1 and T_2. The presence of ample quantity of nutrient in both T_3 and T_4 at early stage than other leads to high uptake of major nutrient might have resulted better performance in vegetative growth. At 4th WAP, T_3 significantly varied ($P<0.01$) among the treatments. Average number of leaves per plant at 4th WAP ranges from 19.93 to 32.40. Decomposition of coir dust in medium increases nutrient contents and more or less equal quantity of available nutrient at the period may be the reason for the equal performance of plant in both T_2 and T_4 at 4th and 6th WAP. At 6th WAP, T_2 and T_4 were not significantly differed ($P>0.01$) each other while at 8th WAP both treatments were significantly differed ($P<0.01$) each other. Reason may be the deviation in the amount of nutrient release from coir dust alone and the nutrient release from the combination of coir dust and paddy husk ash. Nutrient contents (P and K) in paddy husk ash are higher than coir dust. K_2O content of paddy

husk ash and coir dust are 0.1 – 2.54% K_2O [10] and 0.96% [4] respectively and P_2O_5 content of paddy husk ash and coir dust are 0.01- 2.69 % [10] and 0.18% [4] respectively.

Table 4: The number of green leaves per plant in each treatment at two week intervals

Treatment	Number of green leaves				
	At 2nd week	At 4th week	At 6th week	At 8th week	At 10th week
T_1	11.67 ± 0.64 b	19.93 ± 1.34 c	24.87 ± 0.73 c	25.47 ± 0.58 b	10.00 ± 1.32 b
T_2	13.67 ± 0.44 b	25.67 ± 0.59 b	32.47 ± 1.35 b	35.07 ± 0.29 b	15.50 ± 1.91 b
T_3	17.40 ± 0.69 a	32.40 ± 0.83 a	38.67 ± 1.56 a	40.20 ± 0.64 a	17.33 ± 1.40 b
T_4	16.20 ± 1.20 a	26.93 ± 2.35 b	35.07± 2.73 ab	38.33 ± 1.84 a	26.67 ± 2.72 a
F value	**	**	**	**	*

Value represents mean ± standard error of five replicates

F test: - **: P< 0.01; * P< 0.05

Means followed by the same letter in each column are not significantly different according to Duncan's Multiple Range Test at 5% level

Among the treatments, higher number of leaves per plant was recorded in T_3 while lower number of leaves per plant was recorded in T_1 upto 8 WAP. Peak values attained at 8th WAP in all treatments, ranges from 25.47 to 40.20. Effect of the component (paddy husk ash) in T_3 and T_4 i.e high amount of nutrient especially K might be the reason for the better performance of red onion during vegetative growth period. This result was good accordance with those recorded by other researchers [15] [18] [19]. K nutrition has pronounced effect on carbohydrates partitioning by affecting either phloem export of photosynthate (sucrose) or growth of source (leaves) and or sink (bulb) organs [20]. Reduction in number of green leaves at 10th WAP might be due to the translocation of food from source to sink and senescence of leaves. During the period of bulb formation, plants cease to produces new leaves.

Fresh and air dry weights of plant

The results shown in Table 5 indicated that there were significant differences ($P<0.01$) in fresh and air dry weights of plant at the time of harvesting among the treatments. Average fresh weight of plant ranges from 27.87 to 59.30 g and average air dry weight of plant ranges from 25.02 to 54.92 g. Water loss through evaporation is cause for weight reduction between fresh and air dry weights. Higher amount of nutrients increases the leaf area index (LAI) [21]. Leaf area represents the photosynthetic surface of a crop. Variation in the nutrient content in media and uptake amount by the plant might be the cause for variation in growth, which was clearly found in plant height and number of leaves per plant. For the maximum production of dry matter of most crops, maximum LAI is usually necessary and dry matter increases rapidly with larger LAI; it's found to show significant positive correlation with the total dry matter production and crop growth rate [22].

Table 5: Fresh and air dry weights of plant, bulb diameter and bulb length in each treatment at the time of harvesting

Treatment	Fresh weight of plant (g)	Air dry weight of plant (g)	Bulb diameter (cm)	Bulb length (cm)
T_1	27.87 ± 2.19 d	25.02 ± 2.18 d	1.63 ± 0.06 c	2.64 ± 0.59 b
T_2	45.32 ± 1.32 c	41.25 ± 0.76 c	1.81 ± 0.02 b	2.97 ± 0.06 a
T_3	59.30 ± 0.32 a	54.92 ± 0.85 a	1.98 ± 0.03 a	2.88 ± 0.33 a
T_4	52.40 ± 1.07 b	46.89 ± 1.70 b	1.80 ± 0.03 b	2.95 ± 0.44 a
F value	**	**	**	**

Value represents mean ± standard error of five replicates

F test: - **: P< 0.01; * P< 0.05

Means followed by the same letter in each column are not significantly different according to Duncan's Multiple Range Test at 5% level

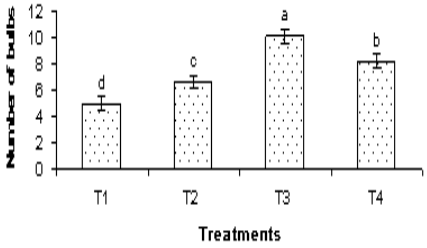
Bulb diameter and Bulb length

Table 5 shows that the bulb diameter significantly varied (P<0.01) among the treatments at the time of harvesting and average bulb diameter ranges from 1.63 cm to 1.98 cm. Bulb length was also showed a significant difference (P<0.01) among the treatments (Table 5). Bulb length ranges from 2.64 cm to 2.97 cm. Increasing K uptake leads to increase in accumulation of carbohydrates and pungency of onion [23]. Increase in food accumulation may be contributed to increase in both bulb diameter and length.

