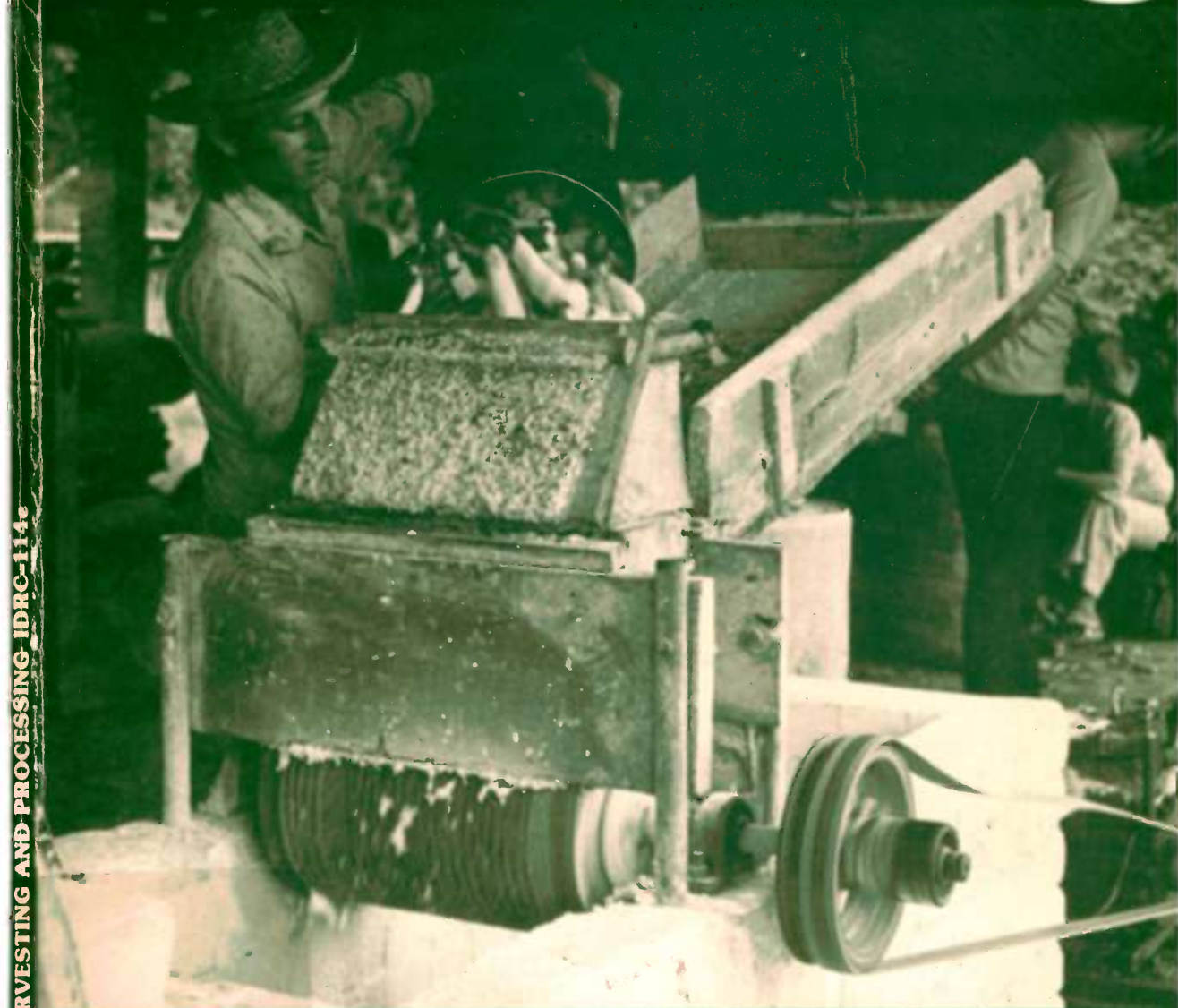


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Cassava Harvesting and Processing



