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Assessment of Nutrient Uptake in Red Onion with Different Nutrient Alternatives in Sandy Regozol Soil in Kalpitiya

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ABSTRACT

Onion (*Allium cepa*) is one of the main cash crops grown in Sri Lanka mainly in the North and East part of the country. A promising problem in onion cultivation areas is wide range of chemical fertilizer and other chemical usage and consequent health problems. Kalpitiya is a well-known region for onion cultivation on Sandy regozol soil where high ground water pollution is reported due to excessive chemical fertilizer usage. Using organic substances such as compost, compost tea and biochar, chemical usage can be minimized while giving benefits of microorganisms to soil and plant surfaces that play a significant role in plant growth and diseases suppression. This study was carried out to assess nutrient uptake in red onion with different nutrient alternatives in sandy regozol soil in Kalpitiya. Seven different combinations were evaluated by plant height, weight of destructive samples and yield, leachate of nitrogen and potassium. Also plant tissues were analyzed. The highest yield and lowest leachate was obtained from the treatment with 100% of chemical fertilizer recommended by Department of Agriculture, compost (10 T/ha)+ Biochar + compost tea (two weeks interval) combination and therefore it can be recommended for farmers to obtain high yield while lowering health problems.

KEYWORDS: Compost tea, Ground water pollution, Kalpitiya, Red onion

INTRODUCTION

Onion (*Allium cepa*) is one of the major constituent in the Sri Lankan house hold diet and a high value cash crop in the dry and intermediate zones. Onion has originated in tropical central or western Asia. China is the highest producer of onion by contributing 20, 507, 759 t for global production (Anon, 2013). An estimated 9,000,000 acres (3,642,000 ha) of onions are grown around the world annually. About 170 countries cultivate onions for domestic use and about 8% of the global production is traded internationally (Anon, 2013). Sri Lanka is 53 in the world ranking and possesses 0.2% of the global onion production.

Onion is one of the vegetable crop which is highly responsive for the fertilizers. Generally, excessive amount of chemical fertilizers is applied to vegetables in order to achieve a higher yield (Stewart *et al.,* 2005). Nitrogen (N) rates from 125 to 150 kg/ha have been reported in several studies as being adequate for onion growth (Sharma *et al.,* 2003; Singh and Singh, 2000). High N rate of 200 kg/ha has increased the yield, when compared to the yield obtained under the application of low N rates (Al-moshileh, 2001). However, inorganic fertilizers alone generate several deleterious effects to the environment and human health. It should be replenished in every growing season because inorganic N, P, K fertilizer is rapidly lost by either evaporation or leaching in drainage water and it causes dangerous environmental pollution (Aisha *et al.,* 2007). Gastric and Kidney related diseases may be health problems due to hazardous chemical and heavy metals that are accumulated in the ground water table.

Kalpitiya is one of the highly productive agricultural areas of the country. The sandy regozol soil of the area is low in nutrients level and water retention capacity due to dry climatic conditions where the intense irrigation is common. Highly permeable sandy soil requires frequent watering which causes a significant loss of applied urea through leaching that result in pollution of the shallow ground water aquifer system. Farmers in Kalpitiya area add excessive amount of chemical fertilizers expecting higher yields from the infertile sandy regozol soil by which gradual accumulation of nutrients in ground water has taken place. Groundwater contamination in terms of nitrate pollution in the area has been studied for several decades (Liyanage *et al.,* 2000). It was found that the Nitrate accumulation rate is 2.3 mg/L per year for the last 10 year period in Kalpitiya. Nitrate pollution in Kalpitiya area is considerably higher compared to the other agricultural areas of the country (Young *et al.,* 2010).

Generally, N, P, K uptakes are significantly higher in both organically and inorganically fertilized plants than their unfertilized counterparts (Babajide *et al.,* 2008). Nowadays, farmers are changing from conventional to organic farming systems which

use no synthetic fertilizers and pesticides (Colla *et al.*, 2002). Organic farming provides several benefits to the planters. It reduces the cost of production and it is an environmental friendly method of cultivation. Addition of organic fertilizer improves soil structure and enhances the activities of useful soil organisms.

But, organic manures alone are unable to give an economic yield and it is essential to find appropriate combinations of inorganic and organic fertilizers to obtain a financially viable yield of crops. Jayathilake *et al.* (2006) reported an onion yield increase with integrated use of organic and chemical fertilizers. Compost and compost tea fit for this purpose due to its wide availability and ease of preparation.

