Title:
Harvester seeding of winter wheat in a sugar beet harvester

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Summary:
Decreasing commodity prices and changing production conditions make profitable plant production more and more difficult. Therefore the continuing reduction of production expenses is necessary. Beside machine combinations and no-tillage harvester seeding systems offer new possibilities. They combine the harvest of one crop with the seeding of the following crop in the rotation.

Therefore from 1996 until 1999 investigations on harvester seeding of winter wheat in a sugar beet harvester were carried out.

The results of the investigations show that seeding winter wheat during sugar beet harvesting has, except under very extreme (wet) soil conditions, no influence on the yields. If the seed is applied in back of the beet lifters, covered with the soil separated by the cleaning units, pressed by the low pressure tires of the harvester and again covered with chopped beet leaves, conditions for regular germination are obtained.

The harvester seeding systems not only reduces work time, energy requirements and field traffic in autumn, but also makes winter wheat cultivation possible in case of late beet harvesting. The beet leaves on top of the soil are a contribution to soil conservation. They protect the soil from erosion during winter and raise the content of organic matter in the topsoil.
Harvester seeding of winter wheat in a sugar beet harvester.

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Introduction:
Decreasing commodity prices and changing production conditions make profitable plant production more and more difficult. Therefore the continuing reduction of production expenses is necessary. Besides equipment and tool combinations, the renunciation of ploughing, no-tillage and direct seeding, harvester seeding systems offer new possibilities (Estler, 1994). They combine the harvest of one crop with the seeding of the following crop in the rotation. Such systems were intensively investigated for (broadcast) seeding oilseed rape before or during winter wheat harvesting (Tebrügge, 1997; Estler, 1994). Also the seeding of winter wheat during sugar beet harvesting can be integrated into a harvester seeding system (Nawroth et al., 1998). The date for sugar beet harvesting is identical with the seeding time of winter wheat - in most rotations winter wheat is following sugar beets. Caused by late harvesting dates in November and December the risk to get winter wheat planted under worse conditions is increasing. In many cases in fall work time requirements are very high.

Therefore in autumn 1996 first tests should show if the combination of sugar beet harvesting and wheat seeding is possible. Also they should clear up which yield level such systems can reach compared to conventionally seeded winter wheat. From 1997 to 1999 based on these results continuing investigations were carried out to test modified seeding technology and to get further information on the potentials and limitations of the harvester seeding on different soils and at different seeding dates.

Methods:
In autumn 1996 investigations of two different harvester seeding systems for winter wheat in self propelled six row sugar beet harvesters with bunker hoppers were started in Bavaria.

In the first trial (location Karlsfeld, black soil - histosol) a mechanical drill with disc coulters was mounted in rear of the harvester. The seeds were placed in the soil and covered with the chopped beet leaves during the next pass of the harvester (fig. 1).

In the second trial (location Pleiling, sandy silt loam - alfisol) winter wheat was sown as broadcast seed in front or directly behind the lifting unit using airseeder technology. The seeds were covered with the soil of the cleaning units and pressed by the harvesters ultra wide tyres. Nearly the whole working width of the harvester could be rolled because the used machine (Holmer TerraDos®) has a combined articulated and four wheel steering which allows "xlog walks", That means the rear tires travel in a different track than the front tires to reduce soil compaction. Again the seeds were covered with chopped beet leaves during the next parallel pass of the harvester.
In 1997 the airseeder technology was modified adapting a seeder beam behind the lifting units on the whole width of the harvester. This beam was built with components of the HORSCH Seeding Exaktor SE®. Only one trial could be established in Karlsfeld (fig. 2).
In 1998 airseeder technology was again modified. Seed was broadcasted behind the left and right wing of the lifter unit with simple seed pipes. Only below the conveyor belt a one meter wide seeding beam was used. Again the harvesters steering technology makes "dog walks" possible (fig. 3). Although the conditions even for harvesting sugar beets have been the worst for a long time, it was possible to carry out trials on three locations at three different dates (location Meising, October 3\textsuperscript{rd}, sandy loam - alfisol; location Reith; October 23\textsuperscript{rd}, silty loam - alfisol; location Thümthenning, November 21\textsuperscript{st}, sandy loam - alfisol; all locations in Dingolfing county).

![Sugar beet harvesting with air seeding system 1998.](image)

**Figure 3:** Self-propelled six row sugar beet harvester equipped with air seeding system 1998.

In all field trials (1996/1997/1998) germination and development of the winter wheat stands where observed. Plant densities were determined in BBCH 21 to 25 (Hack et al., 1992) and ear densities in BBCH 75 to 80. Before harvesting in 1996 the number of grains per ear were counted and in 1998 thousand grain weight was measured. To determine the yield strip plots were exactly marked out, measured and harvested and the grain was weighed on calibrated platform scales.

