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# Design of a ploughshare without mouldboard: an alternative solution to the no-tillage in tropical zone

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## Abstract
The mulch, green manure is an effective means against erosion. This organic matter increases the retention of rainwater and improves the fertility of the soil. In order to achieve these goals, this study designed and tried out the ploughshare without mouldboard, "AZ-1". This tool which ploughs the soil without turning it over constitutes a contribution to the environmental protection in tropical zone and to the energy saving. It is an alternative solution to direct drilling consecutive with no-tillage.

**Keywords:** Togo, tropical zone; mulch; erosion; plough share without mouldboard; no-tillage.

## Introduction
The organic matter increases the fertility of the soil by the improvement at the same time of its physical, chemical and biological qualities (Pieri, 1989; Prevost, 1990; Kotschi, 1991; Soltner, 1996). In tropical zone, the higher parts of the lands under forest (0-15 cm) significantly contain more C and N organics than in soils under herbaceous vegetation (C: 1.85 and 1.35%; N: 0.182 and 0.106% respectively). The protection which the shrubby vegetation offers against erosion is certainly one of the explanation-keys to these differences (Wambeke, 1995). According to Lal (1988) quoted by Stevens (1992), widespread soil degradation is an important factor responsible for the continuing food shortage in sub-saharan Africa. The ploughing with the conventional plough with ploughshare consists to cut out a furrow slice to a depth from 15 to 35 cm and to turn it over. According to Elwell (1989), conventional mouldboard ploughing is a technique imported from European temperate zones, where its damaging impact is much less profound than in tropical hot and dry climates, unless irrigation applied (Stevens, 1992). In too dry soil, one obtains large mounds and fine soil in too great quantity, on the other hand in too wet soil, there is a risk of smoothing and compaction of large mounds, difficult to reduce. In tropical zone, this method of tillage presents two major disadvantages: subsoil deprived of humus goes up on the soil surface because the thickness of the arable layer is often lower than 15 cm; it removes then covers vegetation and consequently facilitates the runoff and erosion (CEEMAT, 1977; CTFT, 1979; Charrière, 1984; Hagmann & Murwira, 1996). In comparison with the disk plough and chisel, the ploughshare without mouldboard makes the tillage while curing the two problems mentioned above. A version of this type of tool proposed for the first time by the Soviet academician Vahsnil T C Malcev was not adopted and extended (Karpenko, 1989). This idea is carried out on a conventional ox-drawn ploughshare, 9 inches. This new designed ploughshare which shape is very different from the soviet one, was tested under the conditions of the wet savanna in Togo. The results obtained especially constitute an approach of solution for the soil and water conservation in semi-arid and arid zones.

## Materials and methods
The material of study relates to a conventional ox-drawn ploughshare manufactured in Togo by "UPROMAH", a manufacturing unit of farm and hydraulic equipments. It is a ploughshare, Bourguignon type (BP 4, BM 2M), which width of tillage equal to 22.5 cm, provided with a stamped share, with nozzle, also extended in Burkina Faso. Table 1 shows the characteristics of the ploughshare to be modified and tested.

*Table 1. Technical specifications of conventional ox-drawn ploughshare*

| Component of the plough share | Characteristics |
|---|---|
| Beam | FP 50 x 20 |
| Landside | FP 40 x 8 |
| Handles | FP 30 x 10 |
| Ploughshare 9" | Imported |
| Mouldboard | Sheet of 5 |
| Horizontal regulator & hitch point | FC 50 x 4 x 4 |
| Vertical regulator & wheel arm | FC 40 x 12 |
| Landside heel 9" | Imported |

*FP: Flat iron; FC: Angle iron; Source: Upromah*

The designing is made with the tools such as: a small ruler, a square, a hacksaw and a file.

## Methodology
*Modification of the conventional ploughshare*

After the drawing of the plough, we cut the mouldboard with the hacksaw. Fettling and the finished off were obtained by fitting with the file.

*Site of experimentation*

The tests of ploughing are carried out in a farm in Notse in the Southern "Plateaux region" of Togo. Pluviometry varies from 1400-1700 mm/year. The soil is sablo argillaceous type where the

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"*digitaria*" prevails. The main crops in the region are the cotton, the corn, the groundnut and the niebe (beans).

*Tests of the ploughshare "AZ-1"*

Compared tests of ploughing are carried out on the one hand with the conventional ploughshare and on the other hand with the ploughshare without mouldboard. The tillage is achieved on both, first on a weedy plot and second on a mown plot.

*Fig. 1. Ploughshare without mouldboard, AZ-1*

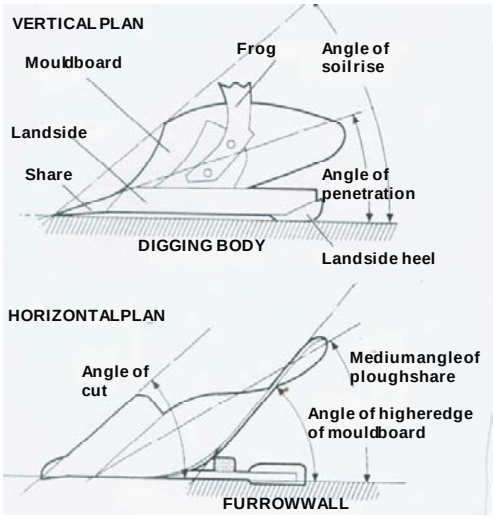
## Results and discussion

The modification of the conventional ploughshare led to the designing of a ploughshare without mouldboard, "AZ-1" (Fig. 1).

