# SOIL COMPRESSION DEGREE IN STUDIES OF VIBROCOMBINATOR TILLAGE TECHNOLOGIES


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## INTRODUCTION

The paper presents a study on the optimization of working regime of vibro-cultivators based on environmental impact assessment for use in seedbed processing. Study presents a method to determinate some physical and mechanical proprieties before and after soil tillage works of aggregates consisting of tractor and vibro-cultivators, in three parcels in the plains of the West of Romania. Vibro-cultivators are machines for seedbed preparation. They are equipped with tools sustained by elastic suspension. The elasticity of supports facilitates the oscillations of working tool – elastic support assembly. This set has a natural mode shapes which corresponds to a natural frequency of vibration[3].

Generally, combinators consist of:

**A.** a vibro-cultivator (cultivator for total processing of soil), composed of: frame 1, coupling device at the power source 2, wheels for limiting of working depth 3, soil loosening bodies 4

**B** a helix harrow , which consists of frame 5, two rodrotors 6, and horizontality adjustment system 7 (Fig. 1). Worldwide, more and more prestigious companies have incorporated into the range of products such vibro-combinators.

## MATERIALS AND METHODS

In order to obtain a global image on the impact of the new vibro-combinator (the prototype ***SANDOKAN 2***) (table 1) in terms of the physical-mechanical properties of the soil, it was necessary to determine its properties before the passage of the equipment (in the state of the soil), and after its passage on all the three parcels and trials.

These parcels will be suggestively named (after the soil type): soil **S1,** soil **S2** and soil **S3**; and the three types of active elements: **Gamma, Delta1** and **Delta2**.

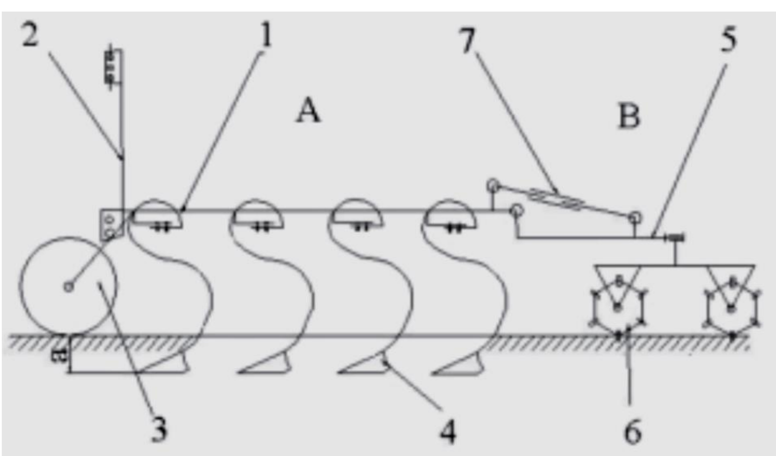



**Fig. 1** General scheme of a vibro-combinator

**Table 1.** Main characteristics of the prototype vibro-combinator SANDOKAN 2

| No. crt. | Characteristics | MU | Values |
|---|---|---|---|
| 1 | Mass | kg | 5670 |
| 2 | Length in transport | m | 6.6 |
| 3 | Height in transport | m | 3.95 |
| 4 | Width in transport | m | 2.93 |
| 5 | Width of the gamma active parts, reversible chipper type | mm | 35 |
| 6 | Width of the delta 1 active parts, arrow type | mm | 150 |
| 7 | Width of the delta 2 active parts, arrow type | mm | 250 |


**Fig. 2** The prototype vibro-combinator SANDOKAN 2 equipped with the three types of active elements (GAMMA, DELTA1, DELTA2)

