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First results on the use of an innovative machine for soil tillage in terraces or steep sloped areas

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In environments characterized by steep slopes
or arranged in terraces



the cultivator equipped with rotary chisel is extensively used.

This is because the rotary chisel allows in one step to clean the soil from weeds, to obtain the soil well crumbled and in excellent condition for subsequent operations.



It can also be adjusted to enhance the tractor coupling and optimize the balance between energy cost and quality of work



However, the effect of the repeated use of the rotary chisel has a considerable influence on soil characteristics; it appears finely powdered, soft and without structure.

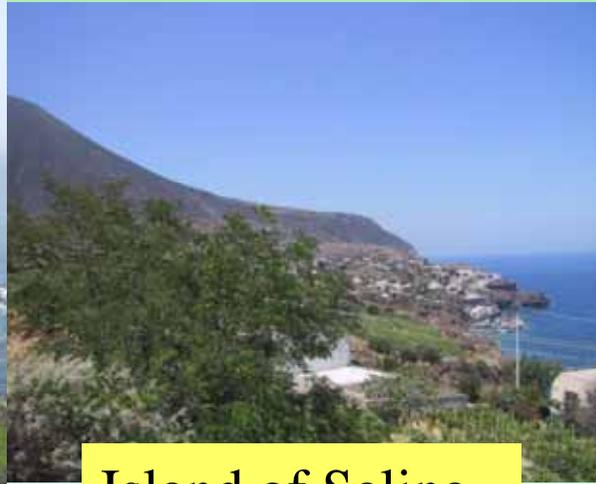
This immediately causes the loss of its storage capacity of reservoir water and, consequently, of its fertility.



This phenomenon is even more favored in environments with volcanic soils (island of Pantelleria, mount Etna, island of Salina, etc.) with pyroclastic deposits predominantly, characterized by compositional and textural heterogeneity, high porosity and poor mechanical strength properties.



Island of Pantelleria



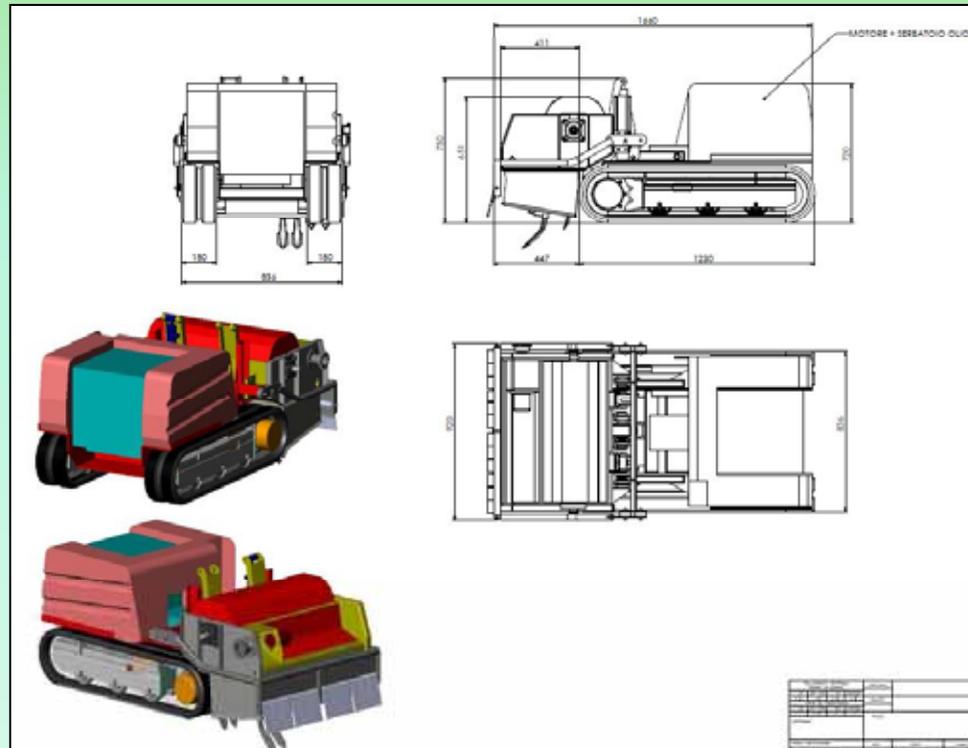
Island of Salina



Mount Etna



In order to limit these inconveniences, an innovative self-propelled machine equipped with working tools such as a spade, was designed by the Mechanics Section of the SAGA Department of the University of Palermo in cooperation with Agrotec company, Padua, Italy.



AIM OF THE RESEARCH

The aim of this study was to assess the quality of the work of this innovative machine and compare it with that of a conventional rotary chisel



Spading machine



Rotary chisel

The first field tests were carried out near the area of the manufacturer of the novel spading machine (by Agrotec company, Padua, Italy) in September 2010.