The ploughshare without mouldboard cuts out the furrow section without turning it over because the medium angle of the mouldboard and the angle of the higher edge of the mouldboard are null (Fig. 2).

The suppression of these two angles reduces the crumbling of the soil in dry conditions. In the semi-arid and arid zones, similar to the savanna region of the tropical zones where the soils are weak arable layer, the no reversal of the soil avoids bringing back to soil surface the subsoil less fertile. This physical phenomenon is highlighted by Fig. 3 and 4 which compare the quantity of mulch on the surface of the ploughed plots. On the experimental level, in wet zone of savanna in the North-Cameroun, the scouring of0-5-7-10-12 or 15 cm of soil on 30 plots of 50 $m^2$ showed a fast fall of 30% of the corn outputs (ploughing+ conventional mineral manure) for the 50 first mm and 50% for scouring of 150 mm humus-bearing soil. The surface humus-bearing horizons are thus strategic for the conservation of the production of the crops (Boli *et al.,* 1998). The quality of the tillage with plough "AZ-1" is better on a little weedy plot or on a mown plot. The mown vegetation practically not covered, a kind of mulch constitutes a factor of resistance to rain and wind erosion. Though, the combination of slope and gravity, the beating rain and the speed of the wind are aggressive factors of the soil especially ploughed with the conventional ploughshare. Among the resistant factors of the soil, remains the quality of the surface of the plot: vegetation, mulch and roughness. Vegetation and mulch contribute to the regeneration of the humus, an element of stability thus of resistance of the soil. However, regarding that the demographic growth rate is very high, about 2 to 3.5% in the developing countries (Symoens, 1991) it becomes increasingly impossible to practise the fallow to regenerate the humus of the ground in the African farms. Vowles (1989) defines conservation tillage as tillage practice which leaves at least a 30% crop residue cover on the soil surface after planting. The crop residues serve two main purposes: to build up organic content in the soil surface from erosion, runoff and extreme temperatures. Therefore, the reduced tillage and the mulch improve the retention of rainwater in the soil and the fertility. As an example, in wet savanna region of the North-Cameroun, the conventional systems comprising a ploughing, two weedings, a mechanical ridging and the extended mineral manure give good yields only during 4 years (2 t/ha of cotton and > 5 tons of maize/ha/year). In spite of a slope <2.5%, the results obtained were not sustainable because the runoff reaches 25 to 35% of the annual rains, >80% of the strongest showers and erosion exceeds 25 to 35 t/ha/year including 5 to 12 tons of organic matter+clay+silts which constitute the most fertile nutrients of the soil. The spreading of organic matter hardly improved neither the infiltration, neither the resistance to erosion, nor the short-term yields. On the other hand, mulching the soil surfaces clearly reduced the erosive risks and the contribution of 3 t/ha/year of manure of goat always gave the best yields (Boli *et al.,* 1998). The tillage with the ploughshare without mouldboard is indicated for the semi-arid and arid zones (Fig. 5) similar to the dry savanna of Togo which shows the following characteristics: soudanaian semi-arid zone, 900 to 1100 mm annual rainfall, temperature range 20 to 34°C, vegetation growing period less of 175 days/year, evapotranspiration more than 500 mm/year, soils are from granite and gneiss, strong density of population, growth rate 2.6%, extensive abandoned fields due to erosion, lack of land, low crop yields (INS, 1991).

*Fig. 2. Characteristically angles of the conventional ploughshare (Cédra, 1993)*




The tillage without reversal is practised in the sahelian zones when the respect of the delay of sowing is more significant than the quality of the tillage (Gret *et al.,* 1993). By considering that the necessary draught force depends more on dimensions of the furrow section than on the weight of the plough, the draught strength of a plough body is often given with formula 1 (Karpenko, 1989).

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$$R_1 = h\,b\,k \quad (1)$$

$R_1$: draught force
h: depth of ploughing
b: theoretical width of ploughing with a plough body or nominal width of the ploughshare
k: specific resistance of the soil
The general formula of the draught strength of a ploughshare (Sapianik *et al.,* 1983) is:

$$R_2 = h\,b\,k + G\left(c\frac{i}{100} + \lambda f\right) \quad (2)$$

$R_2$: draught force; h: depth of ploughing ; b: theoretical width of ploughing of the ploughshare body; k: specific resistance of the soil; G: weight of the plough; C: coefficient of correction of the quantity of soil effectively moved by the plough; i: slope of the field; λ: load factor of the tractor; f: coefficient of friction of the wheels of the tractor; In animal traction technology, the factor, λf is equal to zero.

