Multi-purpose plot machine modules: More flexibility and lower costs - The Flexiseeder Approach

Authors:
- T. Leuchovius, Swedish University of Agricultural Sciences, VPE/Fält Forsk, Uppsala, Sweden, Email: Torbjorn.Leuchovius@vpe.slu.se
- E. J. Stevens, S&N International Ltd, Governors Bay Road, RD1 Lyttelton, New Zealand, Email: stevensj@ihug.co.nz
- D. S. Fraser, John Brooks Ltd, 214 Waltham Rd, Christchurch, New Zealand
- C. D. Roberts, C&C Roberts Engineering, 54 Crossgates Rd, RD3 Leeston, New Zealand
- T. Gaardløs, Bioforsk Arable Crops Division, Apelsvoll, N-2849 Kapp, Norway, Email: Torkel.gaardlos@bioforsk.no

Abstract
Multi-purpose equipment for field experiments needs to include modern technology, be affordable and meet tough requirements on interchangeability, accuracy, reliability and maintenance. It must plant zero tillage, reduced tillage and cultivated ground with equal application to accommodate the change over from historical cultivation. Required levels of technology vary for different countries and applications. By developing, assembling / combining working modules, plot machines can be tailored to meet these new demands, at lower prices than otherwise possible. The module approach is useful for most machine operations in field experiments. The paper introduces and discusses standardization issues for developing these modules, for example free space requirements and interfaces between working modules. Examples of modules are given based on the design and development of two new multi-purpose (Machines equally suited to zero (eco) tillage, reduced tillage and conventional cultivation). “Flexiseeder” plot drill prototypes. If the use of working modules can be increased, production costs can be lowered because of module reuse in different field operations, the use of standard machine components and the local manufacturing of some modules / module components.

Acknowledgements
The authors wish to thank members in the IAMFE/IAU Seed and Seed Drilling Technology Group. Especially we thank Prof. Egil Oyjord, Norway; Bengt Hallerström, Sweden; and George Hampton, Steve Griffith, Adrian Russell, Shane Maley, Lindsay Thian, and Gerry Ovenden in New Zealand for their valuable advice concerning plot drill design. We also thank Mats Andersson, Lars Danielsson, Erik Ekre, Carl Westberg, Geoff Gray, Ian Close, Noel Collins, Lindsay Brooks, Jan Jönsen, Trevor Roberts, Charlie Tana, Söderberg & Haak, Scan Agro a/s and Wym and Michael Bauman who helped to transform ideas into useful machines. Peer review and mentor support by Prof John Hampton, Dr. Keith Armstrong and Sue Stevens is most appreciated, as is the accountancy support provided for the group by Alan Brooks.

Introduction
The demand for multi-purpose equipment for field experiments has grown substantially over the past five years, outstripping available purpose-built technologies including plot seeders and other research equipment suited equally to zero (eco) tillage, reduced tillage and conventional cultivation. During this era, useful technologies introduced and discussed in this paper have been borrowed / adapted / exchanged / interchanged with farmer equipment under the Flexiseeder Project (www.flexiseeder.com, which is part of the IAMFE / IAU Seed and Seed Drilling Technology Help Group - International Association for the Mechanization of Field Experiments / Global Institute and Agricultural University Internet Hub (IAU Trust)) using a modular approach to help “fill the gap”, to economize and to reduce differences between plot and farm technologies, with excellent results (Described in detail at this conference by Stevens et al, 2008 and Fraser et al, 2008). When considered as modules, these technologies have broader application for field experimentation including spray and fertilizer application as well as for specialized cultivation besides general agriculture, horticulture and viticulture.

To proceed further, relevant standards need to be developed for these multi-purpose modules to help refine and bring them into common use, along the lines used more than 30 years ago under IAMFE, for defining standards for arable plot drills (Hallerström, 1992; Oyjord, 1996). This paper in-
introduces and discusses several "multi-purpose module standards", based on working examples developed over the past four years under the IAMFE / IAU Seed and Seed Drilling Technology Group Flex-seeder project. It is backed up with six technical papers listed in the References, also presented as posters at IAMFE 2008 and included in the proceedings.

**Background**

**Key points:**
- What do modern multipurpose plot seeders have that is not needed on farm machines?
- What must they have at same time to ensure a good correlation of field experiment results to cultivation/farmer recommendations?

The most important difference with farm machines is probably that plot equipment must allow a high level of control of the operation (setting up the treatment and monitoring of the result). It must be easy to initialize the treatment for each plot and there should preferably be no interactions between the treatments of each plot. Factors such as carry-over effects, contamination and remains of tested products (for example residues in combines or seed mixtures in drills) must be avoided. Plot machines need to apply products in well-defined portions for each plot, to harvest crops without intermixing between plots, to take representative samples of products and to measure yields, applied rates of products, etc.

- On the other hand, many other demands are the same for plot and farm machines.

Several examples of this are provided in the paper by Stevens et al (2008). Needed are a support system with components for driving/carrying (wheels, engines, lifting and steering systems etc) and for environment and protection (driver cab, protection devices). Farm and plot machinery have rather similar demands on reliability and maintenance. The increased use of precision agriculture systems also applies for plot equipment. In order to simplify and to save costs, tractors or tool carriers (more or less advanced) are often used.

- It is useful to try and define what special operation modules needed in plot experiments and to set up some requirements / criteria for how these can function together with the support systems.

Examples of this are requirements on free space for the modules and on how to exchange information and control implement.

**Plot machine module examples - use and characteristics**

The following multi-purpose working modules are used regularly in modern field trials and warrant defining as multi-purpose modules.

1. **Planting - portion feeder for granular materials**
   - The normal (Oyjord) and belted cones are widely used with mechanical, air or air-assisted distribution to coulters on standard and precision planters and fertilizers machines. Air is also used for cleaning out (especially precision drills).
   - The cones normally rotate one turn over the plot length. The metering system controls the carousel rotation angle as a function of the traveled distance. If the drill stops, the application stops. Lamellae height within the cell wheel varies from between 4.0 mm and 25.0 mm and space between lamellae also varies depending on the size of portions distributed / plot length.
   - Standard 400 mm diameter cell wheels usually contain 48 lamellae, reduced to 24 in some instances while the 320 mm diameter wheel contains 32 lamellae reduced to 16 in some instances. The drop hole can be located towards or away from the operator.

2. **Spraying - liquid application systems**
   - Sprayers can apply a fixed or a changed dose over the plot length. Chemicals can be mixed for each plot or treatment, or concentrated chemicals in syringes can be used. The application rate is often constant (travel speed also fixed as far as possible) throughout the plot or, if linear change of the dose is used, the rate is a function of the traveled distance. In most instances, if the sprayer stops moving, the application/spraying continues at the latest applied rate, until manually stopped.

3. **Tool bars for mounting coulters, nozzles etc.**
   - Various tool bars are useful when rapidly changing the experimental setup. Tool bars on drills can be lifted/lowered and/or rotated. For maximum flexibility (standard planters) a frame can support up to 4 bars with coulters - all with adjustable angles (rotated mechanically or by hydraulics). It should be possible to set two bars at different depth and/or angles compared to the others. The coulter frame would fit most arrangements (used together with two portion feeders): normal drilling (2 bars); combined fertilizer-drilling (1+2 bars); double drilling (2+2 bars for main crop and grass/clover under-crop); technical experiments (sets of row distances, seed rates etc.).

4. **Metering - positioning systems**
   - Some examples are: Navigation based on the
Global Positioning System (GPS); Precision agriculture work operations using Graphical Information Systems (GIS); land-wheel controlled inputs, other steering/tracking/guidance systems. Flexibility is increased if the controlled units are electrically driven. Different drive algorithms can be used for planting and spraying. It is easy to utilize GPS input data and to add various on/off/start/stop functions. Furthermore, the metering system can be easily portable for use on different machines. If standards could be adopted, the control from the metering system will control different applicators/feeder in the same way (according to plot length settings and used regulating algorithm). Development work should be based on international standards like DIN 9684 and ISO 1783.

5. Collecting and weighing units for harvested products
Such modules are needed for forage/grass harvesters, maize harvesters, plot combines, root crop harvesters etc. There are many other measuring devices besides scales, like near-infrared reflectance (NIR) instruments. Often, readings are transmitted to data collectors via computer serial (RS-232 etc.) interface, but cable-less communication methods like Bluetooth (including converters to RS-232) are also available.

6. Coulters including harrows and rollers
The module system should allow for the use of a wide range of different coulters for direct, reduced tillage and normal conditions for different soils and weather conditions. Row and tool bar spacing / configuration should be adjustable. Examples of coulter types are single/double discs, knife coulters and Suffolk coulters. Rotating tool bars and adjustable tool bar axle height can allow for most types to be used. A simple and affordable solution is to use standard 5-tines for mounting of the hoes, knives or discs (here combined with supporting arms). Typically, rakes (harrow) and/or pressure rolls follow the seed coulters. If not attached direct to the coulter, a common set of straight or sweep types of hoes are often used, mounted on a single bar, trailed behind the last row of coulters. Rubber tyre or iron / steel rollers may be used, trailed behind the seeder (www.rollers.co.nz). While knife coulters can penetrate hard ground with little down pressure, plot drills may lack enough down pressure for direct drilling systems using disc coulters (disc coulters are preferable for example, when there are large amount of residue). Here the possibilities are to add the weight of the operator onto the frame, transfer (by hydraulics) down-pressure from a tractor or tool carrier to the frame or using semi-trailed plot drills and adding weights to the drill frame. Two-point linkage options allow operator weight to be effectively cantilevered onto the disc assemblies, by mounting these assemblies well forward on the seeder frame, and positioning the operator(s) toward the rear. Only the front (driving) wheels need to be lifted off the ground for turning, if the back wheels are designed as free steer.

7. Conventional boxes / arrangement for applying basal fertilizer and / or other products
In many cases, specific plot technology will incorporate standard farm components. Examples are seed bins, continuous feeders like commercial cell wheels feeding air delivery systems (also available as plot machine options) and feeders for fodder mix, manure etc. Besides fluted rollers, peg rollers and foam feeds are used either as simple gravity drop or combined with air assistance for delivery of product to the coulter. The use of independent drivelines and air assistance can be helpful in many situations where gravity feed becomes impractical and/or product tends to lodge in hoses to speed up the adaptation of farm technology (for example, in direct drilling) for use in field trials. With air delivery, consideration may be given to including diffuser / cyclones (www.d-cupdiffuser.com) attached to coulters to prevent seed bounce.

Results/examples and discussion
In this section examples of multi-purpose modules developed under the Flexiseeder project for plot machines, especially planters, (Modules have been placed in the public domain for all to use. Besides technologies, members of the Flexiseeder group are available on payment, to provide consultancy support) are demonstrated and discussed.

Tractor fork
- Mounting a plot seeder behind a tractor, behind a tool carrier, or mid-mounted on a tool carrier. A tractor fork can be used for hitching the drill modules to the rear of a tractor. Figure 1 shows a fork with an A-frame quick-coupler inserted inside two vertical profiles. In these profiles a fork can be inserted from the top, that will carry modules for portion feed (Oyjord carousel etc.) and distribution (air system or mechanical rotor), passenger seats etc. At the tower lower end, two support wheels can be inserted from each side (if these are not placed on the drill frame). At the lower rear end a harrow-like drill frame can be hitched. The frame is floating during planting. The rear end is connected with chains so the frame will be lifted off the ground.
Space requirement for tool bars or for harvesting/lifting machinery parts

Plot equipment will often be mounted on tool carriers and tractors. In a module system, self-propelled integrated/special machines (like self-propelled plot combines) would be less common. Tool bars (or other devices) for planting need free space when they are mid-mounted on tool carriers or high-clearance tractors. For rear mounting, the total weight should be as low as possible and distances as short as possible from the rear vehicle wheel axle to the module’s center of gravity.

It is suggested that the drill frame should not be wider or longer than 1200 mm. However, the frame can be 1800 mm in the driving direction if the width is a maximum of 1000 mm. This will apply to tool carriers and tractors having a inner clearance between wheels of a minimum of 1300 mm. Coulters can stick out to the required working width in the 1200 mm cleared zone or further to the rear if placed in the centre zone of maximum 1000 mm width. The drill frame can alternatively support fertilizers nozzles/coulters, weeding hoes etc.

For mid-mounting (only), a ground clearance of minimum 800 might be useful. This will give space for lifting tool bars between plots. Also smaller cutting tables can be mid-mounted – with band transport to a rear mounted bin (with, for example, weighing and sampling devices). A ground clearance of minimum 600 mm can be acceptable for drilling and mechanical weeding.

Space & height requirements for fitting application modules

Tool carriers may have a central body/main bar or two side bars. Application modules (cones, or liquid applicators, module 1-2 above), can be designed for being clamped-on to:

- the centre bar on tool carriers with one mid-bar
- each side bar on tool carriers with two sidebars
- the tool bar frame’s both side bars, placed to the left/right or in the middle.

For clamping on tool carriers, the maximum clamp gap should not be less than 120 mm wide and 160 mm high. For clamping on coulter tool bars, the possible clamp gap should be at least 80 mm wide and 120 mm high.

When mounting these modules on tool or coulter bar frames, the modules cannot be wider than 1200 mm if used on mid-mounted frames for tool carriers with two side bars. If used on frames mounted on mid-bar tool carriers, the modules should be placed at least 200 mm from the centre line. In the driving direction the module must be inside the free 1200 mm space.

Picture 1 shows tool carriers for mid-mounting where certain space is available. The drawing (right) is one example showing free zones for fitting tools to either tool carrier type.

The drill bar can be attached directly to its links for mid-mounting (or via a simple implement A-frame with rear, short, floating arms for the drill frame). The portion feeders and distribution systems can be clamped to each side of the frame or clamped to
Drill frames and tool bars

The possibility to choose type of coulters means that drill frames are most flexible if they can allow for depth, angle (rotating tool bars) and row spacing adjustments. Figure 2 shows a frame attached to a 3-point linkage.