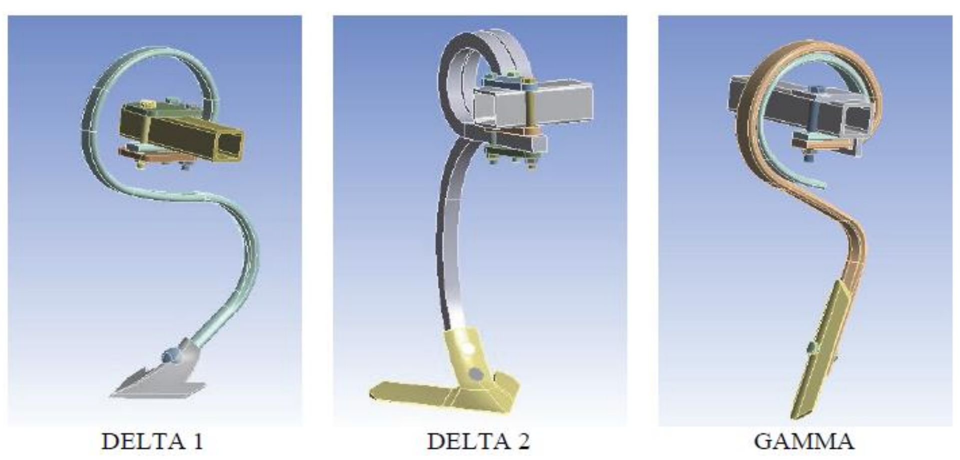



**Fig. 3** Geometrical models for the three active elements

**Fig. 4.** Placement of the sampling rings on different depth stages

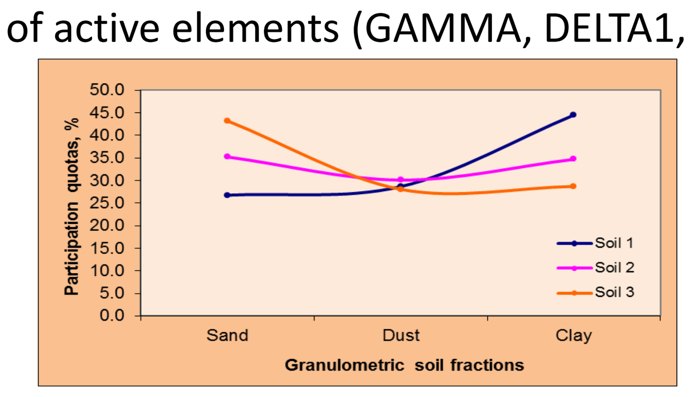



**Fig. 5.** Granulometric curves analysis of the soils

The physical properties were determined by using the method of the cylinders with a constant volume of 100 cm$^3$, carrying out six repetitions at different depth, from **6**, **12** and **18** cm (fig. 4).

## RESULTS AND DISCUSSION

When analysing the granulometric curves presented one can notice the fact that there was a **sandy-clay-dusty** texture in soil **S2** and **S3** encompassed in the experiment at a participation quota that scarcely varies, with the exception of the **S1** soil where the particle size distribution is different: **clay-dusty-sandy** texture.

*Multivariate analysis*

To evaluate the vibro-combinators **soil tillage performances** were studied the variables: apparent density (g/cm$^3$), total porosity (%) and soil compression (%).

To evaluate the **soil environmental impact** of the vibro-combinators were considered the variables: soil moisture (%) and water retention (m$^3$/ha).

In order to assess simultaneously the vibro-combinators soil tillage performances and environmental impact, was involved the multivariate analysis:

- principal component analysis (**PCA**)
- multivariate analysis of variance (**MANOVA, P = 0.05**).

The PCA and MANOVA were done **separately for each soil types S1, S2 and S3**. The PCA method involved as input data the variables correlation matrix and between sample groups algorithm. The MANOVA algorithm used as input data the first two principal components (PCs) coordinates of the group samples. The group samples were described by the interaction factor **Device*h** (i.e. active elements*depth).

