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INFLUENCE OF SOIL TYPE AND SELECTED SOIL MORPHOLOGICAL PROPERTIES ON THE YIELD OF COCONUT (*COCOS NUCIFERA* L.) IN SRI LANKA. II. WALPITA ESTATE, KOTADENIYAWA

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ABSTRACT

Loganathan, P., Perera, K. S. O. and Abeywardena, V., (1976). Influence of soil type and selected soil morphological properties on the yield of Coconut (*Cocos. nucifera* L.) in Sri Lanka. II Walpita Estate, Kotadeniyawa. *Ceylon Cocon. Q.*, 27, 13-21.

The influence of soil type on nut yield and flowering characteristics of young coconut (less than 19 years) on a 10 ha land in the Wet zone was investigated. Detailed soil survey of the area revealed that there are four soil series—(1 a) Boralu (shallow phase), (1 b) Boralu (deep phase), (2) Sudu, (3) a variant of Katunayake, and (4) Rathu pasa, which produced yields of 47, 55, 62, 63 and 65 nuts/palm/yr respectively. Although the palms in Sudu produced high nut yield, they came into bearing later than the others due to the impeded drainage conditions.

Yields were higher on soils having greater soil depths, gravel depths, lighter texture and "moderately well" drainage. In light and medium textured soils, soil depth had a significant bearing on yield—a depth of 120 cm appeared to be the critical depth. At depths $\geq$ 140 cm, yield was significantly affected by texture—lighter textured soils had a significantly higher proportion of high yielding palms than heavier textured soils. The interaction between gravel depth and texture on yield were similar to soil depth and texture. A gravel depth of 60 cm appeared to be the critical level for light textured soils. Under moderate and good drainage, yield continued to increase with both soil and gravel depths without any indication of a critical depth. Generally, under any gravel or soil depths, "moderately well" drainage was preferred to "well" drainage. The interaction between texture and drainage on yield was masked by the influence of soil and gravel depths.

INTRODUCTION

Coconut yield in Sri Lanka varies very widely from one region to the other. These differences in yield are believed to be mainly due to differences in the soil morphological properties and the rainfall of the area. Quantifying the influence of these soil parameters on the yield of coconut is of paramount importance in assessing the yield potentials at different sites and to identify soils which are suitable for economic cultivation of coconut. With this as the aim studies were commenced in estates located in different agroecological regions, where reliable yield records (palm by palm) were maintained for sufficiently long periods. The first of these studies was carried out on palms 45 to 55 years old at Bandirippuwa estate, Lunuwila which lies in the Intermediate rainfall zone of Sri Lanka (Loganathan *et al.*, 1975).

This paper reports the results of a similar study carried out on palms 9 to 19 years old at Walpita estate, Kotadeniyawa, which lies in the Wet zone.

MATERIALS AND METHODS

Experimental Site

The experimental site, 10 ha in extent, lies in Block B of Walpita estate, Kotadeniyawa which receives a mean annual rainfall of about 2500 mm. Six hundred and eighty five palms (variety, typica) planted in 1949, were selected for this study. Cultural practices such as manuring harrowing, and ploughing were carried out regularly and uniformly throughout the block according to the recommendations of the Coconut Research Institute of Sri Lanka.

Flowering and Yield Data

The number of palms in flower from the 9th year since planting and the nut yield of each palm for each pick from the time of bearing till 19 years have been recorded by the Division of Botany of the Coconut Research Institute of Sri Lanka. The proportion of palms in flower in the 9th year and the average yield of each palm from the 15th to 19th year were used in this study.

Soil Data

A detailed soil survey of the site and measurements on soil depth, gravel depth (depth at which gravels begin to appear), texture and drainage were made according to the methods described previously (Loganathan *et al.*, 1975). Measurements were taken down to a depth of 150 cm. The scores assigned to the different textural and drainage classes were the same as before.