Picture 2 shows a couple of drill frames that have adjustable supporting wheels and tool bar axles that can be rotated. The drill frames can be quite simple with two side bars. The side bar should either have a small angle in the driving direction or be about 200 mm narrower in half its length. The frames’ front and rear end can be altered (frame rotated 180 degrees). In this way different row distances can be used without coming in conflict with the side bars. Then 2-4 coulter bars can be clamped to the side frames. 2 or 4 supporting wheels can also be clamped, if needed. The coulter bars are more or less like harrow S-tine bars and it should be possible to rotate the bars by a mechanical handle or with hydraulics. It should also be possible to mount at least two coulter bars at a different depth than the others, and to use a different rotating angle for two bars. If the distances between the coulter bars are fixed with links between the clamps, the rotating part can be set centrally by using parallel links with many holes to select from. Alternatively, the angle can be set with a handle for each bar.

Normally the frame has four wheels that can be adjustable in height (not shown in figure). The frame may also have only two wheels or none – if fully supported by the tractor/tool carrier – but then ground contour following may often decrease. When hitching coulter frames with support wheels,
Floating arms are needed so that lateral contour following is possible (compare with old mounted harrows). See also Figure 1 and 2. Picture 3 shows other examples of drill frame details.

Cell wheels and distributors
Regardless of whether portion feeders of different kinds or adopted farm feeders and cell wheels are used, the equipment needs to be easy to clean (go clean) between plots and to calibrate.
Standard normal Oyjord cones can be used for portion feeding. They will work fine for both seeds and fertilizers. Sometimes, the friction between the base plate and the carousel can be rather high (especially when using brass material for both). Even though the step-motor driveline (See Fraser et al., 2008 for details) produces the torque needed, it is possible to reduce the friction by approximately 50% by inserting a wear sheet of ultra-high-density plastic (UHMWPE-BR (www.ludoplas.com)) in between. Comparative torque data are available.

We have used Oyjord cones manufactured by S&N International Ltd in New Zealand (Picture 4). Both 320 and 400 mm carousels are available. The lamellae height can be from 4 to 25 mm (almost 25 mm in the picture). 48 and 32 lamellae are standard for 400 and 320 mm units. For a modest set up cost, a variety of other lamellae spacing and heights can be supplied. There is provision to cast and supply additional rings which fit under the S&N cell wheels, as per the diagram. Wind covers as well as a range of interchangeable tube sizes are also available. S&N
Cell wheels fit directly onto existing Oyjord base plates.

Cones and distributors (both mechanical and air delivery) are sensitive to slopes. Picture 4 shows automatic leveling devices on the S&N drill sold to Norway (see also Picture 8 later in this paper). Research is under way to also apply this principle to air riser pipes and distributors. Direct coupled S&N electrically driven manual distributors plus variator are available (see Fraser et al., 2008) and the next section in this paper) which can be adapted to existing Oyjord distributors.

**Mechanical seed metering devices and distributors**

Standard farm seed / product metering systems and devices including fluted rollers, star wheels, pegged drums, and sponge feeds have been used routinely for more than 50 years on plot seeders to meter basal applications of a range of products besides seed (including fertilizer and granular insecticide, for example). This same equipment has also been used routinely for continuous sowing of field trials, alleyways and border areas around plots, particularly where a high degree of accuracy is not important and / or low product application rates are not required.

Between row CVs of less than 10% are to be expected and repeatable settings are obtained when this equipment is properly maintained, operated according to manufacturer specifications and coupled to modern gearing / drive systems with finely tuned adjustment. In order to obtain this, the project found that the quadrant / adjustment arms on commonly used gear boxes (Zero-Max for example) may have to be strengthened overall and doubled or trebled in length. Spare parts are still available for most of this farm-based equipment (new and old), making it suitable for either adapting or bringing forward onto modern multi-purpose equipment provided it is operated within the manufacturers specifications for product types and sowing rates. Y2 Zero – Max gear boxes should be fitted with a suitable torque delimiter (available from S&N), to prevent equipment failure should the system overload if something jams.

Older style farm equipment, unless specialized, is seldom suited to metering small seeds / fine products (brassica and/or insecticide prills for example) at low rates of application. For this, modern equipment is required. Thian (www.thianagri.co.nz) modular farmer foam feed units work well for plot seeders, coupled with modified Zero-Max Y2 gearboxes shown in Picture 5. They may be mounted in custom-build boxes, one per row for gravity feed units, or singularly, in tandem, or triplicate feeding into air delivery systems.
Modified Zero-Max Y2 gearboxes (or Flexi digital gearboxes – see Fraser et al., 2008) can be used to provide fine (over-ride) adjustment to fluted rollers (Mistral and Accord, for example) commonly used to meter seed and other products into air delivery systems. This adaptation (applicable to plot seeders and farmer drills) is especially useful for adjusting these cell wheels while they are loaded with seed (product), particularly for reducing delivery rates by reducing the speed of the input shaft, independent of ground speed, rather than trying to force the flute closed. On air seeders, this also allows for more accurate metering, particularly at low rates. Digital systems may in time be connected to GPS systems to enable seeding rates at plot and field levels to be adjusted to soil maps / ground variation / plot plans within the blocks sown.

The impellors of Oyjord mechanical distributors (Picture 5), designed to rotate counter clockwise have been driven mechanically from a land driven wheel, electrically using a converted 12 volt vehicle generator (dynamo) or comparable DC motor, or hydraulically using a small hydraulic motor. Impellors were usually cast from aluminium. Recommended rotational speeds for these impellors range vary between 600 rpm for big beans, 750 rpm for soya and peas, and 900 rpm for grain, oilseeds etc. Fertilizer requires at least 900 rpm. Therefore ranges of working speeds are required between 500 and 1500 rpm or at some fixed speeds 600/750/900/1050/1200. This is achieved mechanically using gearing systems, varying the power supply to the motor, or controlling oil pressure / flow.

Mechanical drive systems are much less flexible for positioning / leveling the cell wheel assembly, compared with direct coupling electric and hydraulic drives. Electric drives are cheaper than hydraulic drives. Electric drives must have sufficient torque to withstand the impact of seed samples loading them, without slowing in rotational speed. For this a heavy motor is required, of at least a power of 180 W. While the project found that vehicle dynamo would suffice as motors (as suggested by Prof Oyjord based on his past experience), they rotated clockwise, were not designed to operate vertically and for direct coupling, required the inverse of the original Oyjord impellor to be cast. This was achieved successfully by the project, retro-fitted to a Farmall up-graded to the Flexiseeder system. Subsequent to this, with the assistance of John Brooks Ltd NZ (Fraser et al. 2008), a much superior (constantly magnetized) 12 volt motor and mechanical variator module was developed and brought into the commercial market. This motor could be rotated either clockwise or counter clockwise. It may be retro-fitted to existing Oyjord systems. It also has the potential to be fitted into distributor heads in air delivery systems.

Besides the Brooks motor and mechanical variator combination, S&N Flexiseeder replacement impellor blocks (clockwise and counter-clockwise rotation) are also available cast either in bronze or aluminium to be machined to retro-fit existing Oyjord as well as other distributor systems. Using the variator to control the impellor speed on this electrically driven combination, means that as the impellor slows, torque increases, since the motor continues to rotate at full speed. A bronze impellor, although heavier and more expensive than its aluminium counterpart, stands up well to fertilizer and acts as a fly-wheel with stored energy, meaning it is unlikely to slow when a sudden dose of seed hits it as the seed tube is tripped. Because of the weight (2.3 kg before machining and balancing (Balancing is achieved during machining, by drilling cores out of the underside of the base)) it should be run constantly between plots. The aluminium block weighs 0.69 kg.

Air assisted distribution

Air can be used for both distribution and transport or just for transport after another distribution de-
vice (below conventional seed bins or after a mechanical impellor/spinner).

We have used an air system for both transport and distribution. There are several makes like Accord (very common system for farm drills), a Canadian make (Flexi-Coil) and the Australian make Smallaire. Smallaire provided a reasonably compact and quite hydraulically driven system that could work on plot drills while at the same time is used on farm drills. Picture 6 shows Smallaire air distribution system components. Thumbnail inserts show improvements made by Norway, (i) plastic cone placed in distributor to reduce CV between outlets and (ii) 60 Mbar pressure gauge for quantitative calibration / repeat settings.

During tests done at the BioForsk Apelsvoll field research station (Small et al., 2008), it was found that the air distribution heads needed a modification so that no seeds were left in the heads between plots. Smallaire modified the heads to solve this issue. Bioforsk also tested the distribution variation between coulters. A coefficient of variation (CV) of less than 15% is deemed necessary. Such a variation means that, in worst cases, the amount of material distributed to each coulter could vary by approx. 40% from the maximum to the minimum amount. Within this variation, the crop (with limited row spacing like 10-20 cm) will compensate for most of the differences provided that it is a random variation and not systematic in a section of the head. Ideally, a CV of 4-6 % would be targeted.

In horizontal position, the CV was found to be from 4 to 13 %. However, which is also normally the case for mechanical spinners, the CV increases if the head is not horizontal. We have not investigated the CV in more than 15% slope and there the CV increased to around 15% or slightly more. A leveling device is therefore recommended for hilly conditions. One important measure is to connect the coulter houses to the distributor head alternatively to the left and right of the machine in order to minimize systematic variation because of a leaning distributor head.

On the Norwegian plot drill, the cones are leveled but not the air distributor heads. We have discussed if adding an extra spinner/propeller in the distributor head would improve the CV % in slopes. Also other types of heads and riser pipes plus self leveling devices for the riser and distributor will be tested but we have not had time to do this.

In order to calibrate blower speed it is also necessary to have a speed meter on the fan or to use manometers to monitor this. In certain cases, you may wish to put cyclones where the seed is delivered into the coulters, especially if blower capacity needs to be very high (large farm machine) or the seed is light and you drill very shallow. We have not needed to fit cyclones for the cereal and grass crops we have sown so far, but we haven’t enough experience to be sure.

Requirements on a metering module / land wheel

In the simplest case, the metering system will just measure and/or indicate the traveled distance. For controlling seeding/fertilizing, the system can advance the cones (or cell wheels etc used for continuous feeding) at a fixed gear ratio. Mechanical
drive (chains, cables etc.) or mini-hydraulics can be used instead of electrical pulses and (step-) motors.

**Driveline**

A driveline can be arranged from the wheels on a tractor fork. A more flexible system, however, is to use a separate land-wheel that controls the feeding mechanism. Cable (Cable whip is common compared with the more positive drive of chains, shafts, sprockets and universal joints) and links/universal joints can be used, but the most flexible solution is letting the land-wheel control an electrical step-motor via a control box. In this way, the driveline can be used for many different purposes. The same control unit could be set/calibrated for planting, broadcasting fertilizers, for liquid application etc. If the system is standardized enough, a unit that fails can quickly be replaced by another backup unit. If attached to the drill frame, the land-wheel can be activated when the drill frame is lowered. With a step-motor system, the motor(s) on the feeders can be started manually or simultaneously with the release of material onto the cones. The motor(s) will stop shortly after the land-wheel stops sending pulses or when the total plot length has been traveled (with some extra margin).

Picture 7 shows a driveline with land wheel, control box and two step motors controlling one Oyjord cone and one Mistral (Accord type) cell wheel for continuous fertilizing. On the control box plot lengths are set for the cone. The plot length setting is also used to set the speed of the motor driving the Mistral cell wheel. The cell wheel also has an adjustable outlet and two gearbox speeds. On the driveline control box the plot lengths can be fine-tuned depending on the actual rolling diameter of the land wheel (now programmed for a diameter of 600 mm). The control box also has start/stop switches for the step motors. The step motor drive-line is further described by Frazer 2008.

**Enhanced controlling algorithm**

As soon as you wish to change the rate within the plot (like a linear or step-wise changes), the frequency/speed of a step motor can be changed at small distance intervals. For liquid application you often set the frequency after the location (traveled distance) within the plot. You try to keep the speed constant at a preset level. The actual speed is often recorded so that one can document the real application rates afterwards. When you wish to adapt the frequency to a variation in speed, the control program will calculate both the intended and the actual dose and decrease/increase the frequency when you travel slower/faster. In addition you must amplify this increase/decrease so that the total number of motor revolutions (the integral sum of frequency over a distance) matches the intended application curve.

A program example is shown in Table 1. The frequency is adjusted when a new distance pulse is received. This will work if the program execution is fast and the microprocessor has a timer with accuracy of one millisecond or better. Alternatively, one may count the number of received pulses at each of the timer’s shortest interval.

The very lowest frequencies of the step motor will be less accurate. If the step motor has, for example, 4000 ticks and you use the range 40 to 2000, you can vary the plot length with a factor of 25 (for example from 2 to 50 meters). At the lower frequency of 40, the minimum dose/frequency change possible is 2.5% (1 of 40 ticks).

If you set the amplifying factor (YC in Table 1) to...
zero, the step motor frequency will just be adjusted according to the traveled distance from the start of the application. However, the true application rate will be different from the planned dose, so the speed should be registered and controlled afterwards.

When you use the step motor program to control the rotation of, for example, Oyjord cones, corrections for uniform speed must be made. Setting to a value greater than zero means that the motor will be controlled so that the planned and actual total doses become as equal as possible. The rotation of the Oyjord carousel should then correspond to the traveled distance in the plot. The higher amplification (YC) factor, the quicker the S and A sums will converge but, on the other hand, the step motor frequency will flicker a lot. The choice of YC value will depend on driveline setup (how many pulses per meter and timer accuracy) and the possibilities to travel at a rather constant speed through the plot. Probably, a YC in the range of 0.1 to 0.3 will be suitable in many cases.