Compost can increase the water holding capacity in sandy soil and retain more nutrients. Some compost has the ability to suppress fungal diseases. Also, it acts as a source of micronutrients for the plants. As compost teas are derived from compost, it contains different species of microorganisms and plant nutrients similar to compost.

Compost tea also becomes popular among farmers in Sri Lanka. Compost tea is beneficial to farmers due to high nutrient concentration, high microbial content and reduction of handling volume with compared to compost (Inghem, 2005). It is also important to reduce the occurrence of plant pathogens in fungal diseases (Inghem, 2005).

The purpose of this research is to select a combination of organic and inorganic fertilizers which results minimum nutrient leaching and maximum nutrient retention in onion cultivation. The outcome of the research will provide an appropriate fertilizer recommendation for onion farmers in Kalpitiya area by which ground water pollution can be minimized in Kalpitiya region.

MATERIALS AND METHODS

Location

This study was carried out at the Agricultural Research Station, Kandakuliya, Kalpitiya from January to April 2016. It is situated at an elevation of 11 m above mean sea level. The soil is well drained and characterized by Sandy Regozol soil. The monthly mean temperature at Kalpitiya during the experimental period was 29 °C while the mean rainfall was 29 mm during the research period.

Experimental Design

There were seven treatments (Table 1) in the experiment and each treatment was replicated three times. The treatments were arranged in a Randomized Complete Block Design (RCBD). Twenty one (35 L) plastic containers (30 x 30 x 38 cm) were prepared as pots and a PVC pipe was used to collect leachate water from the bottom of the pot. 35 L plastic container with a height of 38 cm was prepared for a pot experiment as given in the Figure 1.

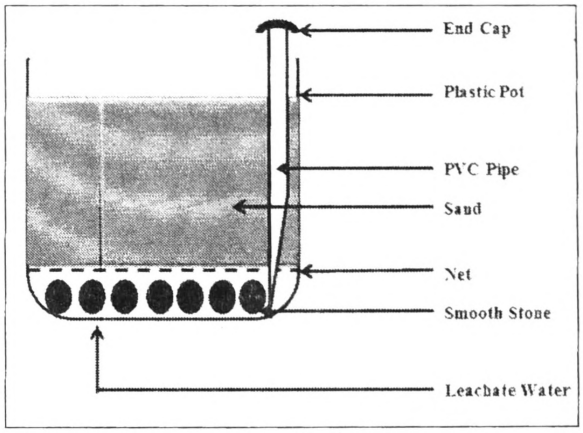

Figure 1. Plastic pot design to measure the leaching amount of nutrients

Smooth surfaced and well-shaped stones were placed at the bottom of the bucket. Then a small hole in the net was cut open so that PVC pipe can be inserted down to the bottom through the stone layer to collect the leachate for chemical analyses. Sand was filled on top of the net until about one inch from top of the bucket.

Crop Establishment and Maintenance

According to the DOA recommended fertilizer schedule (for Kalpitiya region) Chemical fertilizer (Table 2) and compost were applied. Compost tea was applied to T_4, T_5 and T_7 at one month, three weeks and two week intervals respectively. Generally, compost tea was applied in the evening between 2-5 p.m.

Equal sized *Vedhalan* onion variety bulbs were soaked in fungicide nearly half an hour. Then bulbs were sown in every bucket, at a distance of 9 cm. Nine bulbs were established in one bucket. Irrigation was done two times of the day, early in the morning and in the evening. Manual weeding and other cultural practices were done as recommended by the DOA.

Data Recording

Leachate water samples were collected from each and every bucket using syringe and flexible rubber tube through the PVC pipe. Leachate samples of each and every replicate were collected just before applying the fertilizer and three days after application. Initial water sample was analyzed to obtain pH, exchange capacity (EC), nitrogen (N) and potassium (K).

Table 1. Treatments used in the study

Treatment	Content
T_1	No fertilizer
T_2	DOA
T_3	DOA + BC
T_4	DOA + BC + CT (4 weeks interval)
T_5	DOA + BC + CT (3 weeks interval)
T_6	DOA + BC + Additional top dressing
T_7	DOA+ BC + CT (2 weeks interval)

DOA- (Chemical fertilizer (100%) +compost (10T/ha), BC- Biochar, CT- Compost tea, DOA- Department of Agriculture fertilizer recommendation (chemical fertilizer)

Vegetative Parameters

Plant height and weight were measured and recorded at one month intervals from the date of crop establishment.

