

Silage Inoculant Product Manual for:



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Overview

Fibre Technology refers to a portfolio of silage additives....Sila-Bac® brand inoculants 11CFT, 11GFT, 11AFT...developed by DuPont Pioneer to deliver improved fibre digestibility in corn silage, grass/cereal and alfalfa silage, respectfully. These products (U.S. Patent #7799551) each contain a novel, proprietary strain of *Lactobacillus buchneri* along with additional homofermentative *Lactobacillus* strains unique to the crop-specific fermentation demands of each of these crops.

The strain of *Lactobacillus buchneri* found in Fibre Technology (FT) products was discovered by DuPont Pioneer microbiologists and advanced through product testing for the ability to produce specific enzymes during the silage fermentation process. This strain is unique from all other *Lactobacillus buchneri* on the market with the capability of producing fibre-modifying enzymes (ferulate and acetyl esterase) as it grows in the silage mass. These enzymes modify the cell wall lignin complex allowing faster fibre digestion by rumen bacteria. Production of fibre-modifying enzymes by Pioneer's inoculant bacteria is a cost-effective and more efficient alternative to the purchase of stabilized, commercial enzyme additives.

The *Lactobacillus buchneri* in Fibre Technology products is a heterofermentative strain which produces a broad spectrum of volatile fatty acids during silage fermentation. This results in a fermentation profile proven to substantially decrease the growth of detrimental yeast and mold species responsible for silage spoilage. The *Lactobacillus buchneri* is coupled with specific homo fermentative *Lactobacillus* strains unique to each type of silage crop. The inclusion of homo fermentative strains improves fermentation efficiency (e.g. rate of pH decline) and established conditions ideal for the growth of the enzyme-producing *Lactobacillus buchneri*.

Silage treated with Fibre Technology products should be allowed to ferment a minimum of 60 days prior to opening to allow the *Lactobacillus buchneri* strain adequate time to produce enzymes and other fermentation end-products resulting in improved fibre digestibility and aerobic stability. Improving forage digestibility and palatability/consistency allows for higher forage inclusion rates resulting in ration savings from reduced grain and protein supplementation.

These products are available only in water-soluble formulations to facilitate the distribution of these bacteria throughout the intended crop. They are a safe, biological approach to improving the nutrition quality of the silage by increasing fibre digestibility and aerobic stability without the use of caustic acid or expensive feed-grade enzymes.

Fibre Technology products deliver: 1) fermentation efficiency, 2) a significant reduction of spoilage organisms for improved aerobic stability with less heating in the feedbunk and 3) improved fibre digestibility. These combined benefits make the Fibre Technology portfolio of products from Pioneer one of the most important technological advances in silage-making in the last several decades.

Frequently Asked Questions

Q: What value do Fibre Technology (FT) products deliver to livestock producers?

A: FT products delivers multiple benefits:

1. Increased NDFD (neutral detergent fibre digestibility) by an average of four percentage points
2. Crop-specific, “front-end” fermentation to speed pH decline and reduce shrink
3. Reduced shrink and improved bunklife of the silage face during “feedout”

Q: What is Neutral Detergent Fibre?

A: Neutral detergent fibre (NDF) is essentially the plant cell wall composed of cellulose, hemicellulose, lignin and small amounts of protein. These polymers, along with small amounts of other components such as acetyl and phenolic groups, are organized into complex, three-dimensional structures that are neither uniform nor completely described for different plants or cell wall structures. Neutral detergent fibre is a heterogeneous material defined by both its physical and chemical properties.

Q: Is NDF the same in all plants?

A: The basic components of all plant NDF are similar, cellulose and hemicellulose polysaccharides and lignin. The major differences are found in the hemicellulose fraction which is composed of different sugars in grasses (including corn and cereals) and legumes. Additionally, it appears that the lignin in the grasses contain significant amounts of ferulic acid while the lignin in legumes contain much smaller amounts. It is believed that ferulic acid is responsible for linking the polysaccharides to lignin or cross-linking the polysaccharides to each other.

Q: How do Fibre Technology products increase NDF digestibility?

A: The *Lactobacillus buchneri* strain in FT products produces specific esterase enzymes (ferulate and acetyl esterase) that release fibre polysaccharides from the lignin backbone. Decoupling polysaccharides from the lignin alters the three-dimensional structure increasing access to the polysaccharides by rumen bacteria resulting in more rapid fibre digestibility. Lignin is not degraded so levels in the forage remain the same and fibre fragility does not seem to be significantly reduced. Additionally, greater degradation of the polysaccharide fraction is observed due to the removal of digestion inhibiting acetyl groups bound to the sugar components.

Q: Are FT products as effective on legumes as grasses given they contain less ferulic acid?

A: Although the *Lactobacillus buchneri* strain in FT products produce esterase specific for ferulic acid, it does have minor activity on other phenolic constituents that cross-link lignin to fibre polysaccharides. Even though the activity is minor and occurs as a slow rate, time is the key factor in the response. The relative activity of these enzymes is measured in minutes. The ensiling period occurs over days and months giving ample time for the enzymes to exhibit their activity. This is the reason it is recommended that silage be ensiled for 60 days prior to feeding. Sufficient time is required for the enzymes to carry out the hydrolysis of the cross-linking components.

Q: Is the same *Lactobacillus buchneri* strain found in all FT products?

A: Yes, *Lactobacillus buchneri* strain PTA-6138 is found in all Sila-Bac® brand FT products. The additional strains found in each of the specific FT products are different and unique to the ensiling characteristics of each crop-type.

Q: Can the different FT products be used interchangeably across crops?

A: Although the same esterase-producing strain is included in the entire FT product line, each FT product has been specifically formulated with additional bacteria to perform optimally in a specific crop. The additional bacteria strains insure better fermentation of the specific forage and help to set up the ideal environment for the growth and proliferation of the *Lactobacillus buchneri* strain. Growth and proliferation of the *Lactobacillus buchneri* strain maximizes the amount and efficacy of the esterase enzymes produced in the silage.

Q: What is the advantage of improved fibre digestibility?

A: Improved NDFD increases the energy density of the forage and drives more rumen microbial protein production to help lower ration costs by reducing supplemental concentrate or protein needs. Improved NDFD can result in improved intakes, increased feed efficiency and provide opportunity for higher forage inclusion rates to improve rumen health and more economically support milk production and/or body condition.

Q: What will be the expected visible, on-farm effects of feeding FT silages?

