Büscher, Wolfgang; Maack, Christian; Sun, Yuri; Lin, Jianhui; Cheng, Qiang; Meng, Fanjia and Zhang, Huili

Measuring bale density using a penetrometer test bench at different pressing variants and crop DM

The densitiy test bench which had been developed in cooperation with the colleagues of the China Agriculture University was used in a field test to measure the density of 25 round bales pressed with different variants of compaction. The results show on the one hand effects of the different press technique and on the other hand the important influence of the silage crop which has to be compacted. To visualise the results the data are used to generate density maps and diagrams which show the volume fractions of different density classes.

Keywords
Bale density, penetrometer, testbench, round bale, Silage crop

Abstract
Landtechnik 68(2), 2013, pp. 103–107, 5 figures, 8 references

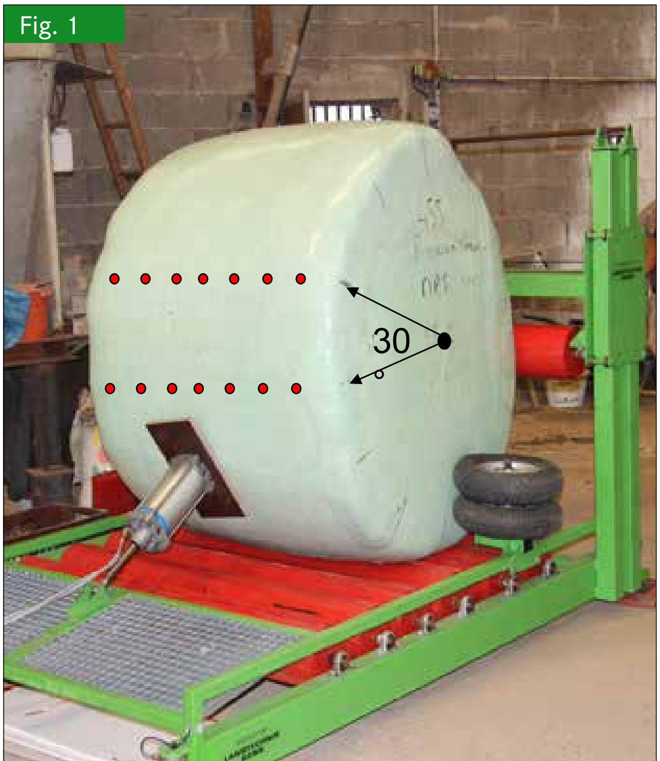
The differentiated investigation of the round bale density with the semi automatic test bench has been proved as practicable method. The analysis of the data and their presentation in two dimensional and three-dimensional maps gives a direct view into the density distribution. This offers the opportunity to compare the effects of different crop properties and divergent adjustments of the press technique. The results of the test series with bales of a fixed chamber baler with additional tools are presented.

Test methods

To observe the effect of silage crop cutting and pressure adjustment in case of round balers with fixed chamber system 2 bales had been pressed at a test field near Metz (France). The bales were pressed using two balers from Claas Company (Rollant 455 und Rollant 375). To ensure similar conditions for the test and a constant mass flow during pressing, homogeneous swads were made. This is important because the realised density in the bales is effected by the thickness of the layer which has to be compacted in the press chamber. To get comparable results it is necessary to drive the baler with a constant load. The power requirement to the tractor rises during the filling of the press chamber because of more pressure in the chamber. Using a tractor with insufficient performance can be a reason because the possible mass flow of the press is not reached. During the test this factor could be excluded so that all bales have been pressed using the full capacity of the balers. The bales were made in the first cut after wilting the gras to DM- contents around 40 % and up to over 50 %.

