Soil Grouping of the Federal University of Technology, Minna, Main Campus Farm Using Infiltration Rate

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Abstract

Different types of soil under different land use system were measured using double ring infiltrometer. After prolonged wetting (2 hrs), the nature of the soils, were determined with these final infiltration rates. The descriptions of soils were then grouped into four infiltration group of sandy, loamy, silt and clay soils. Under the fallowed land use practice, it was discovered to have higher volume of infiltration rate (5.80-46.20cm/hr) while under cultivated land practice (2.40-62.70cm/hr). However, the influence of land use on volumetric water content was not statistically significant which could be attributed to the clayey nature of the soils in the site, which masked the effect of land use. Regression analysis was performed on final infiltration as a function of bulk density, field capacity and initial moisture content. It was discovered that the surface bulk density had the highest correlation coefficient and average soil property down the profile which do not affect infiltration rates. Curve fitting was carried out on Phillip's, Horton's and Kostiakov's models, which showed that Horton's equation had a great consistent deviation during the early part of the test but Phillip's equation started deviating during the later part of the tests, particularly for swelling soils. Kostiakov's equation gave a more accurate result and is recommended for the soils tested and other similar soils.

Keywords: *Infiltration, Kostiakov, Philip, Horton, water, and soil.*

Introduction

Water resources management is an important issue of our days, especially in the arid and semi-arid region of Nigeria where Niger State falls and here a better water balance in the soil is very crucial / important. Proper management of water is one of the key factors to increase agricultural production in these regions. Infiltration is one of the key processes controlling the water budget and transport processes in the soil profile. Thus, evolution of infiltration will determine the proportions of the water moving through the root zone, beyond it stored in the soil and available for surface runoff. If the infiltration characteristics on a field can be kept constant, then irrigation efficiency could be increased to a high level (Daley *et al*. 2004a).

Infiltration refers to vertical movement of water downwards from the soil surface to replenish the soil water/moisture deficiency. Since infiltration causes the soil to become wetter with time, water at the leading edge of the wetting front advances into the drier soil region ahead of the front under the influence of matric potential gradients as well as gravity; for infiltration which are vertical (Daley *et al*. 2004b). Feyen *et al*. (1972) reported large variations in soil infiltration capacity following small changes in bulk density, and Guswa *et al*. (2002) observed much higher cumulative infiltration, infiltration rate and time to attain equilibrium on mulched plots irrespective of tillage treatments.

Infiltration rate data of soils can be used to supplement other soil information which should help soil scientists, engineers, hydrologists, and others to deal more precisely with a wide spectrum of water resources management and conservation problem (Deidda 2000), different types of soil are known to have different water intake rates. Movement of water through the soil profile tells a lot about the pore sizes and permeability. In some cases, the pore sizes can be large but the rate at which water moves through the profile can be slow, this may depend on the presence of air within the profile and where such exit, there will be a sudden upstroke of water releasing the air into the atmosphere and then the process of infiltration will continue. It was therefore based on this that our soil classification was made possible which further helps to determine the type of irrigation practice that will be necessary for that area. Fernandez-Illescas *et al*. (2001) suggested that most soils could be placed into one of the four infiltration groups depending on their measured and inferred infiltration capacity. Work on infiltration (ASCE 1949) showed infiltration rates listed in relation to the texture of the surface soils. However, this approach either assumes uniform deep surface soils or insignificant changes in permeability with depth.

Layered soils are known to induce unstable flow when a fine-textured region lies over a coarse-textured one (Smith *et al*. 1993). During infiltration into dry soil layered in this manner, water cannot enter the coarse-textured zone until the pressure has built up sufficiently to wet the larger pores. If this occurs at discrete locations along the wetting point, the new wetted channels in the coarse-textured zone may become conduits for all the water entering from above. These narrow-flow channels, called fingers can persist through the entire coarse-textured zone. As the flow paths become smaller which explains partly the decline of the infiltration rate in time. By the time infiltration rate has become constant, a pronounced transition zone is established with nearly uniform moisture content close to saturation. Pressure difference here is smaller and the water movement is dominated by the gravity force. The final infiltration rate thus becomes approximately equal to the saturated hydraulic conductivity of the soil.

The Federal University of Technology permanent site is known to have a total land mass of eighteen thousand nine hundred hectares (18,900 ha) which is located along kilometer 10 Minna-Bida road, South-East of Minna under the Bosso local Government area of Niger State. It has a horse-shoe shaped stretch of land, lying approximately on longitude of 06^{o}28' E and latitude of 09^{o}35'N (Sani 1999). The site is bounded Northwards by the Western rail line from Lagos to the northern part of the country and the Eastern side by the Minna-Bida road and to the North-West by the Dagga hill and river Dagga (Sani 1999).

