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Influence of chicken manure and NPK (17-17-17) fertilizer on growth and yield of carrot

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ABSTRACT

This study was conducted to determine the effect of chicken manure and NPK (17-17-17) fertilizer on growth and yield of carrot (*Daucus carota* L.) in a volcanic soil of Musanze District in the Northern Province of Rwanda. This was geared upon by many unattended biotic and agronomic factors pertaining to low yields of carrot crop in this area. The treatments were: the control (T0), 10 t ha^{-1} of chicken manure (T1), 300 kg ha^{-1} of NPK (17-17-17) fertilizer (T2), and 5 t ha^{-1} chicken manure + 150 kg ha^{-1} of NPK fertilizer (T3) and each treatment was in three repetitions. The soil was tested for some of its physical and chemical properties and the soil reaction was moderately acid (pH 5. 97) and the quantities of N, P, K were moderate. The growth and yield parameters were studied along with the effect of treatments and the economic contribution of the intervention was determined by Benefit-Cost-Ratio (BGR) approach. Results revealed that the significantly ($p < 0.05$) highest plant height (45.59 cm) and leaf length (45.29 cm) were obtained in the combination of chicken manure and NPK fertilizer and the lowest were 34.12 and 34.69 cm, respectively, in the absolute control. The sole application of chicken manure and NPK fertilizer recorded plant heights of 43.70 and 39.89 cm and leaf lengths of 43.46 and 39.61 cm, respectively. Results also indicated that marketable root yield was statistically similar between control (5.6 t ha^{-1}) and chicken manure alone (5.7 t ha^{-1}) and between NPK fertilizer alone (8.55 t ha^{-1}) and combination of chicken manure and NPK fertilizer (10.55 t ha^{-1}). The best BCR was obtained in the combination of chicken manure and NPK fertilizer (2.09) compared with the absolute control (1.12), chicken manure alone (1.75) and NPK fertilizer alone (1.62).

Keywords: Benefit cost ratio, carrot, marketable yield, nutrients.

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INTRODUCTION

Carrot is a cool season crop which belongs to Apiaceae family. It is one of the most important crops cultivated throughout the world for its edible roots. Carrot is an excellent source of carotene a precursor of vitamin A and fibre in the diet (Handelman, 2001). It also contains abundant amounts of nutrients such as protein, carbohydrates, fibre and sodium (Ahmad et al., 2004). Carrot fleshy roots are used as vegetables for salads, soups and are also steamed or boiled in other vegetable dishes (Amjad et al., 2005). Besides the food value it has, different parts of carrot can be used for different medicinal purposes due to a wide range of reported pharmacological effects (Rossi et al., 2007).

Besides the importance of carrot in human life, its production has persistently been low in most parts of the world. However, the main causes of low yields are associated with inadequate knowledge on new production methods and appropriate agronomic practices. Generally, most carrot growers use inorganic fertilizers to realize higher yields as opposed to the unfertilized fields (Dauda et al., 2008). The use of inorganic fertilizers as a source of nutrients has however,

been associated with human health problems and environment degradation through pollution (Arisha and Bardisi, 1999). In addition, the rising costs of inorganic fertilizers have made them too expensive to most resource-poor small-scale farmers. Organic substrates such as manures and composts can provide significant quantities of nutrients for crop growth and development and have a constant effect on the soil for a long time (Eghball et al., 2004).

The vegetables produced in soils where organic substrates are incorporated are gaining importance because of less chemical residues and better taste (Rumpel et al., 1998). In Rwanda, for instance, carrot is grown as vegetable, and it is predominantly produced in the Western Province by 87% and Southern Province 8% (Rwanda Export Catalogue, 2010).

Carrot is one of the crops which are highly grown in Rwanda and is known by the majority of farmers in the country. However, the crop does not give promising yield because of low or no use of nutrient inputs to the farmers' fields. This has largely been attributed to the unaffordable high costs of inorganic fertilizers and limited technical and applied knowledge on the alternative sources of nutrients. Soil fertility is the major constraint on soil productivity because of high soil acidity, nutrient loss through leaching, extensive farming with low or no replenishment of nutrients and soil erosion. Chicken manure is not much adopted by most smallholder farmers in Rwanda which would have helped to take care of low soil productivity caused by low nutrient levels. Keeping all the above facts in view, the subject study was conducted in order to assess the influence of chicken manure and NPK (17-17-17) fertilizer on growth and yield of carrots in a selected field in Musanze District, Rwanda.