HARVESTING AND PROCESSING IDRC-114e

PROCEEDINGS OF A WORKSHOP HELD AT
MAGUI, CALDAS, COLOMBIA
24-28 APRIL 1978

EDITORS: EDWARD J. WEBER
JAMES H. COCK
AMY CHOUINARD

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Cassava Harvesting and Processing

Proceedings of a workshop held at CIAT, Cali, Colombia, 24-28 April 1978

Editors: Edward J. Weber,¹ James H. Cock,² and Amy Chouinard³

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Agronomic Implications of Mechanical Harvesting

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Abstract. Cassava harvesting can be separated into three distinct processes: removal of the tops, lifting of the roots, and separation of the roots from the stems. The ratio of tops to roots cannot be reduced below 2:3 without reducing yield. The tops should be pulverized so that the remains do not germinate after harvest. For lifting the roots, it is desirable to have a compact or clumped type of rooting. This can be obtained by selection of the right cultivar and by using stakes cut straight across and planted in ridges in vertical or inclined position. The yield is more affected by plant population than distance between ridges and, hence, these can be varied to suit machinery requirements. New developments in storage techniques show that damage during the separation process may be less important than previously thought.

The cassava crop is traditionally harvested by hand — a job that even under good conditions is very time-consuming and tedious. A reasonable estimate is that three-quarters of a tonne of fresh cassava can be harvested per man-day. The labour requirement is high and the work, extremely arduous. In areas where labour is plentiful, it seems necessary on humanitarian grounds to have at least some mechanical aids for harvesting. In the more acid and less fertile tropical areas, which are in general very underpopulated, it seems that mechanical harvesting is the only way to realize the potential for increased cassava production.

Requirements

Harvesting comprises three steps: first, the tops (leaves and stems) must be cut down; second, the roots must be removed from the soil; and third, the roots must be separated from the stem for packing. The objectives are to lift all the roots and to avoid damaging them. Avoiding damage is extremely important, because the shelf life of roots is closely related to the amount of damage (Booth 1973).

The amount of top to be removed at harvest depends primarily on the cassava variety. Many traditional varieties may produce more than 20 t/ha of fresh tops for a yield of 15–20 t/ha of fresh roots. Present breeding efforts are tending to increase the root/shoot ratio so that the same amount of top, that is 20 t/ha, yields about 30 t/ha of roots. It seems optimum yields are possible at a

root/shoot ratio of 3:2 and that further reducing the tops will adversely affect yield.

The amount of top is also affected by the plant population, soil fertility, the amount of water available to the plant, pest infestation, and disease incidence. Using less fertilizer or planting fewer plants increases the root/shoot ratio but also decreases yield substantially.

Not only the quantity, but also the disposition, of tops is important. A single stem that is upright and that branches not at all, or at least late, appears simplest to remove mechanically. Fortunately, this type of stem structure appears also to be best for yield; profuse branching, nonerect, straggling types are generally poor yielders. The uprightness of the stem can be influenced both by lodging due to heavy winds and the disposition of the stake at planting. Lodging in itself has very detrimental effects on yields and should be avoided. Data recently obtained at CIAT and by Caceres (personal communication) in Honduras suggest that planting the stakes in an erect or inclined position, as opposed to a horizontal position, helps to keep the stems upright and minimizes lodging. Although Conceicao and Sampaio (1973, 1975) recommend horizontal planting in the furrow to aid mechanized plantings, data obtained at CIAT show that vertical or inclined planting is most effective for mechanical harvesting (Table 1).

The tops of the cassava plant may serve as disease and pest reservoirs that, if not removed, will infect the next crop. At present, there are two

Table 1. Effect of stake cutting angle and planting position on root formation and distribution (CIAT 1978).

