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

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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 (eco-tillage), 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.

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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

cleat allowing them to be attached to 12 mm as well as heavier S 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 distributors. 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 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 (Entites 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 USD18,000. 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 S tyne coulters 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 to10 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 N Z through the IAMFE network and being modified, subsequently to suit local conditions). Experience and results gained from designing and using these initial proto-type 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 drilling agro-ecological analogues around the world including Europe; the former Soviet Union, Scandinavia, North, Central and South America, Australia, Africa, Mediterranean and Asia, covering developed and developing economies. Through out these areas, a growing demand was noted for small-scale multi-purpose "eco" seed drills/plot seeders designed primarily for zero tillage, but also suited to reduced tillage and traditional cultivation. These incorporated technologies also apply to other small and medium-scale, field research and farming equipment; sprayers for example.
- New Zealand has for many years been a major southern counterpart in numerous successful North-South and East-West global plant breeding / early generation and commercial seed industry networks, including out-of-season nurseries. The country was also noted to be a major global supplier of commercial seed and other agricultural, horticulture and viticulture technologies, reinforcing the group's notion of overlapping agro-ecologies.
- Started in 2000, a New Zealand fodder oat project initiated under IFERD / SEMEC Trust (SEMEC, the New Zealand and Australian Branch of IAMFE was launched in New Zealand in 2001 in association with the New Zealand Seed Technology Institute Lincoln University, to up-date and expand the mandate and charter of IFERD (International Foundation for Emergency Relief and Development) formed in 1991) went on to spawn first an FAO and then a follow-on NZ Aid Project (www.fodderoats.net).
- Based on, and in support of these observations, the New Zealand / Australia arm of the Flexiseeder project was conceived, developed and co-ordinated voluntarily under SEMEC/IAU by S&N International Ltd along agro-ecological lines, to help support and further develop such North-South and East-West linkages, both in developed and developing economies.
- Out of respect for what Prof Egil Oyjord and his team have contributed in the past, resulting Flexiseeder technologies have been placed in the public domain, to help keep that goodwill alive under IAMFE and IAU, and provide a catalyst for future projects so that all may continue to benefit. Besides hardware and matching software, members of the group agree to provide, on payment, technical consultancy support. It is beyond the financial resources of the group to provide this assistance free of cost.

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, autum 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-utilized 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 manufacture 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.

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 Taege 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 wild life 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 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 forskingssenter) 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.rollers.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 proto-type 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 3/4 time 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 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 Flexiseeder natural rubber seed hose was designed and manufacture 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 mult-purpose locking cleat assemblies. Samples were sent to Norway and Sweden for evaluation on 12 mm tynes.
- A prototype of the S&N "open-plan" Farmer Flexiseeder (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 Flexiseeder 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)
Developments described in detail by Leuchovius et al. (2008) and Fraser et al. (2008).
- 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 tool carrier. It is a co-project between the Applied Field Research group at the Swedish University af Agricultural Sciences (SLU) , Mapro Systems AB (producer of MacTrac) and the Agricultural Soceity 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 variator combination for driving Oyjord and other distributors.
- Modified and pre-tested an arable 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 Flexiseeder (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 ex-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 Flexiseeder Nihard knife shoe was designed, and patterns were commissioned and cast for field testing, as a cheaper alternative to the Flexiseeder 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

Armstrong, K.W. 2008. "Benefiting from NZ aid".The Press, Christchurch, New Zealand, Friday May 6, 2008.

Fraser, D.S., E.J. Stevens, T. Leuchovius, L.P. Brooks, T. Gaardlos, M. Bakkegard. 2008. Flexiseeder drive modules: An overview including technical specifications. *Flexi Technical Note - 001*. Proceedings of IAMFE Denmark 2008. AgroTech, Århus, Denmark.

Leuchovius, T., E.J. Stevens, D.S. Fraser, C.D. Roberts, T. Gaardlos, M. Bakkegard. 2008. Plot machine modules: More flexibility and lower costs. The Flexiseeder Approach. Proceedings of IAMFE Congress 2008, AgroTech, Århus, Denmark.

Small, G.T., N.B. (Jock) Baker, E.J. Stevens, T. Leuchovius, T. Gaardlos, M. Bakkegard. 2008. Flexiseeder air assisted delivery and distribution module: An overview including technical specifications. *Flexi Technical Note - 003*. Proceedings of IAMFE Denmark 2008. AgroTech, Århus, Denmark.

Stevens E. J., C. J. Baker, M. Mayer, M. J. Hill. 2000. International potential of NZ direct drilling technologies for grassland experimentation. Aspects of Applied Biology 61, 2000. IAMFE/AAB UK 2000. The 11th International Conference and Exhibition on Mechanization of Field Experiments. pp. 269-278.

Stevens, E.J., D. S.C. Wright, D. Pariyar, K.K. Shrestha, P.B. Munakarmi, C.K. Mistra, D. Muhammad, J. Han. 2000. The importance of oats in resource-poor environments. Proceedings of the 6th International Oat Conference, Christchurch New Zealand, November 2000. Pp. 74.

Stevens, E. J., K W Armstrong, H.J. Bezar, W. B. Griffin and J. G. Hampton. 2004. Chapter II - Fodder Oats: An Overview. Fodder Oats: a world overview. Edited by J M Suttie and S G Reynolds. Plant Production and Protection Series No. 33. Food and Agricultural Organisation of the United Nations, Rome. ISBN 92-5-105243-3.

Stevens, E. J., P. K. Jarman, P. J. Clarke, J. G. Hampton. 2004. One drill for all establishment systems – is it possible? Proceedings of the 12th international conference on mechanization of field experiments (IAMFE Russia 2004). IAMFE, St. Petersburg, Russia.

Stevens, E.J., T. Leuchovius, T. Gaardlos, I. Close, N.D. Collins, G. Gray. 2008. Flexiseeder seed and fertilizer coulter module: An overview including technical specifications. *Flexi Technical Note - 004.* Proceedings of IAMFE Denmark 2008. AgroTech, Århus, Denmark.

Stevens, E.J., T. Leuchovius, T. Gaardlos, N.D. Collins, I. J. Close, G.M. Gray. 2008. Flexiseeder cell wheel and distributor module: An overview including technical specifications. *Flexi Technical Note - 005*. Proceedings of IAMFE Denmark 2008. AgroTech, Århus, Denmark.

Stevens, E.J., T. Leuchovius, T. Gaardlos, C.D. Roberts, G. M. Gray, L.P Thian. 2008. Flexiseeder frame module: An overview including technical specifications. *Flexi Technical Note - 006*. Proceedings of IAMFE Denmark 2008. AgroTech, Århus, Denmark.

Thian, L.P., E.J. Stevens, T. Leuchovius, T. Gaardlos, K.I. Thian, M. Bakkegard. 2008. Flexiseeder "continuous-run" seed and fertilizer modules for small-scale users: An overview including technical specifications. *Flexi Technical Note - 002.* Proceedings of IAMFE Denmark 2008. AgroTech, Århus, Denmark.