A Wide Span Tractor concept developed for efficient and environmental friendly farming

It is wide and stable during field operations. When on roads it is long and narrow

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Abstract

Tractors, as we know them today, have evolved from the two-wheel driven tractors introduced in the 1920s. Basically, the design has not changed over the years, but the power output has increased more than 10 fold and the weight of tractors has increased by a similar factor. The weight of agricultural machines is compromising the productivity of soils, and the size is a challenge when manoeuvring on public roads. Tractors were successful in replacing horses, but it is now time for redesigning the basic tractor design.

In an attempt to counter the mentioned negative effects of modern agricultural machines a new Wide Span (WS) tractor concept has been designed and a prototype tractor with a span of 9.6 m (wheel centre to wheel centre) has been built. It is designed to optimise the Controlled Traffic Farming (CTF) system that is already in place on the vegetable farm where it is being tested. The tractor is designed to carry out all operations during vegetable production including harvest. Using the tractor means that less than 10% of the field area is affected by compaction due to field traffic. The economical and environmental effects of such a wide span CTF growing system will be assessed.

Fig. 1: First test of the wide span tractor, June 2012. The tractor has three 3-point linkages shown here with three Kongskilde cultivators.

The initiative to the development was taken by farmer Jens Kristian Kjeldahl. The 750 ha Kjeldahl farm on the island of Samsø supplies early potatoes and other vegetables to Danish supermarkets. Especially vegetables grown early in the season rely on healthy fields that drain well and warm up quickly. The farm has been successful in implementing seasonal Controlled Traffic Farming (CTF) as well as reduced tillage practises [1]. As for most other vegetable farmers, the CTF system is only seasonal, as there are no commercially available vegetable harvesters that enable harvest from the permanent tracks. On the Kjeldahl farm, all crops are grown on 3 m wide beds. Cereal crops are harvested with a 35 feet (10.5 m) combine that spans one bed and harvest 3 beds at a time.

Fig. 2: A 3 m Grimme stone separator on the Kjeldahl Farm. Controlled Traffic Farming and reduced tillage cause considerable savings and improved soil structure. Separation of stones from the soil is no longer required every year, as stones and clods are not redistributed to the growing beds during tillage. (Photo: Jens Kr. Kjeldahl)

Vegetables are mostly grown in beds and no crop is grown within the tracked area. By use of Wide Span (WS) tractors, the production is boosted as less area is used for tracks and more

plants can be grown per ha. However, the main reason for developing the new tractor concept was to enable controlled traffic farming also during harvest. Preliminary results from a trial on the farm show that deep ripping of the soil after harvest of potatoes with a traditional 2-row potato harvester cannot compensate for the yield depression in the following onion crop.

Besides cultivation, drilling and plant care operations, the wide span tractor will be used as a bunker harvester for onions. The harvester will unload into trucks at the field edges hereby avoiding traffic with tractors and trailers in the field.

Wide span tractor designed for efficient vegetable farming

The WS tractor as a platform for a future tractor design was inspired by the work of Tim Chamen CTF Europe [2]. An animation shows the great manoeuvrability of WS tractors [3].
25 years ago two-wheel driven WS tractors were tested in the UK. It was demonstrated that all operations in grain growing, including combine harvesting and mouldboard ploughing could be carried out by use of the WS tractors [4]. Compared to traditional growing practises, improvements in the soil structure and reductions in fuel use were documented [5].

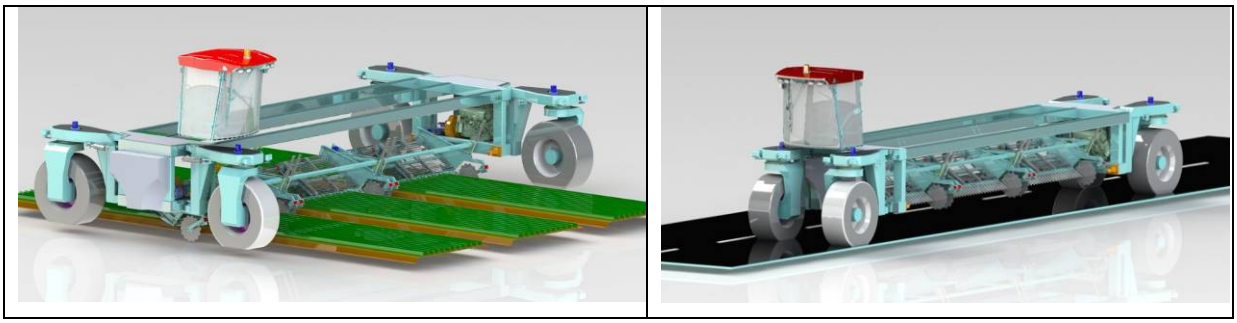

Fig. 3: Conceptual design of a wide span tractor. Left in position for field operations. Right in position for road transport. Drawings: ASA-Lift A/S

