Mulch Seeding of Sugar Beet

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Introduction

Mulch was defined initially as a layer of crop residue respectivly as a layer of organic or nonorganic material above the soil (Kromer et al. 1981). Now conservation tillage practices has broadened the meaning to include the mixture of organic material with soil as a mulch layer (Sturny 1988).

Objectives

One objective of a nine-year study was to test the effect of mulch for sugar beet production. A second objective was to test modified precision seeders for sugar beets. The third objective was to eventually develop an appropriate seeder with minimum destruction of the mulch layer. All seeding systems should include controlled wheeling (i.e. tram lines) and integrated application of fertilizer and herbicides to minimize soil compaction (Kromer et al.1992, Thelen 1992, Stephan et al.1995).

Materials and Methods

Mulch affects chemical , biological and physical processes manyfold. The kind of these effects and their magnitude are due to geographical location(soil, climate, etc.) and properties of the mulching material (Laflen et al.1981, Kromer et al.1981, Gupta et al. 1982). Dominant is the heat and mass transfer through the mulch. Therefore, soil temperature may be used for modelling the effect on plant growth. Difficult to determine are the time dependent properties of the mulch because of their biological and enviromental degradability. The properties affect considerably the beet growth factors as well as the inner and outer sugar beet quality. Li(1994) listed the properties of mulch material in use. Struzina (1990) respectivly Li (1994) give the soil temperature in Equations (1) and (2) below, see also Mahrer et al.(1981)and Gupta et al. (1982). Sugar beet seed, coated or uncoated, reacts different to the microclimate in the germination soil zone, Rademacher (1990) has proved the effect of the germination and early growth rate on extractable sugar yield, Equation (3). Struzina (1990) calculated an estimated beet yield based on one location, Equation (4).

Average soil temperature at 2" depth below straw mulch in °C

$$\vartheta_{soil} = 1.36 + 0.55\,\vartheta_{air\,2\,m} + 1.24\,GR + 0.03\,BG \qquad (Rsq=.90) \qquad (1)$$

with $\vartheta_{air\,2\,m}$ = air temperature in 2 m height, GR = global radiation in kWh per sqm and day, BG = degree of shadow in %

Average daily soil temperature at 4" depth below compost mulch in °C

$$\vartheta_{soil} = 9.13 + 0.82\vartheta_{air\,2\,m} + 0.06\,NR + 0.37m.c. + 0.05\,GR.\vartheta_{air\,0.5\,m} - 0.06\vartheta_{air\,2m} \cdot v_{air} \qquad (Rsq=.89) \qquad (2)$$

with NR = precipitation in mm per day, m.c. = soil moisture content w.b. in %,
GR = global radiation in kWh per sqm and day, ϑ_{air} = air temperature in °C,
v_{air} = air velocity in m per sec.

Extractable sugar yield in dt per ha (40 kg per acre)

$$m = 0.83 + 6.54\,v \qquad (Rsq=.69) \qquad (3)$$

with m = expected sugar yield, v = field emergenc y rate in % field ermergence per day

Estimated beet yield in dt per ha

$$y = -1964.17 + 3.07\ \Sigma\vartheta_{soil\ 5\ cm\ 60\ days} \qquad (Rsq=.99) \qquad (4)$$

with y = expected beet yield, $\vartheta_{soil\ 2"}$ = sum of soil temperature in 2" depth 60 days after sowing

Compost at an application rate of 40t per ha (16 t per acre) had the same effect of reduced soil erosion as crop residue. A back and forth acting boom rainfall simulator (Kromer et al.1996) was used to apply rainfall on 9 x 10 m areas at 50 mm per hour (2" per hour).

Test Procedure

Practically all systems are based on a mulch layer of organic material of an intercrop (crop residue). The kind, the amount of organic material, etc. is affected by agronomical decisions. In this study Yellow Mustard has proved to be very effective for meeting the objectives and for providing a biological pest control for nematodes.

The test site is located in the Rhein valley, precipitation 600 mm(24") per year, average temperature 9 °C, soil type lU, 15% clay, soil class 86. The plots were 18 sqm, beet varieties Eva and Hilma and the total amount of nitrogen 180 kg per ha (72 kg per acre).