Requirements on GIS/GPS control systems
Plot equipment will follow the development and standards used in precision agriculture. The German standard covers the signal exchange between con-
Coulter assemblies

Keeping in mind the basic principle of a contour following drill frame with height adjustment and rotating coulter bars (like normal harrow 5-tine axles), we can think of a wide range of coulters that can be used. Some are commercial products like various tips for mounting on 5-tines and the Amazone RoTeC single disc coulters. Other alternatives, like Kongskilde double discs, can be adopted for mounting on rotating harrow axles. Other coulters have been developed for this project. Picture 8 shows examples of different coulters.
Complete Plot drills – examples

Picture 9 shows a drill frame connected to the rear of the Swedish MacTrac tool carrier. The model on the picture has no rear hydraulic lift. Instead, the coulter bars are centrally rotated into the soil with hydraulics. A link lowers the land-wheel in the same operation. On the MacTrac (for weight/stability reasons), the feeders and passenger/operator are located to the right and left side in the middle/front part of the machine. An air system delivers the seed/fertilizer to the coulters in the rear end. An electrical drive-line is used to easily connect and control the feeders from the land-wheel.

Picture 10 shows a prototype drill delivered to Norway (New Zealand make S&N Flexi-seeder). The prototype partly incorporates the module thinking discussed here. It has a drill frame where coulter bars can be rotated and depth adjusted and it has two feeders and a fully air-based distribution system. This drill also has a front-mounted bin for continuous (free-fall, not air-based) application of fertilizers (mainly for combined drilling). Coulter bars and transport hoses can be arranged so that the machine can do normal drilling, combined drilling (with the bin or using one of the portion feeders) or double drilling (seed and crop, other combinations of seeds, seed rates, row distances). The drill can even do this in combination with applying fertilizer from the front bin (broadcasted or placed in the soil - 5 coulter rows would then be used). The drive-line is mechanical and driven from the front pair of wheels.

References


Hallerström, B 1974. The Oyjord experimental seed drill as a fertilizer distributor. Proceedings of IAMFE USA 1976, Iowa State University, Ames, USA, pp 101-107


“Flexiseeder”: A new modular approach to help improve correlation/cross-over of results between plot and field research and commercial agriculture, horticulture and viticulture

Authors:
- E.J. Stevens, S&N International Ltd, Governors Bay Road, RD1 Lyttelton, New Zealand, 8971, E-mail: stevensj@ihug.co.nz.
- T. Leuchovius, Swedish University of Agricultural Sciences, VPE/Fält Forsk, Uppsala, Sweden, E-mail: Torbjorn.Leuchovius@vpe.slu.se.
- T. Gaardløs, Bioforsk Arable Crops Division, Apelsvoll N-2849 Kapp, Norway, E-mail: Torkel.gaardløs@bioforsk.no.
- R. Zuerrer, Landwirtschaftsbetrieb Steilhus, Steilhus 5, CH 3182 Ueberstorf, Switzerland.
- M. Bakkegard, Bioforsk Arable Crops Division, Apelsvoll, N-2849 Kapp, Norway.

Summary (abstract)
The application, extension and delivery time to end users of research results can be substantially enhanced in cost effective ways through the systematic use of overlapping equipment components designed as modules. This is particularly so where they are suited equally to reduced and zero tillage as well as conventional agriculture and organic farming. Examples of and the history behind the evolution of the Flexiseeder multi-purpose modular approach (www.flexiseeder.com; equally suited to zero (ecotillage), reduced tillage and cultivated ground) are introduced and discussed. The Flexiseeder resulted from collaboration through IAMFE/IAU (Seed and Seed Drilling Technology Help Group: International Association for the Mechanization of Field Experiments / Global Institute and Agricultural University Internet Hub (IAU Trust)) over the past four years, among research and production workers located in New Zealand, Sweden, Norway, Switzerland and Australia. These Flexiseeder technologies have been placed in the public domain in the hope that they will provide a catalyst for follow-on projects which assist food production throughout the developing and developed world.

Acknowledgements
Flexiseeder is a voluntary global team effort in which the authors wish to gratefully acknowledge the combined inputs of the persons listed, both as individuals as well as the organizations, institutions, agencies and business entities which they are part of: Alan McCrostie, Anton Van Tongeren, Bengt Hallerström, Bill Griffin, Bo Sterk, Carl Westberg, Charlie Tana, Chris and Carol Roberts, Collin Hubbard, David Cathawood, Dean Harris, Douglas Fraser, Bodie Marchal, Erik Eire, Geoff Gray, George Hampron, Gerry Ovenden, Gilbert Ten Hove, Glen Fastier, Hans-Joachim Braun, Ian Close, Ian Prime, Jan Jönsson, Jock Baker, John de Ruiter, Keith Armstrong, Kenny Quartermain, Lars Byrdal Kjer, Lars Danielsson, Lex Jocelyn, Lindsay and Karen Thian, Lindsay Brooks, Malcolm and Dawson Warnin, Mark Forres ter, Marcin Mayer, Mats Andersson, Neild Stockdill, Noel Collins, Paul Collins, Paul Jarman, Paul Walls, Prof Egil Oyjord, Prof John Hampton, Richard Moody, Ross Hansen, ScanAgro a/s, Shane Maley, Soderberg & Haak, Steve Griffith, Tony Weeks, Trevor Roberts, Walter Roder, Wym and Michael Bauman. Peer review and mentor support by Prof John Hampton, Keith Armstrong and Sue Stevens is most appreciated as is the accountancy support provided for the group by Alan Brooks.

Introduction
New Zealand has many overlapping agro-ecologies, encompassing developing and developed production systems, between which a range of crop improvement technologies have for many years been successfully exchanged. Fodder oats provides a good example (Stevens et al., 2000; 2004). Similar principles have been applied to plot seeders. Frame and coulter assemblies on many early Oyjord plot seeders (Plate 1) and even later models (Plate 2) imported into New Zealand during the 1970s and 80s had to be modified and strengthened using locally manufactured arable field drill components. When knock-on knife tips (Manufactured in Australia and still readily available (www.bluepoint.com.au) These tips have been included in the range of Flexiseeder tips offered, combined with a special Flexiseeder
Field trial machinery and equipment

clear allowing them to be attached to 12 mm as well as heavier 5 tynes as part of the Flexiseeder coulter module) were fitted, resulting modifications made these drills “multi-purpose”: they became suitable for reduced tillage and light direct seeding under favourable conditions. In New Zealand and Australia, arable plot seed drill frames and coulter components have needed to be more robust than in Europe and North America, due to local conditions.

Additional multi-purpose plot seeder frames (Plate 3) were constructed locally during this era, to which Oyjord cell wheels and distributors were fitted. On these seeders, cut down local arable fertilizer (and at times additional seed) boxes were often fitted, in front of the standard Oyjord cell wheel and distributor. These multi-purpose seed drills served equally for the demands of research, early generation seed multiplication and small-scale farmer evaluations and demonstrations. From this equipment, excellent correlation / cross-over of results and tillage modules for cultivated land and light direct seeding were achieved for plot and field research and demonstration as well as commercial agriculture, horticulture and more recently, viticulture.

While most of these machines now have between 35 and 40 years of continuous use, farmer as well as researcher focus has moved from conventional arable agriculture to zero tillage under conditions that go well beyond the performance capabilities of these original drills. Consequently, much of this early equipment is in need of either being up-dated or replaced (Plate 4). This constitutes a major financial burden to programmes, for which affordable alternatives are being sought. These include modular alternatives introduced and described in this paper and companion papers presented at this conference by Leuchovius et al. (2008) and Fraser et al. (2008).

For the past four years, these perceived needs have been addressed voluntarily under IAMFE / IAU by a core global group of concerned scientists, technicians, farmers and engineers in Norway, Sweden, Switzerland, Australia and New Zealand, organized and co-ordinated by John Stevens and Torbjorn Leuchovius (Entitas represented by the Authors of this paper in Norway, Sweden and New Zealand each contributed between 60 and 70,000 US dollars; Switzerland (Private Farmer) contributed USD 18,000. Of the New Zealand component USD 50,000 comprises research and development costs borne by S&N International Ltd, directly associated with developing this project, hopefully to be recovered through future trading / consultancy surpluses). Modifications made in New Zealand to early Oyjord plot seeders and local fabrications to which Oyjord cell wheels and distributors were fitted, provided the group with a working example as well as a proven networking model for setting up and co-ordinating what has grown into the Flexiseeder project, placed in the public domain to help end users help themselves.

Besides building new machines, the aim of this project is also to help end-users re-cycle and up-grade existing equipment in effective and affordable ways. By design, parts for the Flexiseeder including the new deep-walled cell wheels, distributor components, electric drives, digital gearboxes and coulters also serve as spare parts and/or upgrades for early Oyjord seeders, to help extend their working lives.

In so doing, the Flexiseeder project fully acknowledges and pays sincere tribute to the application and longevity of these older technologies originally conceived and developed almost 50 years ago by Professor Oyjord and his team. At the same time, full acknowledgement is given to early designers, engineers and manufacturers of robust seed drills and other agricultural equipment in New Zealand, Australia and Scandinavia, dating back more than 100 years.

An invaluable legacy of concepts and experience has been given to modern agriculture which is still applicable, when re-interpreted and up-dated. This work is backed up with six technical papers listed in the References, also presented as posters at IAMFE 2008 and included in the proceedings.

Background

When early Oyjord plot drills were converted and other similar drills fabricated locally during the 70s and 80s, a range of interchangeable “knock on” tips were often used (Plate 5). These tips were developed in Australia during the same era for commercial agriculture. They are still available and used today. Depending on the tips used on the day of sowing, arable drills / plot seeders, besides serving for traditional cultivation, became suited to light reduced tillage and zero-tillage for grass, clover and/or brassica. Disc (Conner Shea and Duncan) and 12mm 5 tynes fitted with (Australian) knock-on tips (Duncan Till Seeder) were also used on these early seeders. In other instances, Oyjord cell wheels were mounted directly behind the regular tool boxes on small-scale farmer drills (Plate 6).

This type of overlap in equipment (modules) and logic facilitated researchers and farmers moving backward and forward between reduced tillage, light direct drilling and traditional cultivation in plot seeding and farmers fields much earlier than in other countries. This meant that research results often tended to be more directly applicable to farmer fields than elsewhere at the time, and resulting
farmer up-take of technologies was considered more rapid than otherwise expected.

Out of this experience grew the expectation by New Zealand researchers and farmers that farmer arable plot and seed drill technologies should be equally suited to (light) zero tillage and reduced tillage. As the demand for zero tillage has grown (especially over the past five to 10 years), this historical order of seeding priority has reversed, creating a substantial market demand for robust intermediate technology direct drills also able to be used for reduced tillage and cultivated ground. Meeting this change in demand has been pivotal in developing a vibrant multi-purpose direct seed drill design and manufacturing industry in New Zealand targeting 50 to 120 HP tractors (described and reviewed by Stevens et al. 2000 and 2004), selling into local and foreign markets. By the year 2000, these technologies were reported to already be in use in more than 25 countries including developed and developing economies.

By 2004 small-scale production models of these new generation New Zealand-based “eco / direct” drills had started to enter the research arena at home and abroad (Plate 7), as farmer models retro-fitted with specialized plot seeding equipment. (Following in reverse, the much earlier cycle of development triggered by the original Oyjord plot seeders reaching NZ through the IAMFE network and being modified, subsequently to suit local conditions). Experience and results gained from designing and using these initial prototype conversions was promising; highlighting the need for, and potential advantages of, formally developing a modular research-based approach to help improve the correlation and cross over of drill components as well as results between research and production. This prompted an intensive cycle of research and development over the past three and a half years under the IAMFE / IAU Seed and Seed Drilling Technology Group covering equipment for research, extension, demonstration and commercial use. Besides general production, this also includes early generation seed and variety maintenance, evaluation and demonstration in agriculture, horticulture and viticulture, and recreation and wildlife management.

Materials and methods
Design criteria applicable to multi-purpose plot seeders and other equipment for field experiments have been outlined by Leuchovius et al 2008 (additional details of selected components have been given by Fraser et al. 2008). While developing and testing protocols, it was noted that:

- New Zealand has many “overlapping” seed drill-
Results

Development of the Flexiseeder Project - Time line in brief

Year 2000

- The international potential of NZ direct drilling technologies suited equally to reduced tillage and traditional cultivation was reviewed and reported at the IAMFE, UK Congress (Stevens et al., 2000) (As an invited paper). In this article, particular mention was made of (i) locally developed technologies being used in more than 25 countries, including both developed and developing economies and of (ii) drills fitted with “laid back” 12 mm S tynes, with substantial under-exploited global potential. (Including, in developed and developing economies, hard soil not easily penetrated by existing seed drills, especially dry land ecologies where crop residue is either grazed or harvested. For these situations there is only limited simple / light weight / affordable technology available).
- IAMFE Seed and Seed Drilling Technology Help Group conceptualized at IAMFE 2000, including provision for developing an agronomy / plant breeding (end-user) group. (Open to end users of mechanized equipment for field experiments – agronomists and plant breeders, for example. See Plate 2, fodder oats being sown for Keith Armstrong’s project using Oyjord plot seeder, autumn 2008) out of which a successful fodder oat project subsequently emerged (K. W. Armstrong, pers. com., Oat Breeder, New Zealand Crop and Food Research Institute Ltd, Armstrong, 2008; www.fodderoats.net).

- The under-utilised global potential of drills with laid back 12 mm tynes was targeted and an outline of follow-up activities conceived, paving the way for the following.