High cargo capacity for vegetable harvest

In grain crops up to 10 t are harvested per ha, while vegetable crops may yield 100 t per ha when including residues and soil that is also transported from the fields. Transporting such amount of material using heavy machinery cause a severe risk of compacting the soil profile to a great depth, especially when crops are harvested from moist fields.

The WS tractor is designed to carry an onion bunker harvester (Fig 4). With 650 mm tires and a span width of 9.6 m, the tracked area is as low as 7% and more than 90% of the field area is not compacted during harvest. One or two 3 m wide beds can be harvested at a time, so the tractor needs to drive twice over each 9.6 m bed to complete the harvest. The

tank of the harvester can hold 15 t of onions. The harvester is designed to achieve a net capacity of 60 to 80 t per hour which is similar to harvesters presently used for onions [6].

Fig. 3: The wide span tractor mounted with an onion bunker harvester. Photos: Rasmus Meyer, ASA-Lift A/S

Replaceable middle section

The WS tractor consists of two engine ends that are largely mirrors of each other except that one end has a cabin mounted for the operator. The middle section can be a frame for mounting of implements as in Fig. 1, or the middle section can be an implement designed for a specific task such as the onions harvester in Fig. 3. The middle section is changed simply by pulling of the two tractor ends. This flexibility allows the use of either standard implements or for more complex operations, implement designed to fit on the WS tractor.

Compared to implements mounted on a standard tractor or trailed by a tractor, design of implements for a WS tractor is simpler. A 9 m potato planter could for example relatively easy be build on the WS tractor. When shifting to transport mode, no complex folding mechanism is required. The implements are simply lifted from the ground and the WS tractor shifts to road mode (Fig. 2).

The implement frame on the prototype (Fig. 1) is designed for mounting standard 3 m wide implements in the 3-point linkages. At each 3-point linkage, 30 kW can be transferred through a power take off (PTO) to the implement. Each end of the tractor has a 130 kW engine with a hydraulic pump (300 l/min) and two transmission pumps.

The width of the WS tractor can be changed by changing the length of the frame. For accurate steering, the length of the frame needs to be registered in the steering computer.

Controlled Traffic farmers like the wide span concept

As input to further development and design of the wide span technology, designated and structured interviews have been performed with 31 farmers and farm managers in Denmark, UK, the Netherlands, Germany, Australia and New Zealand. Those interviewed were primarily vegetable producers interested in Controlled Traffic Farming. These farmers are conside-

red potential customers for WS technology. This was confirmed by the fact that of those interviewed, 39% would invest in WS technology in the future providing the technology had been proven technically robust and economically competitive, 52% would possibly invest, and only 10% did not foresee wide span technology as part of their future farming practises.

The interviewees were asked to prioritize 28 customer requirements. The average priority of the requirements can be seen in Fig. 4. “Automatic precise steering of machine” and “Reduce Soil Compaction” scores very close to the maximum score of 4. The five requirements with the highest score are from five different categories indicating that designing technology based on user requirements is not an easy task. The user requirements have been transferred into technical design parameters by involvement of a group of experts. The results of the survey can be used in the future design of wide span technology [7].