MATERIALS AND METHODS

Description of the study area

This research was conducted in the farm of the College of Agriculture, Animal Sciences and Veterinary Medicine in Musanze District, in the Northern Province of Rwanda. The climate is typically temperate with mean annual temperature of 17°C. The field is located at 01° 33′ S and 29° 33′ E and at an altitude was 2200 m above sea level and the mean annual relative humidity is 86%. The climate has an average annual temperature of 15.6°C and receives average annual rainfall of 1400 mm (ISAE, 2014). This area was chosen due to the fact that the soils are rich in organic materials and vegetable crops are mostly grown in which carrot is also included. The soil of the study site is volcanic in nature with pH of 5.6.

Land preparation

In order to achieve the objective of the research initially the land preparation was done by adopting traditional practices in order to obtain appropriate seedbed for carrot crops. Similar tools were also used in controlling weeds and turning over the vegetation. This aimed at adding more humus to the soil; facilitate easy sowing and retention of moisture by the soil. It also aimed at providing sufficient aeration for proper growth of root crop.

Acquisition of experimental materials

The carrot seeds, variety (Nantes 2) were sourced from Kenya Seed Company. The following materials were used in this study: chicken manure equivalent to 10 t ha^{-1} which was applied before planting, and NPK (17-17-17) fertilizer equivalent to 300 kg ha^{-1} which was applied at planting. The mode of application of both nutrient sources was through trenches or rather lines whereas chicken manure was applied by broadcasting.

Experimental set-up and experimentation

The experiment was a factorial laid down in a randomized completely block design (RCBD) which was consisted of four treatments: T_0 = control, T_1 = chicken manure (10 t ha^{-1}), T_2 = NPK (17-17-17) (300 kg ha^{-1}) fertilizer, and T_3 = chicken manure and NPK (17-17-17) fertilizer (5 tha^{-1}+ 150 kg ha^{-1}). All treatments were replicated three times. Carrot seeds were sown in December 2013 at a spacing of 20 cm × 5 cm at a rate of 1.8 kg per acre.

Data collection

Soil of the study area was tested for physical and chemical properties following standard procedures described by Mutwewingabo and Rutunga (1987). The agronomic parameters collected from carrot crop were on growth and yield of carrot which was done 7 times from 34th to 121th days after sowing (DAS). Data collection which on growth attributes was from 10 plants selected randomly in three middle rows of each plot. These were the plant height, number of leaves and leaf length. The economic analysis was worked out to assess the profitable practice for appropriate recommendation for adoption. Harvesting of the carrots was done after 121 days from sowing during which fresh weight of roots was obtained. Other parameters collected at harvest were total biomass, root shoulder and root diameter, root length, forked roots, cracked roots, total and marketable yield, harvest index and benefit-cost ratio.

Statistical analyses

The data generated from the study was subjected to analysis of variance where GenStat software was employed. The significance treatment means were compared at 5% level of error.

RESULTS

Soil analysis

The complete subject study in terms of growth and yield of carrots with different rates of chicken manure and NPK (17-17-17) was monitored. The results of the soil test of the study area are presented in Table 1. The outcome of the study revealed that plant height, number of leaves, and leaf length differ very significantly between application of different rates of chicken manure and NPK (17-17-17) fertilizers as mention in Table 2.

The soil of the study area was generally sandy loam. The chemical properties revealed that the contents of N,

Table 1. The physical and chemical properties of the soil of the study area.

No.	Parameters	Values
Physical properties		
1	Sand (International pipette method) (Piper,1966)	70%
2	Silt (International pipette method) (Piper,1966)	23.28%
3	Clay (International pipette method) (Piper,1966)	6.72%
Chemical properties		
1	Total nitrogen (%)	0.48
2	Available phosphorus ($mg\ kg^{-1}$)	28.00
3	Exchangeable potassium ($cmol(+)\ kg^{-1}$)	0.25
4	pH (H_2O)	5.97
5	Cation exchange capacity ($cmol(+)\ kg^{-1}$)	18.07
6	Total exchangeable acidity ($cmol(+)\ kg^{-1}$)	2.69

Table 2. Effect of chicken manure and NPK fertilizer on growth parameters.