Years 2001-04

- September 2001: SEMEC Trust, the New Zealand / Australia Branch of IAMFE formed in association with the New Zealand Seed Technology Institute, Lincoln University. (Institute sold into the private sector in 2003, after which the association with SEMEC ended in 2004).
- January 2004: IAU Trust (Global Institute and Agricultural University Internet Hub) formed under IAMFE as a global operational support umbrella for the activities of IAMFE Centre including its Branches.
- 2001 – 04: Taege tyne drills (www.taege.com) were targeted for assistance, fitted with 12 mm S tynes, laid back and fixed at 48 degrees and mounted on a rigid frame. Tynes were fitted with knife points. At the beginning of 2001, seven experimental units were identified with farmers at a pilot level. These units were field evaluated by Dr Stevens within New Zealand during 2001. Follow-up technical and other applied assistance was then provided (2002-04) under the umbrella of SEMEC to help refine and promote the upgraded design and use of these drills to help expand them into the local market. Approximately 300 “improved units” were manufactured and sold by mid 2004 including both farmer and vineyard drills (Plate 8). Of these drills, approximately 250 farmer units were sold and serviced through an ad hoc network of farmer help groups set up and co-ordinated by Stevens under SEMEC. Agronomy as well as drill support was provided. Progress was reported at IAMFE St Petersburg Congress (Stevens et al., 2004).
- June 2004: SLU (Swedish University of Agricultural Sciences) received (at the time of IAMFE 2004), a Taege multi-purpose vineyard tyne drill frame (shown in Plate 7). The frame was fitted with 12 mm S tynes and knife points. It was purchased from New Zealand and imported into Sweden for conversion into a plot seeder, by retro-fitting an Oyjord Cell wheel plus distributor, and a local fertilizer box brought forward from an older machine. The drill was set up to place fertilizer between and below the rows of seed, fed from this box directly into an additional row of tynes and knife tips mounted on a separate (additional) tool bar. This drill is now owned by, and working for the Ag Society of Stockholm/Uppsala. Torbjorn Leuchovius and Carl Westberg led this activity. John Stevens visited Uppsala after the IAMFE Conference to help receive, assemble and demonstrate the basic frame on this drill.
- July 2004: A working group was set up between Sweden and New Zealand to assist with (a) converting the Taege drill imported into Sweden and, subject to a favourable outcome, (b) go on and help identify and further develop follow-on initiatives, including expanding the core working group. At this time, a 1970’s “Tume” harrow manufactured in Finland with rotating tool bars (Plate 9) was donated to SEMEC by SLU, linked with the request that it form the basis of a new style of modular seed drill, suited equally for research, seed industry, extension, commercial farming, horticulture, viticulture, wild life reserves and recreational areas in developed and developing economies.
- November 2004: Contact made with Mistral (Agrofinal s.r.o. Slovakia). Agreement reached with then for the procurement of parts as required, at OEM prices, including seed metering and air delivery components.

IAMFE Denmark 2008
Years 2005-07

2005

- Research stations and farms searched throughout New Zealand for pre-1980s agricultural equipment which had stood the test of time under rugged field conditions, as a source of proven ideas lying within the public domain, applicable to the group’s concept of a “new generation” modular seeder for the global market. Key items located, included:
  - Old (late 1800s) well used horse drawn spring tyne harrows (two sets from different locations) with adjustable tool bars (Plate 10). Both had been used for many years under very rough conditions and survived, which provided useful design information for the Flexiseeder. This idea was combined with the Finnish harrow concept for the Flexiseeder rotating drawbar module.
  - Duncan offset discs with combined trailing and three-point linkage towing device, plus a variety of two-point linkage trailing ploughs, some converted from trailing models. When combined with the drag-link arms used on the Finnish tyne harrow, they provided inspiration for the Flexiseeder floating headstock – cum – drawbar module (Plate 11).
  - Numerous New Zealand 701 Duncan arable seed drills fitted with trailing coulters and interchangeable knock-on tips including hoe, knife (lucerne) and split Blackmore coulters, all sufficiently worn to prove that these technologies had been used to sow many thousands of hectares.
  - These tip assemblies have been integrated into a Flexiseeder module including a universal SG iron bolt-on cleat and a bolt-on knife tip designed and cast by the Project (Plate 5). This cleat, besides bolting on 12mm and other tynes, can also be welded onto hoe coulters. Knife tips are faced with Tungsten encrusted weld.
  - A number of Australian Conner Shea disc drills were located in Otago and the McKenzie Basin where they had worked for more than 35 years in particularly rough/stony conditions and survived after sowing thousands of hectares of native pasture with grass, clovers and herbs. They were also a successful drill for sowing arable forage, fodder and grain crops. While the fertilizer boxes of many of these drills had rusted out, seed boxes and disc assemblies were still fully serviceable. Particular note was taken of how well their disc assemblies had lasted, and that major wear points could easily and affordably be re-built using modern materials and technologies. These disc assemblies are heavier than what has been used historically on European plot seeders and have been up-dated and brought forward to the Flexiseeder (Plate 12).
  - Many simple three- and four-way springing systems were found on early horse-drawn gigs, carts and wagons (from the late 1800s and early 1900s) which allowed the cart frame / driver seat to remain relatively level, while the shafts and the wheel worked independently, on an opposing axis. This provided inspiration for the Flexiseeder tool bar suspension model – cum – universal carrier frame for plot and farmer seeders, sprayers, etc (Plate 13).
  - Finnish (Tume) harrow donated to SEMEC by SLU received in Christchurch from Sweden, transported free of cost from Europe by CB Norwood (Palmerston North, New Zealand) with the permission of Vaderstad (Sweden) who prepared and packed it free of cost after it had been delivered to their yard by Torbjorn Leuchovius. Transport to Christchurch from Palmerston North was paid by S&N International Ltd. (E.J. and S.J Stevens, Directors and major share holders).

Once in Christchurch, the harrow was circulated by John Stevens through SEMEC to a number of local engineers (including Taage Engineering Ltd) for quotations to supply (a) an up-dated head stock, including designing and fitting a floating three-point / two-point / trailing headstock; and then, based on field results (b) design and manufacture a stronger pilot seed drill frame / test bed using the combined concepts of a floating head stock and rotating tool bar. This was to be done in a way suitable for rugged New Zealand conditions while also applying globally, based on the wide international agro-ecological overlap New Zealand has. Technologies were to be equally suited to plot seeders as well as farm and other parallel uses including horticulture, viticulture, recreation and wildlife management.

Collin Hubbard, Lex Jocelyn and Kerry Quartermain (Hubbards Machinery Ltd) in Ashburton agreed to design and fit the required head stock, free of cost (Plate 9, right side). These modifications were then field tested in Canterbury and the McKenzie country by John Stevens. Field results were successful and on the basis of this, a Hubbard Flexiseeder “open-plan” test bed (Plate...
13, centre) was designed, constructed and field tested successfully across a wide range of agro-ecologies in the South and North Island of New Zealand. This product was paid for and evaluated by S&N International Ltd with assistance from SLU. On the basis of these results, SLU ordered a unit.

2006
- www.flexiseeder.com registered and put on line, hosted at SLU.
- SLU supplied with and open-plan Hubbard Flexi 110 Plot Seeder Frame which included adjustable 13 inch (metric unit required) bolt-on wheel module (Plate 14). The frame was designed for 175 cm normal working width. The four wheels were set to a tracking width of approx. 220 cm, thus leaving extra row distances between plots. It normally has two axles with 7 Suffolk shoe coulters each (14 coulters, row distance 12.5 cm) and, for drilling in spring, combined with a leading axle with 7 fertilizer knife coulters. All coulters are S-tyne mounted. The seeding system is a standard Oyjord cone with mechanical distribution (electrical spinner). The fertilizer application is done by a standard bin with free fall (gravity feed) to the coulters.
- Robert Zuerrer (Switzerland) ordered a 2.4m wide open plan Hubbard Farmer Flexi frame fitted with a Thian seed box (www.thianagri.co.nz). The frame was started by Hubbard using a scaled up version of the one supplied to Sweden, but not completed because meanwhile, the business had been sold and Colin Hubbard retired due to ill health. After completing the Flexi 110 Plot seeder for Sweden, the new owners (Hubbard Machinery (2005) Ltd) decided not to continue the line. The incomplete frame was therefore purchased by S&N International Ltd and moved to Thian Agricultural Industries (Southbridge) while the New Zealand part of the Flexiseeder project re-grouped.
- Drill components including the Thian Seed Box were drawn up in CAD by Chris Roberts as a basis for continuing the project once a suitable engineering base could be re-established. This was commissioned by S&N.
- Norway (Apelsvoll forskingscenter) joined the group and ordered a complete plot seeder, against very tight design restrictions of 150 plot widths and to which two Kincaid cones from USA and a Smallaire seed delivery system from Australia, and a Thian Fertilizer box was to be fitted. (Once delivered, the Kincaid cones were found to be incapable of dispensing the required range and volume of product, and therefore returned to New Zealand. Up-dated S&N Oyjord deep-lamellae cell wheels were developed and supplied as replacements – see comments under remainder of 2007 and 2008).
- A local foundry (The Casting Shop) and a pattern maker (Collins Patterns) were identified and included in the working group. Patterns and castings made for Flexiseeder tip assemblies and tyne holders (Plate 15) were commissioned by S&N.
- Manufacture of SEMEC rubber tyre rollers (Plate 16, www.roller.co.nz) started under S&N in support of the Flexiseeder Project. Rollers were designed and manufactured by Geoff Gray Limited of Christchurch in association with S&N International Ltd.

2007
- A prototype of the tool-bar carrier developed and field evaluated (Plate 13, centre, upper portion).
- A prototype of the “S&N Flexi Plot Seeder – Heavy Duty” was completed (Plate 17), exported to and evaluated by Norway. The frame unit was designed (using CAD) and manufactured jointly by Chris Roberts (Southbridge), Geoff Gray (Christchurch) and S&N International Ltd. Imported components included two Kincaid Cell wheels, Smallaire air delivery system, Zero Max Y2 gear boxes and Kongskilde tynes. Locally manufactured components that were outsourced included the Thian fertilizer box. (www.thianagri.co.nz and www.flexiseeder.com).
- Follow-up work on this machine, explained in detail by Leuchovius et al. (2008) included:
  - Kincaid cones replaced with an up-dated S&N Oyjord-type cell wheel cast with 23mm high lamellae.
  - Manometer fitted to Smallaire distribution system to quantify fan settings.
  - Distributor modified to prevent carry-over residual remaining within head.
  - Plastic cone machined and fitted into top of the air distributor head to reduce variation between outlets.
  - Three-point linkage mounts cut, shortened and re-welded to meet European standards.
  - Operator foot rests lowered to allow for “long Norwegian legs”.
- Manufacture and assembly of drills (excluding Thian Seed Boxes) was consolidated at Geoff Gray Ltd, to which was added the 3-1/4 hour applied input of John Stevens covering both seed drills and SEMEC rollers.
- A Farmall Flexi plot seeder conversion was designed and manufactured for Plant Research New Zealand. This product was paid for and evaluated by SLU. Up-range and volume of product, and therefore re-fitted. (Once delivered, the Kincaid cones were found to be incapable of dispensing the required range and volume of product, and therefore turned to New Zealand. Up-dated S&N Oyjord deep-lamellae cell wheels were developed and supplied as replacements – see comments under remainder of 2007 and 2008).
- A local foundry (The Casting Shop) and a pattern maker (Collins Patterns) were identified and included in the working group. Patterns and castings made for Flexiseeder tip assemblies and tyne holders (Plate 15) were commissioned by S&N.
- Manufacture of SEMEC rubber tyre rollers (Plate 16, www.roller.co.nz) started under S&N in support of the Flexiseeder Project. Rollers were designed and manufactured by Geoff Gray Limited of Christchurch in association with S&N International Ltd.

IAMFE Denmark 2008
Zealand Ltd (Plate 4), including modifying and direct coupling a 12 volt car dynamo as the motor driving directly, a reverse image of an Oyjord type distributor impellor, to allow for clockwise rather than counter clockwise revolution of the motor (see Leuchovius et al., 2008).

- A heavy duty Flexi seeder natural rubber seed hose was designed and manufactured as a special order / feature (Plate 15, lower right fitted to Farmall, and Plate 18, fitted to Swiss drill).
- Tyne mounts, tips and seed coulters were standardized through patterns and casting in SG iron including bolt-on knife and Suffolk shoe plus knock-on knife tips and multi-purpose locking cleat assemblies. Samples were sent to Norway and Sweden for evaluation on 12 mm tyne.
- A prototype of the S&N “open-plan” Farmer Flexi seeder (Plate 18) was developed, field tested and shipped to Switzerland (early 2008), including a carrier frame with spring mounts for the tool bar assembly plus an up-graded head stock compliant with European Standards. This was achieved in a way that would apply directly to open-plan plot drills as part of the Flexi seeder modular approach for improved correlation and cross over of components and planting results with research plot as well as other seeders.

2008 (Up to June)

- S&N deep lamellae Oyjord cell wheels (400 and 320 mm diameter) designed, patterns and core boxes commissioned, products cast in bronze, machined and supplied to Sweden (The aim of the MacTrac project has been to make a drill module for this cool carrier. It is a co-project between the Applied Field Research group at the Swedish University of Agricultural Sciences (SLU), Mapro Systems AB (producer of MacTrac) and the Agricultural Society of Halland (user of the drill). The main part of the component costs are paid by the end user while SLU and Mapro have taken development costs. Components provided by S&N were supplied at cost, and excluded research and development / pattern costs) and Norway respectively, with extended lamellae (23mm high), requiring new pattern making and casting techniques.
- Identified and tested ultra high density plastic bases for cell wheels, as a low friction alternative to bronze base.
- Designed and engineered reversible, bolt-on land wheel module (supplied to Sweden) able to be used either to manually drive cell wheels and/or the encoder for electric drives.
- Identified and tested affordable 7.5 to 1 and 15 to 1 reduction right angle drive worm driven gearboxes as an alternative to bevel gears for transferring power to a range of cell wheels and other mechanisms on plot and farmer equipment.
- Developed and pre-tested a digitally controlled stepper motor combination for powering cell wheels.
- Developed and pre-tested a permanently magnetized 12v motor and manual varior combina for driving Oyjord and other distributors.
- Modified and pre-tested as a pliable disc-coulter module heavier than European options using 12 mm S tyne to supply down pressure, to be used also for light direct drilling as well as arable seeding.
- Designed, commissioned patterns and cast ratchet self locking system for locating tool bars in various positions on the main frame and for moving internal support bars to give added flexibility of row and tyne spacing.
- Patterns commissioned, and replacement distributor impellors cast in brass and aluminium for Oyjord and other planters. Samples sent to Sweden / Norway for evaluation.