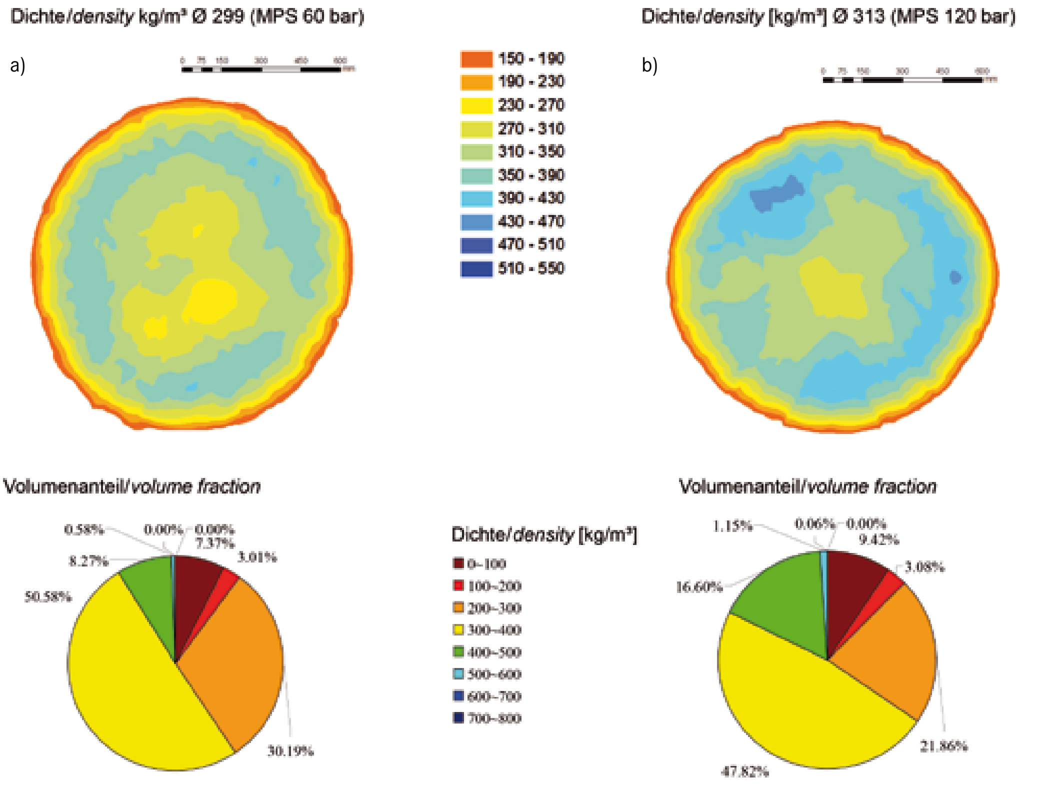
The bales were stretched with 4 layers film (dark green) and marked to recognize the different test variants at the time of the density measurement.

Fig. 1



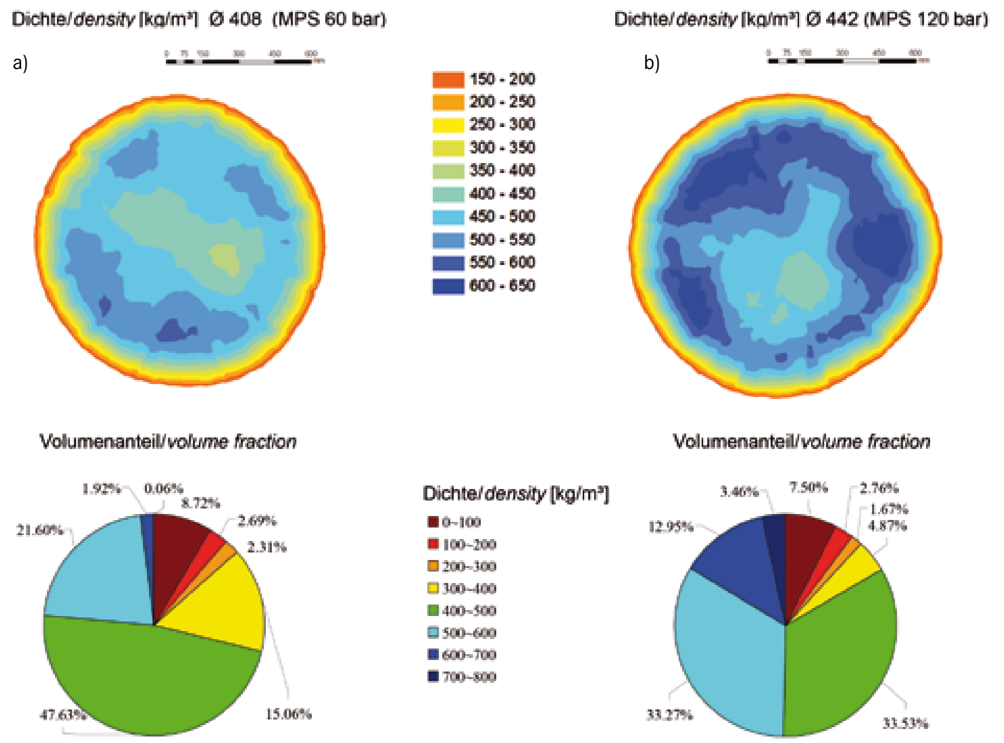
Silage Bale at the density test bench and position of the measuring points (Foto: Maack)