Three tillage treatments respectivly seeding systems and one crop rotation system at one site were established. The statistical design was a row block with 6 replicates.The seeding systems after installation of an intercrop were :

-conventional seeding after fall plowing (30 cm),seed bed preperation with a power harrow with cage roller (8 cm), conventional precision seeder (Unicorn of Kleine Co. and Monopill of Kverneland Accord Co.)

-mulch seeding with seedbed preperation after conservation tillage, chisel plow (45 cm), mulching mower, power harrow with cage roller (8 cm), conventional precision seeder.

-mulch seeding without seedbed preperation after conservation tillage, modified precision seeder.

Three sugar beet seeder types were tested:

-conventional precision seeder

-modified precision seeder (mulch seeder)

-punch seeder (Bonner Spade Seeder)

Seeder Development - Bonner Spade Seeder

Hole seeding systems for seeding sugar beet have used mechanical soil opener, Jafari and Fornstrom(1972); Flake and Brinkmann(1979), Kromer(1984). Besides the disadvantages of limited adjustment of different spacing and plant density, the complex mechanism made them less reliable and more expensive compared to conventional share seeder (line seeding). Hole seeding did not destruct the mulch (cutting, moving) and did not create rills; lowering the danger of soil erosion. Therefore, a reliable and simple tool was developed to open a hole for placing the seed or any granular material;i.e.for side dressing, through a mulch cover. Since 1986, a spade-wheel for seeding was successfully tested for corn, since 1992 also for sugar beet. The spade-wheel works like a ground driven beet thinner but with a yaw of 7.5 degrees and a vertical inclination of 23 degrees. A hole is opened, on a cycloidic path through the soil. Since the spade is an open tube, a conventional precision seeder can charge the spades with single seeds and place the seeds in the dipper holes. In 1995 and 1996 the spade seeder was included in the mulch seeding trials of sugar beets.The comparable simple design of the spade seeder for a fixed spacing of 200 mm is shown in **fig. 1.**

Results

The research for the three seeding systems were conducted from 1988 to 1996 , the punch seeder test was added in 1995 and 1996. Sugar beet field emergence, population, beet yield and extractable sugar yield were calculated.

The plant population at the time of harvest versus the seeding system, **fig. 2**, proves, that mulch seeding without seed bed preparation will always result in lower population. However, technical improvements and management knowledge have closed the gap to the conventional system and lowered the risk.The mulch seeding system with seed bed preperation averaged in the 9-year test period the highest plant population compared to all other systems.The beet yield versus the seeding sytem, **fig. 3**, confirms the former result with also a higher yield when mulch seeding with seed bed preperation is applied. Equal tendency is approved for the extractable sugar yield, **fig. 4**.
When testing the new spade seeder, the conventional seeder Monopill of Kverneland Accord was used as the check. Because of the mechanism of hole seeding, depth control and imbedding is not the major problem. Instead the open hole has to be protected from clogging as well as for keeping the seed moist during germination. Therefore 3 different types of press wheel arrangements were used, **fig. 1 and 5**.The same data were taken as on the mulch seeder test, but only included in this paper are the cumulative field ermergence in 1996 and the extractable sugar yield in 1996.The press wheel arrangement had no significant influence at a low field emergence level. The LSD 5% level, shown in the diagram indicates, that in a later stage the spade seeder with no soil coverage performed significantly worst, but with no significant lower field emergence when using the finger-wheel or an inflated rubber wheel as press wheel, compared to the conventional system using the finger-press-wheel, **fig. 5**. However, this did not create a significant lower sugar yield, but with basically the same tendency, **fig. 6**. In all of the 1996 mulch seeding trials, the conventional seeding system performed better compared to mulch seeding with seed bed preperation, due to a very wet growing season. The differences were less appearent for the spade seeder.

Conclusions

Mulch seeding with seed bed preperation has proved to be a competitive system to conventional precision seeding with economical end ecological advantages. The 9-year comparative field test gained a higher beet and sugar yield versus the conventional seeding system on a high yield level of 24 tons of beet per acre (60 tons per ha) and 4.8 tons sugar per acre (12 tons sugar per ha).The newly developed spade seeder performed equally well in a 2-year field test, when using a finger-type press wheel for mulch seeding with seed bed preperation compared to conventional seeding.