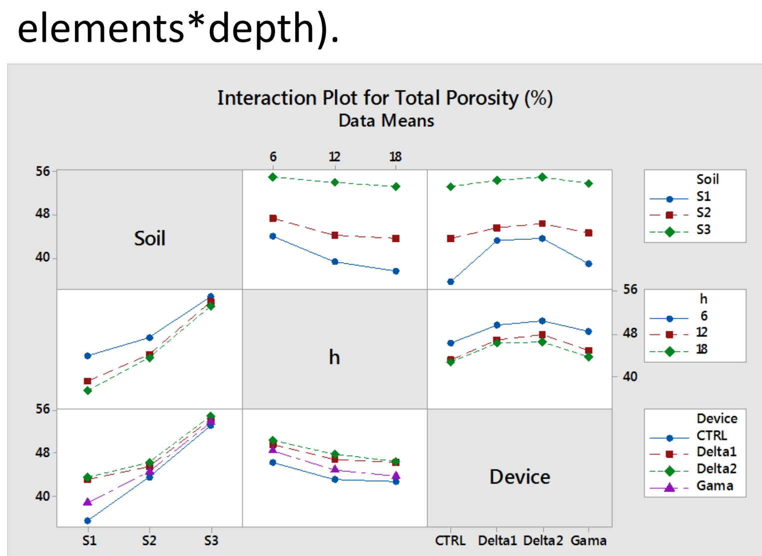



**Fig. 6.** Interaction plot for total porosity (from three-way ANOVA) for soil types (factor Soil), depth (factor h) and active elements (factor Device).

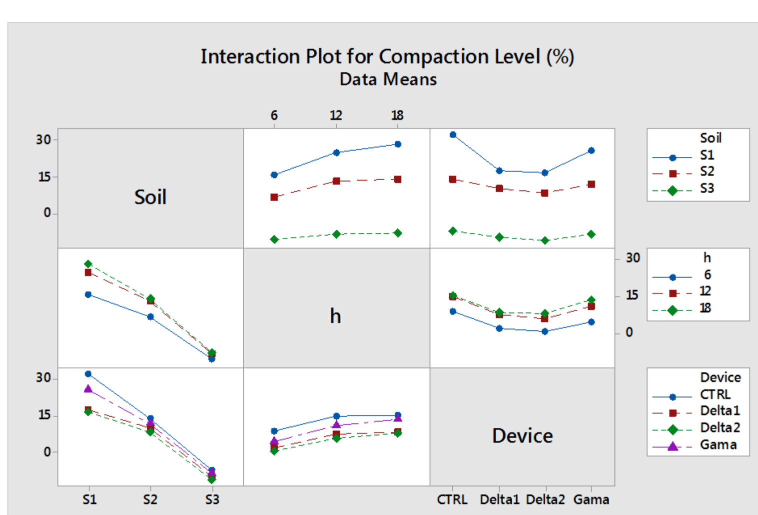



**Fig. 7.** Interaction plot for compaction level (from three-way ANOVA) for soil types (factor Soil), depth (factor h) and active elements (factor Device).

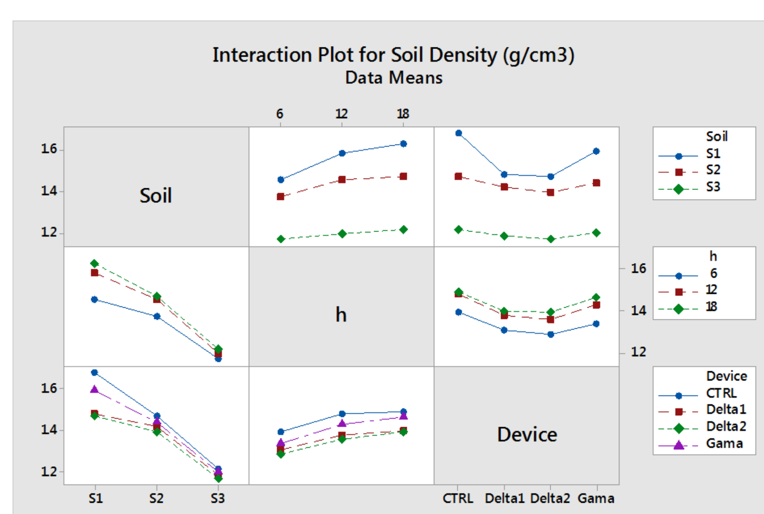



**Fig. 8.** Interaction plot for soil density (from three-way ANOVA) for soil types (factor Soil), depth (factor h) and active elements (factor Device).