Fig 2



Density distribution of the bale profile and volume fractions of the different density classes in case of pressing with a) maximal and b) minimal pressure adjustment of the MPS, Silage crop 50–55 % DM

Fig. 3



Density distribution of the bale profile and volume fractions of the different density classes in case of pressing with a) maximal and b) minimal pressure adjustment of the MPS, Silage crop 35–45 % DM

The density testing was carried out after the fermentation of the gras in the time from 3rd to 7th September at the place where the bales were stored over the fermentation time. Differences caused by transport of the bales could be excluded. The electro-mechanical function of the test bench has already been described [1-7]. In order to that in this article the measuring pattern of the conducted test is explained.

The angle of rotation for the 12 test series is marked with a former plate before. The turning of the bale (30°) has to be controlled manually because the silage bales are not completely round and so differences have to be balanced by the test operator (**Figure 1**).

The test runs in 12 series of 7 samples with a depth resolution of 10 mm. The finally density map of each bale is calculated by more than 5400 values. During the measuring the data are shown in a two dimensional map on the user interface of the Labview program which gives a direct feedback about the actual measurement. Unexpected results offer the opportunity to check the equipment and find out defects of the system. The data processing for the density maps of different test variants was done by the software ArcView. The penetration of the bale from the curved surface to the centre leads to the effect that in the bale centre more values stand for the same volume than near the bale surface. In comparison the sampling with 12 series in 30° interval has been proved as detailed enough for the description of the bale density. Round bales are theoretical composed radial symmetric but in practice often show disparities in density at different rotation angles.

Results:

The testet bales showed obvious density differences in relation to the press adjustment and to the DM content of the compacted crop. In case of the press adjustment variants effects of different pressures at the chamber door and at the MPS system were clearly to observe in the density maps of the bales. A comparison of the absolute achieved densities to the results in former tests gives only a limited information because of the different crop properties.

Figure 2 shows density maps of bales (55 % DM) pressed with 60 and 120 bar at the MPS. Last one has in hole a 5 % higher density.

The distribution in the profiles gives the information about a smaller soft bale centre at the “high pressure” bale (**Figure 2**, b). The parts of the classes in the diagram show a shift from 200–300 to 300–400 kg/m³ and further from 300-400 to 400-500kg/m³. The low density in the bale centre is similar in both cases.

Figure 3 illustrates the two adjustment variants of the MPS in case of a silage crop of 40 % DM. As expected the average FM-density was with 405 to 470 kg/m³ at a higher level than the values of the high DM-bales. The effect of the different MPS pressure was similar to the high DM bales. The difference of in mean 35 kg/m³ (8 %) was even higher than in case of the high DM crop.