- A: Feeding FT silage can result in one or more of the following:
- » Improved income over feed cost (IOFC) by reducing supplemental concentrate and protein needs. See FT “Feeding Considerations” for help in guidelines for balancing rations containing FT silages.
 - » Reduced silage heating (similar to Sila-Bac brand 11C33 and 11G22) and much improved over inoculants that do not contain *Lactobacillus buchneri* strains
 - » Improved feed efficiency due to enhanced fibre digestibility
 - » Improved body condition, especially among heifers and early-lactation cows
 - » Potential for more milk/beef production (measuring this is a challenge given production variation on commercial farms)

Q: Will FT products work on all hybrids or varieties?

A: Research has shown that FT improves NDFD across genetically diverse hybrids and varieties. Studies with Brown MidRib (BMR) silage hybrids have been mixed as might be expected given the reduced lignin content in these hybrids. It is important to recognize that the starting point for the NDFD of any forage is affected by growing season, harvest maturity, chop height and to a lesser extent, crop genetics. For example, DuPont Pioneer research shows similar relative improvements in NDFD when the same corn silage hybrid was treated with 11CFT in two distinctly different seasons; however the absolute NDFD values can be very different between growing seasons. Selection of forage genetics should be made completely independent of FT usage decisions.

Q: Do any competitive products contain enzyme-producing bacteria to increase NDFD? Why not just add enzymes directly to the silage or to the Total Mix Ration (TMR)?

A: No other commercial products are known to contain silage-fermenting bacteria specifically selected for fibre-altering enzyme production. The proprietary strain of *Lactobacillus buchneri* found in FT products produces specific esterase enzymes suited to low silage pH's and delivers enzymes cost-effectively as the organism multiplies and grows in the silage mass. Some forage additives do show the addition of enzymes on their label. However, this is often "window dressing" because the addition of purified enzymes are too costly to provide sufficient amounts, tend to lose activity over time, and may not be effective in the low pH conditions found in silage. Furthermore, the use of enzymes can't deliver the added silage fermentation and bunklife benefits available from FT products.

Q: How soon can I start feeding FT silage?

A: FT silage should ideally be stored at least 60 days before feeding to allow time for growth and enzyme production by the proprietary *Lactobacillus buchneri* strain. In transitioning to FT silage, producers should account for baseline NDFD, nitrogen solubility and sugar levels in the new-crop silage. Producers who wait 6-7 months before feeding FT corn or cereal silage should consider adjusting rations to account for increasing starch digestibility due to the length of time in ensiled storage.

Q: How can a nutritionist balance rations without knowing the exact NDFD?

A: From the many animal experiments and field trials conducted by DuPont Pioneer and University researchers, a four percentage point increase in 48-hour NDFD (over baseline estimates) would be a good starting point to factor in the effect of FT products. Changes in digestion rates (Kd) resulting from FT enzymatic activity can be made in formulation models, such as CPM or CNCPS, by employing gas-production analysis (e.g. Fermentrics™) to specifically quantify carbohydrate pool (e.g. B1, B2 and B3) digestion rates. For more detailed information, please consult the document entitled "FT Feeding Considerations."

Q: Has data on FT silages been published or reviewed by any outside agencies?

A: DuPont Pioneer presented initial FT research posters at the 2006 Dairy Science Meetings. Subsequent positive studies have been reported at the University of Delaware, University of Illinois, University of Florida, Canadian Agriculture and Agri-Food Lethbridge Research Centre, University of Padova (Italy) and Agricultural Chamber Schleswig-Holstein (Germany). A paper on the 11CFT fibre digestion technology was also published in *Animal Feed Science and Technology* (v.145, 2008). DuPont Pioneer received permission (January 5, 2007) from the Canadian Food and Inspection Agency to make the following (6) 11CFT product claims in Canada:

1. Improved dry matter intake
2. Improved NDF digestibility
3. Improved gain/tonne of silage fed
4. Improved feed efficiency
5. Reduced heating at feeding
6. Reduced dry matter loss at feeding

Q: Will feeding FT silages result in measurable differences in milk or meat production?

A: While many controlled research studies have shown measurable differences in animal production, it will be difficult for most commercial producers to measure the response from FT silages in the bulk tank or across the scale. To put in perspective, NDFD meta analysis by ARS/USDA dairy scientist, Dr. H.G. Jung, suggests 0.14 kgs more milk and 1.18 kgs more dry matter intake from every one percentage point increase in corn silage NDFD. UW MILK2006 predicts 14.5 kgs more milk per as fed tonne of corn silage that exhibits four percentage point higher NDFD. For cows consuming 23 kgs of as fed corn silage per day, this would translate to about 0.4 kgs more potential milk/cow/day. With typical variations in daily milk production of 0.9 - 1.4 kgs/cow/day, this response will be extremely difficult to detect on a commercial dairy given the variability introduced from weather patterns, feedstuff changes, herd health issues, estrous, changing percentages of fresh cows and heifers, etc.



Feeding Considerations

Q: How do Fibre Technology products increase NDF digestibility?

A: The *Lactobacillus buchneri* strain in FT products produces specific esterase enzymes (ferulate and acetyl esterase) that release fibre polysaccharides from the lignin backbone. Decoupling polysaccharides from the lignin alters the three-dimensional structure increasing access to the polysaccharides by rumen bacteria resulting in more rapid fibre digestion. Lignin is not degraded so levels in the forage remain the same and fibre fragility does not seem to be significantly reduced. Additionally, greater utilization of the polysaccharide fraction is observed due to the removal of digestion inhibiting acetyl groups bound to the sugar components.

Q: Can forage labs detect the improvement in NDFD in FT silages?

A: Current NIR calibrations and commonly available *in vitro* (test tube) methods do not have the sensitivity to predict the NDFD and digestion rate (Kd) improvements that have been proven with *in vivo* (live animal) feeding trials. FT products produce enzymes which cause physio-chemical changes in the polysaccharide lignin linkages, while not actually changing the amount of lignin or fibre in the silage. Rumen bacteria recognize this change and digest the decoupled polysaccharides at a faster rate and often greater extent. *In vivo* experiments have consistently detected changes in fibre digestibility, as do *in situ* methods (replicated, 6mm-ground samples placed in nylon bags and hung in fistulated animals). Labs utilizing gas-production methods (e.g. Fermentrics™) have been able to detect the effects of FT in modifying carbohydrate pool (e.g. B1, B2 and B3) digestion rates. This allows nutritionists to adjust rations and reduce concentrate and protein supplementation based on FT-altered, B-pool digestion rates.

Q: What are the guidelines for balancing rations containing FT silages?