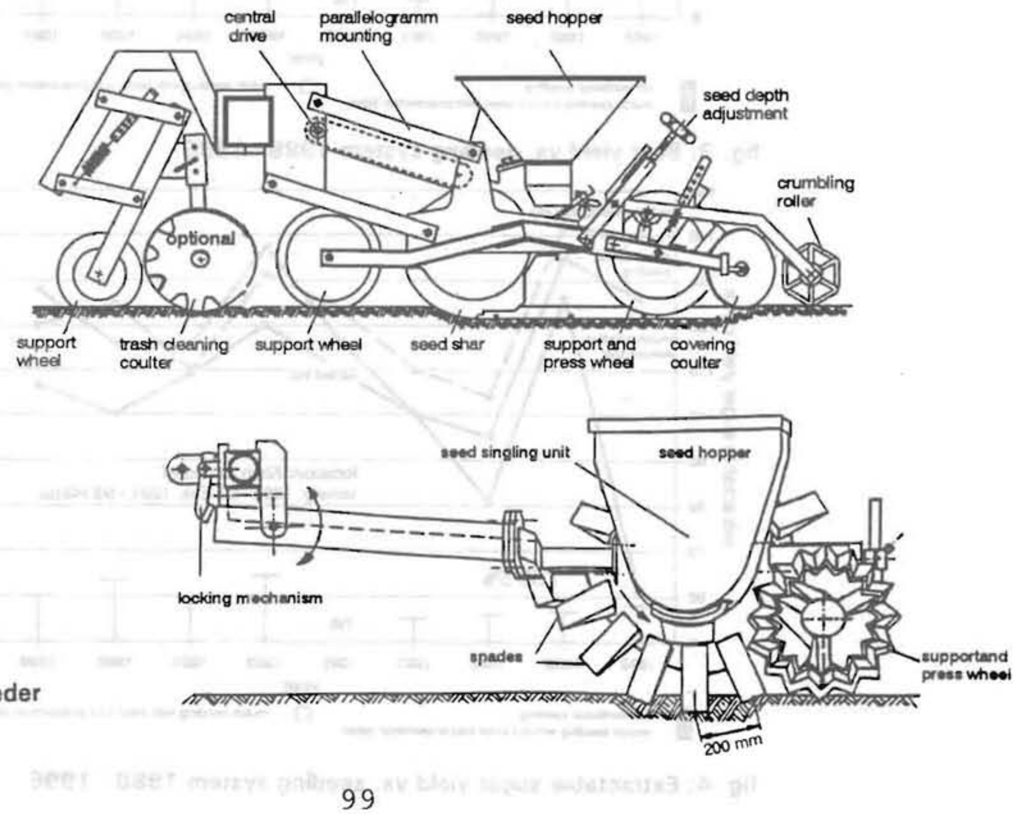

fig. 1: Mulch seeder

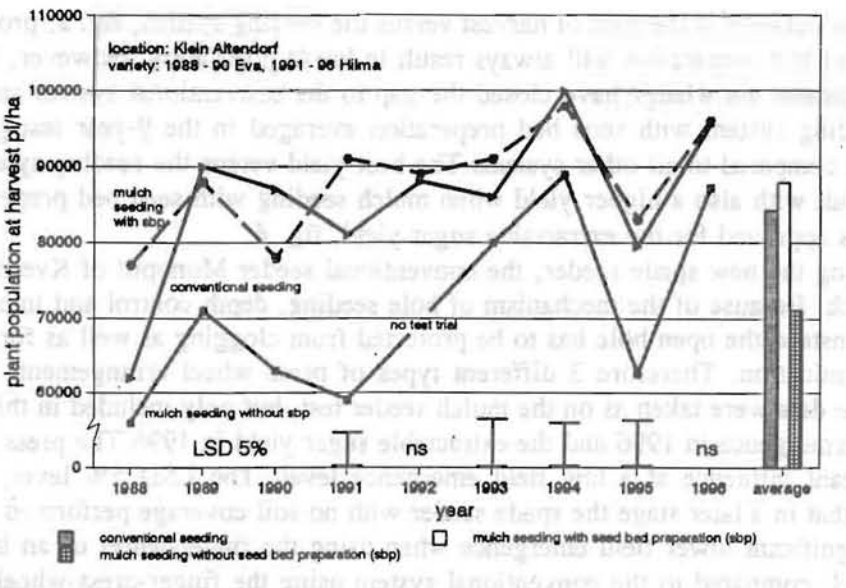

fig. 2: Plant population vs. seeding system 1986 - 1996

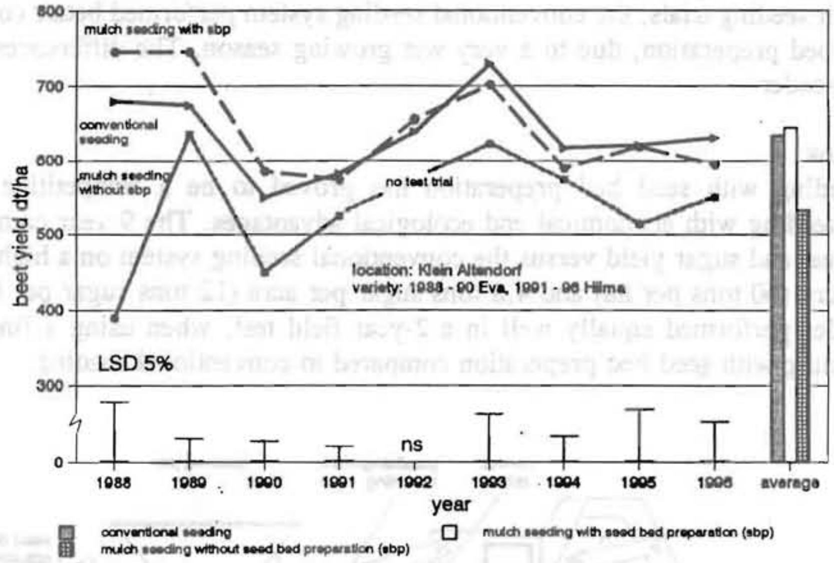