Other achievements included:

- A Swiss Farmer Flexi seeder (Plate 18), completed field tested at multiple locations in the South and North Islands of New Zealand and on the basis of results, was released into the New Zealand market, after which it was dismantled, thoroughly cleaned to meet phytosanitary requirements, and shipped to Switzerland as an demonstration machine. John Stevens will go to Switzerland after IAMFE 2008 to re-assemble this drill, then demonstrate and provide training for its operation.
- An improved bolt-on Flexi seeder Nihard knife shoe was designed, and patterns were commissioned and cast for field testing, as a cheaper alternative to the Flexi seeder knock-on knife tip (Plate 5, left).

Discussion and conclusions

Perceived advantages of these technologies over those already available include:

- A wide range of components have been developed which are suitable for being integrated into plot machine modules.
- The Taege drill design was more compact while the Flexi approach proved more useful.
- The overall goal of identifying farm machine components that can be used on plot machines will reduce costs and facilitate maintenance.
The module concept means that elements can be replaced by alternative components and still work together with other modules.

- Air distribution allows for much more flexibility in designing drills/fertilizers for tractors and various tool carriers. It is convenient not to be dependent on free fall of material during operation.

- A universal, stand-alone, driveline system for mechanical or step-motor drive of plot machines gives considerable freedom to use and to adopt plot machines for new demands like GPS monitor/control systems.

- The flexi drill frame with depth and tool bar axle angle setting provides a flexible base for using different seeding/fertilizing technologies as well as different row spacing and/or tool-bar separation and configuration when used in conjunction with the S&N Flexi tooth-lock system.

- The step-motor driveline can be further developed for use for spraying and for linear changed rates along the plot of seeds, fertilizers or liquids/chemicals.

Early modifications and subsequent use of Oyjord arable plot seeders in New Zealand provided a useful working example and model for our Flexiseeder Project. A number of useful modules have been developed and brought into production as a result. They target the manufacture and maintenance of affordable direct seeders which are modular, equally suited to reduced tillage and arable seeding, and have high correlation/cross-over of components (modules) and results between modern plots, field research and commercial agriculture, horticulture and viticulture. This includes all stages of the seed industry.

Global networks for out-of-season plant breeding and the seed trade can be usefully paralleled by seed drill development projects, particularly where conscious use is also made of agro-ecological overlap at the same time. Within this context, New Zealand can play a significant role in helping to develop and supply original technologies to the northern hemisphere, as well as back-up engineering and fabrication support.

Without the internet, it would not have been possible to set up, organize and run the Flexiseeder Project. Further development of engineering, evaluation, application and promotional aspects of this project will depend heavily on the concurrent development of internet support.

By placing Flexiseeder technologies in the public domain for all to use, backed up with the three inaugural papers presented at this international conference, the authors conclude that a useful catalyst has been provided allowing those wishing to apply these principles, to go forward under IAMFE / IAU and mobilize the necessary funding required to realise their goals. This covers both the developing and developed world, to help continue the good will started so many years ago by Prof Oyjord and his team. We wish people well in their endeavours and stand ready to help them where needed, to the extent possible within our limited resources.
References


Summary

J. Haldrup a/s has been producing plot harvesters since 1973, the year when the first Grass harvester was built. Now our program consists of Plot Combine Harvesters, Grass Harvester, Swath Mower, Self-propelled Maize Harvester, Mounted Harvesters and Tool Carriers.

Haldrup Plot Combine Harvester

The first Haldrup combine was built in 1985, since then the combine has gone through a major development phase and the program has been expanded to include a wider range of types.

All Haldrup Combine Harvesters are very strong machines incorporating feeding systems the same as a commercial combine. They are constructed according to the latest designs in order to obtain maximum capacity. These machines have a very limited numbers of belts, chains and lubrication points, so that lubrication, belt and chain tightening only have to be done once a year.

Our combine program exists nowadays of:

- 3-Strawwalker Combine Haldrup 640 (640 is the inside width)
- 4-Strawwalker Combine Haldrup 850 & 850 STOR
- 2 x 3-Strawwalker Haldrup TWIN Shaker
- Rotor Combine Haldrup SINGLE Rotor & TWIN Rotor

The Combine program is divided between traditional Harvesters and Rotor Harvesters.

Traditional Harvesters

The threshing procedure of our traditional harvesters: 640, 850 and TWIN Shaker is as follows:

- Our combines can be equipped with a 1.210, 1.510, 1.740, 2.045, 2.350 mm hydraulically operated head / platform, with provision for quick coupling and reversing rotation.
- A variable distance of between 500 or 900 mm is offered between fingers and feeder housing.
- A continuous supply of air for cleaning comes from a high-pressure blower. The air comes out
directly behind the fingers, from both sides of the cutting table and at the entrance of the

- Head / platform flotation is achieved with the assistance of a 0.75 l hydraulic accumulator responding to ground pressure from the cutting table, set at approximately 50 kg.
- Continuously variable adjustment of stubble height is provided from 50 - 500 mm by electro-hydraulically raising / lowering of the head / platform through a master control lever.
- The platform is mounted with a cutter bar, plus two straw dividers and ear lifters at every third finger, plus a straw guide at the right side. (One spare knife is supplied in the knife-box.)
- The reel is operated hydraulically with provision for continuously variable speed adjustment from 0 - 40 rpm. The distance between fingers is 150 mm. Reel height (raising and lowering) is controlled electro-hydraulically through a master control lever.

**Threshing drum**

- The threshing drum has a diameter of 450 mm for our Haldrup 640 and a width of 850 mm for our Haldrup 850 & 850 STOR, both with six rasp bars.
- The belt pulley allows threshing at 900 - 1,500 rpm, or 300 – 800 rpm while using an extra pulley and belt.
- Drum speed is regulated hydraulically from the driver’s seat.
- The concave area is 0.3 m² for the Haldrup 640 and 0.40 m² for the 850 with eleven concave bars. Three de-awning bars are included, also. The wire diameter is 11 mm and the concave wrap has a graduation of 90°.
- The concave can easily be removed from the right side without use of any tools.
- The bottom blower is powered through a belt pulley, which is can be regulated from the driver’s seat, to operate between 300 and 1,100 rpm.

**Sieve Box**

- The sieve box is fitted with an adjustable chaffer and bottom sieve. The opposed reciprocating action of the chaffers relative to the bottom sieve provides a thorough cleaning of the sieve and thus makes the combine completely free of vibrations. This ensures maximum accuracy of the weighing results. The total area of the sieve box is 1.92 m².

**Straw Walkers**

- Three straw walkers with a total area of 1.3 m² and length of 2 m.
- Four straw walkers with a total area of 1.7 m² and length of 2 m.

**Grain Tank**

- Tank capacities and special features:
  - Haldrup 640 tank capacity is 900 litres.
  - Haldrup 850 & 850 STOR tank capacity is 1,200 litres (possible to extend to 1,500 litres).
- Both models are fitted with hydraulic discharge auger, discharge height 3.2 m.

**TWIN Rotor Combine Harvester**

In 2005 we introduced our TWIN Rotor Combine, which is a combine based on axial flow threshing principles used in commercial machines.

Our TWIN Rotor machine is used for maize and rapeseed. With our TWIN machine we harvest 2 plots at one time, which provides us with a capacity of approx. 200 plots per hour. The working procedure is as follows:
2 Axial threshing cylinders, with a 450 mm. diameter, length of threshing unit 500 mm. separation unit 950 mm. Variable speed from 400 – 1,500 rpm. regulated from the driver’s seat.

Threshing unit: The concave wrap has a graduation of 100° degrees.
Separation unit: The concave wrap has a graduation of 90° degrees. The wire distance is 30/40 mm.

Two sieve boxes with adjustable Agri Broker Alfa CZ/4 chaffer and round holed bottom sieve each. The opposed reciprocating action of the chaffer relative to the bottom sieve provides a thorough cleaning of the sieve and makes the combine completely free of vibrations. That insures maximum accuracy of the weighing results. The total area is 2 x 1.4 m².

The opposed reciprocating action of the chaffer relative to the bottom sieve provides a thorough cleaning of the sieve and makes the combine completely free of vibrations. That insures maximum accuracy of the weighing results. The total area is 2 x 1.4 m².

TWIN Shaker
The latest novelty is stage two of a project which started in 2005 a traditional TWIN machine, at that time the machine wasn't totally separated. In the winter 07/08 we finished this project and now build a totally separated machine: The Haldrup TWIN Shaker.

The machine is built as follows:

TWIN Shaker
The latest novelty is stage two of a project which started in 2005 a traditional TWIN machine, at that time the machine wasn’t totally separated. In the winter 07/08 we finished this project and now build a totally separated machine: The Haldrup TWIN Shaker.

The machine is built as follows:

TWIN Shaker
The latest novelty is stage two of a project which started in 2005 a traditional TWIN machine, at that time the machine wasn’t totally separated. In the winter 07/08 we finished this project and now build a totally separated machine: The Haldrup TWIN Shaker.

The machine is built as follows:
Haldrup Grass Harvester

Since 1973 Haldrup has built Grass Harvesters, since then there have been sold almost 400 units all around the world. From the first machine to the machine which is here at the IAMFE symbolises the evolution the company Haldrup as well as the changes the mechanization has gone through. From simple cutting and weighing to direct analysis on the Grass Harvester.

The machine is mounted with a 1.510 mm. header, but can be delivered with a 1.230 mm. header.

Both headers have full width and large passage to the weighing hopper so the material will not be damaged – this is a great advantage when harvesting vegetables.

Our machine is equipped with double knives from ESM which are wear resisting and cuts everything. The knives are hydraulically operated with variable speed control from 800 – 1,400 rpm. Two strong springs to relieve the cutting table and reduce the ground pressure to about 50 kg.

Large crop dividers for separation of plots.

The reel is hydraulically driven with variable speed control 0-50 rpm. Reel diameter 1.000 mm. with 5 reel bars and 2 brushes for cleaning the knives. Lift above the fingers 0-400 mm.

Rotating brush to gather the material at one side to increase sample quantity. Especially an advantage when the crops aren’t so high.

Two different sizes of chopper: 140 or 270 mm. The chopper is delivered with hydraulically driven auger, and conveyor for transporting the sample to the platform. The quantity is regulated by the foot switch.

Our Grass Harvester is mounted with a Mettler IND 425 weighing system: Mettler IND 425 weighing display, rust, dust and waterproof according to IP65. RS232 data output. 1,200 litres weighing hopper on 4 bending weighing cells, of each 220 kg, which gives a capacity of 880 kg. Discharge to both sides and wind shields at each side to minimize the influence of wind on the weighing results.

There’s mounted a Lombardini 2204/T 2.2 litres turbo diesel engine, 42kW/2,600 rpm, at the back of the machine. Hydrostatic 4WD transmission with POCLAIN MSE03 and OMR200 steering motors. Optional there can be mounted a differential lock.

The Haldrup Grass Harvester can be mounted with cabin and NIRS for direct analysis of the harvested material. At present there has been built almost 400 Haldrup Grass Harvesters. The machine can also be adapted for the harvest of herbs.
The Haldrup Swath Mower

The first Swath Mower was produced in 1984, it is a user friendly machine with a small turning radius and large capacity, available with a 1.500, 1.750 and 2.000 mm. header.

The machine is standard delivered with 2 strong hydraulically rotating torpedoes. Optional are 2 extra torpedoes in front and 2 under the machine. This guarantees an efficient separation of the plots, even with the most vigorous crops. The torpedoes have continuously variable speed control from 0-50 rpm.

Just by removing 4 screws the knife is dismounted and the machine can be used for separation or as a tool carrier.

Like on the Grass Harvester we have mounted a Lombardini engine on the Swath Mower, here we use a 2204 2.2 litres diesel engine, which gives 30kW/2600 rpm. Also here there can be mounted a 4 wheel-drive.

Haldrup Maize Harvester

Haldrup is also producing Maize Harvester, both self-propelled and lift-mounted. Both machines are delivered with a Kemper Champion 1200 row independent chopper.

The self-propelled tractor unit with platform for driver and assistant, is powered by a Deutz BF4L 914 turbo diesel engine, 67kW, and 2-speed PTO-CLAIN wheel hub motor. A front lift is fitted with category II linkage, capacity 3.100 kg.

A hydraulically, rotary sampler with variable speed control from 0-60 rpm, which takes one sample per second at 60 rpm. A 600 Litres weighing hopper with 3 bending weighing cells, capacity 660 kg. A Mettler IND 425 weighing display, rust- dust and waterproof, according IP65. A very powerful blower with feeding auger. The blowing time for 100 kg silage is about 10 seconds and the casting length up to 6 m. Revolutions PTO 1.000 rpm. Power consumption during blowing approx. 50kW and during harvest 2-3kW.

The tractor unit can be used as a tool-carrier, outside the harvest season.
Our lift-mounted unit has the same rotary sampler and weighing hopper as the self-propelled, but the instead of the tractor unit an ordinary tractor is used, minimum demand is 100 hp.

Advantage is a lower investment, taking less space in the machine hall. Most research stations already have a tractor, which can be used for this purpose, so you’re only investing in a new sampling unit and a chopper.

The unit can delivered with wind-shield for the assistant, hydraulic unit on the sampler, so you’re not dependent on the hydraulics of the tractor.