The objectives of this study was to determine the infiltration rates of some selected soil under various management practices and fit the soil into infiltration groups; to predict relative infiltration rates using some time dependent infiltration equations and to determine which equation best fits the permanent site of the University Farm located along the Minna-Bida highway.

Materials and Methods

The infiltrometer rings were rolled iron sheet of 12-gauage steel and the diameters of the inner and outer ring were 300 mm and 600mm, respectively, as suggested by Bambe (1995). The two rings have a height of 250mm and the bottom ends of the ring were sharpened for easy penetration into the soil.

Each infiltrometer was equipped with a float consisting of a plastic rule placed perpendicularly to one face of the wooden block. This wooden block was painted so as to prevent it from soaking water as it floats on the water. The plastic meter rule was clamped to the inner side of the inner rings; with another sharp-edged wood placed near the rule to facilitate taking reading from the rule.

The infiltrometer rings were randomly placed from each other and the measurement were taken to the nearest centimeter. The rings were driven into the ground by hammering a wooden bar placed diametrically on the rings to prevent any blowout effects around the bottoms of the rings. In areas where ridges and furrows existed, the inner rings were always placed in the furrow. Having done that, a jute sack was spread at the bottom of the inner and outer compartments of each infiltrometer so as to minimize soil surface disturbance when water was poured into the compartments. In grass-covered areas, they were cut as low as possible so that the float could have free movement during which care was taken not to uproot grasses. Four infiltration measurements were conducted at each location of which an average was to be taken later.

Water was poured into the infiltrometer compartments simultaneously and as quickly as possible. The water level from the inner cylinder was read from the float (rule) and the local time was also noted. Repeated readings were taken at intervals of: 0, 1, 2, 5, 10, 15, 20, 30, 45, 60, 75, 90, 100 and 120 min. The cylinder compartment was refilled from time to time when the water level dropped half way. The water levels at both compartments (inner and outer) were constantly kept equal by adding water, as needed, into the outer compartment, which is faster. Some time is allowed before starting another replicate. So that no two infiltrometer should require reading at the same time, each replicate was allowed a time duration.

At each site, ten soil samples were taken using the 50 x 50mm core sampler from the surface layer (0-50cm) in the area outside the outer rings. These were bulked for the determination of the initial moisture content and bulk densities.

Results and Discussion

Table 1 shows the initial soil moisture content and the bulk densities of tested soils. Table 1 shows that a high moisture content of 0.0620g was observed, which may due to the clayey nature of soil and its closeness to a stream. Sites 3, 5, 6, 7 and 8 closely follows site 11 in terms of weight of water present in the area and this may be due to the clay nature of the soil around the area, except for site 5, which has a different soil characteristic (loamy in nature). There is a higher correlation between the cumulative infiltration {I (cm)} and time {$t^{-1/2}$(min.)}, site 6 (had the highest wet bulk density of 1.83 g/cm3 which is slightly plastic, when felt and dark sandy clay) on Table 1 shows that the bulk density is slightly than that of the wet bulk density of site 12, this could be as a result of the type of soil available in the area. The bulk density as presented, were taken for both dry and wet soils. This was closely followed by sites 12, 8, 4, 15 and 14, respectively. The particle size was classified into the various soils using the soil-textured triangle. The presence of organic matter at each of the range was clearly represented also.

Table 2 shows the percent count of *R* square values from the curve fittings from which it could be observed that the Kostiakov's equation has the best fit with 99.35% for fallowed land and 98.79% for cultivated land. Philip's equation had a *R* square value of 53.10% for cultivated land and 55.22%for fallowed land, when compared with the *R* square value of Kostiakov's, it was far lower, since Philip's model is limited to swelling homogenous soils and for vertical flow while Kostiakov's equation has no limitation, it is also known to apply to the three-dimensional flow.