A: From many animal experiments and field trials conducted by DuPont Pioneer and University cooperators, a four percentage point increase in 48-hour NDFD (over baseline NDFD estimates) is a reasonable starting point to factor in the effect of FT silages. However, most approaches that use single, time-point NDFD values in summative equations to predict NE-L (e.g. NRC or UWMILK2006) do not appear sensitive enough to the digestion rate changes as a result of treating silages with FT products. Changes in the digestion rates (Kd) of the B3 (NDF) carbohydrate pool in silages can be made in formulation models, such as CPM or CNCPS, from single, time-point NDFD values by employing the VanAmburgh Rate Calculator (VARC) available directly from Cornell professor, Dr. Mike VanAmburgh (mev1@cornell.edu) or from DuPont Pioneer. However, field experience suggests that increasing B3 rates by 15-20%, (which VARC predicts from a four percentage point increase in NDFD), will not fully account for the effect of FT products. Labs utilizing gas-production methods (e.g. Fermentrics™) have been able to directly measure the effects of FT in modifying carbohydrate pool (e.g. B1, B2 and B3) digestion rates. Gas production analysis of FT silages suggests that when cell wall components are decoupled from lignin, their rates of digestion begin to approach that of faster digesting carbohydrates such as soluble fibre or starch. To prevent over-feeding of concentrate and protein (from increased rumen microbial protein production), field experience suggests the “shifting” of these nutrients into different pools requires that the rates of B1 (starch) and B2 (soluble fibre) pools also be modified in FT silages.

General FT silage feeding guidelines:

1. Feeding FT silage typically allows for reduction in both “fast pool” nutrients (e.g. starch) and protein (from increased microbial protein production). In practice, this means reducing grain and protein in the TMR to offset increased availability of fibre components and shifting of “slow pool” nutrients (B3) to the “fast pools” (B1 and B2). Using 11CFT corn silage as an example, in typical dairy rations containing 23 kgs of corn silage/cow/day (as fed), field experience has shown that about two lbs of corn meal and .34 kgs of 44% crude protein soybean meal can be removed from the diet without any change in cow production or body condition (corn silage intake was increased to offset the removal of grain and protein). This provides the economic advantage to FT silages to compliment product benefits associated with faster silage fermentation, reduced silage face heating spoilage and improved ration bunklife.

2. Closely monitor dietary starch levels. This is magnified if corn or cereal silage inclusion rates are significantly increased when feeding FT silage. Adjustments will also be necessary for increased starch digestibility over time in storage for corn or cereal silage (and high-moisture corn).

3. Field experience with herds who experienced milkfat depression problems when starting to feed FT silage, were typically borderline for effective fibre and/or acidosis issues and quickly resolved the problem (and lowered feed costs) by reducing grain (especially high-moisture corn), increasing silage inclusion rates (and effective fibre) and/or adding co-products such as soyhulls (additional source of soluble fibre).

4. Gas-production laboratory comparisons and field experience suggest that carbohydrate pool digestion rates be increased as follows (if specific carbohydrate digestion rates are not measured) to reflect the enzymatic activity of FT products and their impact on altering rates and/or shifting nutrient pools. Example: FT corn silage book value B3 rate of 3.4%/ hour should be increased by 35% to 4.6%/hour.

	11CFT/11GFT	11AFT
B1	50%	60%
B2	30%	60%
B3	35%	20%

5. When feeding high levels of highly digestible forages (corn silage, grass or legumes), it is helpful to frequently monitor cud chewing, TMR particle size consistency and sorting issues due to changes in TMR mixing/delivery, along with ensuring adequate levels of ration NDF and peNDF (>23%). The peNDF or fragility of fibre in 11CFT silage appears similar to that of conventional corn silages. As with any ration, observing animal performance, intakes, effective fibre levels, and manure consistency will help nutritionists further refine FT silage-based rations.

Shrink Loss Economics

This article first appeared as the Bottom Line of Nutrition column in the February 8, 2010 issue of Feedstuffs and is reprinted with permission from Feedstuffs, 12400 Whitewater Dr., Suite 160, Minnetonka, Minn. 55343. Bill Mahanna, Ph.D., Dipl. ACAN, is a collaborative faculty member at Iowa State University and a board-certified nutritionist for DuPont Pioneer based in Johnston, Iowa.

One of the few silver linings associated with low milk prices is renewed interest in improving the efficiency of the entire feeding process. This includes reducing feed shrinkage which can be caused by wind, rodents, heating, spoilage and feedbunk refusals. Some losses are readily noticeable, such as corn meal being wind-blown when filling mixer wagons. Other losses, such as silage shrink (dry matter loss) are more insidious. The relatively inconspicuous nature of silage shrink is evident when you consider the wide range in shrink loss estimates provided from queried livestock producers. This column will attempt to detail the biology and nutritional cost of silage shrink losses.

Fermentation Principles

Silage fermentation can be simplified into three phases. Silages experience aerobic conditions during harvest and filling, followed relatively quickly by anaerobic conditions which initiate pH decline, and finally, back to aerobic conditions during feedout.

Dry matter loss (shrink) begins with plant cell respiration and aerobic microflora utilizing carbohydrate sources (primarily sugar) producing water, heat and carbon dioxide (CO₂) (Fig.1). It is this carbon, lost to the atmosphere, which causes shrink loss. These processes will continue until the oxygen in the silage mass is depleted. Speed of harvest, wilting (if utilized) and filling are the primary drivers of these losses. However, adequate moisture to reduce silage porosity and adequate compaction also play a role to reduce the length of this initial aerobic phase. An estimate of the loss of net energy (in pure starch equivalents) from this initial aerobic activity is 1-2% and is largely unavoidable (Woolford, 1984).

The subsequent anaerobic condition establishes an environment suitable for domination by homofermentative and heterofermentative lactic acid bacteria (LAB). There would be no shrink loss in this phase if only homofermentative LAB (Fig. 1) were active. However, that is not the case as less than 0.5% of epiphytic organisms found naturally on fresh crops are LAB and only a small proportion of these are homofermentative LAB (Lin et al., 1992). To put the loss from heterofermentative LAB in perspective, there is a 24% loss of dry matter from the heterofermentative fermentation of glucose (Woolford, 1984). The average net energy loss from (in pure starch equivalents) from epiphytic LAB fermentation is 4% (Woolford, 1984). These anaerobic fermentation losses can be reduced by 25% or more with the use of homofermentative strains found in reputable silage inoculants (Dennis, 2010).

The re-exposure of silage to aerobic conditions can be divided into two areas: 1) top and side exposure during storage, and 2) face exposure during feedout. The combination of these two sources of shrink loss can vary significantly due to management level but estimates of upwards of 20% loss in net energy (in pure starch equivalents) have been reported in the literature from aerobically unstable silages (Woolford, 1984).