Treatments	Plant height (cm)	No. of leaves	Leaf length (cm)
T_0	34.12^d	4.4^a	34.69^d
T_1	43.70^b	5.2^a	43.46^b
T_2	39.87^c	4.7^a	39.61^c
T_3	45.59^a	5.7^a	45.29^a
SE(±)	0.18	0.17	0.13
LSD (P = 0.05)	0.63	0.6	0.5
CV (%)	11.3	6.7	8.7

Means along the same column sharing similar letter do not differ significantly.

P and K soil were medium and the pH was moderately acid. These preliminary findings indicated that the soil favours production of carrot.

Plant height

Results indicated that at 121DAS, significantly high plant height (45.59 cm) was recorded with the combination of 150 kg NPK ha^{-1} and 5 t ha^{-1} of chicken manure while the lowest plant height (34.12 cm) was obtained in the absolute control.

Number of leaves

With respect to the number of leaves per individual plant, generally there was no significant difference due to the effect of treatments. However, the combination of 150kg NPK $ha^{-1}$and 5 t ha^{-1} of chicken manure recorded numerically the highest mean number of leaves (5.7) and the lowest (4.4) was obtained in the absolute control.

Leaf length

Results also indicated that the length of leaves differed significantly among treatments and the highest leaf length (45.2 cm) was recorded in the combination of 150 kg NPK ha^{-1} and chicken manure at 5 t ha^{-1} and the lowest (34.69 cm) was obtained in the absolute control.

Relationship between yield and yield components

The relationship between unmarketable yield and forked root yield was very high; the forked root yield has influenced the unmarketable yield at the level of 94% (Figure 1). Correlation between yield and yield components was a positive, root length has influenced the root yield at 89%, so there was high relationship between them (Figure 2). Correlation between shoulder and core diameters was positive, shoulder diameter has influenced the core diameter at 80%, so there was high relationship between them (Figure 3). Likewise the impact of different rates of chicken manure and NPK (17-17-17) on the carrot yield, yield attributes and economics are depicted in Table 3.

Based on results from analysis of variance at level of 5% following observations were recorded for the aforementioned parameters during the whole research period.

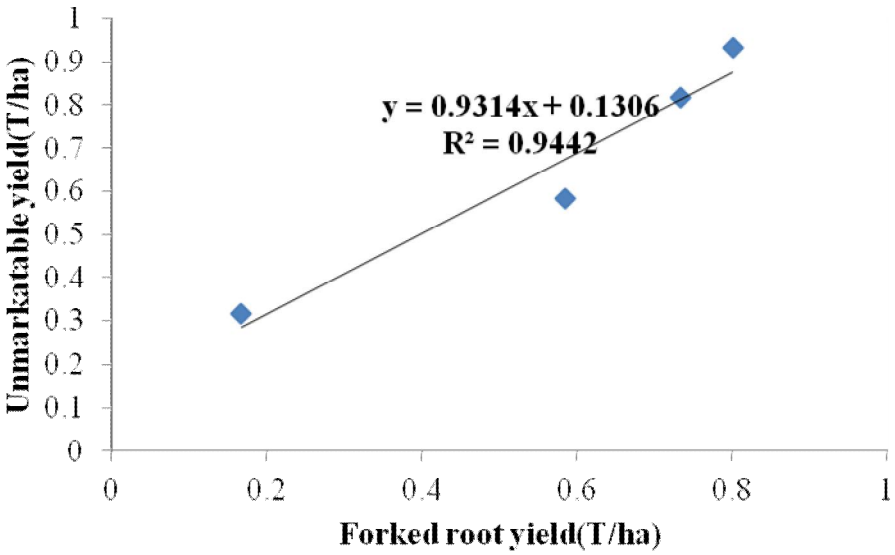

Figure 1. Unmarketable yield as influenced by forked root yield.