It was discovered, however, that the infiltration rate of cultivated land when compared with the fallowed land was higher which may be due to the undisturbed nature of soils or the area may have a high water table. It was observed in the month of April, an average of the final infiltration rate for cultivated land was 35.54 cm/hr, with a cumulative water intake of 70.32cm at the end of the infiltration while for the fallowed land had a final infiltration rate of 15.23cm/hr and a cumulative water intake rate of 30.47cm. In the month of May, the cultivated land had an infiltration rate of 32.28cm/hr, and cumulative water intake rate of 64.57cm while the infiltration rate for the fallowed land was 11.30cm/hr and the cumulative water intake rate was 22.60cm; a reduction in the water intake rate was observed between the month of April and May which may be due to the two day rain during that month. In the month of June, a further reduction was observed in the cultivated land, an infiltration rate of 24.37cm/hr and a cumulative water intake rate of 48.74cm was observed. There was further reduction in soil-water intake rate in the month of July, for the cultivated land the infiltration rate was

17.12cm/hr and cumulative water intake rate was 34.24cm while for the fallowed land the infiltration rate was 14.12cm/hr and the cumula- tive water intake was 28.31cm. These reductions signify the intense rate of rainfall during those months when the tests were carried out.

Table 3A shows the average infiltration rate (cm/hr) for the dry season for the various land use practices which show that the cultivated land had an infiltration rate of 33.91cm/hr while the cumulative intake was 67.45cm. The fallowed land infiltration rate was 13.27cm/hr and the cumulative water intake rate had a staggering figure because at the 75^{th} min, the intake rate increased to 36.38cm and at the 90^{th} min, it dropped to 21.33cm from were it increased gradually to 26.54cm at the 120^{th} min. Table 3B shows the average infiltration rate (cm/hr) for the wet season for various land practice which shows that infiltration rate for the cultivated land was 20.75cm/hr while the cumulative water intake was 41.49cm and the fallowed land, the infiltration rate was 15.02cm/hr and the cumulative water intake was 30.04cm. When the data obtained from the dry and wet seasons were compared, the values of wet seasons were known to have a higher water intake rate. On the average, as seen on Table 4, the infiltration rate for cultivated land was 27.33cm/hr and the cumulative water intake was 54.47cm while for the fallowed the infiltration rate was 14.14cm/hr and the cumulative water intake was 28.29cm. It was observed, therefore, that on the average there was a higher water intake rate in the cultivated land when compared with the fallowed land.

Comparing the data of Philip, Horton and Kostiakov's a greater degree of accuracy was shown in terms of parameters that best describe the soil properties of the irrigation farm of the Federal University of Technology Minna Permanent Site.

The best fit line for the graph of infiltration rate {I(cm/hr)} against elapsed time {t(min)} for 12 weeks during which the infiltration rate test was carried out in the irrigation farm of the Federal University of Technology Minna, Niger State, Nigeria. The R square value for 12 weeks is 89.9% for the whole farm site while equation that best describes this area is given in the form of $Y = MX + C$ as n that best describes this area is given in the form of $Y = MX + C$ as $Y = 0.48881x + 1.2192$; where:

M = Slope = 0.48881,

C = Intercept =1.2192,

X = variable factor = time,

while the best fit line for the cumulative infiltration {i(cm)} against elapsed time {t(min)} for 12 weeks during which the rate of infiltration of water into the soil was carried out for the same site, the irrigation farm site of the Federal University of Technology, Minna, Niger State, Nigeria. The R square (R^2) value was 84.99% which is slightly lower when compared with that obtained from the best fit line for the graph of infiltration rate {I(cm/hr)} against elapsed time {t(min)} for 12 weeks.

An equation in the form of $Y = MX + C$ was also obtained, which is given as $Y = 0.5094\ X - 9.0431$; where:

M = slope = 0.5094,

C = intercept = -9.0431,

X = variable factor = time.

From the above two equations, it can observed that value for the intercept obtained for the first was positive while of the second was negative which may be due to the fact that water was being emitted/given off from the soil during the rainy season.

It was discovered that the curve fitting graphs drawn under cultivated land showed similar shapes while those of the fallowed land were different which may be due to the nature of the soil, the underlay and organic matter present in the area. Though, the conditions of operation were different, the results obtained compared with Ahmed and Duru (1982) and that of Eze (2000) under similar conditions the result were found to be almost the same.

Curve fitting was carried out using the chi-square/regression and least square methods, to calculate the excepted infiltration rate data for the three equations as affects the various land management practice for the various seasons. The curve fitting methods gave an almost same figure for a given parameter in the equations considered under the cumulative infiltration is compared to the calculated date for the cumulative infiltration under

Kostiakov's model, it shows a negligible difference between the calculated and the observed data, which makes the model more closer in predicting infiltration rate when compared to those of Philip and Horton's. It is also discovered from the data obtained, Philip model had a higher deviation in all cases tested which means that Kostiakov's model adequately describes the field experimental data and predicts the infiltration rates of soils within the irrigation farm of the permanent site of the Federal University of Technology Minna. It was observed that the figures obtained for the calculated cumulative infiltration was negative under the Kostiakov's equation which could be due to water been given off during the rainy season and that water is not required during the rainy season on the farm, instead water is given off which in turn accounts for the fadama nature of some parts of the farm.