RESULTS AND DISCUSSION

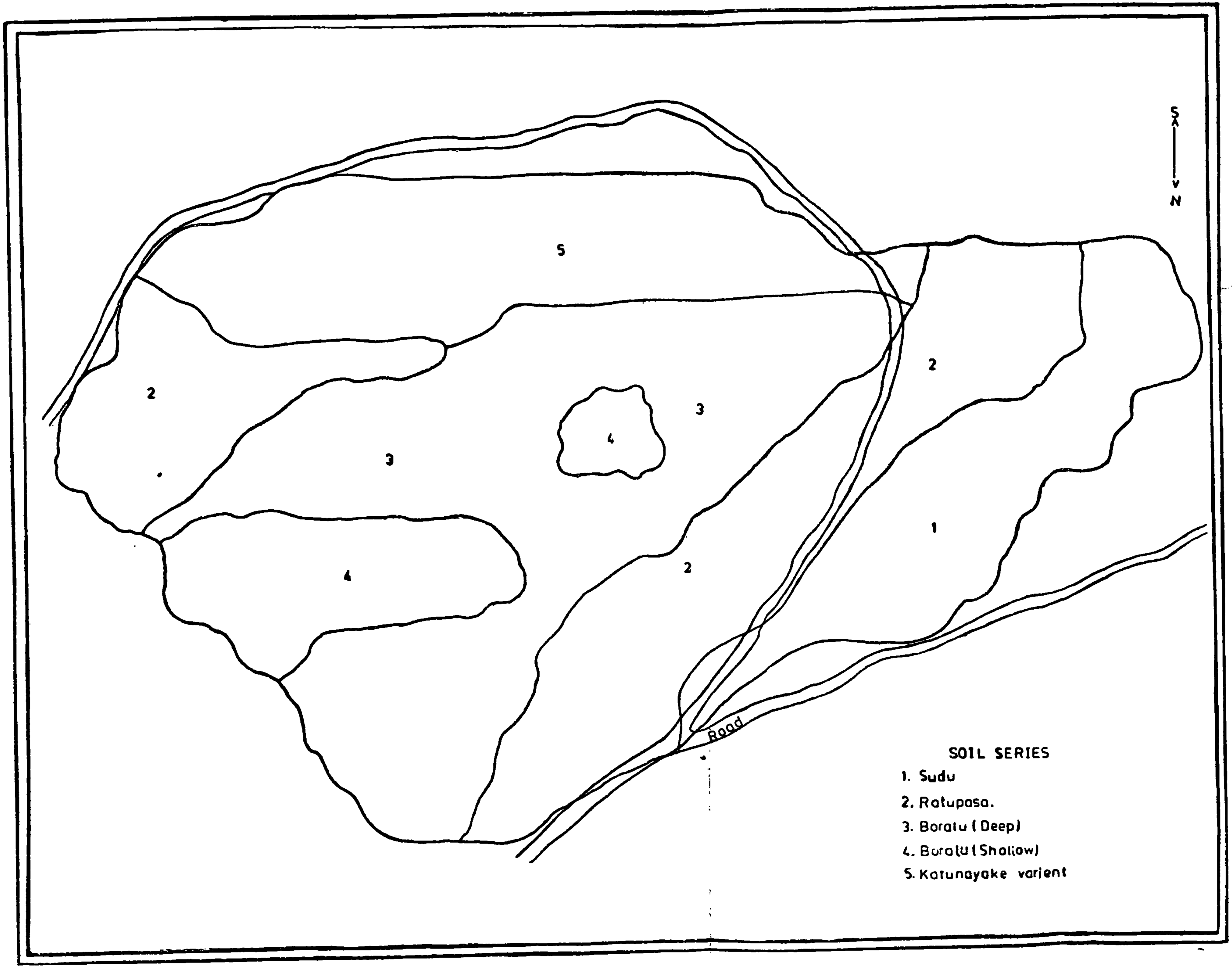
Influence of Soil Type on Initial Flowering and Nut Yield