Root formation around stake	Vertical position (%)		Inclined position (%)	
	Straight cut	Slanted cut	Straight cut	Slanted cut
Circular	70.6	35.6	55.0	23.8
Extreme end	29.4	64.4	45.0	76.2

ways to remove the infection potential: one is to chop the tops finely and damage them to such an extent that no volunteer plants will form from the remaining debris, and the other is to remove all the debris from the field. The latter practice, however, is not recommended because it removes nutrients and rapidly depletes the soil. In fact, Nijholt (1935) and Oelsligle (1975) have shown that from 80 to 190 kg/ha N, 20 kg/ha P, and 80 to 190 kg/ha of K can be removed in the tops when root yields vary from 40 to 56 t/ha. Thus using dried leaves as a protein source — a practice of recent interest in Thailand — has not been widely accepted by the farmer because of the extra fertilizer that must be spread to maintain soil fertility (Chareinsuk 1977).

Lifting the Roots

After the tops have been cut down, the cassava roots are harvested. They must be dug up and collected with as little damage as possible. The problems involved in the task depend on the way the cassava has been planted, the distribution of the roots, and the root shape, size, etc. This is true for both manual and mechanical harvesting but is especially true for the latter.

To date cassava harvesters (Briceno and Larson 1972; Makanjoula et al. 1973; Hossne 1971) all have one characteristic in common: the cassava to be harvested must be planted in rows. Furthermore, Beeny (1970) recommended that it be planted on ridges, and Onochie et al. (1973) recommended the development of bunch-type rooting, suggesting that the root pattern could be changed by plant breeding and agronomic practices.

Cassava is normally planted in rows; therefore, the first requirement for mechanical harvesting appears to be met. However, standard row spacings for cassava are generally 1 m — a problem for centrally mounted harvesters. At this spacing two rows must be harvested at the same time so that the tractor wheels do not run over the unharvested crop. If row spacings are increased to about 1.6 m, this problem is avoided.

Our data suggest that an increase to 1.6 m would not cause the roots to spread between the rows and would not reduce yields. Our findings were that the spread of roots along the ridges increased as plant density decreased from 20 000 to 5000 plants/ha (Fig. 1), but the root spread across the ridge remained fairly constant. Furthermore, as long as plant density per row was maintained, the yields per row were not adversely affected (Fig. 2).

Planting on ridges, as suggested by Beeny (1970), is common practice in cassava areas where drainage is a problem. In these areas if cassava is planted on the flat, root rot can become so severe that losses are nearly 100% (Lozano, personal communication). When planted on ridges, losses are considerably reduced. In well-drained soils, however, it is common practice to plant on the flat. Because the soil around the stakes stays moist for longer periods, planting on the flat may actually prove advantageous for establishing plants when rainfall is sporadic. Thus, the best agronomic practices appear to conflict with suggested practices for mechanical harvesting. There are two factors that tend to mitigate the conflict. Firstly, one of the main reasons to plant on ridges is to minimize the quantity of soil moved and, hence, the energy required in harvesting. Well-drained soils, because they are likely to have good structure and to be lightweight, do not usually cling together to create a problem for harvesting equipment. Secondly, recent results have shown that planting material can be chemically treated to prevent dehydration of the stakes (Lozano et al. 1978), protecting them during short periods of water stress after planting. The new treatments are extremely cheap (approximately U.S. \$3/ha), and their use may make it possible to plant on ridges even in light, well-drained soils where rainfall is uncertain. Lynam and Diaz (personal communication) have shown that, after planting on the flat, almost perfect stands could be obtained with treated material, although more than 50% loss was recorded with untreated materials.

Root shape, size, and stem attachment are highly dependent on crop variety, the most