Yield Parameters

First vegetative parameters were measured in seven plants of each replicate pot. Second vegetative parameters were taken from five plants. Two randomly selected plants were uprooted for destructive samples. Plant tissue analysis is performed to determine nutrient uptake in those selected plants. Data were recorded in one month intervals. Fresh weight and dry weight of two destructive samples from each treatment of each replicate were recorded.

Nutrient Analysis

Total Nitrogen and available Potassium were estimated by Kjeldahl method and acid base flame photometric methods respectively.

Table 2. Chemical fertilizer Requirement of Red onion in Kalpitiya

Fertilizer application	AS	TSP	MOP
BD	150	100	50
TD1	65	-	-
TD2	65	-	-

BD- Basal dressing, TD 1- First top dressing, TD 2- Second top dressing; AS- Ammonium sulphate, TSP- Triple super phosphate, MOP- Murate of potash

RESULTS AND DISCUSSION

Initial water characteristics in Kalpitiya

The pH, exchange capacity (EC), nitrogen and potassium levels of initial water sample was recorded as 6.85, 0.372 ds/m, 16.8 ppm and 12 ppm respectively.

Mean Height

All seven treatments recorded a higher mean value for plant height compared to control from 1 to 3 MAP (Figure 2). Both T_5 and T_7 recorded the highest mean value from 1 to 3 months while T_5 recorded the highest mean value in first month and the second month.

Height of T_5 was significantly higher compared to T_2 throughout the cropping period. It may be due to the favorable soil characteristics in the pot when inorganic fertilizers with compost and compost tea is applied rather than applying inorganic fertilizer alone. T_7 recorded a different mean value, less than T_5, most probably due to the effect of compost tea application. Mean height of T_7 recorded significantly higher value than T_2 throughout the cropping period. This may be due to the effect of compost tea applied in T_7. Treatment one which had no fertilizer application demonstrated slight increase in height. This may be due to root development of particular plant and therefore plant can uptake more nutrient from the soil even without any fertilizer application.

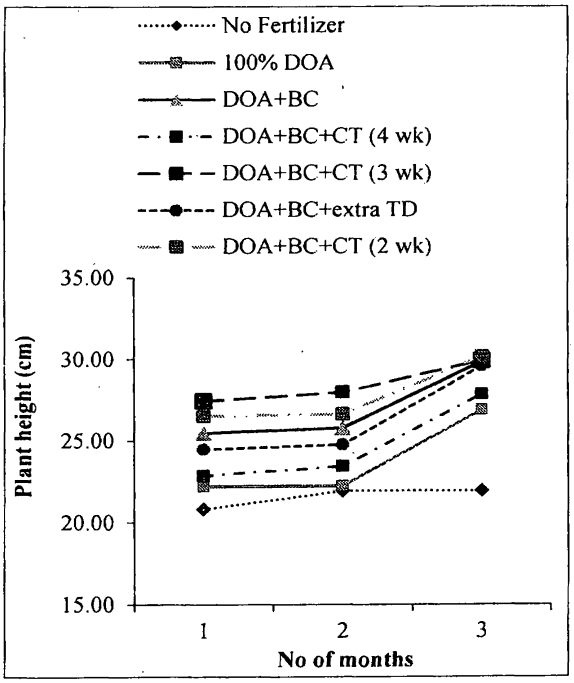

Figure 2. Mean plant height of treatment with time. *DOA- Department of Agriculture fertilizer recommendation, BC- Biochar, CT- Compost tea, extra TD- extra top dressing*

Mean Dry Weight and Mean Yield

The mean dry weight and yield of all treatments have been increased throughout two months and the weights of all treatments were significantly higher compared to the control (Table 3). There is no significant difference between T_2 and T_6 throughout the cropping period. Although an extra top dressing was applied to T_6, no difference between the dry weights of T_2 and T_6 were observed. Dry weight and yield of T_7 were significantly higher than other treatments (Table 3). There was no significant difference between the yield of T_2 and T_6. It may be due to the presence of small root system of onion. Which can take some time

to absorb nutrient, supplied by additional top dressing or else vegetative growth is over by 9 week after planting. So the application of extra top dressing was not useful (Table 3).