Upwards of 20% of the silage will be contained in the top three feet in many bunkers and drive-over piles. One of the classic studies regarding top spoilage was conducted by Kansas State researchers (Dickerson et al, 1990). Their survey work included 30 covered and uncovered bunkers in western Kansas. Given that most producers today cover their bunkers, it is still of interest that the five covered bunkers averaged 27% organic matter loss in the top 18 inches, and another 2% loss in the 18 to 36 inch zone. This research team also developed an interesting model system to show the value of covering bunkers using alfalfa silage ensiled in covered or uncovered 55-gallon drums. In a subsequent study, Kansas researchers also showed that dry matter intake, nutrient digestibility and integrity of the rumen mat was linearly decreased as increasing levels of spoiled corn silage was purposely incorporated into normal corn silage rations fed to cannulated steers (Whitlock et al., 2000). The recent introduction of oxygen-barrier film has certainly been a tremendous step forward in reducing the problem of top spoilage.

Figure 1. Sources of lost CO₂ contributing to dry matter (shrink) loss

	<u>Substrate</u>	<u>End Products</u>
- Continued plant respiration		
- CO ₂ losses from:		
- Aerobic organisms active until oxygen is depleted	$C_6H_{12}O_6$ (glu & fru)	$2C_3H_6O_3$ (lactic acid)
- Heterofermentative anaerobic bacteria found naturally on crops	$C_5H_{10}O_5$ (xyl, arabin)	$C_3H_6O_3 + C_2H_4O_2$ (lactic acid) (acetic acid)
- Aerobic organisms that again become metabolically active when exposed to air at feedout		
	$C_6H_{12}O_6$ (glu & fru)	$C_3H_6O_3 + C_2H_4O_2 + CO_2$ (lactic acid) (acetic acid) (CO ₂)
	$3 C_5H_{12}O_6$ (glu & fru)	$C_3H_6O_3 + C_2H_4O_2 + 3 C_5H_{12}O_6 + CO_2$ (lactic acid) (acetic acid) (mannitol) (CO ₂)

A more pressing problem today is managing shrink on the wide, exposed silage faces inherent with large bunkers and piles. As a comparative, silage bag research at the University of Wisconsin (Muck and Holmes, 2001) showed that relatively well-compacted, 8-9 foot diameter silage bags incurred a 9.7% total shrink loss. I often think of this study when I have producers standing in front of piles with 60-80 foot faces, trying to convince me they have less than 10% shrink.

Two recent advances have certainly helped reduce aerobic face losses: mechanical facers and inoculants containing *L. buchneri* strains proven to reduce yeast growth. The fact that *L. buchneri* is a heterofermentative LAB may lead to questions as to why inoculant manufacturers would use a LAB known to be less efficient in fermentation efficiency than homofermentative strains. The quick answer is that “back-end” aerobic losses are a much bigger source of shrink loss in large bunkers and piles and *L. buchneri* strains effectively limit yeast growth which initiates the cascade of events leading to silage heating. In addition, most products containing *L. buchneri* also contain homofermentative strains to facilitate a rapid, “front-end” decline in silage pH.

Research from Wisconsin which addressed, not only silage density, but also the porosity of silages (with the goal of less than 40% porosity) will also serve to help producers target harvest moistures that will reduce air penetration into the exposed face of large bunker and piles (Holmes, 2009).

What Does Shrink Cost

Producers might have more respect for shrink losses if they had a better perspective on what it was costing them. They may not fully realize that shrink literally consumes their most valuable silage nutrients and thus, must be replaced with an equal energy source, such as corn grain. For example, even in a relatively well-managed bunker, if management changes could reduce shrink by 20% (from 15% to 12.25%), that is similar to saving \$2.21 per wet tonne in corn grain equivalents when grain is valued at \$7.00/bushel. Table 1 provides a handy approach to putting a dollar value on shrink loss based upon the current value of corn grain.

Table 1. Cost of dry matter shrink per tonne when replaced with corn grain as and equivalent energy source

	% Shrink	10.0%	12.5%	15.0%	17.5%	20.0%	22.5%	25.0%	27.5%	30.0%
Corn Cost (\$/bu)	\$3.00	\$3.78	\$4.73	\$5.67	\$6.62	\$7.56	\$8.51	\$9.45	\$10.40	\$11.34
	\$3.50	\$4.41	\$5.51	\$6.62	\$7.72	\$8.82	\$9.93	\$11.03	\$12.13	\$13.24
	\$4.00	\$5.04	\$6.30	\$7.56	\$8.82	\$10.08	\$11.34	\$12.61	\$13.87	\$15.13
	\$4.50	\$5.67	\$7.09	\$8.51	\$9.93	\$11.34	\$12.76	\$14.18	\$15.60	\$17.02
	\$5.00	\$6.30	\$7.88	\$9.45	\$11.03	\$12.61	\$14.18	\$15.76	\$17.33	\$18.91
	\$5.50	\$6.93	\$8.67	\$10.40	\$12.13	\$13.87	\$15.60	\$17.33	\$19.07	\$20.80
	\$6.00	\$7.56	\$9.45	\$11.34	\$13.24	\$15.13	\$17.02	\$18.91	\$20.80	\$22.69
	\$6.25	\$7.88	\$9.85	\$11.82	\$13.79	\$15.76	\$17.73	\$19.70	\$21.66	\$23.63
	\$6.50	\$8.19	\$10.24	\$12.29	\$14.34	\$16.39	\$18.43	\$20.48	\$22.53	\$24.58
	\$7.00	\$8.82	\$11.03	\$13.24	\$15.44	\$17.65	\$19.85	\$22.06	\$24.26	\$26.47
	\$7.50	\$9.45	\$11.82	\$14.18	\$16.54	\$18.91	\$21.27	\$23.63	\$26.00	\$28.36
\$8.00	\$10.08	\$12.61	\$15.13	\$17.65	\$20.17	\$22.69	\$25.21	\$27.73	\$30.25	

Pictures Worth a Thousand Words

All producers are keenly aware of the losses they observe from top or side spoilage. However, they may need additional convincing as to the loss in feed value in what may appear to be “normal” silage. What does not work very well for convincing producers that shrink is a real issue is relying on truck weights into the bunker against TMR weights out of the bunker. There is just too much room for measurement errors and it does not account for the biological fact that silage comes out of the storage structure higher in moisture than when it was ensiled.