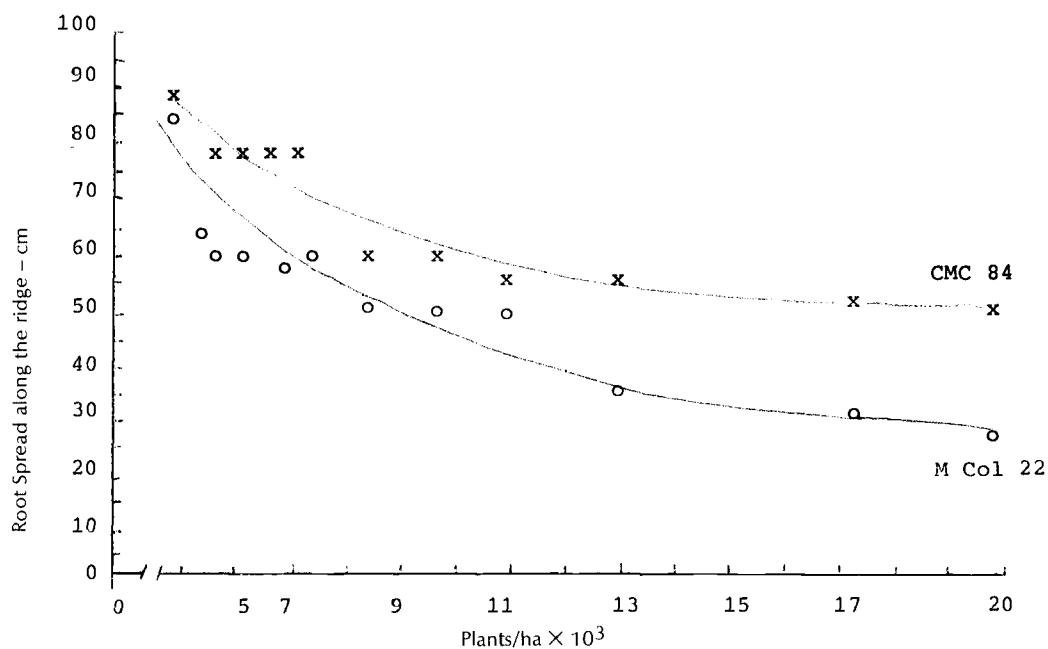


Fig. 1. Root spread along the ridge as affected by increasing plant density within the ridge.

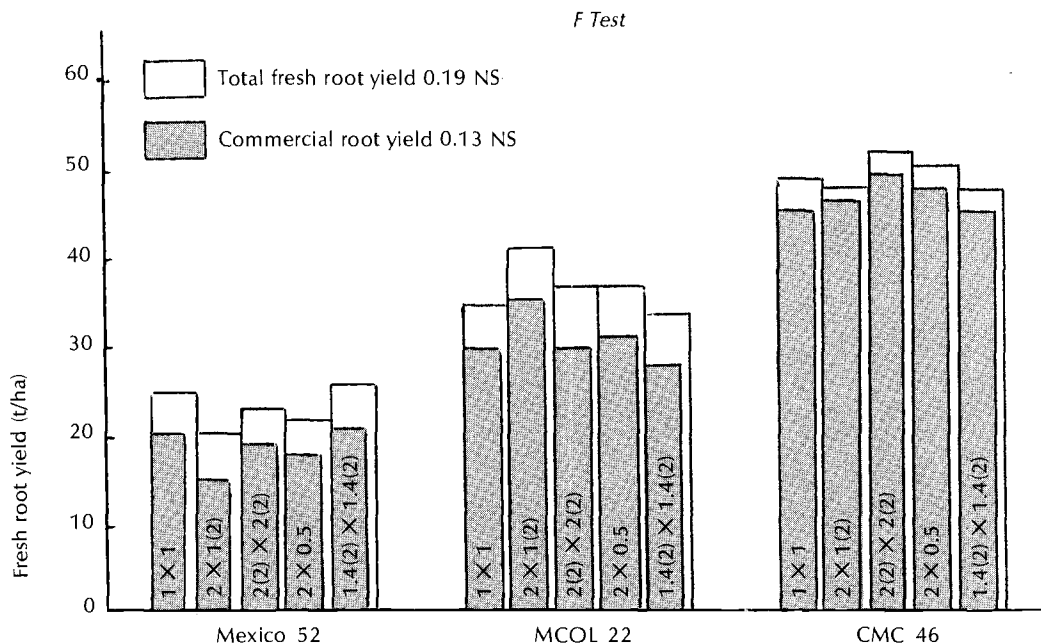


Fig. 2. Effect of planting pattern on total and commercial root yield of three cassava varieties at a standard density of 10 000 plants/ha. Figures in columns indicate distance (m) between x within rows. The figures in parentheses indicate the number of plants per site.

desirable for mechanical harvesting being short roots attached directly to the planting piece. Plant selection for these characteristics is relatively simple, and to date has not been reported to affect yield adversely. Most cassava varieties tend to disperse their roots either horizontally or inclined slightly downward; varieties that have roots penetrating more deeply are found rarely and can be eliminated in a selection program. Hence, it appears that varieties can be readily selected for ease in mechanical harvesting.