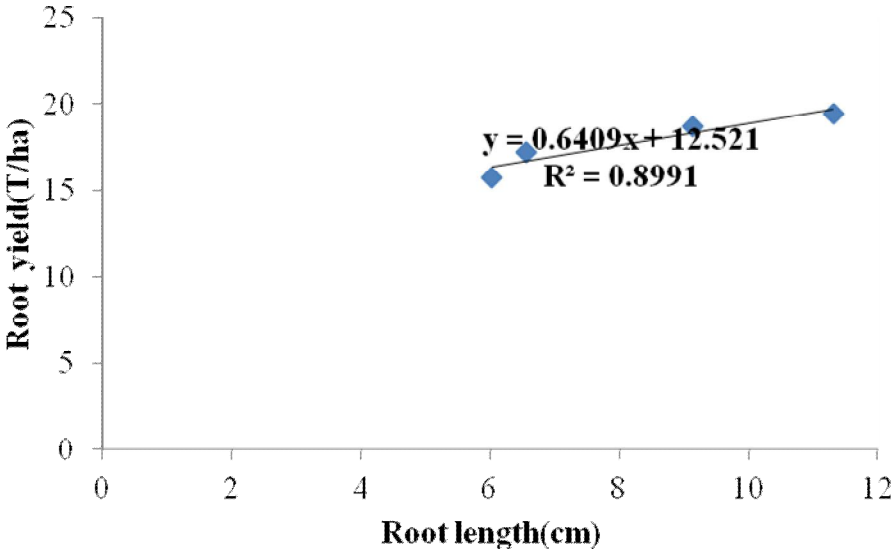

Figure 2. Root yield as influenced by root length.

Root core diameter

Core diameter recorded at harvest time was influenced by chicken manure, N.P.K and their combination and significant difference was observed between all treatments. High core diameter was recorded with the combination of 150 kgha^{-1} N.P.K + 5tha^{-1} chicken manure (1.8 cm) which was on par with 10 tha^{-1} chicken manure treatment (1.58 cm) and 300 kgha^{-1} NPK treatment (1.503 cm). While the lower core diameter was noticed in control (1.168 cm). As stated by Agyarko and Adomako (2007), that the mean root length per plant and mean root diameter were significantly longer than the unammended soil.

Root shoulder diameter

The shoulder diameter showed significant difference due to chicken manure, $NPK_{17\text{-}17\text{-}17}$ and their combination. The combination of 150 kgha^{-1} N.P.K + 5 tha^{-1} chicken manure recorded higher shoulder diameter with 5.2 cm and was significantly different with 10 tha^{-1} Chicken manure treatment followed by 300 kgha^{-1} NPK treatment (3.9 cm), while control recorded significantly lower carrot shoulder diameter with 3.45 cm. The present finding is in

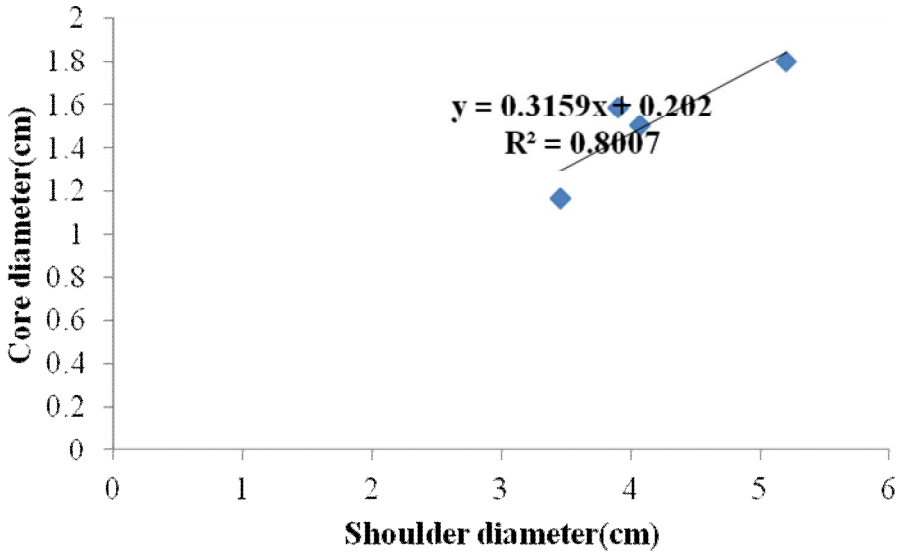

Figure 3. Shoulder as influenced by core diameter.

Table 3. Effect of chicken manure and NPK fertilizer on carrot yield.