However, there are several approaches that can be used to convince producers of the nutritional cost of shrink. One is the use of ash, pH and temperature measurements of silage on the bunker face compared to a deeper probed (e.g. 20 inches) sample. In a 2003 Idaho field study of 12 non-inoculated bunker and piles conducted by DuPont Pioneer researchers, the average ash, pH and temperature were 0.27% units, 0.3% units and 12.9° F higher for the face compared to the deep probe sample. When the ash data was input into an organic matter recovery equation developed by Ashbell et al., (1990), it estimated a 5.6% higher organic dry matter loss in the surface silage presumably from

aerobically induced instability (Seglar, 2003). Totally replacing the lost organic matter with corn starch would require more than a bushel of corn for every tonne of silage fed. Another less analytical, but highly effective approach is the use of a thermal-sensitive camera to help producers visualize the heating caused by aerobic microbial activity. **Figure 2** shows a very well-managed bunker that utilized a mechanical facer. The bunker was split down the middle because it was excessively wide and the producer routinely sprayed the exposed side face with propionic acid. However, it is very apparent that air is penetrating the silage mass and the resultant increase in temperature is indicative of nutrient loss to aerobic microbes.

Figure 2. Normal and thermal-sensitive images of a well-managed, split-corn silage bunker showing heat produced from air penetration.



The Bottom Line:

It makes little sense to invest in superior plant genetics and incur the cost of growing and harvesting to allow a poor fermentation to rob producers of the most energetic constituents in their silage. The nutritional community needs to increasingly sensitize silage producers to the true cost of shrink by valuing it against an equal energy source such as corn meal. There have been recent technological advances that can reduce shrink losses including a better understanding of the role of harvest moisture and silage porosity, oxygen-barrier film, mechanical facers and inoculants containing both homofermentative and *L. buchneri* strains.

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11CFT

Sila-Bac® brand 11CFT is a revolutionary patented corn silage product designed to:

- Improve fibre digestibility.
- Enable higher corn silage inclusion rates.

11CFT contains a novel strain of *Lactobacillus buchneri* which:

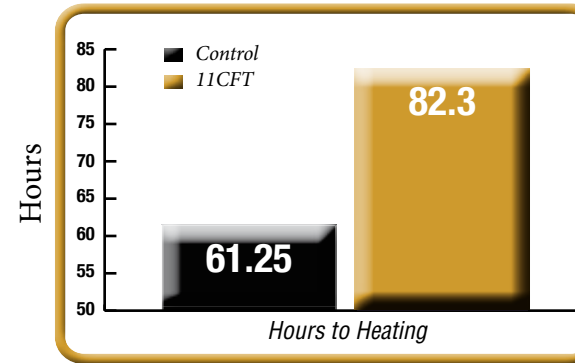
- Produces specific fibre-digesting enzymes as it replicates in silage.
- Reduces shrink and improves bunklife of the silage face during feedout.

In addition to fibre-digesting enzyme production, 11CFT contains unique patented strain of *Lactobacillus casei* formulated to:

- Stimulate “front-end” fermentation efficiency by rapidly dropping pH, helping to retain valuable nutrients (sugar, starch).
- Establishes the ideal environment for growth and proliferation of the enzyme-producing *L. buchneri* allowing enzymatic activity to be expressed, pre-digesting NDF and making it more available to the rumen microbes.

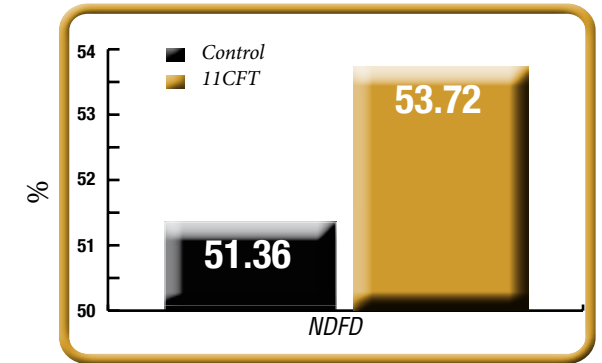


Improving aerobic stability resulting in less heating



Source: DuPont Pioneer Livestock Nutrition Center, Iowa

Animal research shows 11CFT is effective in improving NDF digestibility:



Source: University of Florida and the Lethbridge Research Center summarized third party *in situ* NDFD across four different hybrids.

11CFT received authorization in January, 2007 from the Canadian Food and Inspection Agency to make the following product claims: improved NDF digestibility, improved feed efficiency, reduced heating at feeding, reduced dry matter loss at feeding, improved beef gain/tonne of silage fed and improved dry matter intake.

11CFT showed an improvement in *in situ* NDF digestibility in four university studies (Univ of Florida, Univ of Delaware, Univ of Illinois and Lethbridge Research Center, Alberta, Canada). Complete trial data available upon request.

11CFT Ration Impact

Original ration balanced for 41 kgs milk/3.6% fat with cows fed 28.3 kgs corn silage (as fed basis). Modeled using CNCPS 6.1.36.0. Ration cost reduced by removing some soybean meal and corn grain while maintaining ME and MP predicted milk at original levels.

Reduced corn grain by .71 and SBM* by .45 kgs	35.0¢/Cow/Day
28 kgs of CS treated with 11CFT cost	9¢/Cow/Day
Additional 3 kgs of 11CFT corn silage (as fed)	11¢/Cow/Day
Net Gain:	15¢/Cow/Day

* Soybean meal was valued at \$350/Tonne and corn grain at \$6.00/bu

Additional value not included in calculations: reduced silage shrink in the bunker, higher forage diet for better rumen health and improved ration palatability

Sila-Bac® brand 11CFT is recommended for use on corn silage. Moisture recommendations for the use of 11CFT are shown in Table 1.

Silage should be allowed to ferment a minimum of 60 days prior to opening to allow the 11CFT bacteria time to produce enzymes and other fermentation end-products that can lead to improvement in fibre digestibility and aerobic stability.

Sila-Bac brand 11CFT is available in a water-soluble formulation for easy and convenient application. The product is non-corrosive and non-toxic.

Table 1. Optimal whole-plant moisture ranges for corn silage treated with Sila-Bac brand 11CFT

Crop	Maturity	Inoculant	Storage Type % Whole Plant Moisture			
			Bunker/ Pile	Stave	Sealed	Bagged
Corn Silage	Milkline 1/8-3/4 down the kernel	11CFT	62-70	62-70	60-70	60-70



For complete research reports, send an e-mail to one of the DuPont Pioneer contacts provided on the inside cover of this manual.

Research Trial Data Summary	# of Trials	Advantage	% Advantage
	Aerobic Stability	41	
Time before heating		24 hrs	35
Feedout loss		1.3%	50
In situ Digestibility	54		
NDF		4% units	8
Animal Digestibility	8		
DM		1.4% units	2.3
NDF		3.9% units	7.5
ADF		4.0% units	8.0
Animal Performance (Beef)	3		
Intake		0.14 kgs	2.0
ADG		.07 kgs	5.3
Feed Efficiency		0.33 units	6.2
Gain per tonne feed		2.7 kgs	4.0
Animal Performance (Dairy)	5		
Milk/Day		1.2 kgs day	3.4

Mini-silo Research Data:

Sila-Bac® brand 11CFT was tested in 41 corn silage research trials using experimental silos between 2002 and 2006. The fermentation of corn forage inoculated with 11CFT resulted in well-preserved silage as determined by terminal pH. The low terminal pH is an excellent indicator of nutrient preservation and dry matter recovery.