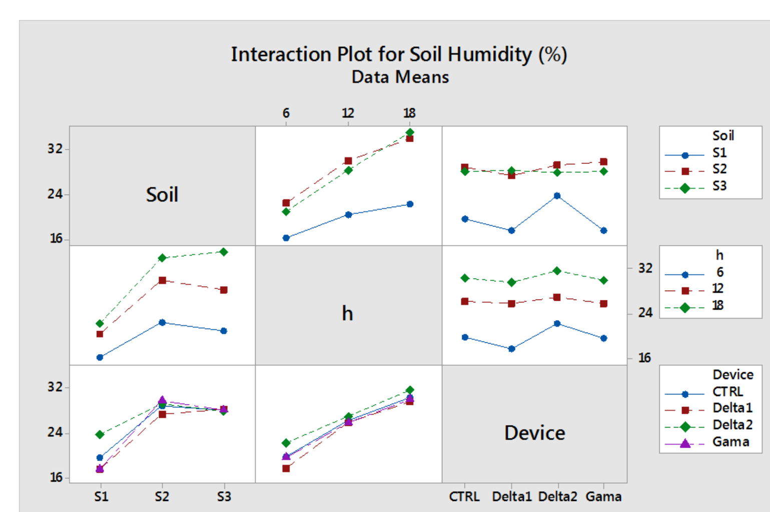



**Fig. 9.** Interaction plot for soil humidity (from three-way ANOVA) for soil types (factor Soil), depth (factor h) and active elements (factor Device).

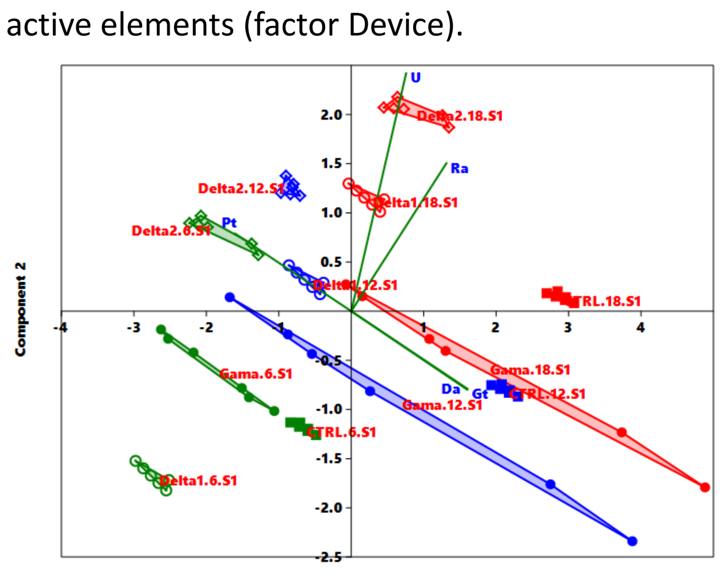


**Fig. 11.** Principal component analysis (PCA) biplot for different depths (factor h) and for the three active elements (factor Device) for soil type S1.

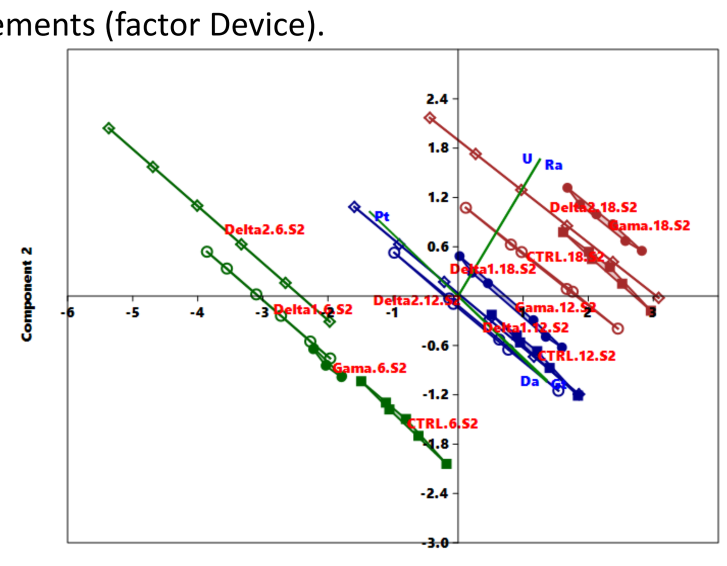


**Fig. 12.** Principal component analysis (PCA) biplot for different depths (factor h) and for the three active elements (factor Device) for soil type S2.