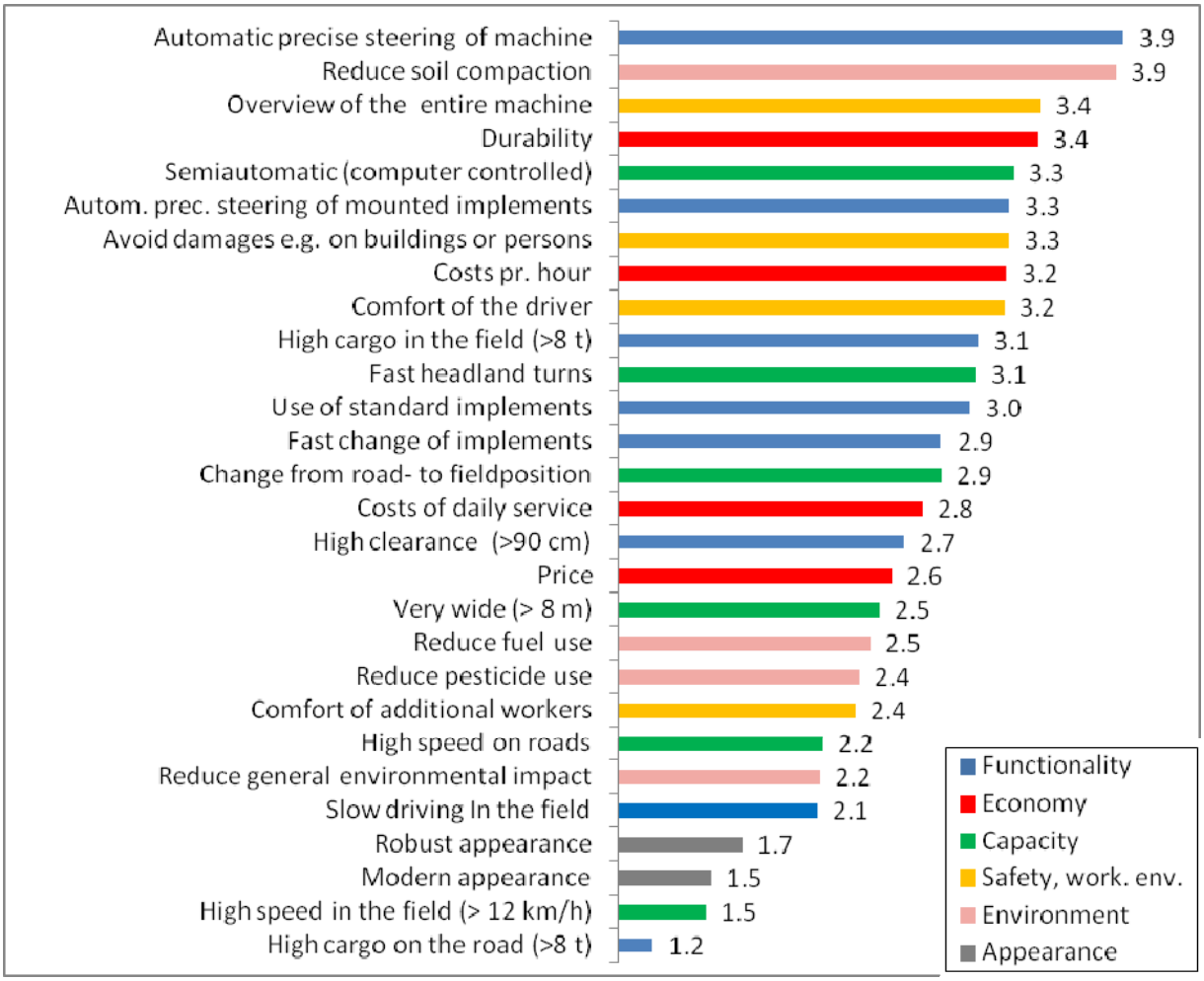

Fig. 4: Average result of interviews where farmers and farm managers were asked in a 0 - 4 scale, to prioritize different customer requirements for wide span technologies. The requirements are grouped in six categories.

Wide span cooperation

Earlier work has failed to introduce wide span technology to arable farmers. Wide span tractors can solve some specific challenges in vegetable production such as harvest in growing systems based on Controlled Traffic Farming. Once established in the vegetable industry, the wide span tractors may easily be adopted by arable farms as well.

The wide span prototype tractor will be tested in 2013 and 2014. The economic and environmental effects of the wide span growing system of different crops will be assessed.

The next series of machines will be re-designed based on the experiences gained. We seek partners among implement manufacturers to enable wide span growing practises on vegetable farms where lots of different machinery is often used.

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Fig. 5: The wide span tractor has approximately the size of a bus when transported on roads. Drawing by ASA-Lift A/S