CIMG5984.MOV

The innovative machine is self-propelled and is equipped with five working tools of the spade-type with two blows each.

Characteristics of the machine	Spading machine	Rotary chisel
Wheelbase [m]	0.90	0.90
Width across bar axles [m]	0.94	0.90
Overall height [m]	1.10	0.50
Power [kW]	12	12
Mass [kg]	360	150
Tools [number]	5	5
Overall length [m]	1.70	1.20



Spading machine



Rotary chisel



CIMG5984.MOV

The operating parameters considered were:

- working width,
- tillage depth,
- forward speed,
- rated engine speed.



All the tests were replicated three times without overlapping of adjacent passages, over a distance of 20 m.

The quality of the work of the machines has been evaluated by the analysis of the crushing of the soil expressed as the mean diameter of the clods, that is the method commonly used in experiments



After each test, the whole volume of tilled soil was taken from a 0.5 m² area located at the center of the plot.

Each soil sample was sieved using the following mesh sieves: 0.5, 1, 2 and 3 inch (corresponding to 13, 25, 51 and 77 mm).

The mean clods diameter was calculated as a weighted average of the different classes

RESULTS

Results of the physical-mechanical analyses on the soil

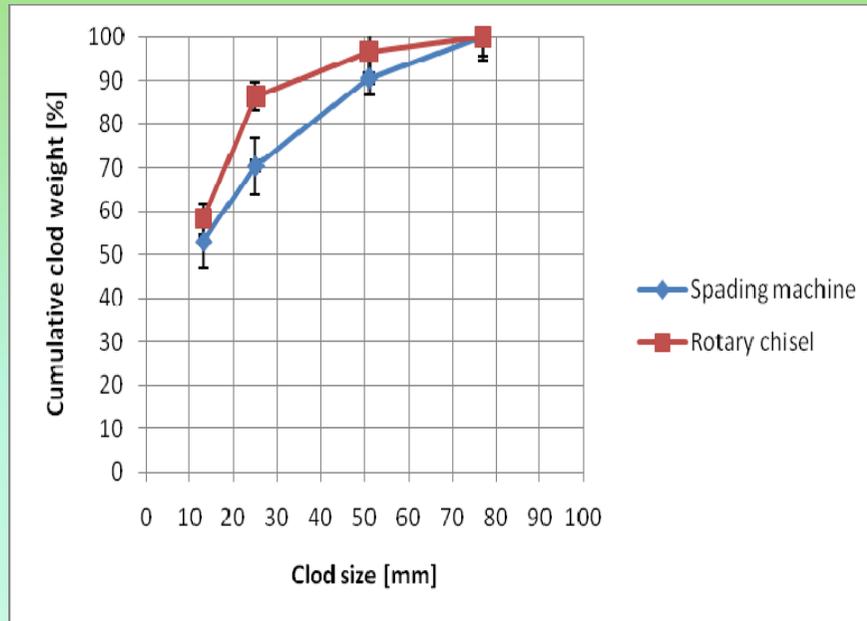
Soil moisture [g/kg]	38.9±0.10
Sand [%]	50.1±0.90
Silt [%]	24.0±0.32
Clay [%]	25.9±0.68
Organic matter [%]	1.5±0.20
Penetration resistance [kg/cm ²]	9.45±0.70
Bulk density [Mg/m ³]	1.4±0.18

In terms of particle size distribution, the soil is a silty clayey sand

The values of soil moisture, equal to 38.9 g/kg and penetration resistance measured from 0 to 0.2 m depth, equal to 9.45 kg/cm², show that the soil has excellent workability conditions.

Measured clod size distribution for the two machines

The comparison between the two machines reveals that the novel spading machine has provided less harrowing than the rotary chisel



Classes	Spading machine	Rotary chisel
mm	%	%
0-13	53,15	58,25
13- 25	17,32	28,16
25- 51	20,08	10,19
51- 77	9,45	3,40
	100,00	100,00

percentages of the clods by weight

Data are reported as means \pm standard deviations of the three replicates.

Rotary Chisel %	Spading Machine %
58,25	53,15
86,41	70,47
96,60	90,55
100,00	100,00

The percentage of clods with larger diameter in the spading machine was found in the class 25-51 mm with a percentage by weight equal to 20.08% against 10.19% obtained by the rotary chisel.

In the class 51-77 it was found 9.45% for the first machine against 3.4% for the other one.

In the 0-13 mm and 13-25 mm classes, the novel spading machine gave 9% and 39% lower values in soil weight than the traditional one.

Conclusions

From the first tests of tillage performed using the innovative self-propelled machine equipped with working tools such as a spade and by comparing it with the traditional rotary chisel, interesting observations emerge



The use of the self-propelled machine allowed to obtain a higher cloddiness than the conventional one, hoping that the introduction of this machine in steep sloped areas, where the rotary chisel is well spread, would contribute to limit the problems associated with the use of the traditional one besides eliminating the plow sole.