The result is similar to those of Eze (2000), Wuddirira (1998) and Ahmed and Duru (1985) who used similar models for the soil of Minna, Niger State and Samaru in Zaria (Kaduna State), respectively. The Kostiakov's model is presented by the expression:

$$I = Mt^n + b,$$

where: I = accumulated infiltration (cm); t = elapsed time since infiltration started (min); and M, n and b = constants.

The parameters M, n and b were evaluated for the tested soils by the method of average as suggested by Davis (1943). Differences were observed in the values for a particular area, which may be because of the soil heterogeneity and variations in the surface conditions. It was discovered that sandy loam soil upon wetting started with very high values from 114cm/hr in the first few minutes to 43.35cm/hr at the end of the time of 2 hours.

The end values of each data for the infiltration rate in centimeter per hour was grouped according to the classification of the American Society Of Civil Engineers found under the manual of engineering practice, no 28 (ASCE 1949). These results were compared with that obtained from the classification based on the soil textural triangle. The difference between the two was observed, except for a few cases where the classification corresponds, which implies that the hydrological grouping method based on infiltration rate be studied over a long period of time.

Table 7 shows typical infiltration rate values according to ASCE (1949) used for soil grouping. The corresponding cover factor for savannah region was selected to be 6.985 (ASCE 1949). On multiplying this cover factor for with values in Table 7 resulted in values showed in Table 8. These set of values where then used to classify the soil in the study area based on the measured soil intake characteristics (infiltration rate).

It was observed that site 23 had a very high infiltration rate, which implies that the area is predominantly sandy soil while the rest of the site were predominantly known to have low rate of infiltration, which implies that they were mainly sandy, loam clay and silt soils, which does not completely correspond with the classification. A clear difference was observed with the classification carried out using the infiltration rate method. When compared with the Adesoye soil classification map for the same study area.

Conclusion

This study involved the use of double-ring infiltrometer to measure infiltration rates of soils left to fallow and those under cultivation. Some factors affecting infiltration includes the texture, management practice and bulk density the most important. Light textured soil were observed to have a higher infiltration rates than the heavier textured soils which is due to the large conducting pores in sandy soil. It was discovered that the infiltration rates of the tested soil range between 5.80 – 46.20 cm/hr. This infiltration capacity can become stable over a long period of time say eight years.

Based on the end data obtained from the infiltration rates, classification of the various soils on the irrigation farm of the Federal University of Technology, Minna was made possible. The soil grouping of the tested soils of the irrigation farm was carried out with the soils been divided into the high infiltration rates (sandy soils), the intermediate infiltration rate (Loam, clay and silt) and the low infiltration rate (clay and clay loam). The equation that best describes the irrigation farm of the Federal University of Technology, Minna, Niger State, Nigeria, is given as $Y = 0.4881x + 1.2192$, while that which describes the graph of cumulative infiltration against elapsed time $\{t(\text{mins.})\}$ as $Y = 0.5094x - 9.0431$ for the same area, where x is the time.

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Table 1. Initial soil moisture content and density of the soil samples of the experimental site (depth of between 10cm to 50cm).

Site	Weight of sample (G)	weight of oven-dry sample (g)	Weight of water (g)	wet (g/cm^3) (bd)	dry (g/cm^3) (bd)
1	161.48	158.73	0.0173	1.634	1.545
2	168.88	165.28	0.0218	1.709	1.581
3.	167.18	159.56	0.0478	1.692	1.574
4	178.67	171.19	0.0402	1.793	1.641
5	166.83	159.02	0.0491	1.597	1.517
6	189.81	182.76	0.0386	1.831	1.688
7	166.94	159.21	0.0486	1.639	1.560
8	179.62	172.28	0.0426	1.819	1.652
9	187.11	161.22	0.0363	1.691	1.611
10	167.97	161.04	0.0430	1.720	1.640
11	160.52	153.97	0.0620	1.624	1.537
12	180.05	176.98	0.0173	1.823	1.700
13	146.35	141.23	0.0362	1.480	1.397
14	176.95	171.03	0.0346	1.791	1.690
15	178.00	172.45	0.0322	1.792	1.715
16	161.20	157.10	0.0261	1.631	1.538
17	150.69	148.00	0.0182	1.524	1.509
18	149.66	144.18	0.0380	1.514	1.468
19	155.51	152.08	0.0226	1.573	1.548
20	155.47	150.54	0.0327	1.573	1.533
21	158.26	153.81	0.0285	1.611	1.600
22	151.93	146.77	0.0352	1.547	1.515
23	155.36	152.61	0.0180	1.581	1.564
24	155.85	152.41	0.0226	1.586	1.552
25	167.12	162.68	0.0273	1.701	1.687
26	160.78	157.67	0.0197	1.637	1.605
27	155.56	153.36	0.0143	1.583	1.561
28	159.84	156.25	0.0229	1.627	1.591
29	162.59	157.44	0.0327	1.655	1.633
30	168.99	164.54	0.0331	1.710	1.675