Table 3. Mean dry weight and yield with time

Treatment	Dry weight(g)	Yield/ plant (g)
T_1	3.58^{e}	16.36^{f}
T_2	6.23^{bc}	36.88^{c}
T_3	4.64^{d}	33.32^{d}
T_4	6.26^{b}	27.19^{e}
T_5	6.54^{b}	40.73^{b}
T_6	5.62^{c}	36.60^{c}
T_7	9.21^{a}	45.15^{a}
CV	5.90	2.36

Means in a column with the same letters are not significantly different at 0.05 level T_1- no fertilizer, T_2- DOA, T_3- DOA+BC, T_4- DOA+BC+CT (4 weeks interval), T_5- DOA+BC+CT (3 weeks interval) T_6- DOA+BC+Additional Top dressing T_7- DOA+BC+CT (2 weeks interval), DOA- Department of Agriculture, BC- Biochar, CT- Compost tea

Leachate in Potassium

The highest value for mean potassium (K) in leachate was recorded in T_2 (Table 4). The significant difference observed between T_7 and T_2 could be mainly due to the soil characteristics. At the initial stage of this research, bio char and compost tea was not applied to the soil of T_2. It may be the reason to show the higher mean nutrient leachate in T_2. Treatment seven shows the lowest mean value of the K leachate (Table 4) and also T_7 is significantly different from all the treatments except T_4.

It may be due to the application of compost tea for T_7 in 2 weeks intervals by which microbial activities may be boosted in soil. A significant difference of leachate of K observed between T_5 and T_7 may be due to the effects of different level of compost tea.

Table 4. Leachate in N and K

Treatment	Leachate in N (%)	Leachate in K (ppm)
T_1	34.50^{c}	32.16^{c}
T_2	57.27^{bc}	60.75^{a}
T_3	55.00^{bc}	59.91^{a}
T_4	70.00^{a}	50.08^{ab}
T_5	50.00^{cd}	50.50^{a}
T_6	70.00^{ab}	57.58^{a}
T_7	38.88^{dc}	39.75^{bc}

Means in a column with the same letters are not significantly different at 0.05 level T_1- no fertilizer, T_2- DOA, T_3- DOA+BC, T_4- DOA+BC+CT (4 weeks interval), T_5- DOA+BC+CT (3 weeks interval) T_6- DOA+BC+Additional Top dressing T_7- DOA+BC+CT (2 weeks interval), DOA- Department of Agriculture, BC- Biochar, CT- Compost tea

Leachate in Nitrogen

Both T_4 and T_6 recorded higher values for Nitrogen in the leachate (Table 4). Higher N content of T_6 may be attributed to the top dressing used and no application of compost tea for T_6. The Lowest mean value was recorded in T_7. It was significantly different from T_2, T_3, T_4 and T_6. It may be due to the application of compost tea which create a favorable soil conditions and help to retain more nutrients in soil (Prasad *et al.*, 1999).

Mean Value of Nutrient Uptake (N, K)

In onion, plant tissue analysis was performed to measure the uptake of Nitrogen and Potassium. Higher mean value of N uptake was recorded in T_4 while the lowest mean value of N uptake was recorded in T_3 (Table 5). It may be due to additional top dressing and application of excess Nitrogen leading to increase bulb growth (Pire *et al.*, 2001). The highest mean value of K uptake was recorded in T_5 while the lowest mean value was recorded in T_4. The significant difference observed between T_5 and T_4 may be due to the application of compost tea. Microorganisms found in organic manures may release phytohormones and thereby stimulate the plant growth and absorption of nutrients (Aisha *et al.*, 2008).

Table 5. Mean value of nutrient uptake (N, K)

Treatment	Uptake N (%)	Uptake K (K_2O %)
T_1	0.51^{bc}	1.22^{c}
T_2	0.46^{bc}	1.33^{b}
T_3	0.42^{c}	1.22^{c}
T_4	0.70^{a}	1.21^{c}
T_5	0.51^{bc}	1.47^{a}
T6	0.60^{ab}	1.27^{bc}
T7	0.51^{bc}	1.47^{a}
CV	15.33	3.73

Means in a column with the same letters are not significant different at 0.05 level T_1- no fertilizer, T_2- DOA, T_3- DOA+BC, T_4- DOA+BC+CT (4 weeks interval), T_5- DOA+BC+CT (3 weeks interval) T_6- DOA+BC+Additional Top dressing T_7- DOA+BC+CT (2 weeks interval), DOA- Department of Agriculture, BC- Biochar, CT- Compost tea

CONCLUSION

As significant differences were observed with all parameters of T_7 except uptake of N T_7 treatment package (100% of DOA+Compost (10 T/ ha)+BC+CT (2 WI) can be recommended for onion cultivation for higher yield and lowest nutrient leachate leading to sustainable farming system in Kalpitiya region.

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