Aerobic stability, as measured by temperature rise after the silage was exposed to air, was improved more than 24 hours over control. The improvement in aerobic stability and DM loss gives the producer the advantage of more silage to feed per tonne of forage ensiled along with silage that stays fresher longer in the feedbunk.

In situ neutral detergent fibre digestibility (NDFD) improved 2 to 7 percentage units compared to control silage in 10 different studies across hybrids. There was no evidence of a hybrid by inoculant interaction. Improved fibre digestibility has been linked to increased dry matter intake and animal performance or the ability to reduce concentrate levels in the ration.

11GFT

Sila-Bac® brand 11GFT is a revolutionary patented grass and cereal silage product designed to:

- Improve fibre digestibility.
- Improve forage energy density to help reduce supplemental feed cost.
- Improve grass/cereal fermentation.

11GFT contains a novel strain of *Lactobacillus buchneri* which:

- Produces specific fibre-digesting enzymes as it replicates in silage.
- Reduces shrink and improves bunklife of the silage face during feedout.

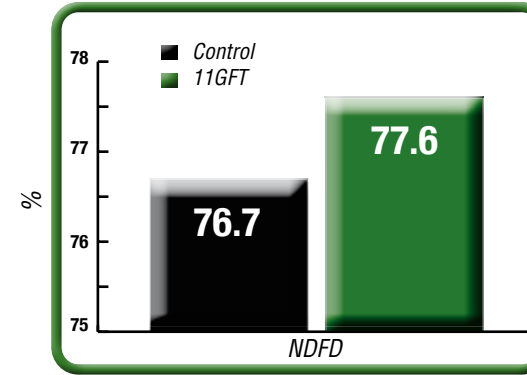
11GFT also contains unique, patented strains of grass/cereal-specific *Lactobacillus casei* and *Lactobacillus plantarum* formulated to:

- Stimulate “front-end” fermentation efficiency by rapidly dropping pH, helping to retain valuable nutrients (sugar, starch).
- Help lower feed costs by reducing grain and protein supplementation.

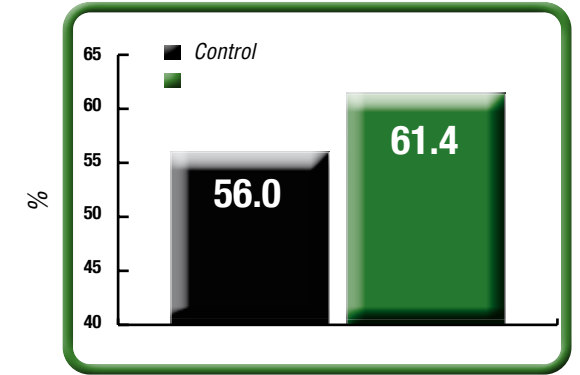


Available as a water-soluble product in packaging suitable for use in tank mixes or with Pioneer's Appli-Pro® Application Systems

Animal research shows 11GFT is effective in improving NDF digestibility:

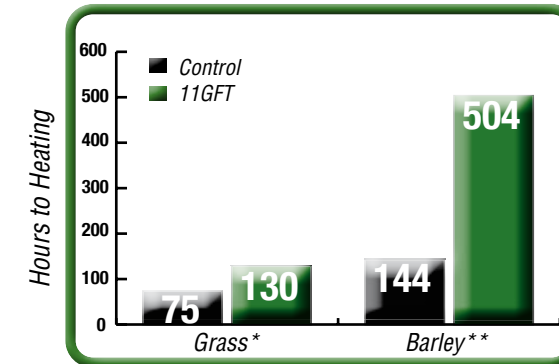


Source: Chamber of Agriculture Schleswig-Holstein, Germany
First cut 2-sward rye grass silage sheep digestion trial using 4 replicate lambs per treatment



Source: DuPont Pioneer Livestock Nutrition Center, Iowa
First cut grass silage sheep digestion trial with 12 replicate lambs per treatment

Improving aerobic stability resulting in less heating



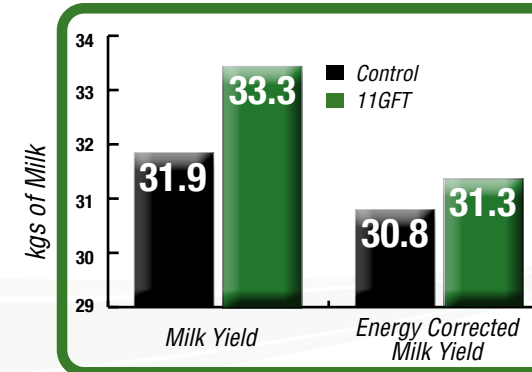
Source: *DuPont Pioneer Northern Europe, Germany (Summary of 8 trials rye grass with 5 experimental silos per treatment)

**Agriculture Canada, Lethbridge, AB (Barley silage trial using 5 experimental silos per treatment)

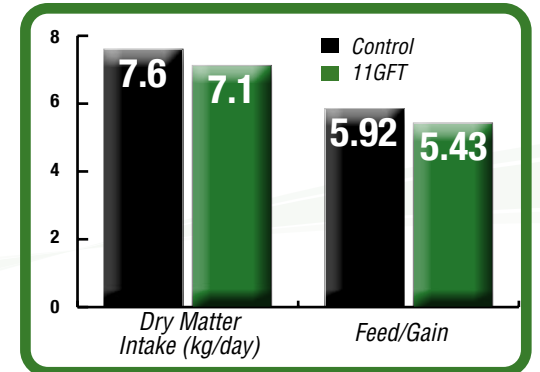
Improved animal performance

Dairy performance with 11GFT-treated Grass Silage

Beef performance with 11GFT-treated Barley Silage



Source: Chamber of Agriculture Schleswig-Holstein, Germany
First cut rye grass silage dairy performance with 24 replicate cows per treatment



Source: Agriculture Canada, Lethbridge, AB
Barley silage beef performance with 50 replicate steers per treatment

11GFT Product Use

Sila-Bac® brand 11GFT is recommended for use on grass and cereal silage. Moisture recommendations for the use of 11GFT are shown in Table 1.

Silage should be allowed to ferment a minimum of 60 days prior to opening to allow the 11GFT bacteria time to produce enzymes and other fermentation end-products that can lead to improvement in fibre digestibility and aerobic stability.

