FLEXISEEDER AIR ASSISTED DELIVERY AND DISTRIBUTION MODULE: AN OVERVIEW INCLUDING TECHNICAL SPECIFICATIONS

Flexi Technical Note - 003

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SUMMARY (ABSTRACT)

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 up-grading 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.

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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 5-15% 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-scale equipment, reported in this technical note.* This technical note is one of six listed in the attachments prepared as technical background to Leuchovius et.al. (2008) and Stevens et al. (2008)[7].

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

[7] Covering the evolution and development of modular components of the Flexiseeder project, under the IAMFE / IAU Seed and Seed Drilling Help Group formed at IAMFE 2004 in St Petersburg.

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.

Plate 1. Photo-composite of Smallaire factory and key facilities.

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.

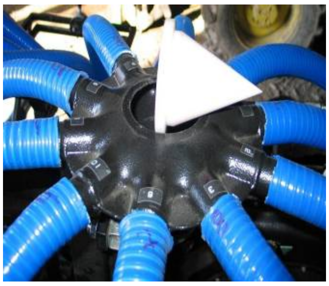
During 2007, the New Zealand section of the Flexiseeder project identified and moved ahead with Skellerup Industries Ltd in Christchurch to produce a standard Flexiseeder line of thick walled (9 mm wall x 28 mm ID) natural rubber seed hose according to European specifications. This was essential to withstand 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

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

Smallaire components including venturii(lower right) – note slim line of blower on plot machine – centre top 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



Norway Flexi-Plot Machine – modified distributer insert (Norway Cone), manometer *and free-flow distributor*

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.

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 32mm 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 to have excess air capacity so that the blower can be run at a slower (and quieter) speed. The 19 series straight bladed blower with a six inch (150 mm) outlet is capable of feeding up to 75 x 32 mm ports. The 22 series turbo blower fitted with six inch outlet shown below (Plate 3) and above in Plate 2 (lower left, Smale equipment) can supply enough air for 130 x 32 mm ports.

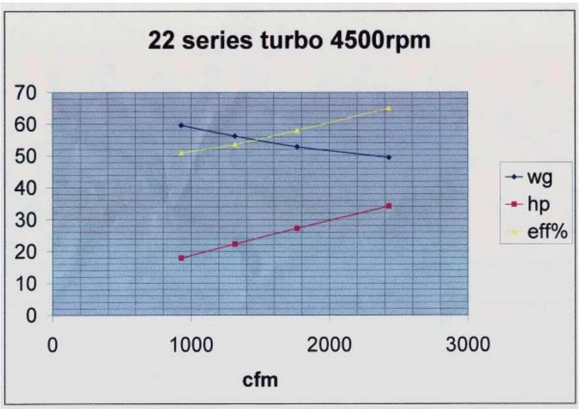


Plate 3. Example of the efficiency and performance of one of Smallaire's custom designed blowers (22 series turbo 4500 rpm).

Note:

cfm - 1 cubic foot / minute (cfm) = 28.316 846 999 liter/minute

hp - 1 horsepower [international] = 0.745 699 87 kilowatt

wg - 1 Water Column [inch] = 249.088 908 33 pascal (0.5-0.6 wg approximately equal to 15 Pa)

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.

Computer Programme

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 distributer 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 distributer 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

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

Good progress made in Norway during 2007 for up-grading 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 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. 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.

Before – note slip ring insert for altering number of rows sown

After – note slide for dropping motor away from distributor housing to change slip rings easily.

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).

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 distributor 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 5. Flexiseeder Brooks-S&N mechanical vari-speed module including two impellor blocks, one cast in bronze and the other aluminium.

Wheat 500 gms Coulter	Delivery of Seed (gms) per Coulter x Variation				Wheat 250 gms Coulter	Delivery of Seed (gms) per Coulter x Variation			
	Rep 1	Rep 2	Rep 3	Rep 4		Rep 1	Rep 2	Rep 3	Rep 4
1	84	86	75	80	1	38	34	39	36
2	70	72	61	64	2	31	35	33	36
3	69	67	65	67	3	36	36	34	33
4	63	56	55	54	4	33	32	31	33
5	66	46	61	61	5	33	34	33	33
6	46	54	47	47	6	26	26	26	28
7	59	50	57	57	7	31	32	30	30
8	55	53	50	50	8	30	29	31	28
Total	512	484	471	480	Total	258	258	257	257
CV%	17.7	22.2	15.0	16.0	CV%	11.5	10.3	11.6	9.9

Table 3 . Distribution of 500 and 250 gm samples of wheat sown with Farmall tractor at approximately 3 km/hr over 20m plot length. Data supplied 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-scale 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).