Treatment	Root core diameter	Root shoulder diameter	Root length	Total root yield	Total biomass	Forked root	Cracked root	Marketable yield	Harvest index	Benefit cost ratio
T0	1.17^{b}	3.45^{b}	15.77^{b}	6.02^{c}	7.52^{c}	0.17^{a}	0.15^{a}	5.6^{b}	79.9^{a}	1.12
T1	1.50^{ab}	4.07^{b}	17.23^{b}	6.55^{c}	8.42^{bc}	0.80^{a}	0.13^{a}	5.7^{b}	80.03^{a}	1.75
T2	1.59^{ab}	3.9^{b}	18.73^{a}	9.13^{b}	11.23^{ab}	0.58^{a}	0.0^{a}	8.55^{a}	81.3^{a}	1.62
T3	1.8^{a}	5.2^{a}	19.50^{a}	11.3^{a}	13.90^{a}	0.73^{a}	0.23^{a}	10.48^{a}	81.29^{a}	2.09
SE(±)	0.32	1.39	0.296	0.40	0.70	0.19	0.13	0.57	4.83	NA
LSD (p = 0.05)	0.35	0.67	1.023	1.39	2.25	0.66	0.46	1.96	16.7	NA
CV (%)	11.7	8.3	2.9	8.4	4.6	15	14.8	6.1	8.1	NA

NA: Not Analysed. The means along the same column sharing similar letter(s) do not differ significantly.

agreement with (Kristensen and Kristensen, 2002) who reported that in sandy soil, combination of organic and inorganic fertilizers improves the soil structure and apart from this it also allows the shoulder of carrots to expand with ease.

Root length

The length of carrots showed significant difference due to the fertilizer $NPK_{17\text{-}17\text{-}17}$, chicken manure and their combination. The combination of 150 kgha^{-1} N.P.K + 5tha^{-1} chicken manure recorded significantly higher root length (19.50 cm) and was on par with treatment 300 kgha^{-1} NPK treatment (18.73 cm). Control recorded significantly lower root length (15.77 cm). The higher root length was mainly attributed to the increased nutrient use efficiency of both macro and micro nutrients from the combination of chicken manure and $NPK_{17\text{-}17\text{-}17}$; this is in conformity with the finding of Murwira et al. (2002). The shortest root length was observed with control where no fertilizer source was applied (15.77 cm) owing to nutrient shortage which resulted in reduction in the growth and yield components of carrot.

Forked and cracked roots

The analysis of variance for forked roots shows that the difference among the treatment was not significantly different. The control has the lowest losses related to forked roots (0.166 t ha^{-1}) followed by 300 kgha^{-1} $NPK_{17\text{-}17\text{-}17}$ with 0.583 tha^{-1}. The top losses were in 10 tha^{-1} chicken manure treatment with 0.8 tha^{-1}. The means of weight for cracked did not show significant difference due to the fertilizer $NPK_{17\text{-}17\text{-}17,}$ chicken manure and their combination. The combination of 150 kgha^{-1} N.P.K + 5tha^{-1} chicken manure recorded higher weight of cracked

roots (0.233 tha^{-1}) which was on par with treatment the rest of all treatments. This might due to the many factors such, clay soil, application of fresh manure, application of excess nitrogen and improper irrigation management especially in sandy soil.

This is in agreement with the finding of Fritz (2007) who stated that although organic fertilizer is taken as the sole promoter of forking and hairy roots in carrots, the review of previous studies showed that forking was the result of many factors such as poor soil structure (compacted soil) and heavy applications of fresh manure. Application of high nitrogen fertilizer rates in sandy soil with low moisture levels also increases forked roots, and visa versa. The results were in conformity with Atakora (2011) who reported that the number of cracked roots from the manure plots was higher than the sole NPK and the control. The cracked roots might due to the increased levels of manure supplied to the plant. Large quantities of manure supplied to vegetables tend to result in their roots being cracked.

Unmarketable yield

The unmarketable yield was varying from 0.316 to 0.933 tha^{-1}. The low unmarketable yield was recorded on control followed by the treatment of 300 $kgha^{-1}$ NPK. The highest unmarketable was recorded on 10 tha^{-1} chicken manure treatment (0.933 tha^{-1}). The difference among the treatment was not significant.