The detailed soil survey revealed that there are five distinctly different soils within the experimental site (Fig. 1). Selected soil properties, percentage of palms in flower in the 9th year and average nut yield for the period 15 to 19 years in each soil are shown in Table 1. At Bandirippuwa three soil series—Boralu (deep and shallow), Sudu and Pallama were identified and the average yields on these soils were reported (Loganathan *et al.*, 1975). At Walpita, yields in two new soil series—Rathupasa and a variant of Katunayake in addition to the soil series Boralu and Sudu are recorded. The variant of Katunayake is so called because its properties are similar to Katunayake series (De Alwis, 1978). The Katunayake series is imperfectly drained and has no gravels whereas this variant is well drained and has few quartz and ironstone gravels. The results showed that though differences in yield between the Rathupasa, Sudu and Katunayake (variant) series were not significant, they were significantly higher than the Boralu-deep soils which in turn were higher than the Boralu-shallow soils. This suggests that depth is the major soil factor influencing the yield at Walpita.

Table 1 also gives the percentage of palms in flower under each category of soil. The differences are highly significant—Rathupasa and Katunayake (variant) > Boralu-deep > Boralu-shallow > Sudu. Both the percentage of palms in flower as well as nut yield showed the same order of superiority, with the exception that the lowest percentage of palms in flower was given by Sudu series. This is probably due to the poor to imperfect drainage condition of the Sudu. The seedlings were planted at a depth of about 50 cm and the initial roots would have appeared below this depth. As Sudu soils are poor to imperfectly drained, aeration of these young roots might have been limited for a significant part of the early years and hence the seedlings suffered a set back in their early performance, such as delay in the formation of the initial flowers. But in the adult stage, the roots would have reached the surface soil for sustaining satisfactory growth of the palms and the impeded drainage condition of the soil appears to have not affected the bearing capacity of the palms to any degree. Further, the water requirement of the adult palms being very much higher than that of the young palms the water table would not be expected to be in the root zone for a period long enough to affect the growth of the adult palms.

Fig. 1.

SOILS OF WALPITA ESTATE, KOTADENIYAWA (LATTICE - B)



The palms in the Sudu and Boralu soils at Bandirippuwa produced higher yields than those at Walpita. The main reason for this was perhaps the differences in the age of the palms in the two places. At Bandirippuwa the palms, being 45 to 55 years, had become stabilized in their peak bearing capacity compared to those at Walpita where the palms, 15 to 19 years, had not yet reached the peak bearing stage.

Influence of Soil Morphological Properties on Yield

At Walpita, there are more experimental palms and wider range of values for the soil properties than at Bandirippuwa and therefore the yield and the soil properties are demarcated into three groups as opposed to two groups at Bandirippuwa. The scores for the different groupings are, in general, the same for all soil properties except where the number of palms in certain groupings is insufficient for statistical analysis. For these other values are used. The results presented are for yield groupings, ≥80, 60-79 and < 60 nuts/palm/year. Similar analysis carried out for groupings, ≥70, 50-69 and < 50 led to the same general conclusions.

Tables 2 to 5 show that there are significantly higher proportion of high yielding palms from greater soil depths ($\chi^2 = 30.60^{***}$), gravel depths ($\chi^2 = 37.04^{***}$), lighter textures ($\chi^2 = 26.66^{***}$) and moderately well drainage ($\chi^2 = 24.22^{***}$). The effect of interaction between these soil properties on yield are discussed below.