The density maps in **Figure 2** and **Figure 3** confirm on the one hand that bales made by a fixed chamber baler have a relatively soft centre, but on the other hand additional tools like the MPS can minimize the soft volume part. General the maps show better effects of the compaction tools in case of material with moderate (up to 45 %) DM contents than in compaction of dry material.

In **Figure 4** bales with different chopping lenght of the gras were compared. Theoretical cutting of gras to a smaller particle size leads to reduction of relaxation and has the effect of a more effective crop compaction. The bale pressed without any blades had nearly the same density like the bale pressed with 12 blades. The difference of about 5 kg/m³ was only small. In the test only 2 bales were pressed without blades so this result has to be seen as not very well confirmed. In former investigations higher effects caused by cutting were observed [8].

The other fixed chamber baler Type Claas Rollant 374 has not the additional compaction tool MPS and is only equipped with a manual adjustment of the pressure at the chamber door. In fig. 5 bales from the different press types are compared. The presses were similar adjusted, worked at maximum pressure but have different number of blades (12 at the type 455 and 16 at the type 375).

The average density of the bales differs only slightly (**Figure 5**). The bales of the type 374 show very high values near the round surface and in contrast a bigger low compacted centre. The bales from the type 455 have a more homogenous density distribution with a smaller volume part of the soft centre. The differences have to be seen as effect of the MPS tool. The type 455 was driven with a higher speed and more mass flow which explains the lower density near the round surface of the bales where both presses work in a similar way

Conclusion

The penetrometer test bench was used as method to test the differential density of round bales pressed in different variants with two baler types. The calculated density maps and diagrams show the differences of the bales although they had a similar average density. The test bench does not offer a simple test method to control the press quality in practice but it can be used to get more detailed information about the bales, which can be used to improve the pressing tools of the balers. Additional tools like the MPS show that the soft centre of fixed chamber bales can not be completely balanced but the volume part with low density can be minimized.