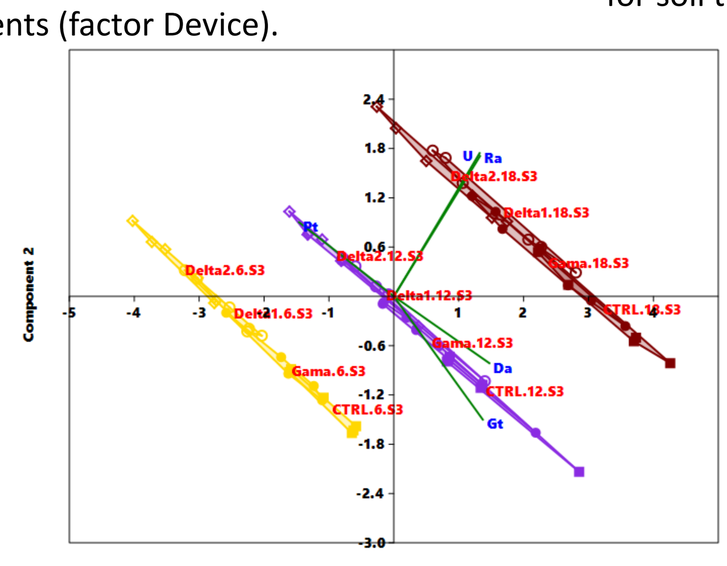
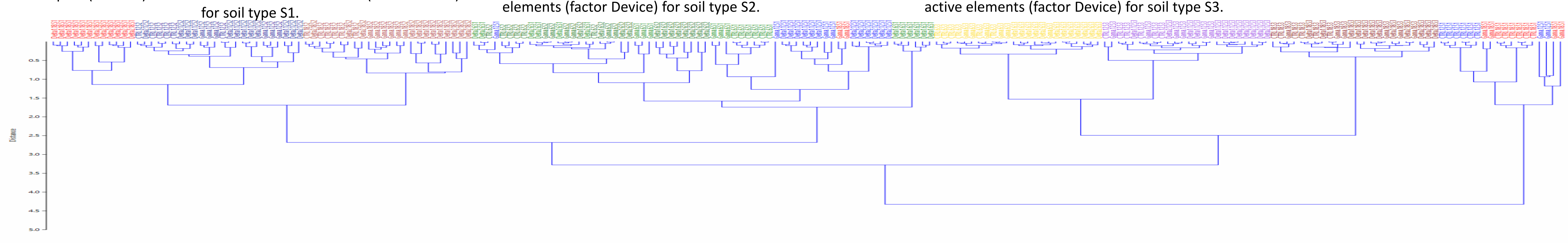


**Fig. 13.** Principal component analysis (PCA) biplot for different depths (factor h) and for the three active elements (factor Device) for soil type S3.

**Table 5.** Principal components analysis statistics for soil factor (PC represents the principal component).

| S1 | PC | Eigenvalue | % variance |
|---|---|---|---|
| | **1** | **3.578** | **71.567** |
| | **2** | **1.258** | **25.166** |
| | 3 | 0.163 | 3.2669 |
| | 4 | 1.22E-05 | 0.0002 |
| | 5 | 5.49E-09 | 1.10E-07 |
| S2 | PC | Eigenvalue | % variance |
| | **1** | **4.380** | **87.614** |
| | **2** | **0.585** | **11.710** |
| | 3 | 0.033 | 0.673 |
| | 4 | 0.0001 | 0.002 |
| | 5 | 6.86E-06 | 0.0001 |
| S3 | PC | Eigenvalue | % variance |
| | **1** | **4.239** | **84.793** |
| | **2** | **0.743** | **14.877** |
| | 3 | 0.0158 | 0.3172 |
| | 4 | 0.0006 | 0.0120 |
| | 5 | 4.01E-05 | 0.00080181 |



## CONCLUSIONS

The research investigated the soil tillage performances and the environmental impact of several active elements of the vibro-combinators, at certain soil depths and soil types. The advantages of using vibro-combinators are: perfect preparation of seedbed in difficult working conditions and preservation of soil moisture. Such important factors can ensure fast, uniform and early germination of seeds, these requirements standing at the basis of abundant harvests. The multivariate analysis allowed to assess for each soil type which active elements performs both best soil tillage and environmental protection of the soils. From the technical point of view, the **6 cm depth is the most important to soil tillage for crop production**. For this depth the active elements of the vibro-combinator: **Delta2** and **Delta1** are those that performs **both best soil tillage** and **environmental protection** of the studied soils.