Table 2. *Main effects of soil depth on yield*

Yield Nut/palm/year	*Percentage of Palms under Soil Depth (cm)* <120	120 - 139	≥140
≥80	5.11	11.64	17.87
69 - 79	16.79	27.40	29.78
<60	78.10	60.96	52.36

Table 3. *Main effects of gravel depth on yield*

Yield Nut/palm/year	*Percentage of Palms under Gravel Depth (cm)* <60	60 - 119	≥120
≥80	7.73	11.18	20.27
60 - 79	21.03	23.68	32.56
<60	71.24	65.13	47.18

Table 4. *Main effects of texture on yield*

Yield nut/palm/year	*Percentage of Palms under Textural Class* <55	55 - 69	≥70
≥80	9.79	10.55	23.59
60 - 79	30.64	22.66	27.18
<60	59.57	66.80	49.23

Table 5. *Main effects of drainage on yield*

Yield Nut/palm/year	*Percentage of Palms under Drainage Class* <60	60 - 74	≥75
>80	18.60	19.82	6.53
60.79	27.33	24.77	27.84
<60	54.07	55.41	65.64

Soil Depth and Texture: Table 6 presents data on the interaction between soil depth and texture. In light and medium textured soils, soil depth has a significant bearing on yield ($\chi^2 = 9.89^{**}$ and $\chi^2 = 15.85^{**}$ respectively). But in heavy textured soils, there is no significant influence of soil depth on yield ($\chi^2 = 1.38$ N.S.). It appears that in light and medium

Table 1. *Selected soil properties, percentage of palms in flower and nut yield*

Soil No.	*Series Name**	*Depth cm*	*Texture*	*Drainage*	*Gravel*	*pH*	*% palms in flower in 9th year*	*Nut/palm/year 15 to 19 years old*
1	Sudu	150 +	Sand to loamy sand	poor to imperfect	absent	5.0 to 5.9	61	62
2	Rathupasa	150 +	Loamy sand to sandy loam	well	absent	4.3 to 5.2	97	65
3	Boralu (shallow) ..	~90	sandy clay loam	well	ironstone	5.0 to 5.2	76	47
4	Boralu (deep)	~120	Sandy clay loam	well	ironstone	5.0 to 5.2	86	55
5	Katunayake (variant) ..	150 +	Loamy sand to sandy loam	well	quartz and ironstone	4.4 to 5.9	94	63

*De Alwis (1978)

textured soils, a soil depth of at least 120 cm is required for coconut whereas at depths shallower than this the yield would be significantly reduced. For heavy textured soils this critical depth may be less than 120 cm, but statistical analysis at these shallower depths could not be carried out due to lack of data.

The effects of soil depth on yield under the different textural classes at Walpita were similar to those at Bandiripupwa.

Table 6 also shows that at soil depths less than 140 cm, texture had no significant bearing on yield. But at depths ≥ 140 cm, yield was significantly influenced by texture—the light textured soils having a significantly higher proportion of high yielding palms ($\chi^2 = 13.55^{**}$) than the heavy textured soils. Deep soils have greater soil volume for root exploration of nutrient and moisture. The light textured soil would allow unrestricted root penetration for this exploration and hence a light texture is preferred in deep soils. The light textured soils are considered to hold very little moisture and therefore would appear to be less favourable for coconut. But this is not a problem in areas of the wet zone such as at Walpita where there is sufficient moisture but perhaps poor or inadequate aeration as the soil pores are mostly saturated with water. In contrast, at Bandirippuwa, texture had no influence in deep soils when the depth of demarcation was 120 cm (data were not sufficient to carry out analysis at greater depths). But a preference for heavy texture was shown in the shallow soils (< 120 cm).

Gravel Depth and Texture: In light textured soils although the relationship between gravel depth and yield was not statistically significant ($\chi^2 = 6.89$ N.S.) yet there appears to be a tendency for the deeper gravel depths to show a higher proportion of high yielding palms (Table 7). A gravel depth of 60 cm appears to be the critical level. On the other hand in medium textured soils there was a highly significant ($\chi^2 = 27.2^{**}$) and consistent relationship between gravel depth and yield, without any indications of a critical depth as seen in the case of light textured soils. In heavy textured soils, gravel depth (be it 60 or 120 cm) had no significant bearing on yield ($\chi^2 = 3.44$ N.S.). In heavy textured soils, gravel depth may have influence on yield at gravel depths less than 60 cm (as at Bandirippuwa where the critical gravel depth was 30 cm) but the data were not sufficient to carry out any analysis at such depths.