The root distribution and attachment to the stake can be altered by mode of planting the stakes (Table 1, 2; Fig. 3). When the stakes are driven deep into the soil, the roots form along them, and the peduncles become longer. Manual harvesting becomes more laborious, but yield is not affected.

The rooting pattern of cassava is profoundly affected by the position of the stake at planting and the way the stake is cut. Traditionally, stakes are cut diagonally with a machete. When the stakes are planted vertically or inclined, the roots only form from the extreme end of the cut; on the other hand, when the cut is made straight across by the use of a circular saw, the roots are evenly distributed around the circumference of the original cut and are of more uniform size (Fig. 4).

Uniform distribution and size appears to be more favourable to mechanized harvesting and, according to investigations by the second author of this paper, does not significantly affect yield (Table 3). The root distribution with straight cuts and inclined or vertical stake placement appears ideal, although the depth at which thickened roots

Table 2. Effect of depth of planting on some characteristics of root formation and distribution (CIAT 1978).

Variables	Depth of planting (cm)		
	10	20	30
No. of roots/plant	12.2	11.0	9.5
Yield (t/ha)	27.1	29.2	27.3
Root distribution	Clumped	Separated	Very separated
Manual harvesting	Easy	Difficult	Very difficult
Detachment of roots	Difficult	Easy	Easy

Table 3. Effect of stake planting position on cassava root yield, t/ha (CIAT 1978).

Stake position	M COL 638	MECU 47	CMC 76
Vertical	27.7	34.7	30.1
Inclined	25.0	30.5	28.2
Horizontal	23.0	31.0	27.5

Table 4. Starch content of fresh cassava roots as affected by varieties, age of crop, planting date, and location.

Age at harvest (days)	Varieties (% starch)									Planting date	Location
	Montero	CMC 40	MCOL 638	CECU 47	Chiroza	MMEX 59	CMC 59	CMC 57			
198	25.2	24.1	-	-	-	-	-	-	-	-	-
215	-	-	-	-	22.8 (33.5)	-	-	-	-	13 May (15 July) 1977	-
241	28.7	23.8	-	-	-	-	-	-	-	-	-
250	-	-	-	-	30.9 (31.1)	-	-	-	-	13 May (15 July) 1977	-
280	-	-	-	-	30.8	-	-	-	-	-	-
304	30.8	23.2	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-
310	-	-	-	-	30.8	-	-	-	-	-	-
350-380	-	28.7	-	-	-	31.8	-	-	-	-	CIAT
-	-	26.0	-	-	-	28.0	19.0	15.0	-	-	Media Luna
-	-	26.0	-	-	-	36.0	27.0	24.0	-	-	Carimagua
360	-	-	29.6	27.6	-	-	-	-	-	-	-

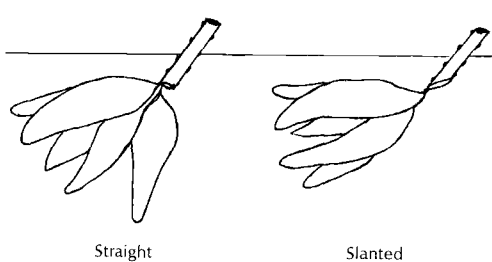
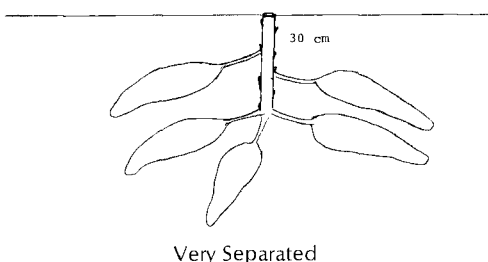
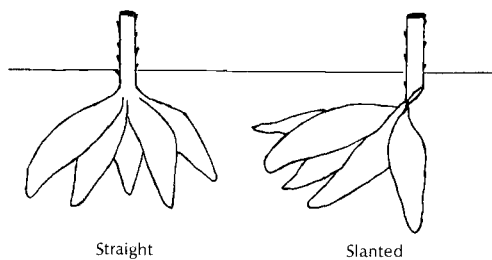
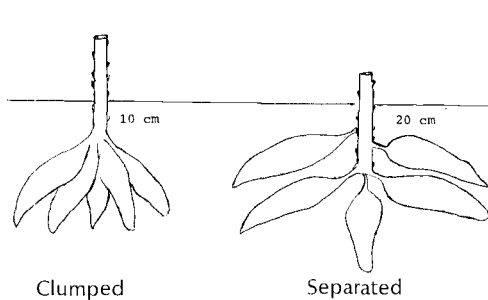