Sila-Bac brand 11GFT is available in a water-soluble formulation for easy and convenient application. The product is non-corrosive and non-toxic.

Table 1. Optimal whole-plant moisture ranges for grass and cereal silage treated with Sila-Bac brand 11GFT

Crop	Maturity	Inoculant	Storage Type % Whole-Plant Moisture			
			Bunker / Pile	Stave	Sealed	Bagged
Grass Silage (Not >20% Legumes)	When stems start elongating	11GFT	55-68	55-68	40-60	55-65
Cereal Silage (oat, wheat, barley)	Grain: boot to soft dough	11GFT	55-68	55-68	40-60	55-65



Research Trial Summary

For complete research reports send an e-mail to one of the DuPont Pioneer contacts provided on the inside cover of this manual.

Research Trial Data Summary		# of Trials	Advantage	% Advantage
	Fermentation		19	
	Fermentation dry matter loss		0.9 units	25
Aerobic Stability		20		
	Time before heating		24 hrs	27
	Feedout loss		2.1 units	61
Animal Digestibility		6		
	NDF		2.0% units	2.8
Animal Performance (Beef)		3		
	Intake		-0.48 kgs	6.3
	ADG		0.02 kgs	-
	Feed Efficiency		0.015 units	8.9

Mini-silo Research Data:

Sila-Bac® brand 11GFT was tested in 19 grass and cereal silage trials, using experimental silos between 2003 and 2007. The fermentation of the forage inoculated with 11GFT resulted in well-preserved silage as determined by low terminal pH and lower fermentation dry matter losses. Treatment with 11GFT resulted in 25% DM loss when compared to the untreated control.

Aerobic stability, as measured by the temperature rise after exposure to air, was improved more than 24 hours over the untreated control. The delay in heating of the silage results in a decrease in feedout loss of 2.1 units, a 61% improvement over untreated silage. These improvements result in more feed per tonne of forage ensiled along with silage that stays fresher longer in the feedbunk.

Animal Feeding Research Data:

Digestion studies:

Sila-Bac brand 11GFT was compared to untreated control grass silage in six research studies from 2005-2008. Silages covered a wide range of dry matter contents and quality parameters. Silages were analyzed for routine nutrient composition and fermentation acid profiles. Digestibility trials were conducted with wether sheep and according to the recommendations specified by the German Society for Nutrition Physiology. Studies were designed to measure the affect that 11GFT has on improving fibre digestibility. Across all trials comparing untreated controls to 11GFT

11AFT

Sila-Bac® brand 11AFT is a revolutionary new patented alfalfa silage product designed to:

- Improve fibre digestibility.
- Improve forage energy density to help reduce supplemental feed cost.
- Improve fermentation.

11AFT contains a novel strain of *Lactobacillus buchneri* which:

- Produces specific fibre-digesting enzymes as it replicates in silage.
- Reduces shrink and improves bunklife of the silage face during feedout.

11AFT also contains a unique strain of alfalfa specific *Lactobacillus plantarum* formulated to:

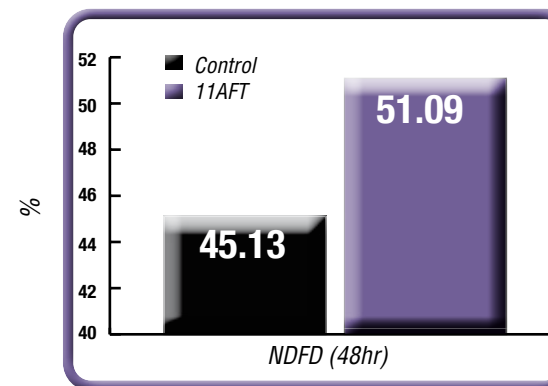
- Stimulate “front-end” fermentation efficiency by rapidly dropping pH, helping to retain valuable nutrients (sugar).
- Reduce protein degradation.
- Help lower feed costs by reducing need for bypass protein supplementation.



Available as a water-soluble product in packaging suitable for use in tank mixes or with Pioneer’s Appli-Pro® Application Systems

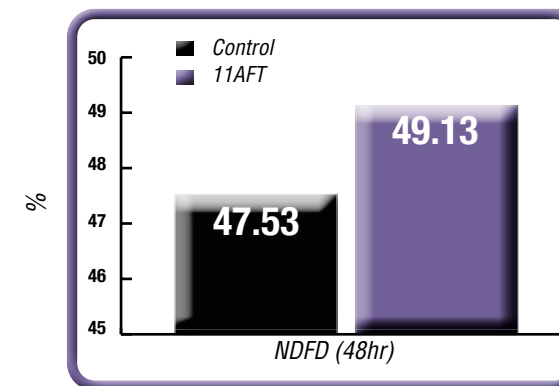
Animal research shows 11AFT is effective in improving NDF digestibility

Rumen *in situ* digestibility of Alfalfa Silage

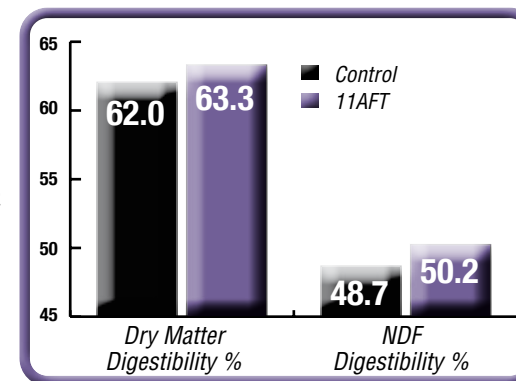


Source: DuPont Pioneer Livestock Nutrition Center, Iowa
Summary of two trials (1st and 2nd cut alfalfa) with 5 experimental silos per treatment. *In situ* measurements were conducted with 16 replicates on each silo using fistulated beef steers.

Rumen *in situ* digestibility of Alfalfa Silage



Source: DuPont Pioneer Livestock Nutrition Center, Iowa
Summary of four trials (1st and 2nd cut alfalfa) with 5 experimental silos per treatment. *In situ* measurements were conducted with 16 replicates on each silo using fistulated beef steers.



Source: DuPont Pioneer Livestock Nutrition Center, Iowa
First cut alfalfa silage lamb digestion using 16 replicate lambs per treatment.

11AFT Ration Impact

Original ration balanced for 40 kgs milk/3.6% fat with cows fed 9 kgs alfalfa silage (as fed basis). Modeled using CNCPS 6.1.36.0. Ration cost reduced by removing some soybean meal while maintaining ME and MP predicted milk at original levels.

