treatment was only 2 mm. Deforestation contributed to a significant amount of seepage or ground water flow. The intermittent stream with only traces of flow during periods of heavy rains is now a perennial stream with measurable flow throughout the year. The maximum surface runoff was observed in September; the subsurface flow in October was almost equal to surface runoff. Continuing flow through the dry season also indicates the possibility of sizeable ground water storage that may be important at least in analyzing the hydrological balance of a cleared watershed.

Table 8. Effects of land clearing methods on soil bulk density in g/cm³ for the 0-5 cm depth (IITA, 1978-80).

Treatment	1978[1]	1979	1980
Traditional farming	0.64	1.06	1.07
Manual clearing—no tillage	0.68	1.14	1.05
Manual clearing—conventional tillage	0.68	1.20	1.29
Shear blade	0.70	1.19	1.37
Tree pusher—no tillage	0.66	1.25	1.37
Tree pusher—conventional tillage	0.53	1.22	1.32

Mean of 25 replications.
[1]1978 data prior to clearing.

Effect on surface runoff and erosion. Soil erosion and water runoff were lower for cassava than maize. Moreover, there were no significant differences among treatments either for runoff or erosion, except for the tree pusher—conventional tillage treatment. In spite of the protective cover of the cassava canopy, this treatment had 48 mm of water runoff and 4.2 t/ha/annum of soil erosion (Table 9). In comparison to this, runoff and erosion from the shear blade—no-tillage cassava was 5.0 mm and 0.08 t/ha. On the contrary, runoff and erosion from the shear blade—no-tillage maize treatment was 53 mm and 1.9 t/ha/annum, respectively. These results on the effects of methods of land clearing and post-clearing soil management have important practical agronomic implications. It seems that, in the long run, post-clearing soil management has the most important effect on soil erosion, runoff and decline of soil physical and chemical properties. This is not to say that the methods of land clearing are not important because a combination of harmful land clearing and post-clearing soil management methods, such as land clearing with tree pusher/root rake followed by conventional plowing and harrowing, results in the most losses in water runoff and soil erosion and in rapid degradation of soil physical and chemical properties.

Table 9. Effects of land clearing methods on surface runoff and erosion (IITA, 1980)

Treatment	Run-off, mm	Ero-sion, t/ha
Traditional farming	0	0
Manual clearing—no tillage	0.2	0.001
Manual clearing—conventional tillage	6.0	0.06
Shear blade—no tillage	5.0	0.08
Tree pusher—no tillage	3.0	0.04
Tree pusher—conventional tillage	48.0	4.2

Effect on cassava growth and yield. Seedling mortality was about 50 percent in these treatments because of shading by trees in the traditionally managed plots and by maise in the no-tillage plots (Table 10). Since cassava was planted in no-tillage treatments through 6-8 week-old maize, row spacing was often more than 1 m (sometimes 1.5 m), which also contributed to a low plant population. Cassava tuber yield varied by a factor of 2-2.5 among treatments with the lowest yield in the traditionally managed plots. Conventional tillage plots were planted at least 6 weeks later and harvested about a month after no-tillage plots. Tuber yield in conventional tillage plots would have been even more if they had been harvested 2-3 months later. Nevertheless, tuber and stalk yield from the no-tillage plots were comparable with those from the plowed and ridged plots.

Table 10. Effects of land clearing methods on cassava growth and yield (IITA, 1980)

Treatment	Plants/ ha	Tubers/ ha	Yield t/ha	
			Tubers	Stalks
Traditional farming	4,540	31,570	7.7	14.6
Manual clearing—no-tillage	5,230	36,640	15.0	22.4
Manual clearing—conventional-tillage	4,850	36,180	11.7	26.1
Shear blade—no-tillage	5,420	30,550	14.1	14.6
Tree pusher—no-tillage	5,800	39,580	20.2	16.8
Tree pusher—conventional-tillage	12,700	59,940	17.5	23.0

Tillage systems and small tools development

Effects of tillage methods on maize production. No-tillage methods with residue mulch have proven useful for some row crops in kaolinitic Alfisols in the forest zone of Western Nigeria. However, long-term studies at IITA have indicated that soil compaction can be a problem in no-tillage plots within 3-4 years. Moreover, soil compaction is more severe on mechanized than manually cultivated plots. Crop residue mulch is needed for many other uses (fodder, buliding houses and fences, fuel, etc.) and, therefore, may not be always available in the quantity required for effective soil and water conservation. Chiseling in the row zone rather than plowing the entire field, which makes the soil vulnerable to erosion, may be an alternative to ameliorate the soil of the compaction hazard. Plowing at the end of the rainy season may be another method. With this background, an experiment was carried out at IITA with the following treatments:

A. No-tillage with residue mulch.
B. No-tillage with chiseling in the dry season.
C. Moldboard plowing followed 2 harrowings (residue plowed in).
D. Disc plowing (residue disced).
E. No-tillage with residue removed.
F. Moldboard plowing at the end of rainy season and harrowing at planting.