Table 2. The *R* square values for the three models used.

% of *R* square greater than	Horton's	Philip's	Kostiakov's
0.50	Nil Nil	53.10 (Cultivated land) 55.22 (Fallowed land)	Nil Nil
0.60 0.70	75.88 (cultivated land) 75.69 (fallowed land)	Nil Nil	Nil Nil
0.80 0.90	Nil Nil	Nil Nil	98.79 (cultivated land) 99.35 (fallowed land)

Table 3A. Average infiltration rate (cm/hr) for the dry season for various land use practice.

Time (mins)	Dry season			
	Fallowed land Cultivated land			
	Cum. water intake (cm)	Infiltration rate (cm/hr)	Cum. water intake (cm)	Infiltration rate (cm/hr)
0	-	-	-	-
1	0.82	49.00	1.33	79.50
2	1.42	42.50	2.38	71.50
5	2.65	31.58	4.94	58.58
10	4.30	25.80	8.56	51.35
15	5.72	22.87	11.73	46.90
20	6.93	20.80	15.22	45.90
30	9.15	18.28	21.45	42.86
45	12.56	16.75	28.98	39.98
60	15.61	15.61	38.42	38.42
75	36.38	14.34	46.00	36.80
90	21.33	14.22	53.98	35.99
100	23.09	13.86	58.35	34.99
120	26.54	13.27	67.45	33.91

Table 3B. Average infiltration rate (cm/hr) for the wet season for various land use practice.

Time (min)	Wet season			
	Fallowed land Cultivated land			
	Cum. water intake (cm)	Infiltration rate (cm/hr)	Cum. water intake (cm)	Infiltration rate (cm/hr)
0	-	-	-	-
1	0.72	42.98	0.91	54.68
2	1.22	37.09	1.60	47.85
5	4.93	29.58	3.32	39.42
10	4.96	25.55	5.74	34.44
15	5.89	23.55	5.74	31.12
20	7.85	22.16	9.56	28.83
30	10.10	20.17	13.18	26.35
45	13.56	17.86	18.61	24.81
60	16.96	16.81	23.69	23.73
75	20.47	16.36	28.43	22.74
90	23.95	15.99	33.15	22.10
100	25.97	15.63	36.26	21.74
120	30.04	15.02	41.49	20.75

Table 4. Average infiltration rate (cm/hr) for 12 weeks for the various land use practice.

Time (min)	Wet season			
	Fallowed land Cultivated land			
	Cum. Water Intake (cm)	Infiltration Rate (cm/hr)	Cum. Water Intake (cm)	Infiltration Rate (cm/hr)
0	-	-	-	-
1	0.77	45.99	1.12	67.09
2	1.32	39.80	1.99	59.68
5	2.56	30.58	4.13	49.51
10	4.28	25.67	1.15	42.89
15	5.80	23.21	9.83	39.01
20	7.39	21.48	12.39	37.36
30	9.16	19.22	17.31	34.61
45	13.06	17.30	23.79	32.39
60	16.29	16.21	31.05	31.08
75	19.42	15.53	37.21	29.77
90	22.64	15.10	43.56	29.04
100	24.53	14.74	47.30	28.36
120	28.29	14.14	54.47	27.33

Table 5. Estimated soil parameters for infiltration for curved fitting equations for 12 weeks.