The influence of texture on yield at various gravel depths was the same as in the case of soil depth vs texture discussed earlier. At gravel depths < 120 cm, yield was not significantly influenced by texture, but at gravel depths ≥ 120 cm, yield was significantly influenced by texture ($\chi^2 = 11.99^{*}$)—there being a higher proportion of high yielding palms in the light textured soils (critical texture score is 55).

Soil Depth and Drainage: Under moderate and good drainage conditions soil depth had a significant influence on yield (Table 8)—the deeper soils having a higher proportion of high yielding palms ($\chi^2 = 17.39^{**}$ and $\chi^2 = 10.97^{**}$ respectively). The results show that within the range of depth tested (140 cm) the yield continues to increase with depth without any indication of a critical value. However, under impeded drainage, depth had no significant influence on yield ($\chi^2 = 1.68$ N.S.). This suggests that under impeded drainage conditions, deep roots do not have significant influence on yield. The results obtained here are similar to those at Bandirippuwa.

No clear trend was obtained on the effect of drainage on yield under the various soil depths, although at intermediate depths (120-139 cm) yield was significantly influenced by drainage ($\chi^2 = 10.22^{*}$) there being a higher proportion of high yielding palms under "moderately well" than under "well" drained conditions. The reason for this is not clear. But it may possibly be due to the fact that the soils falling within these intermediate depths range belong mostly to the Boralu (deep phase) where the profile contains a large proportion of gravels which have a very low water holding capacity. Under these conditions too good a drainage may be not favourable as it would drain away even the little moisture in the soil. Although at depths < 120 cm, there was no significant influence of drainage ($\chi^2 = 6.05$ N.S.), the indications are that at these depths too, "moderately well" drained is preferred to "well" drained.

Table 6. *Soil depth × texture interaction*

Yield nut/palm/year	*Light Texture, ≥70 % palms under soil depth (cm)*			*Medium Texture, 55-69 % palms under soil depth (cm)*			*Heavy Texture, <55 % palms under soil depth (cm)*		
	<120	120 - 139	≥140	120	<120 - 139	≥140	<120	120 - 139	≥140
≥80	10.0	20.0	25.3	3.5	10.8	16.7	6.5	11.9	9.5
60 - 79	10.0	40.0	28.8	15.1	24.3	28.1	25.8	29.9	32.1
<60	80.0	40.0	45.9	81.4	64.9	55.2	67.7	58.2	58.4

Table 7. *Gravel depth × texture interaction*

Yield nut/palm/year	*Light Texture, ≥70 % palms under gravel depth (cm)*			*Medium Texture, 55-69 % palms under gravel depth (cm)*			*Heavy Texture, <55 % palms under gravel depth (cm)*		
	<60	60 - 119	≥120	<60	60 - 119	≥120	<60	60 - 119	≥120
≥80	8.4	23.5	26.0	5.3	10.1	24.1	11.8	9.1	8.6
60 - 79	20.8	17.7	29.2	16.5	24.6	35.2	28.9	24.2	36.6
<60	70.8	58.8	44.8	78.2	65.2	40.7	59.3	66.7	54.8

Table 8. *Soil depth × drainage interaction*

Yield nut/palm/year	*Good Drainage, ≥75 % palms under soil depth (cm)*			*Moderate Drainage, 60-74 % palms under soil depth (cm)*			*Impeded Drainage, <60 % palm under soil depth (cm)*		
	<120	120 - 139	≥140	<120	120 - 139	≥ 140	<120	120 - 139	≥140
≥80	4.6	3.8	10.6	5.6	17.0	22.3	10.0	25.0	18.3
60 - 79	17.4	29.5	37.5	5.6	21.3	28.0	40.0	25.0	26.8
<60	78.0	66.7	51.9	88.8	61.7	49.7	50.0	50.0	54.9