Fig. 3. Effect of depth of planting on root distribution and formation.

Fig. 4. Effect of cutting angle and planting position on root formation and distribution.

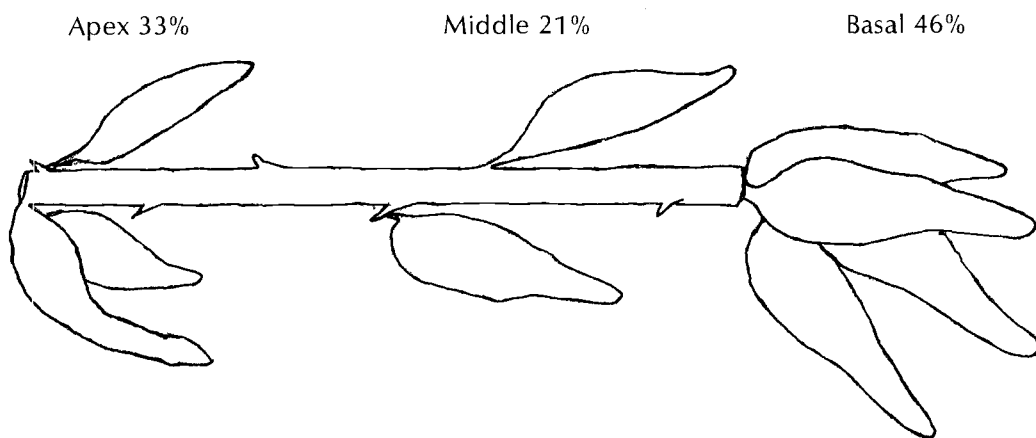


Fig. 5. Root formation and distribution from a 20-cm stake planted horizontally.

occur is greater than with horizontal planting and may present some problems for mechanical harvesters. Horizontal planting, on the other hand, increases lodging, decreases yield, and disperses the roots from the nodes as well as from the callus at the original cut surface (Fig. 5). Furthermore, and perhaps beyond the scope of this paper, mechanical planting methods for inclined planting must be developed — in fact, prototypes already exist in Cuba and Australia.

Processing Lifted Roots

The cassava root, once harvested, is extremely perishable. Several studies, therefore, have been devoted to increasing its shelf life. Averre (1967) and Booth (1975) suggested that if the roots were subtended on short "peduncles" of fibrous root, they could be separated easily from the original planting piece by making a cut across the "peduncle," limiting the damaged area and hence

improving shelf life. However, long peduncles are contrary to the compact-root type suggested by Onochie et al. (1973) and favoured by us for ease of mechanical harvesting. Lozano et al. (1978) recently showed that by removing all the greens, i.e., the leaves and young stems, about 3 weeks before harvest, the shelf life is markedly improved. Combined with a postharvest fungicidal treatment, this method further extends shelf life, even if roots are severely damaged at harvest.

Cassava Roots for Processing

In processing cassava for animal food, starch, or alcohol, it is important that roots have a high starch content. Although starch content is primarily dependent on the variety of cassava, it is also affected by climatic conditions. In general, starch content declines in the dry season and increases when the wet season begins. As plants become older, starch content tends to increase (Table 4).