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Table 1. Distribution of Seed - Flexiseeder Air Delivery Module: Part I - Test of variation in grain delivery between ports (22.02.2008)

Material	Air Pressure	Delivery Time	Distributor Head		Terrain	Unit	**Coulter Number x Delivery of Seed per Coulter x Variation**												
	Millibars	Sec	Type	Unit	Deg*	Gram	1	2	3	4	5	6	7	8	9	10	TOT	MED	CV%
Wheat	15	20	Old	Rear	0	gms	17.4	19.83	23.5	17.36	26.08	24.82	19.5	22.64	31.61	31	233.74	23.37	21.9
						%	-26	-15	1	-26	12	6	-17	-3	35	33			
Wheat	18	20	New	Rear	0	gms	20.16	21.87	23.9	21.8	29.2	27.06	20.65	26.09	29.28	30.9	250.91	25.09	15.7
						%	-20	-13	-5	-13	16	8	-18	4	17	23			
Wheat	18	20	New	Rear	0	gms	20.72	22.95	23.73	20.06	28.4	29.3	19.32	27.23	27.63	32.12	251.46	25.15	17.5
						%	-18	-9	-6	-20	13	17	-23	8	10	28			
Wheat	22	15	New	Front	0	gms	24.68	23.94	24.65	23.33	26.36	25.72	24.79	25.04	27.97	23.76	250.24	25.02	5.5
						%	-1	-4	-1	-7	5	3	-1	0	12	-5			
Wheat	22	15	New	Front	15	gms	17.78	19.4	19.56	24.32	33.59	23.22	27.27	27.01	26.17	30.42	248.74	24.87	20.3
						%	-29	-22	-21	-2	35	-7	10	9	5	22			
Barley	20	20	New	Rear	0	gms	24.86	24.12	27.46	21.36	28.17	27.16	22.18	23.46	27.51	30.1	256.38	25.64	11.1
						%	-3	-6	7	-17	10	6	-13	-8	7	17			
Barley	24	20	New	Rear	0	gms	21.51	23.14	25.59	21.72	28.72	26.72	21.28	24.51	26.48	27.02	246.69	24.67	10.7
						%	-13	-6	4	-12	16	8	-14	-1	7	10			
Barley	22	15	New	Rear	0	gms	20.46	21.65	25.34	21.33	27.48	27.44	20.95	23.83	28.67	29.92	247.07	24.71	14.3
						%	-17	-12	3	-14	11	11	-15	-4	16	21			
Barley	18	20	New	Front	0	gms	27.73	24.88	29.2	25.01	22.44	29.86	20.02	22.59	24.96	20.68	247.37	24.74	13.7
						%	12	1	18	1	-9	21	-19	-9	1	-16			
							195.30	201.78	222.93	196.29	250.44	241.30	195.96	222.4	250.28	255.92			

* Horizontal machine = 0 degrees

Table 2. Distribution of Seed - Flexiseeder Air Delivery: Part II - Test of variation in grain delivery relative to position of distributor head (new type) on riser pipe (11.03.2008)