The same sampling unit can also be adapted so it fits on a Unimog or Fendt Xylon.

**Haldrup Tool Carrier**

- Free height 800 – 1,200 mm.
- Chassis from high-strength steel
- Power transmission through chains
- Track width 2,200 – 3,500 mm.

**NIRS**

In 1998 Haldrup started a project together with the University of Braunschweig, Dr. Chr. Paul and Carl Zeiss Jena. The objective of the project was to make a direct analysis of the harvested material on the Haldrup Grass Harvester through Near Infra Red Spectroscopy. This was possible with the CORONA 45, which is adapted to operate on Combines etc. There has been produced a lot of prototypes, but now we can say that we have a system that works both for grass, grain and silage.

For grasses we work with a piston module, where the chopped grass is pressed in front of a window, the CORONA is measuring through the window in a pendulous movement to increase the measuring area.

For grain the method is as follows the CORONA hangs over a conveyor which transports the grain from the pre hopper to the weighing bucket.

The adjustment of existing tractors, both new and used ones, to Tool Carriers is something Haldrup has done since 1998.
Silage maize is measured in the flow from the chopper to the rotary sampler. The CORONA is placed in a drum, which is mounted on the Kemper chopper.

On all systems there’s built an external black and white reference.

The NIRS system can be delivered for our Plot Combine Harvester, Grass Harvester, Silage Maize Harvester and as stationary systems for grasses and grain as well.
Weighing Systems and Field Research Software - Possibilities and Deployment

Authors:
Mag. Alexander Aigner, Wintersteiger ag, 4910 Ried/I., Austria, Dimmelstrasse 9, www.wintersteiger.com, E-mail: Alexander.aigner@wintersteiger

Summary
Mobile weighing systems on plot combines are becoming more and more important. WINTERSTEIGER offers reliable and easy to use weighing systems together with a field PC (portable computer) and the appropriate software.

Article
WINTERSTEIGER offers amongst others, plot combines that fulfil all requirements for fast, 100% mix free harvesting, variety trials and seed increases. Mobile weighing systems on plot combines are becoming increasingly important, as they allow the collection of accurate and high quality data immediately after harvesting.

Automated collection of harvesting data covers the following parameters:
- Plot weight with maximum accuracy, up to a slope of 10%
- Moisture content of harvested crop
- Test weight

WINTERSTEIGER places great emphasis on developing and providing future-oriented solutions in the field of mobile data acquisition. Only state of the art systems are used in our harvesting machines, which have been specifically developed for agriculture research equipment. The system records the plot weight, percentage of grain moisture and test weight. The data collected is saved in the electronic field PC and printed out simultaneously on the field printer.

Data acquisition is carried out using an integrated weighing system. The measuring sensors determine the plot weight, test weight and moisture content. The built-in slope equalizer ensures maximum possible accuracy. The heart of the harvesting data acquisition system is a Windows compatible, hand-held PC. The harvesting data is stored and printed out simultaneously.

The following types of weighing systems manufactured by WINTERSTEIGER are commonly used:
- Harvest Master weighing system High Capacity Graingage
- Harvest Master weighing system
- Weighing system “High Capacity Graingage”
  Features
  - Single weigh bucket with two holding hoppers
  - FRS (define) Harvest Software
  - Grain level detection devices for strip harvest
  Advantages:
  - HM800 electronics with CAN eliminate bulky cables
  - Highly accurate, repeatable measurement of moisture and test weight
  - Weight measurements are compensated for movement of combine
  - Single set of calibrations increases accuracy over double bucket systems
  - Harvest two plots simultaneously
  - Ability to harvest strip trials without stopping the combine

Weighing system “Graingage”
Features:
- Three different sized moisture chambers available for low yield crops
- Windows Mobile based FRS Harvest software
- Grain level detection device for strip harvest

Advantages:
- HM800 electronics with CAN eliminate bulky cables

IAMFE Denmark 2008
Highly accurate, repeatable measurement of moisture and test weight

Weight measurement compensated for movement of combine

Ability to collect moisture and test weight on samples as small as 900 grams

Harvest strip trials or normal length plots without stopping the combine.

**Field PC “Allegro”**

The field PC Allegro has the following features:
- Full Color – TFT, Active Matrix
- MQ1178 Video Graphics accelerator for increased performance
- High screen contrast in all lighting conditions
- 320 x 240 pixel resolution
- Backlight … to screen and key pad (please confirm)
- 128 MB RAM / 512 MB
- Bluetooth
- WIN CE

The Allegro can be connected to the Allegro PC as follows:
- Docking station: works with USB
- Serial interface

In connection with the weighing systems, WINTERSTEIGER uses the new Field Research Software (FRS) on the Allegro. The software has the following options:
- Field map Import / Export Agrobase, ARM (define) etc.
- Field map with traits to collect data.
- Export of Data as csv file
- Touch Screen or function key to select the activity
- Display 2D field map with collected and empty plots
- Windows CE based Application, Win XP as next step
- Database with interface to exchange data
- Available languages (German, English, French, Spanish, Italian).

Figure 1. After the single high capacity grain gauge fills with grain, the EM grain sensor measures moisture and test weight and the load cells and slope and motion sensor measure plot weight. (Note: level detection is available for strip test plots).
Figure 2. Picture of the “GrainGage” weighing system.

Figure 3. Allegro with Field Research Software

Figure 4. Screen dump of the Field Research Software.

If you have any further question, please contact our company:
WINTERSTEIGER AG, 4910 Riedl., Austria, Dimmelstrasse 9
Tel.: +43 7752 919-0, Fax: +43 7752 919-57, seedmech@wintersteiger.at
www.wintersteiger.com
Abstract
According to the requirements of the cultivation pattern and agricultural techniques for planting peanut in the north area of China, a new combined peanut planter has been developed. It consists of plastic-film-cover, spraying herbicide system, applying seed and fertilizer and building a soil ridge on the film right above the seed row etc. The key parameters of the planter were analyzed. Performance test results in the fields show that working performance of the sample machine is excellent and can increase the peanut yield about 20%, labor productivity increased by 30 times and cost of production was reduced by 50%.

1. Introduction
In North of China, there are two main methods of peanut cultivation, interplanting and summer sowing after the winter wheat is harvested. In the lower altitude areas where the effective accumulated temperature between post-wheat-harvesting and before the latest harvesting time of peanut is enough for the growth of peanut. Post-wheat-harvest sowing (also called direct seeding) is applied. In this case, the techniques are not difficult and the mechanization can be easily applied. In the higher altitude areas, however, interplanting or planting peanut between wheat rows must be used. It is usually used as a way to fill the gaps between seedlings. Nevertheless, interplanting cannot be done easily using machines. The plastic-film-covered cultivation of summer sown peanut is beneficial in that it can be increase the temperature, protect soil moisture and keep a good physical and chemical condition of the soil. According to the requirements of the agricultural techniques a new combined peanut planter was developed and experiment were conducted in the fields using the sample machine.

2. Operation items
The combined machine has to complete many operations simultaneously to meet the agricultural technique requirements. The structure of the combined machine is shown in Fig1. The operation items include the following:
1. Leveling and compacting soil
2. Furrowing
3. Fill water in the furrows
4. Place seed
5. Covering soil to enhance seed/soil contact
6. Spraying pesticide
7. Laying plastic film
8. Covering soil on the film right above the seed row.

3. Planter design
3.1 Frame
The frame was designed with tubular steel elements that resisted the horizontal, vertical and torsional forces imparted on them by openers. The hitch points were designed according to the standard 3-point hitches of matched tractor. The levering soil roller was fixed on the front the frame. The device of laying plastic film and spreading soil device were fixed on the rear of the frame. The frame consists of two-section and the rear part can be winged up convenience for transport.
3.2 Leveling and compacting soil

Before sowing and laying plastic film, soil should be leveled and compacted. A roller was fixed in the front of the machine. The width of the roller is as same as that of covered plastic film (B = 48cm). It can break small soil block and level plot. At the same time it drives the seeds metering device. It can support the machine and control the depth of the soil interacting tools. In order to run freely the diameter of the roller should be subjected to below equation

\[ R \geq \frac{\omega_r + \omega_p}{Q \times f} \]

where \( \omega_r \) - the friction moment of the roller bear (N. m)
(\( \omega_p \) - the resistance moment of driving the meter device (N. m)
Q - the weight of roller (N)
\( f \) - the friction coefficient of the roller and soil

the test results are \( \omega_r + \omega_p = 3.34, Q = 254 \text{ N}, f = 0.2 \). \( R \geq 0.07 \text{ mm} \)

Considering the whole construction, \( R \) is 0.17m

3.3 Furrow openers and seed metering

The furrow opener is the specific device that creates the furrow into which the seed and water is placed and furrow depth can be adjusted (considering depth in relation to seed size, soil temperature, soil moisture, light requirements, etc). The furrow opener is narrow so cause less soil disturbance to the seed-bed, has a lower draft requirement and is more easily restrained or held in an effective working position. It has provision for adjustment (relative to the soil surface) to enable alteration of planting depth.

A precision seed meter of vertical plate type was fixed on the machine. The experimental results show that the optimum diameter of precision meter plate is 6.5mm at the 0.16m/s linear speed when planting small size peanut. The percent of single seed is 92% and zero seed is about 0.9%

3.4 Spraying system

The spraying system of the combined machine consists of herbicide box, assembly of nozzle etc. After sowing seed and before laying plastic film it is necessary to spread herbicide on the plot. The electronic controlled super-little spreading device was fixed in the middle of the machine and the herbicide box was mounted on the tractor. The switch is controlled by tractor driver. (If using herbicide coated film the spreading device can be removed.) The volume ratio of herbicide and water can be calculated by below equation.

\[ r = \frac{BVL}{1000Q} \]

Where
\( r \) - the volume ratio of herbicide and water
B - the operational width (m)
V - the working speed (m/s)
L - the amount of spraying herbicide arranged (liter/hm²)
Q - the spray nozzle flux (liter/h)
3.5 Laying plastic film and spreading soil device

The device of laying plastic film is consisted of plastic film dispenser, disc digger and film pressing wheel etc. In spreading the soil on the plastic film, it is necessary to spread the loose soil dense enough to prevent light but thick enough to enable the plumule to prick through the film without pushing it up. A soil transmitting basket is used in spreading the loose soil on the top of the plastic film for a more reliable.

3.6 Specifications of the sample machine

The sample machine is operated by 9~11kW tractor. The specifications of the planter include the following

1. Dimensions: 1880×960×730mm
2. Application of water from tank: 900~1800 l/ha
3. Gross weight: 108kg
4. Volume of water tank: 105 l
5. Operating speed: 3~5 km/h
6. Capacity: 0.2~0.3 hm²/h
7. Narrow spacing between rows: 28 cm
8. Wide spacing between rows: 48~50cm

4. Field experiment

4.1 The planting quality

Working performance of the sample machine was tested in the fields. The results of test in the experimental field were shown in Table 1.

Table 2. Pod yield and plant growth.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test plots</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Height of soil ridge on the plastic film/mm</td>
<td>52</td>
</tr>
<tr>
<td>Depth of planting/mm</td>
<td>42</td>
</tr>
<tr>
<td>Offset/mm</td>
<td>15</td>
</tr>
<tr>
<td>Row spacing/mm</td>
<td>280</td>
</tr>
<tr>
<td>Width of covering plastic film/mm</td>
<td>485</td>
</tr>
</tbody>
</table>

Table 1. The planting quality.

<table>
<thead>
<tr>
<th>Planting ways</th>
<th>pod yield/kg/hm²</th>
<th>main stem height/mm</th>
<th>side stem length/mm</th>
<th>all stems /number/plant</th>
<th>double seed ratio/%</th>
<th>The number of seeds per kilogram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine planting</td>
<td>4363.5</td>
<td>266</td>
<td>345</td>
<td>10.7</td>
<td>64.9</td>
<td>8440</td>
</tr>
<tr>
<td>Manual planting</td>
<td>420.5</td>
<td>256</td>
<td>339</td>
<td>10.5</td>
<td>58.4</td>
<td>890.9</td>
</tr>
</tbody>
</table>

4.1 Pod yield and plant growth

The pod yield and plant growth were tested in the experimental fields and it was compared with manual planting at the same fields. The test results were shown in Table 2.

5. Conclusion and recommendation

1. The new planting peanut technology can increase the peanut yield about 20% and save the seed used approximately 25% than traditional planting methods. It is necessary to develop the new technology by the machines because it is a very complex one. The combined machine developed according to the requirements of the new planting technology can accomplish all the working procedure. Satisfactory results have obtained through a lot of field experiments.

2. Single-seed sowing is applied with 225000-255000 plants per hectare. Then covered with plastic film and a ridge is built above the line of sowing row. The ridge is 50-60 mm high. It is necessary to spread the loose soil dense enough to prevent light but think enough to enable the plumule to prick through the film without pushing it up. Field experiment results showed that labor productivity increased by 30 times and cost of production was reduced by 50%.
3. When the moisture content of the upper 100 mm of the soil is less than 10 percent, the rate of water use during planting should be about 2600 l/ha for a regular growth, hence increasing yield of the crop.
4. The plastic-film-covered cultivation of sown peanut is beneficial in that it can increase the temperature, protect soil moisture and keep a good physical and chemical condition of the soil.
5. Peanut planter is a key implement for the mechanized sowing peanut. To achieve the reliable planter, considerable further mechanical research is required.