Marketable yield

Significantly higher marketable yield was recorded with combination of 150 $kgha^{-1}$ N.P.K + 5 tha^{-1} chicken manure treatment (10.48 tha^{-1}) which was on par with 300 $kgha^{-1}$ NPK (8.55 tha^{-1}). The lower marketable yield was noticed in control treatment (5.61 tha^{-1}). This result was in conformity with Hartemink et al. (2000) who reported that the combination of poultry manure and inorganic N provided a significant marketable root tuber crops. It was also observed by Atakora (2011) who reported that the marketable root weight of carrot with inorganic fertilizer (NPK) and organic manure was significantly higher than other treatments.

Total root yield

The total root yield was ranged between 6.02 and 11.3 tha^{-1}. The analysis of variance showed that there is significant difference among the treatments. Higher root yield was recorded with combination of 150 $kgha^{-1}$ N.P.K + 5 tha^{-1} chicken manure treatment (11.3 tha^{-1}) followed by 10 tha^{-1} chicken manure treatment (9.13 tha^{-1}) while the lower root yield was noticed in control treatment (6.017 tha^{-1}). The results are in conformity with the finding of Kang et al. *(*1990), who reported that high crop yield can be obtained with judicious and balanced NPK fertilization combined with organic matter amendment.

Total biomass

The total biomass yields were ranged between 7.52 and 13.9 tha^{-1}. The combination of 150 $kgha^{-1}$ N.P.K + 5 tha^{-1} chicken manure treatment has recorded the highest significant total biomass (13.9 tha^{-1}) followed by the 300 $kgha^{-1}$ NPK treatment (11.23 tha^{-1}). While, control recorded lower total biomass with 7.52 tha^{-1}. These results are in conformity with the findings of Agbede et al. (2008) and Abdel-Mawly (2004) who reported that the best growth and yield performance of yam was observed under complementary use of poultry and NPK and this was attributed to the increased nutrient use efficiency of both macro and micro nutrients from poultry manure and other growth substances such as hormones and macro nutrient from NPK.

Harvest index

The harvest index did not show significant difference due to the fertilizer chicken manure, NPK $_{17\text{-}17\text{-}17}$ and their combination. It was varying from 79.9 to 81.3%, the 300 $kgha^{-1}$ N.P.K treatment recorded higher harvest index (81.3%) and was on par with the rest of all treatments. The lower harvest index was observed with control (79.9%) due to the use of nitrogen fertilizers increases shoot weight sometimes more than the root yield as reported by Schaller and Schnitzer (2000).

Benefit cost ratio

The combination of chicken manure and NPK showed the highest Benefit Cost Ratio (2.09) that means to grow carrot with the use of combination of chicken manure and NPK is the more sustainable, profitable and recommendable to farmers compared with other treatments.

CONCLUSION

The combination of chicken manure and NPK had shown significant influence on the growth and yield of carrot. The tallest carrot plants (45.59 cm), highest number of leaves (5.7), highest leaf length (45.29 cm), the highest root length (16.17 cm), maximum total root yield (11.3 tha^{-1}), and maximum marketable yield of root (10.48 tha^{-1}) were found in combination of 150 $kgha^{-1}$ N.P.K + 5 tha^{-1} chicken manure treatment. Therefore, from the current

study it may be concluded that, combination of 150 $kgha^{-1}$ N.P.K + 5tha^{-1} chicken manure were suitable for optimum growth and yield of carrot. Further study may be conducted in different agro-ecological zones of Rwanda under variable field condition to confirm the result of the present experiment before recommending it to the carrot growers.

Suggestions

In the light of the study carried out it is suggested that the farmers should conduct a soil analysis test of their land before cultivation. The soil samples must be carried out on the basis of block diagram of each area and from each block one composite sample must be collected for the soil analysis tests accordingly. Furthermore, in order to get precise results and good production the soil should to be well tilled, pulverized and as level as possible. In addition to this it is essential that soil should be fumigated for nematodes. For the safe keeping of the quality of carrots the farmers, must assure that the soil should never be allowed to dry out. Too much moisture causes short carrot with light colour and larger diameter. As the area under study was sandy loam; therefore these research findings are applicable only for sandy loam soils while the results may vary for other types of soil.

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