Material	Air Pressure	Delivery Time	Distributor Head		Terrain	Collection	Unit	**Coulter Number x Delivery of Seed per Coulter x Variation**												
	Millibars	Sec	Rotation	Unit	Deg*	Position	Gram	1	2	3	4	5	6	7	8	9	10	TOT	MED	CV%
Wheat	18	20	Normal	Rear	0	Coulter	gms	20.68	23.39	25.58	20.02	27.9	27.32	23.82	27.71	26.25	30.24	252.91	25.29	13.0
							%	-18	-8	1	-21	10	8	-6	10	4	20			
Wheat	18	20	Normal	Rear	0	Coulter	gms	21.42	23.2	23.35	20.4	28.3	27.91	22.16	26.04	27.56	29.04	249.38	24.94	13.0
Wheat	18	20	Normal	Rear	0	Coulter	gms	21.84	23.1	23.90	20.56	28.67	26.58	22.58	26.37	26.96	28.58	249.14	24.91	12.0
							%	-12	-7	-4	-17	15	7	-9	6	8	15			
Wheat	18	20	Normal	Rear	0	Distributor	gms	23.79	24.02	25.33	22.35	27.91	25.62	22.46	25.44	23.4	29.49	249.81	24.98	9.2
							%	-5	-4	1	-11	12	3	-10	2	-6	18			
Wheat	18	20	Normal	Rear	0	Distributor	gms	22.65	23.52	24.58	22.05	26.41	25.86	25.08	25.59	26.12	28.64	250.5	25.05	7.8
							%	-10	-6	-2	-12	5	3	0	2	4	14			
Wheat	18	20	Normal	Rear	0	Distributor	gms	22.35	22.9	24.19	23.69	25.25	27.11	23.24	25.01	27.46	28.62	249.82	24.98	8.5
							%	-11	-8	-3	-5	1	9	-7	0	10	15			
Wheat	18	20	90 deg	Rear	0	Distributor	gms	21.94	21.23	22.85	25.2	24.07	23.89	26.93	27.23	28.28	27.4	249.02	24.90	10.0
							%	-12	-15	-8	1	-3	-4	8	9	14	10			
Wheat	18	20	90 deg	Rear	0	Distributor	gms	25.44	22.4	24.71	24.8	26.8	22.95	25.56	25.91	25.31	25.87	249.75	24.97	5.4
							%	2	-10	-1	-1	7	-8	2	4	1	4			
Wheat	18	20	90 deg	Rear	0	Distributor	gms	24.98	23.19	21.22	24.62	25.67	23.18	26.99	28.85	26.71	24.05	249.46	24.94	8.9
							%	0	-7	-15	-1	3	-7	8	16	7	-4			
Wheat	18	20	180 deg	Rear	0	Distributor	gms	25.38	26.02	25.02	25.97	22.83	22.51	24.93	26.69	25.59	24.46	249.4	24.94	5.4
							%	2	4	0	4	-8	-10	0	7	3	-2			
Wheat	18	20	180 deg	Rear	0	Distributor	gms	26.51	23.74	23.03	24.82	24.9	25.5	24.73	27.08	24.16	25.4	249.87	24.99	4.9
							%	6	-5	-8	-1	0	2	-1	8	-3	2			
Wheat	18	20	180 deg	Rear	0	Distributor	gms	25.17	23.03	25.24	25.18	24.76	25.36	26.72	24.77	26	24.23	250.46	25.05	3.9
							%	0	-8	1	1	-1	1	7	-1	4	-3			

Wheat	18	20	180 deg[1]	Rear	0	Distributor	gms	24.68	24.34	24.83	27.2	24.53	24.7	26.88	26.48	23.56	24.38	251.58	25.158	4.9
							%	-2	-3	-1	8	-2	-2	7	5	-6	-3			
Wheat	18	20	180 deg[1]	Rear	0	Distributor	gms	23.94	25.05	23.62	26.39	25.39	24.33	25.7	25.18	25.98	25.93	251.51	25.151	3.7
							%	-5	0	-6	5	1	-3	2	0	3	3			
Wheat	18	20	180 deg[1]	Rear	0	Distributor	gms	23.53	23.25	23.66	26.91	23.95	23.95	26.05	26.45	27.03	26.93	251.71	25.171	6.4
							%	-7	-8	-6	7	-5	-5	3	5	7	7			
Wheat	12	20	180 deg[1]	Rear	0	Distributor	gms	25.56	23.92	21.31	27.4	25.86	20.87	27.03	26.33	27.6	23.32	249.2	24.92	9.8
							%	3	-4	-14	10	4	-16	8	6	11	-6			
* Horizontal machine = 0 degrees																				
[1] Cone inserted								225.19	214.94	212.64	233.29	224.69	213.35	234.59	237.74	231.94	224.57			