References
Flexiseeder air assisted delivery and distribution module: An overview including technical specifications  Flexi Technical Note - 003

Authors:
G.T Small, Smallaire Pty Ltd, 170 Golf Course Road, Horsham Victoria, Australia. www.smallaire.com.au
N.B. (Jock) Baker, Smallaire Pty Ltd, 170 Golf Course Road, Horsham Victoria, Australia. www.smallaire.com.au
E. J. Stevens, S&N International Ltd, Governors Bay Road, RD1 Lyttelton, New Zealand, 8971, E-mail: stevensj@i hug.co.nz,
T. Leuchovius, Swedish University of Agricultural Sciences, VPE/Fält Forsk, Uppsala, Sweden.
T. Gaardloes, Bioforsk Arable Crops Division, Apelsvoll, N-2849 Kapp, Norway.
M. Bakkegard, Bioforsk Arable Crops Division, Apelsvoll, N-2849 Kapp, Norway.

Summary
Air assisted delivery and distribution systems are more versatile for integration into plot seeders than gravity feed and mechanical distribution and delivery systems. This applies to a wide range of particulates when open-plan coulter layouts are used to improve residue passage during zero tillage and reduced tillage as well as for close row spacing on cultivated ground. It is a key component for upgrading older seeders in affordable and efficient ways to the multi-purpose Flexiseeder system, without substantially re-designing and re-building the original chassis. Likewise, it applies when you wish to broadcast fertilizers or other dry, granular materials, and also for operating at wider working widths than plot trials, including commercial agricultural and other operations. Smallaire, an Australian company already supplying large scale commercial agriculture, joined the Flexiseeder Project two years ago to help develop and supply “scaled down” air delivery and distribution equipment in modular form, for small and medium-sized farm, horticulture, viticulture and plot seeders. These modules are introduced and described in this technical note, including technical specifications.

Acknowledgements
Flexiseeder is a voluntary global team effort in which the authors wish to gratefully acknowledge the combined inputs of the persons listed, both as individuals as well as the organizations, institutions, agencies and business entities which they are part of; Adrian Russell, Bengt Hallerström, Carl Westberg, Charlie Tana, Chrissy Gibson, Chris Roberts, David Cashwood, Erik Eke, Geoff Gray, George Hampton, Gerry Ovenden, Ian Close, Jan Jönsson, Lars Byrdal Kjaer, Lars Danielsson, Lindsay Thian, Mats Andersson, Mike Flanagan, Noel Collins, Prof Egl Oyjord, ScanAgro a/s, Shane Maley, Söderberg & Haak, Steve Griffith, Trevor Roberts. Peer review and mentor support by Prof John Hampton, Keith Armstrong and Sue Stevens is most appreciated as is the accountancy support provided for the group by Alan Brooks.

Introduction
Air delivery and distribution systems have been used for many years on commercial agricultural seeders and broadcasters, powered either by PTO or (increasingly) hydraulic or electric motors. Historically, these units have been “broadacre” (suited to more than 3m sowing width), unaffordable for plot seeders compared with gravity / mechanical distribution, too bulky (over specified) to accommodate on compact plot seeder frames, and (the fan) too noisy for plot seeder operator safety and comfort.

Originally (1970s and 80s) air distribution systems were inherently less reliable than the original Oyjord distributor / gravity feed system both in their distribution patterns and clean out. A coefficient of variation (CV) of 5% can be achieved with the best mechanical distributors and with individual fluted feeders. A CV of up to 15% can often be acceptable where row distances are moderate - up to 25 cm. In these cases, the crop is often able to compensate almost all of this variation. Such high CVs are not acceptable with narrow row spacing, and in small plots.

The design and manufacture of air delivery systems has improved substantially over the past 20 years, particularly their distributor heads. With modern well designed and manufactured equipment CVs of between 3-15% can be expected on level / flat.
ground, depending on how the equipment is managed / materials sown / sowing (application) rates etc. The design of some distributor heads have been reported to be more successful than others, in respect of clean-out functions plus the evenness and repeatability of product partitioning between distributor ports. In all cases, for research work it is important to check / calibrate machines (as you would a spray rig) using the actual product being sown, while running the machine as it is going to be used (Kumar and Divaker Durairaj, 2000).

The performance of even the best equipment can vary substantially over a relatively small range of operating / operator conditions. Once a satisfactory range for operation has been determined, it is important to stay within this range, particularly where there are requirements to minimize CVs. Performance drops off very quickly as equipment is moved from flat to sloping / undulating ground and / or if it is overloaded, as with mechanical distributors of the type used on many plot seeders (Oyjord, for example).

The spatial design of traditional integrated air units made it virtually impossible to routinely set up and run dual delivery and distribution systems in parallel, as required for interfacing two separate / independent cell wheels used for metering seed and fertilizer / different particulates independently of each other. Over the past year however, by using assistance provided by Smallaire coupled with additional strategic input from Norway, Sweden and New Zealand viable solutions have been found under the Flexiseeder project which are both affordable and efficient for use on plot seeders and other small to medium scale equipment. As a result, a special purpose high pressure blower, a new style venturi system and self cleaning distribution heads were developed, and with the assistance of Norway, Sweden and New Zealand refined to the point of proving them to be an accurate and efficient system module under level conditions, for research as well as other small-scale and medium-scale uses. Chris Roberts in New Zealand was contracted under the Flexiseeder Project to draft these components in CAD for Smallaire. It remains for self levelling devices to be developed and incorporated.

**Background**

Smallaire P/L - air movement specialists of Horsham Australia have been designing, developing and manufacturing fans and other air seeder components for 30 years, supplying a number of air seeder manufacturers in Australia and globally. Their core products cover ventures, primary heads, secondary heads, splitters, blowers, riser pipes plus a range of other components and accessories. They also custom make practically any thing to do with air assisted farm machinery. A photo-composite of the factory is presented in Plate 1.

Over the years Smallaire have developed a computer program that calculates the optimum pipe sizes for any machine module which they design and fabricate, allowing the resulting device to function at its optimum working capability without seed damage. During the past three decades they have built up a vast pool of knowledge and experience in fitting out machines from plot seeders to 80 foot air seeders. Smallaire is one of the largest seeder component manufacturers in Australia.

During December of 2005, Smallaire was approached by, and agreed to work with the Flexiseeder Project to help develop and supply air system modules for plot seeders and other small to medium scale equipment. As a result, a special purpose high pressure blower, a new style venturi system and self cleaning distribution heads were developed, and with the assistance of Norway, Sweden and New Zealand refined to the point of proving them to be an accurate and efficient system module under level conditions, for research as well as other small-scale and medium-scale uses. Chris Roberts in New Zealand was contracted under the Flexiseeder Project to draft these components in CAD for Smallaire. It remains for self levelling devices to be developed and incorporated.

Plate 1. Photo-composite of Smallaire factory and key facilities.
During 2007, the New Zealand section of the Flexiseeder project identified and moved ahead with Skellerup Industries Ltd in Christchurch to produce a standard Flexiseeder line of thick walled (9 mm wall x 28 mm ID) natural rubber seed hose according to European specifications. This was essential to withstand the intense vibration of S tyne coulters on Flexiseeders (their key feature in producing a fine tilth under hard conditions, as an ideal seed bed) while direct seeding into hard ground, under conditions where all other traditional sources / types of flexible air and other hose had failed.

Module components

High Pressure Blowers

The 19 and 22 series notation refers to the diameter (in inches / imperial measure) of the impeller. There are several different impeller combinations for each size. So far, blowers used on Flexi-plot seeders have been of the 19 series type with straight blades and a three inch (75 mm) outlet. Normally these units are capable of servicing 30 x 32 mm distributor ports (outlets). On the Norway Flexi-plot seeder it services 24 distributor ports. While this may be considered “over kill” both Flexiseeder and Smale prefer

Smallaire components - 19 series blower (150 mm and 75 mm outlet)

Smallaire components including venturi( lower right) – note slim line of blower on plot machine – centre tap blower has 150 mm outlet while the others have 75 mm outlets.
S&N heavy-duty natural rubber seed hose, made in New Zealand – released after drill sent to Norway.

Main features of Smallaire high pressure blowers include:
- Strong pressed steel casing and well balanced aluminium fan;
- Easily mounted in any of a number of positions;
- Mesh guard inlet (after-market diversion kit available to deflect intake away from operator);
- Quiet – particularly so when diversion kit fitted;
- Magnetic rev pick up bracket;
- Durable powder coated finish;
- Choice of hydraulic, belt or petrol / diesel drives;
- Custom built to suit specific needs – components documented in CAD for repeat supply / consistent product specifications; and
- Manometer (60 mbar) adaption for calibration and repeat settings – developed by Norway.

Three examples of larger machines fitted with Smallaire technologies which overlap with the Flexiseeder modules. Note the hydraulic drive on fans. The two machines on the left, built by Smale (www.smale.com.au) in Australia are fitted with 22 series blowers and the Horwood Bagshaw (www.horwoodbagshaw.com.au) machine on right is fitted with a 19 series blower. Both have 150 mm blower outlets.

Plate 2. Air Module components.
The Smallaire computerised program can be used to determine the correct sizes of hoses, primary and secondary heads and also the correct fan and venturi or pressurised box system.

This computer program takes the guess work out of design / up-grades. It is a key factor contributing to trouble free systems with seeders working at their optimum air speed to minimize blockages, limit seed bounce, and reduce pipe wear.

Field usage and up-grades

Norway

Test data generated by Norway using their Smallaire system is presented in Tables 1 and 2. Two problems were encountered initially with distributor heads; (i) poor clean out and (ii) un-even distribution between ports. Two modified distributors were provided free of cost by Smallaire as replacements (shown in Plate 1). These were installed and re-tested. Clean out was improved by the new design, but variation in delivery between individual distributor ports was still unacceptable. A plastic cone (shown in Plate 1) was machined and inserted with excellent results, developed around concepts for distributor modifications / operation suggested by Kumar and Divaker Durairaj (2000). By using this modification, acceptable CVs of 10% and less (down to 3.7%) were recorded. Results are given in Table 2.

Sample size, seed / particulate size and density plus air pressure are but a few of the variables known to impact significantly on the performance of air distribution systems including distributor heads. Although it cannot be explained at present, there seem to be an optimal rotational position for the distributor in its location on top of the riser pipe. A number of positions should therefore be tested while setting up and adjusting the system. Modified heads which clean out combined with the use of plastic cone inserts are recommended. More work is required to evaluate and if necessary modify the air riser line and distributor head for use on sloping ground, steeper than 10 to 15 degrees. It is important that individual machines are regularly calibrated for samples / materials being sown. For this, the manometer fitted (0 to 60 mbar) proved invaluable as a simple, affordable and reliable adjunct for quantifying the operating speed of the fan in terms of delivery air pressure in the system.

Diffuser cups / cyclone relief vents may be needed to prevent seed bounce within the row. This has yet to be established. Besides the Smallaire diffusers, an additional source has been identified on-line at www.d-cupdiffuser.com, yet to be evaluated.

Sweden

Good progress made in Norway during 2007 for upgrading their air delivery system prompted Sweden to adopt the same system for its MacTrac project. The object of the Swedish project is to make a drill module for the MacTrac tool carrier. It is a co-project between the Applied Field Research group at the Swedish University of Agricultural Sciences (SLU), Mapro Systems AB (producer of MacTrac) and the Agricultural Society of Halland (user of the drill).
The main part of the component costs are paid by the end user while SLU and Mapro have taken development costs. Besides the Flexiseeder – Smallaire module, portion feeder, digital drive, and tool bar / tyne / tip modules are being used from the New Zealand / Australia arm of the Flexiseeder project.

New Zealand

At the same time as the Flexiseeder – Smallaire module was being evaluated and up-graded, after-market modifications were being made in Christchurch, to a “Farmall” plot seeder built locally seven years ago. It included a locally manufactured Oyjord-type mechanical distributor. The distributor was powered by a 1/8 hp, 12 volt electric motor of the type used in car heaters. While operating adequately for small- and medium-sized seeds and small plots, it proved unreliable for larger seeds and longer plots (20 m). The motor was under powered. It ran at 2,800 RPM while not under load, but lacked torque to maintain speed settings under load. It was replaced with a modified ¼ hp vehicle generator (dynamo) used as a motor, direct coupled to an inverse fabrication of the traditional Oyjord impellor. Powered in this way, at full speed, the distributor ran at 800 rpm. Six settings were built into a control system, equally spaced between 400 and 800 RPM using a resistor.

Data generated using this equipment while sowing 250 gm samples (presented in Table 3) was comparable to that obtained in Norway while evaluating the Flexiseeder – Smallaire module fitted with the replacement head (full clean out model used on flat ground) and no cone inserted. Once the cone was inserted, the Smallaire distributor gave more even distribution. Attempting to use this mechanical distributor to sow 500 gms of wheat seed while traveling at 3 km/hr appeared to be too fast, judging from the higher CVs. This emphasized the need for operators to routinely calibrate their equipment before sowing using representative samples and adjust sowing and impellor speeds accordingly.

Recommended operating speeds for impellors of this type vary between; 600 rpm for big beans, 750 rpm for soya and peas and 900 rpm for grain, oilseeds, etc. Fertilizer requires at least 900 rpm. Therefore ranges of working speeds are required between 500 and 1500 rpm or at some fixed speeds 600/750/900/1050/1200. These impellor speeds cannot be obtained using the above modification. The project is therefore working with John Brooks Ltd to develop and promote an alternative 12 / 24 volt drive of 180 / 250 watt and 1500 and 2000 rpm capacity coupled with an in-line mechanical variator (see Fraser et.al. 2008 and Plate 5).

Plate 3. MacTrac (www.mactrac.se ) use of Flexiseeder - Smallaire module on its new prototype modular plot seeder, under construction.

Plate 4. Mechanical distributor with direct-coupled electric drive and replaceable slip ring inserts for altering number of rows sown. Equipment owned by Plant Research (NZ) Ltd (www.plantresearchnz.co.nz).
Discussion and conclusions

Cross over with Farmer Equipment

There is much to be gained from linking farm machinery with research equipment through overlapping modules. Thirty years of experience gained by Smallaire, mostly on large sized machines was put to good use under the Flexiseeder Project by its members in designing and providing a range of equipment air modules suitable for plot seeders and other small-scale users, thereby confirming the role which farm machinery can have in helping research. In return, Smallaire gained experience and other input from the plot seeder project which helped them further refine their products, not only for small but also “broad acre” machines.