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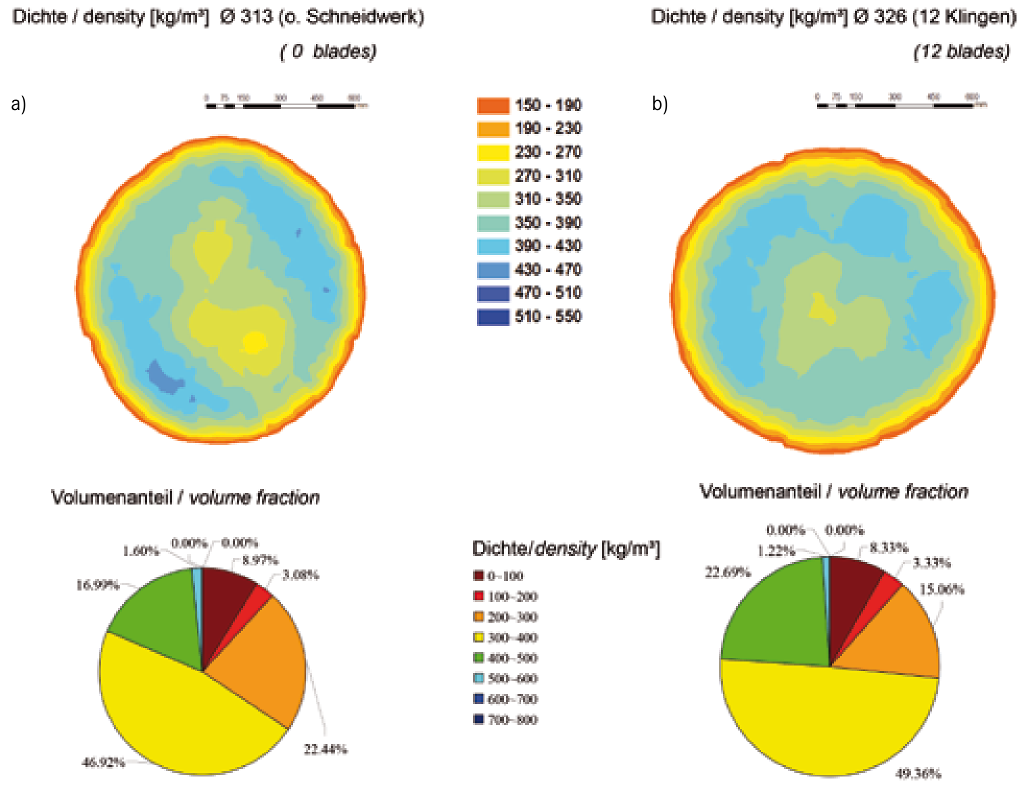
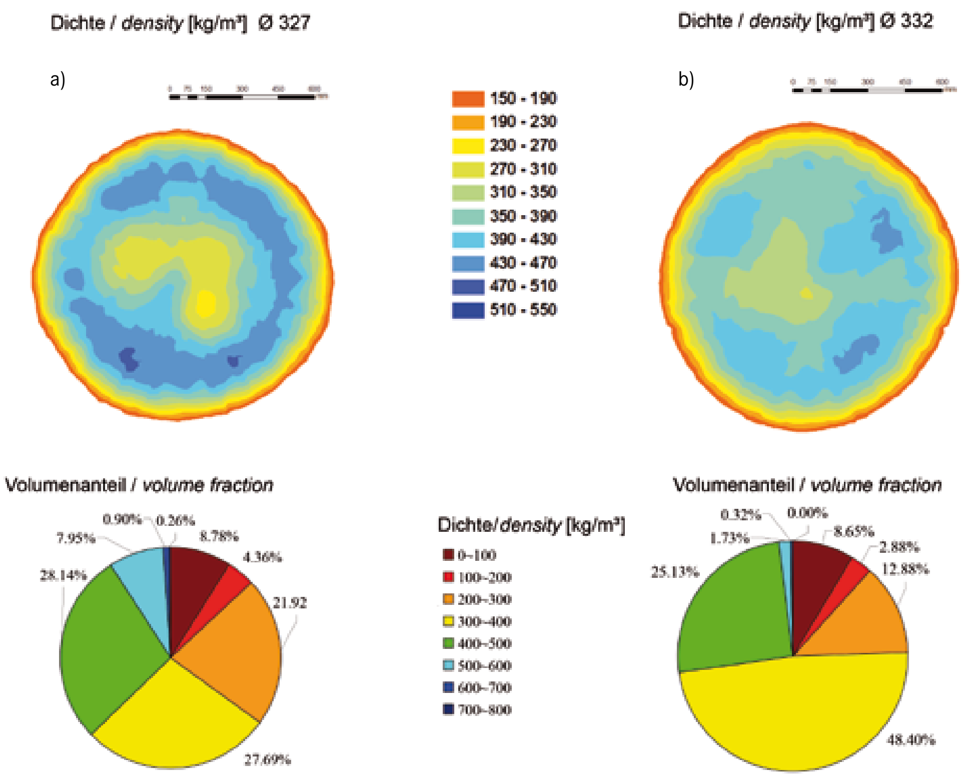
Fig. 4



Density distribution of the bale profile and volume fractions of the different density classes in case of pressing a) with 12 blades and b) without blades, Silage crop 50–55 % DM

Fig. 5



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Authors

Prof. Dr. Wolfgang Büscher ist head of the department Livestock Technology at the Institute for Agricultural Engineering at the University of Bonn Bonn, Nussallee 5, 53115 Bonn, e-mail: buescher@uni-bonn

Dr. Christian Maack is scientific assistant am at the Institute for Agricultural Engineering at the University of Bonn, e-mail: C.Maack@uni-bonn.de

Prof. Dr. Yuri Sun ist head of the department precision farming at the China Agriculture University of Beijing

Dr. Jianhui Lin is scientific assistant at the department science of forestry at the China Agriculture University of Beijing

Qiang Cheng, **Fanjia Meng** und **Huili Zhang** are Ph.D. students at the China Agriculture University of Beijing

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