Table 9. *Gravel depth × drainage interaction*

Yield nut/palm/year	*Good Drainge, ≥75 % palms under gravel depth (cm)*			*Moderate Drainage, 60-74 % palms under gravel depth (cm)*			*Impeded drainage, <60 % palms under gravel depth (cm)*		
	<60	60 - 119	≥120	<60	60 - 119	≥120	<60	60 - 119	≥ 120
≥80	5.3	6.5	9.5	14.6	14.0	25.5	11.1	16.7	20.5
60 - 79	21.9	26.0	44.5	12.7	24.6	30.9	29.6	16.7	28.3
<60	72.8	67.5	46.0	72.7	61.4	43.6	59.3	66.6	51.2

Table 10. *Texture × drainage interaction*

Yield nut/palm/year	*Good Drainage, ≥75 % palms in textural class*			*Moderate Drainage, 60-74 % palms in textural class*			*Impeded Drainage, <60 % palms in textural class*		
	<55	55 - 69	≥70	<55	55-69	≥70	<55	55 -69	≥70
≥80	6.7	4.2	14.0	15.6	18.2	26.5	7.5	19.4	25.3
60 - 79	35.2	22.4	27.9	22.1	22.1	30.9	34.0	25.0	24.1
<60	58.1	73.4	58.1	62.3	59.7	42.6	58.5	55.6	50.6

Gravel Depth and Drainage: The pattern of the relationship between soil depth and yield under varied drainage conditions holds for gravel depth as well (Table 9)—there was a higher percentage of high yielding palms associated with deeper gravel depths under good ($\chi^2 = 14.5^{**}$) and moderate ($\chi^2 = 14.4^{**}$) drainage. As in the case of soil depth the yield continued to increase with gravel depth at all gravel depths tested. Therefore no critical limit for gravel depth could be determined.

The influence of drainage on yield under different gravel depths was similar to those under different soil depths—generally for all gravel depths, "moderately well" drained had a higher percentage of high yielding palms than "well" drained, although it was significant only for intermediate gravel depths ($\chi^2 = 13.35^{**}$).

Texture and Drainage: Under moderate and impeded drainage conditions there was no statistically significant relationship between texture and yield ($\chi^2 = 6.7$ and 7.1 respectively). However, there were indications of a preponderance of high yielding palms in light textured soils as at Bandirippuwa (Table 10). Under "well" drained conditions, the relationship between yield and texture was significant ($\chi^2 = 10.97^{*}$). There was a significantly higher proportion of very high yielding palms in light textured soils (Texture $\geq$ 70). A likely explanation for this is that under good drainage and at textures < 70, the soils belong mostly to Boralu series and therefore due to their shallow soil depths and gravel depths, the proportion of high yielding palms are lower. However, between the two textural classes, 55 - 69 and < 55, there was a significantly lower proportion of low yielding palms in the latter class. This is expected as heavy texture is preferred under "well" drained especially in these gravelly soils to facilitate better moisture and nutrient retention condition in the soils.

Similar observations were made on the effect of drainage on yield under different textural classes. In light ($\geq$ 70) and heavy (< 55) textured soils, drainage did not significantly affect yield. But at intermediate textural levels, drainage significantly influenced yield, there being a lower proportion of high yielding palms with "well" drained ($\chi^2 = 14.75^{**}$). The explanation for this is that the soils belonging to the textural class 55 - 69 are mainly Boralu, where the soils consist largely of gravels which have poor moisture retention properties and therefore "well" drained may further aggravate the moisture problem. Soils belonging to the textural class < 55 are also Boralu but because of the heavier texture, the moisture problem may not be as bad as in the intermediate textural levels.

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