fig. 3: Beet yield vs. seeding system 1988 - 1996

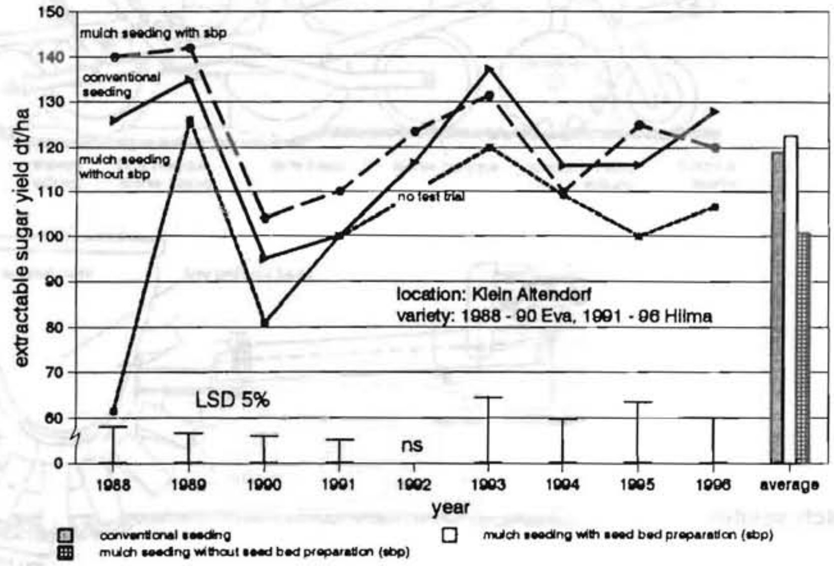

fig. 4: Extractable sugar yield vs. seeding system 1988 - 1996

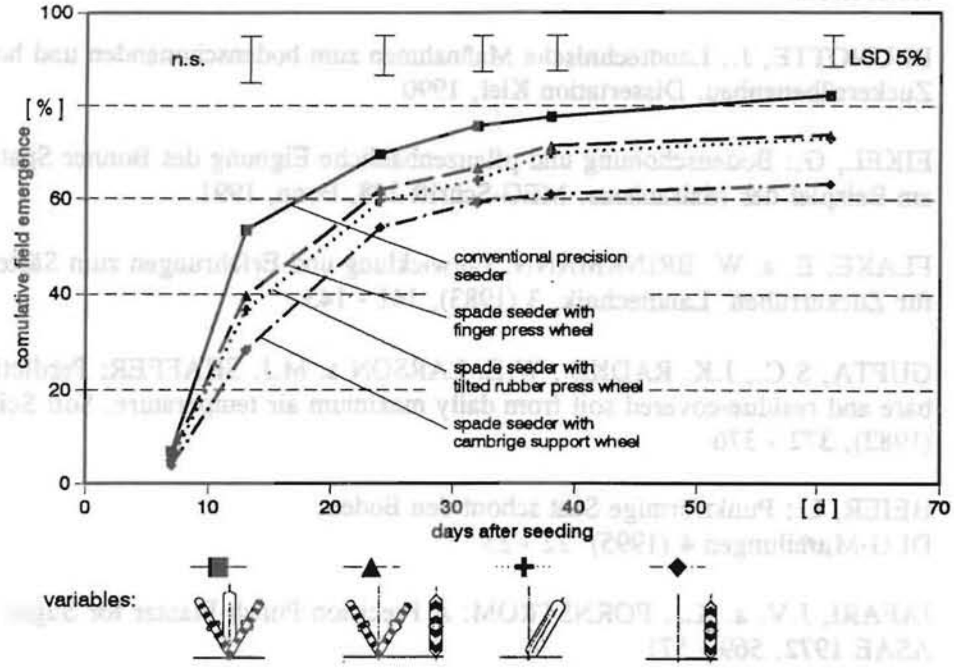

fig. 5: Cumulative field emergence 1996 of