**Results:**
Because in autumn 1996 harvester and conventional seeding was done at the same day at both locations the differences of germination dates could be detected. At both locations it was found, that the harvester seeded wheat germinated about 5 days earlier due to the insulating layer of the beet leaves.

At the emergence and the beginning of tillering (BBCH 21-25) in spring 1997 there were significant differences in the plant density between conventional and harvester seeding variants. The harvester seeded plots showed 7-30 % less plants/rrf (fig. 4).
Figure 4: Density of plants BBCH 21/25 - harvester seeding investigations 1996/97.

But on the stage of fruit development the differences between the variants regarding ear density were insignificant (fig 5).

Figure 5: Density of ears BBCH 75/80 - harvester seeding investigations 1996/97.

Also in the numbers of grains/ear no significant differences were observed. This development shows that during the vegetation period the harvester seeded plots caught up on the lower number of plants/m² at the beginning, by developing more tillers/plant with ears compared to conventional plots.
Winter wheat harvest in summer 1997 showed identical grain yields compared to the conventional planted winter wheat at the same locations (fig. 6).

The seeding beam used in autumn 1997 reached a very homogeneous seed distribution but showed severe problems with soil sticking on it and piling up under wet soil conditions. This build up then disturb the harvesting unit. The trial was totally (harvester seeded and conventionally seeded plots) destroyed by ravens or crows in spring 1998. Therefore it has to be replanted with com and was lost as harvester seeding trial.

Although in autumn 1998 the conditions even for harvesting sugar beets have been the worst for a long time, establishing well developing winter wheat stands was possible on two of the three locations.

At the first two "harvester seeding dates" (Meising, October 3rd; Reith, October 23rd) it has rained for some times, the soil was saturated with water and harvesting was just possible. At the last date (Thümthenning, November 21st) temperature was below -5°C, the soil was frozen and harvesting has to be stopped on the next day.

Because of the weather situation and the wetness of the soils the conventional seeding of the observation plots has to take place 10 (Meising) or 7 (Reith) days later than the harvester seeding. Only in at Thümthenning all wheat was planted at the same day.

Although the wheat was planted with similar seed densities (increasing by approximately 10% with later seed dates) the densities of plants at BBCH 21-25 showed high differences (fig. 7).
It is typical for the investigations in 1998/99 that the standard deviations of the harvester seeded plants per m² were dramatically higher than of the conventionally planted wheat. On the location Meising an uphill curve at the end of the side sloping field caused the harvester slipping and moving a lot of soil -- including the wheat seeds -- downhill. This was the reason for reduced plant density at that spots. Especially on the location Reith there have been large areas in the harvester seeded plots where nearly no wheat germinated. It seems that the heavy rains directly after harvester seeding caused germination problems.

The number of ears in BBCH 75/80 did not show that dramatic differences mentioned above. At all locations the numbers of ears of conventionally seeded plots were higher than on harvester seeded (fig. 8).

But at Meising and at Thümthenning (the grain samples of Reith were lost) the thousand seed weight of the harvester seeded plots were about 10% higher than of the conventionally seeded wheat.

At that two locations the yields were equal to those conventionally (plough, power harrow and drill) planted. Only at the above mentioned location Reith with silty loam soil and very wet conditions during and heavy rain after harvester seeding, the yield was reduced by 35% compared to the conventional seeding (fig. 9).
Continuing investigations:
In autumn 1999 an additional investigation was started in which winter wheat was seeded directly before sugar beet harvesting using a pneumatic boom spreader. This "pre-harvest-seeding principle" was used before for seeding oilseed rape into winter wheat 20-30 days before combine harvesting (Tebrügge, 1997). Germination of the winter wheat was uniform and a very good development of the stand can be observed.
Discussion and conclusions:
The results of the investigations show that seeding winter wheat during sugar beet harvesting has, except under very extreme (wet) soil conditions, no influence on the yields. If the seed is applied in back of the beet-lifting-unit, covered with the soil separated by the cleaning units, pressed by the "dog walking" low pressure tires of the harvester and again covered with chopped beet leaves, conditions for regular germination are obtained. Air-seeder technology should be used because of the possibility to place the seed hopper, the hydraulically driven fan and the electrically driven metering unit wherever a free space is available at the machine.

The harvester seeding systems not only reduces work time, energy requirements and field traffic in autumn, but also makes winter wheat cultivation possible in case of late beet harvesting. The beet leaves on top of the soil are a contribution to soil conservation. They protect the soil from erosion during winter and raise the content of organic matter in the topsoil.

References:


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