*Fig. 3. Mown plot ploughed with a conventional ploughshare*

The formula 2 shows that the draught strength of a plough body is a function of the turned over furrow section, the texture and the percentage of moisture of the soil, but it also varies with the shape and the surface of the working parts of the plough. The comparison analysis (formula 1 and 2) shows that the ploughshare without mouldboard reduces the draught force because the weight of the plough decreases. In animal traction technology, it is an approach of solution to the problem of the weakness of the oxen draught force met in the savannas of West Africa. This draught force varies from 480 to 840 N for two oxen (Azouma *et al.,* 2007). In motorized traction, from 2 to 10 plough bodies, whose width varies from 12 to 20 inches (Barthélemy *et al.,* 1987), this tool contributes to the energy saving. Several solutions are tested under the agro-pedo-climatic conditions of the tropical zones in order to replace or reduce the conventional ploughing: the direct drilling or "zero-ploughing", the tillage in dryness using the coulter, the practice of the zai in Burkina and the tillage without reversal (Ivontchik, 1987; Roose, 1994; DIMA, 1995; Blancaneaux, 1998). The study of the limits of these tillage methods shows the interest for the use of the ploughshare without mouldboard. The ploughing requires additional draught force in order to turn over the furrow slice and in the arid conditions it increases the telluric water losses.

In the tropical zone, the reversal of the furrows has as negative consequences to lead to a fast drying and to the wind erosion of the soil (Ivontchik, 1987). To carry out the deep tillage, the chisel is used but the ploughshare without mouldboard can also be used. If an irregularity or a delay of useful rains settles, the mulch maintains the humidity and reduces the drying of the soil. The tillage in dryness is without interest and impossible respectively for the sandy and very argillaceous soils (Le Thiec, 1996). The direct drilling often requires weeding more mechanical weeding and is to be excluded in clay soils (more than 15% of clay), muddy being compacted easily or sensitive to the water excess. In the dry and hard land or very compacted land, it does not allow a good soil cover of sown seeds and the rooting is impossible. Also, the rate of loss varies from 10 to 20% and so it is necessary to increase a little bit the quantity of the seeds sown in order to respect the objective of the number of raised plants (Anonymous, 1994). The others limit possible of the zero ploughing relate to the management of the crop waste products and in particular of the cereal straws on the soil surface, the development of certain populations of bad specific grasses which could increase the plant health pressure to treat the adventitious ones, risks of compressing or formation of rut in too wet condition of soil. However, the tillage without reversal partially covers the vegetation and allows drying of the remainder fresh mulch on the soil surface. The specific material of direct drilling is expensive. To reduce or remove the conventional ploughing by the mentioned

*Fig. 4. Mown plot ploughed with the ploughshare without mouldboard, AZ-1*

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farming methods involves a global solution of soil and water conservation. In order to achieve this goal, in regard to the loss and the degradation of the soil caused by the intensive farming in many developing countries, FAO (2001) recommends the conservation agriculture. This method of farming means to reduce the tillage to the minimum and to preserve a layer of sheets, stems and stalks of the preceding farming, which protects from heat, of the wind and of the rain, the soil with the expenses maintains and reduces the losses of moisture per evaporation. This also involves a reduction in the costs of fuel, labour, and agricultural machinery.

The rotation of crops is essential to reduce the infestations of pests and the diseases. This farming system was adapted to the cereal and leguminous plants, as with the sugar cane, vegetables, potatoes, beets, the cassava and the fruits. In the world, the conservation agriculture is currently practised on some 58 million hectares, of the tropics until proximity of the circle arctique: majority in the United States (approximately 20 million ha), in Brazil (13.5 million ha), in Argentina (9.5 million ha), in Canada (4 million ha) and in Paraguay (800, 000 ha) (FAO, 2001). The conservation agriculture adopted in several regions of the world is justified by several other pragmatic arguments. As an example, mineral manures, urea and manure NPK which cost approximately 160, 000 F CFA per ton in 1998 in Togo passed to 320, 000 F CFA per ton in 2009. The draft animals have little time pasture and food especially in period welding in dry savannas zone whereas they need a higher quantity of food to satisfy the needs for maintenance and work (Greig *et al.,* 1992; Attiglo, 2006). Also, the fuel represents up to 30% of the time cost of a tractor (Anonymous, 2007). According to Culpin (1986), tillage represents the most costly single item in the budget of an arable farmer and is a part of the business of farming which remains almost entirely an art. The blaze of the price of the oil barrel increases the possession cost of a tractor.

*Fig. 5. Bared farm area in Timbou, in the dry savanna zone of Togo*

## Conclusion

This study has permitted to design an ox-drawn ploughshare without mouldboard "AZ-1" under the local manufacturing conditions of agricultural equipments. The ploughing in wet savanna zone with this ploughshare leaves the mown weed on the soil surface, a kind of mulch which protects the soil against the impact from the drops of rain, the runoff and rain and wind erosion. This way of tillage is an unquestionable interest for the semi-arid and arid zones characterized by a weak arable layer and rate of humus then confronted with the turning into a desert. The extension of the ploughshare without mouldboard contributes to the environmental protection and the energy saving especially in motorized culture.

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