Number of bulbs

The number of bulbs per plant at the time of harvesting was showed significant difference (P<0.01) among the treatments (Figure 1). T3 gave more number of bulbs per plant while T1 showed low value in number of bulbs per plant. Average number of bulbs per plant ranges from 4.93 to 10.06. Onion is a heavy feeder plant and it gives good response to organic manures [3]. K increases the photosynthetic rate of crop leaves [24] CO2 assimilation [25] and facilitates carbon movement [26]. Further more, K has an important role in the translocation of photosynthates from source to sink [20].

Figure 1: Number of bulbs per plant in each treatment at the time of harvesting



Means followed by the same letter are not significantly different according to Duncan's Multiple Range Test at 5% level.

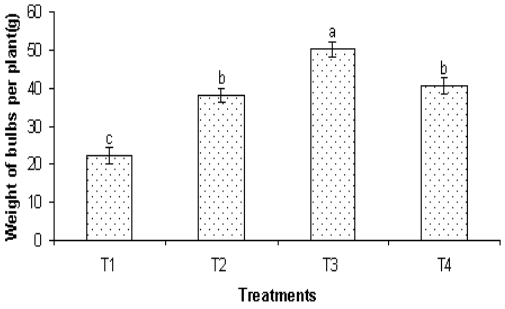
The reason for higher number of bulbs per plant in T_3 might be the high uptake of nutrient P and K by plants in that medium than others. The combination with higher plant height and higher number of leaves per plant in T_3 than others ensure more leaf area for photosynthesis, this leads to increase in photosynthetic rate and promotes accumulation of food in sink organ, ultimately end up with increase in number of bulblets formed itself. In addition to N, P and K paddy husk ash contains magnesium in the form of MgO, MgO content of paddy husk ash is 0.23 – 1.59% [8] and magnesium is a constituent of chlorophyll molecule and many enzymes involve in carbohydrates metabolism requires Mg as an activator [27]. Therefore Mg present in the paddy husk ash

might play a part of role in increasing photosynthetic rate of plants in T_3. Thus, addition of paddy husk ash to T_3 and T_4 media showed enhancement of plant growth and formation of bulbs.

Weight of bulbs per plant

It was noted that that there was significant difference ($P<0.01$) in weight of bulbs per plant among the treatments (Figure 2). Increase in number of bulbs per plant and increase in both diameter and length of bulb contributed to increase in weight of bulbs per plant. Average weight of bulbs per plant ranges from 22.17 g to 40.65g. The highest weight of bulbs per plant was obtained in T_3 while control treatment (T_1) showed lowest weight of bulbs per plant.

Figure 2: Weight of bulbs per plant in each treatment at the time of harvesting



Means followed by the same letter are not significantly different according to Duncan's Multiple Range Test at 5% level.

Nutrient Contents (P and K) in bulbs

Nutrient contents (P and K) in bulbs of red onion were significantly differed ($p<0.01$) among treatments (Table 6). Highest P and K contents were recorded in bulbs harvested from T_3. Average Phosphorus content (mg/100g) ranges from 48 to 74 and potassium content (mg/100g) ranges from 820 to 1080. Many investigators reported that high level of K fertilization to onion resulted in bulb with high quality and higher total soluble sugar, N, P and K. Using potassium sulphate plus a stimulate dose of potassium oxide as a foliar application resulted in the highest plant growth and bulbs quality [15] [28]. In addition, K-fertilizer increased onion yield and increase in dry weight, P and K uptake [29]. Results were agreed with those findings.

Table 6: Nutrient contents (P and K) (mg/100 g) of bulbs in each treatment

Treatments	Phosphorus	Potassium
T_1	48 ± 0.20d	820 ± 1.00 d
T_2	67 ±0.15 c	870 ± 1.54 c
T_3	74 ± 0.25a	1080 ± 1.54 a
T_4	69 ± 0.20b	900 ± 2.53 b
F value	**	**

Value represents mean ± standard error of five replicates
F test: - **: $P< 0.01$
Means followed by the same letter in each column are not significantly different according to Duncan's Multiple Range Test at 5% level

4. Conclusion

In this experiment, the results clearly indicated that growth and yield performance of red onion grown in pots were affected by the composition of potting media. Red onion planted in medium contained sandy soil, cattle manure and paddy husk ash at the ratio of 6:2:1 (v/v) showed best performance and gave highest bulb yield. Mixing organic manure with soil to make potting medium for red onion cultivation in pot culture technique promotes nutrient contents of medium and nutrient uptake by plant, ultimately enhanced onion bulb yield and nutrient contents of bulbs in pot technique. Among the tested media, medium containing paddy husk ash play a major role in yield performance of onion.

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