Natural rubber seed hose identified for the project by S&N International as a suitable replacement for a much stiffer plastic hose used on farm machines also proved successful for plot seeders. Because of this overlap, hose was purchased in bulk for both classes of machines, with considerable savings. This reduced the cost of purchasing hose for plot seeders by 75% compared with purchasing this same material otherwise.

Air Distribution Systems

Significant advances were made in the adaptation, evaluation and use of air distribution systems on plot seeders, including (i) minimizing the risk for residues left in the system, (ii) using over-sized blower for silent operation with enough spare capacity, (iii) and design, manufacture and use of slim, exchangeable, distributor heads with a range of outlet ports. By using air compared with gravity feed, the transport time for product from cell wheel to coulter is very short - fractions of a second. By using air, operator(s) and equipment can be placed in any of a number of positions on seeders without concern for low spots in hoses, etc.

Mechanical Distribution Systems

The historic use of vehicle dynamos for driving mechanical distributors was revisited and evaluated. On the basis of this, more versatile electrically driven / direct coupled 12 / 24 volt option was identified for driving the impellors using modern technologies which cost approximately the same amount installed. By having more accurate seed and fertilizer distribution to your coulters, higher germination rates may...
be expected. With air systems users must take care to plumb the system so there are no dead patches and remain aware of the potential risk of seed bounce at the soil – coulter interface which is able to be eliminated using micro cyclone “add-ons”.

**Comparative Evaluation of Distribution Systems**

Based on the observed CVs of seed delivered through each port on distributors under the conditions tested, the performance of mechanical distribution systems and of the Smallaire system fitted with a self cleaning distributor were comparable, provided they are operated within their limitations for loading and slope. Air delivery was superior where a Norwegian cone was fitted to the self cleaning Smallaire distributor. The importance of operators regularly calibrating and adjusting their systems as they use them is emphasised.

**Common Problems**

The need remains to design and incorporate self levelling devices on hilly / sloping land for both systems.

**Where Next?**

We have not explored so far, whether there is something to be gained by adding electrically driven mechanical impellors (of the kind described by Fraser et al. 2008) into the Smallaire and other air distributor heads used under very hilly conditions (especially if the slope is more than 15 degrees).

**References**


<table>
<thead>
<tr>
<th>Material</th>
<th>Air Pressure</th>
<th>Delivery Time</th>
<th>Distributor Head</th>
<th>Terrain</th>
<th>Unit</th>
<th>Coulter Number</th>
<th>Delivery of Seed per Coulter</th>
<th>Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>15</td>
<td>20</td>
<td>Old Rear</td>
<td>0</td>
<td>gms</td>
<td>17.4</td>
<td>19.83</td>
<td>23.5</td>
</tr>
<tr>
<td>Wheat</td>
<td>18</td>
<td>20</td>
<td>New Rear</td>
<td>0</td>
<td>gms</td>
<td>20.10</td>
<td>21.87</td>
<td>23.9</td>
</tr>
<tr>
<td>Wheat</td>
<td>15</td>
<td>20</td>
<td>New Rear</td>
<td>0</td>
<td>gms</td>
<td>26.72</td>
<td>22.52</td>
<td>23.73</td>
</tr>
<tr>
<td>Wheat</td>
<td>22</td>
<td>15</td>
<td>New Front</td>
<td>0</td>
<td>gms</td>
<td>24.88</td>
<td>23.94</td>
<td>24.65</td>
</tr>
<tr>
<td>Barley</td>
<td>20</td>
<td>20</td>
<td>New Front</td>
<td>0</td>
<td>gms</td>
<td>24.66</td>
<td>24.12</td>
<td>27.46</td>
</tr>
<tr>
<td>Barley</td>
<td>22</td>
<td>15</td>
<td>New Front</td>
<td>0</td>
<td>gms</td>
<td>26.49</td>
<td>21.65</td>
<td>25.34</td>
</tr>
<tr>
<td>Barley</td>
<td>18</td>
<td>20</td>
<td>New Front</td>
<td>0</td>
<td>gms</td>
<td>27.73</td>
<td>24.88</td>
<td>29.2</td>
</tr>
</tbody>
</table>

* Horizontal machine = 0 degrees

<table>
<thead>
<tr>
<th>TDT</th>
<th>MED</th>
<th>CV%</th>
</tr>
</thead>
<tbody>
<tr>
<td>193.30</td>
<td>201.70</td>
<td>223.83</td>
</tr>
<tr>
<td>Material</td>
<td>Air Pressure</td>
<td>Distance (m)</td>
</tr>
<tr>
<td>----------</td>
<td>--------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Wheat</td>
<td>18 20</td>
<td>Normal</td>
</tr>
<tr>
<td>Wheat</td>
<td>16 20</td>
<td>Normal</td>
</tr>
<tr>
<td>Wheat</td>
<td>18 20</td>
<td>Normal</td>
</tr>
<tr>
<td>Wheat</td>
<td>16 20</td>
<td>Normal</td>
</tr>
<tr>
<td>Wheat</td>
<td>16 20</td>
<td>Normal</td>
</tr>
<tr>
<td>Wheat</td>
<td>16 20</td>
<td>Normal</td>
</tr>
<tr>
<td>Wheat</td>
<td>18 20</td>
<td>Normal</td>
</tr>
<tr>
<td>Wheat</td>
<td>16 20</td>
<td>Normal</td>
</tr>
<tr>
<td>Wheat</td>
<td>16 20</td>
<td>Normal</td>
</tr>
<tr>
<td>Wheat</td>
<td>18 20</td>
<td>Normal</td>
</tr>
<tr>
<td>Wheat</td>
<td>16 20</td>
<td>Normal</td>
</tr>
<tr>
<td>Wheat</td>
<td>16 20</td>
<td>Normal</td>
</tr>
<tr>
<td>Wheat</td>
<td>18 20</td>
<td>Normal</td>
</tr>
<tr>
<td>Wheat</td>
<td>16 20</td>
<td>Normal</td>
</tr>
<tr>
<td>Wheat</td>
<td>16 20</td>
<td>Normal</td>
</tr>
<tr>
<td>Wheat</td>
<td>16 20</td>
<td>10 deg</td>
</tr>
<tr>
<td>Wheat</td>
<td>16 20</td>
<td>15 deg</td>
</tr>
</tbody>
</table>

*Harvest height = 20 cm
1 Core sampled

Table 2: Distribution of seed. Flockwood Air Delivery. Part B. Test of variations in seed delivery relative to position of distributor head (crop type: rice area, sown 15.03.09)
Summary (Abstract)

Drive systems are a pivotal component of plot and farm seeders as well as many other pieces of agricultural equipment. Drive modules which can be easily adapted, adopted and shared across a wide range of equipment, both for research and production, have considerable application for increasing efficiency and saving costs without compromising quality. This technical note introduces and provides technical specifications for two new Flexiseeder drive modules released at this conference, a digital gearbox and an electrically powered, "vari-speed" mechanical drive, developed jointly by John Brooks, S&N International, SLU and BACD under the Flexiseeder Project, (www.flexiseeder.com). A voluntary user-group project of the Seed and Seed Drilling Technology Help Group: International Association for the Mechanization of Field Experiments / Global Institute and Agricultural University Internet Hub (IAU Trust) and launched for use into the public domain.
FLEXISEEDER "CONTINUOUS-RUN" SEED AND FERTILIZER MODULES FOR SMALL-SCALE USERS

Flexi Technical Note - 002

Summary (Abstract)
Small-scale continuous-run seed and fertilizer modules are an essential adjunct to cell wheels on plot drills, used also for metering and applying other particulates. For these technologies, there are excellent opportunities for cross-over with commercial systems, to develop multi-purpose affordable and efficient modules. Thian Agri joined the Flexiseeder project (www.flexiseeder.com), a voluntary user-group project of the Seed and Seed Drilling Technology Help Group: International Association for the Mechanization of Field Experiments / Global Institute and Agricultural University Internet Hub (IAU Trust) two years ago and since then by working together with S&N International, SLU and BACD, has contributed two modules to the Flexiseeder project, as described in this technical note. These modules are easily and simply incorporated into a wide range of custom built small-scale gravity fed boxes, hoppers and/or air delivery systems, as well as Oyjord-type distributors. They match up well with the Thian gearbox, Zero Max Y2 gearbox (with torque delimiting attached) and probably, after further programming and testing, with the Brooks-S&N digital gearbox and the Brooks-S&N electric "variable-speed" unit fitted with an Oyjord-S&N impeller. Individual seeders and other componentry are available commercially, because they are already registered and part of a larger commercial operation, they could not be put into the public domain.
Summary (Abstract)
Air assisted delivery and distribution systems are more versatile than gravity feed and mechanical distribution and delivery systems for integration into plot seeders. This applies to a wide range of particulates when open-plan coulter layouts are used to improve residue passage during zero tillage and reduced tillage, as well as for close row spacing on cultivated ground. This is a key component for upgrading older seeders to the multipurpose Flexiseeder system, without the costs of substantially re-designing and re-building the original chassis. It also applies for broadcasting fertilizers or other dry, granular materials, and for greater working widths. Smallaire, an Australian company already supplying large scale commercial agriculture, joined the Flexiseeder Project (www.flexiseeder.com). A voluntary user-group project of the Seed and Seed Drilling Technology Help Group: International Association for the Mechanization of Field Experiments / Global Institute and Agricultural University Internet Hub (IAU Trust) two years ago and began working with S&N International, SLU and BACD to develop and supply “scaled down” air delivery and distribution equipment in modular form, for small and medium-sized seeders. These modules, including technical specifications, are introduced and described in this technical note. Components are available commercially, because they are already registered and part of a larger commercial operation, they could not be put into the public domain.
Air assisted delivery and distribution systems are more versatile than gravity feed and mechanical distribution and delivery systems for integration into plot seeders. This applies to a wide range of particulates when open-plan coulter layouts are used to improve residue passage during zero tillage and reduced tillage, as well as for close row spacing on cultivated ground. This is a key component for upgrading older seeders to the multipurpose Flexiseeder system, without the costs of substantially re-designing and re-building the original chassis. It also applies for broadcasting fertilizers or other dry, granular materials, and for greater working widths. Smallaire, an Australian company already supplying large scale commercial agriculture, joined the Flexiseeder Project (www.flexiseeder.com), a voluntary user-group project of the Seed and Seed Drilling Technology Help Group: International Association for the Mechanization of Field Experiments / Global Institute and Agricultural University Internet Hub (IAU Trust) two years ago and began working with S&N International, SLU (Swedish University of Agricultural Sciences (SLU), VPE/Fält Forsk, Uppsala, Sweden), and BACD (Bioforsk Arable Crops Division, Apelsvoll, N-2849 Kapp, Norway), to develop and supply “scaled down” air delivery and distribution equipment in modular form, for small and medium-sized seeders. These modules, including technical specifications, are introduced and described in this technical note. Components are available commercially, because they are already registered and part of a larger commercial operation, they could not be put into the public domain.
Summary (Abstract)
Hundreds of Oyjord and “Oyjord-like” cell wheels and mechanical distributors remain in use globally, some more than 40 years old. Spare parts, new units and upgrades are included. These include cell wheels of different sizes and lamellae spacing cast with different numbers, as well as deeper than normal lamellae, (suited to metering larger than normal seeds / fertilizer and other particles / sizes of samples) and distributor impellers of clockwise and counter-clockwise rotation. Such specialized units have been fabricated at additional cost rather than being cast routinely, for want of improved pattern making and casting ideas and procedures as developed recently under the Flexiseeder Project (www.flexiseeder.com). A voluntary user-group project of the Seed and Seed Drilling Technology Help Group: International Association for the Mechanization of Field Experiments / Global Institute and Agricultural University Internet Hub (IAU Trust) by S&N International Ltd in association with SLU (Swedish University of Agricultural Sciences, VPE/Fält Forsk, Uppsala, Sweden), BACD (Bioforsk Arable Crops Division, Apelsvoll, N-2849 Kapp, Norway), The Casting Shop, Collins Patterns and Geoff Gray Ltd. These improved Flexiseeder technologies including an improved cell wheel / portion feeder assembly are introduced and described in this technical note together with details of two modern hard-wearing, low-friction materials that are being used in combination with traditional materials to improve efficiency and to reduce costs. These technologies have been put into the public domain.
Summary (Abstract)
Conceptualizing and designing frame modules within strict dimensional and weight limitations is the most challenging part of building multi-purpose plot seeders that are equally suited to zero tillage, reduced tillage and cultivated ground. Because this is a relatively new area of application, there is only limited history and accumulated experience to draw on, mainly from scaled down versions of farmer / horticulture / viticulture machines which seldom meet the immediate dictates of plot seeders and have to be modified / re-built to suit individual needs. This is time consuming and expensive. To save costs and increase efficiency a two-way cross-over modular approach has been developed by the Flexiseeder Project (www.flexiseeder.com). A voluntary user-group project of the Seed and Seed Drilling Technology Help Group: International Association for the Mechanization of Field Experiments / Global Institute and Agricultural University Internet Hub (IAU Trust), under the combined leadership of S&N International Ltd, SLU (Swedish University of Agricultural Sciences (SLU), VPE/FÅlt Forsk, Uppsala, Sweden) and BACD (Bioforsk Arable Crops Division, Agelsvoll, N-2849 Kapp, Norway) which (a) takes on board relevant technologies from large-scale commercial production lines and (b) systematically matches these with specialized research components / modules in ways that are interchangeable and reciprocal. It is upon this underlying philosophy that the applied Flexiseeder Project is built. Practical examples are introduced and described in this technical note. Resulting developments have been put into the public domain.
REFERENCES