conventional precision seeder and spade seeder

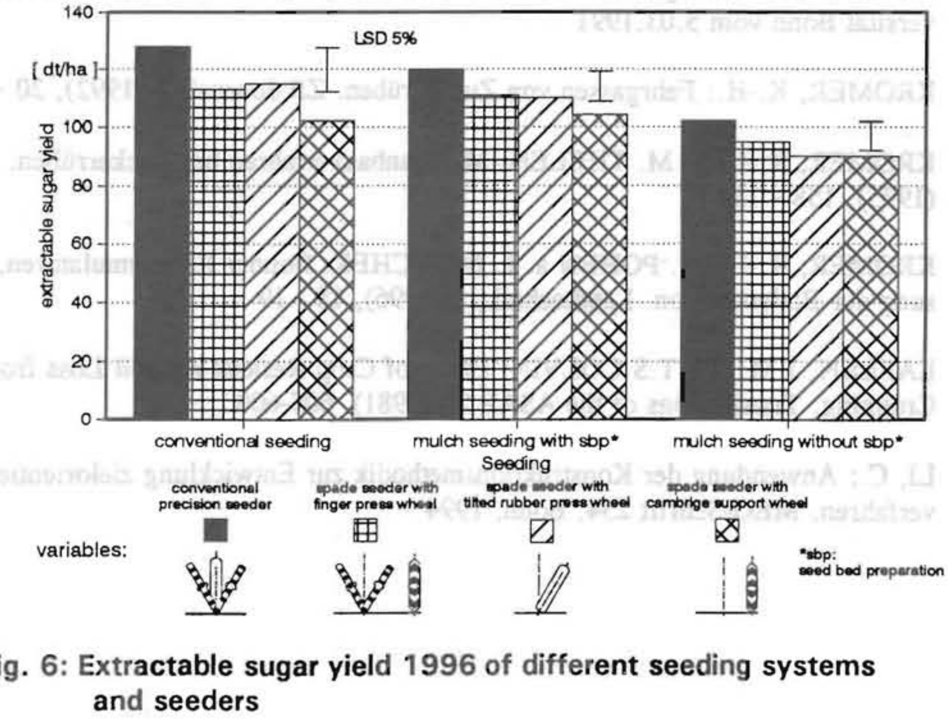

fig. 6: Extractable sugar yield 1996 of different seeding systems and seeders

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