Land Use Practice	Estimated Soil Parameter (Kostiakov's)	Estimated Soil Parameter (Philip's)	Estimated Soil Parameter (Horton's)
Cultivated Soil	M = 1.069 n = 0.821 b = 0.054	A = 25.811 S = 45.131	I_o = 67.09 I_c = 27.33 M = 0.006 Ø = 2.98
Fallowed Soil	M = 0.741 n = 0.760 b = 0.034	A = 12.259 S = 26.506	I_o = 45.99 I_c = 14.14 M = 0.0081 Ø = 2.98^{-3}

Table 6. Estimated soil parameters for infiltration for curved fitting equations for dry and wet seasons.12 weeks.

Land use practice	Estimated soil parameter (Kostiakov's)		Estimated soil parameter (Philip's)		Estimated soil parameter (Horton's)	
	Dry	Wet	Dry	Wet	Dry	Wet
Cultivated soil	M = 1.2454 n = 0.834 b = 0.102	M = -1.3970 n = 0.8363 b = 1.9074	A = 6.6865 S = 11.074	A = 4.0961 S = 6.4691	I_o = 79.50 M = 0.0057 K = 0.0021	I_o = 54.68 I_c = 20.75 M = -0.0065
Fallowed soil	M = 0.7269 n = 0.7759 b = 0.023	M = -3.9057 n = 1.1265 b = 0.0303	A = 2.9456 S = 4.2292	A = 2.8682 S = 3.8257	I_o = 67.09 I_c = 27.33 M = 0.006 Ø = 2.98	I_o = 42.98 I_c = 15.02 M = -0.0072 K = -0.0026

Table 7. Typical infiltration rate {*I*(cm/hr)} values with corresponding soils.

Soil Group	*I* (cm/hr)
High (sandy soils)	1.27 – 2.54
Intermediate (Loam, Clay, Silt)	0.254 – 1.27
Low (Clay, Clay loam)	0.0254 – 0.254

Source: ASCE (1949).

Table 8. Typical infiltration rate {*I*(cm/hr)}values after it were multiplied with a cover factor of 6.985 with the corresponding soils.

Soil Group	*I* (cm/hr)
High (sandy soils)	8.87 – 17.742
Intermediate (Loam, Clay, Silt)	1.774 – 8.87
Low (Clay, Clay loam)	0.1774 – 1.774

Table 9. Soil classification of the permanent site farm of the Federal University of Technology, Minna.

Site	Infiltration rate (cm/hr)	Classification	Type of land
1	44.70	High	Cultivated
2	46.20	High	Fallowed
3	36.75	High	Cultivated
4	29.00	High	Fallowed
5	10.85	High	Cultivated
6	6.25	Intermediate	Fallowed
7	2.40	Intermediate	Cultivated
8	6.15	Intermediate	Fallowed
9	49.55	High	Cultivated
10	9.95	High	Fallowed
11	39.95	High	Cultivated
12	20.60	High	Fallowed
13	7.90	Intermediate	Cultivated
14	9.60	High	Fallowed
15	10.00	High	Cultivated
16	20.35	High	Fallowed
17	11.35	High	Cultivated
18	8.60	Intermediate	Fallowed
19	21.30	High	Cultivated
20	4.30	Intermediate	Fallowed
21	43.35	High	Cultivated
22	32.05	High	Fallowed
23	62.70	(Very) High	Cultivated
24	30.00	High	Fallowed
25	19.10	High	Cultivated
26	39.35	High	Fallowed
27	6.65	Intermediate	Cultivated
28	6.70	Intermediate	Fallowed
29	27.45	High	Cultivated
30	17.15	High	Fallowed
31	34.20	High	Cultivated
32	33.05	High	Fallowed
33	4.50	Intermediate	Cultivated
34	6.15	Intermediate	Fallowed
35	4.90	Intermediate	Cultivated
36	6.30	Intermediate	Fallowed
37	37.75	High	Cultivated
38	27.40	High	Fallowed
39	24.90	High	Cultivated
40	26.45	High	Fallowed
41	22.55	High	Cultivated
42	25.00	High	Fallowed
43	24.15	High	Cultivated
44	18.30	High	Fallowed
45	23.90	High	Cultivated
46	7.70	Intermediate	Fallowed
47	16.10	High	Cultivated
48	12.25	High	Fallowed
49	18.45	High	Cultivated
50	10.75	High	Fallowed
51	12.50	High	Cultivated
52	5.80	Intermediate	Fallowed
53	7.35	Intermediate	Cultivated
54	23.10	High	Fallowed
55	15.30	High	Cultivated
56	18.55	High	Fallowed
57	7.80	Intermediate	Cultivated
58	24.60	High	Fallowed
59	10.70	High	Cultivated
60	7.90	Intermediate	Fallowed