Reduced SBM* by 286 g	11.0¢/Cow/Day
Typical cost to treat 9 kgs of alfalfa silage with 11AFT	3.0¢/Cow/Day
Additional cost of feeding 680 g more 11AFT-treated silage	3.7¢/Cow/Day
Net Gain:	4.3¢/Cow/Day

* Soybean meal was valued at \$350/Tonne

Additional value not included in calculations: reduced silage shrink in the bunker, higher forage diet for better rumen health and improved ration palatability.

11AFT Product Use

Sila-Bac® brand 11AFT is recommended for use on alfalfa silage. Moisture recommendations for the use of 11AFT are shown in Table 1.

Silage should be allowed to ferment a minimum of 60 days prior to opening to allow the 11AFT bacteria time to produce enzymes and other fermentation end-products that can lead to improvement in fibre digestibility and aerobic stability.

Sila-Bac brand 11AFT is available in water-soluble formulation for easy and convenient application. The product is non-corrosive and non-toxic.

Table 1. Optimal alfalfa moisture ranges for alfalfa treated with Sila-Bac brand 11AFT

Crop	Maturity	Inoculant	Storage Type % Whole-Plant Moisture			
			Bunker/ Pile	Stave	Sealed	Bagged
Alfalfa Silage (Not <20% legume)	Mid-to-late bud or 26-36" stems or <40% NDF	11AFT	55-68	55-68	40-60	55-65



Research Trial Summary

For complete research reports send an e-mail to one of the DuPont Pioneer contacts provided on the inside cover of this manual.

Research Trial Data Summary		# of Trials	Advantage	% Advantage
	Fermentation	7		
	Ammonia, % CP		-0.6 units	7.6
	In situ Digestibility	7		
	DM		0.76%	2.0
	NDF		3.6% units	7.6
	ADF		5.0 units	11.0
	Animal Digestibility (Lambs)	2		
	DM		0.72% unit	1.2
	Protein		1.5% units	2.1
NDF		1.1% units	2.2	
ADF		1.2% units	2.5	

Mini-silo Research Data:

Sila-Bac® brand 11AFT was tested in seven alfalfa research trials using experimental silos between 2009 and 2010. The alfalfa silage treated with 11AFT exhibited a more efficient fermentation process as seen in the lower ammonia levels compared to untreated alfalfa silage.

Nutrient digestibility, *in situ*, showed improvement with the addition of 11AFT. Dry matter digestibility (DMD) was .76% units better for 11AFT compared to control silage. The fibre fraction was similarly affected by 11AFT inoculation, neutral detergent fibre digestibility (NDFD) and acid detergent fibre digestibility (ADFDF) were 3.6% units and 5.0% units greater, respectively, compared to the untreated silage.

Animal Feeding Research Data:

Digestion studies:

Sila-Bac brand 11AFT was fed to lambs in two digestion studies in 2010. Growing wether lambs were fed untreated alfalfa silage or alfalfa silage treated with 11AFT. Lambs were assigned by weight to the treatments. Lambs were housed in metabolism crates divided evenly across two environmentally-controlled rooms. A 7-day adaptation period was followed by a 5-day collection period, during which time lambs were fed their respective treatment diets. The ration consisted of 100% alfalfa silage and was fed twice daily, with quantities fed recorded. Individual nutrient digestibility's (DM,

FT Product Mixing Instructions

1. It is recommended to only mix enough product that can be applied within 4-6 hours.
2. Mix the product with cool water:
 - » Fill the bottle only 1/3-1/2 full with water to assure adequate headspace for mixing.
 - » Place your finger over the 250T bottle opening and shake and swirl vigorously until all contents are in suspension. Point the bottle away from you and allow for gas venting if you feel any pressure build-up.
 - » Finish filling to the fill line. Do not overfill bottle. Look for the “fill to here” marking etched on the bottle near the top of the label.
3. If mixed product cannot be utilized within 4-6 hours and must be stored:
 - » Remove unfinished 250T bottle, back-flush and clean the Pioneer Appli-Pro® SL applicator then either:
 - » Store bottle in cool place with cap removed; or
 - » Reinstall bottle on applicator (applicator has been designed with a vent to prevent pressure build-up)
 - » Due to a formulation enhancement, refrigeration is no longer necessary unless mixed product will be stored longer than 3 days.
 - » If mixed product will be frozen, leave the plastic storage cap off the 250T bottle. Before using, allow 24 hours for product to thaw naturally in air or a warm-water bath.
4. Always follow recommendations in operator’s manual for back-flushing and cleaning the applicator.

If you encounter any mixing or handling issues with FT products, retain product bottles and immediately contact your DuPont Pioneer sales professional for assistance.

Appli-Pro® SLV (Super Low Volume) Application System

The Appli-Pro® SLV applicator is more than just an applicator. It’s a patented system designed and calibrated specifically for Sila-Bac® brand inoculant products. This unique design reduces water requirements and offers a high level of application precision and convenience. The Appli-Pro SLV, designed and developed by DuPont Pioneer Inoculant Research, uses air from a compressor and a small amount of water to deliver the inoculant solution. The total liquid applied is 10 ml/tonne, so each 2.5-liter inoculant bottle treats approximately 250 tonnes of chopped forage. You add water to the bottles of inoculant, shake the bottles to solubilize the product and screw the bottles to the applicator. Each applicator holds two bottles. The cab-mounted control panel allows the operator to turn the applicator on and off to precisely control the application rate. The panel reports the number of tonnes of forage treated based on the tonnes/hour rate selected, giving the operator an indication of treatment left in the bottle. Appli-Pro units come with manufacturer-approved, field-tested mounting brackets for most major forage choppers. Installation is quick and easy.



Advantages of the Appli-Pro SLV System:

- Treats up to 500 tonnes before refill is needed.
- Saves time! Less stopping and reloading of both water and inoculant.
- Eliminates mixing of inoculant material in large water tank.
- More accurate, more precise application with the unique injection system.
- Less waste, improved quality control because you can remove and refrigerate the mixed inoculant bottle at end of the day.
- Small Completion-Pac® bottle available for finishing fields.
- Unique back-flush system reduces waste, makes system cleaning easy.
- Compatible with John Deere GreenStar system, which provides variable rate application based on chop rate.

Appli-Pro® SLV (Super Low Volume) C2000 Application System

The Appli-Pro® SLV C2000 applicator utilizes the same precision technology offered in the Appli-Pro SLV with higher tank capacity for large self-propelled choppers. It's a patented system designed and calibrated specifically for Sila-Bac® brand inoculant products. This unique design reduces water requirements and offers a high level of application precision and convenience. Like the original Appli-Pro SLV, the C2000 uses air from a compressor and a small amount of water to deliver the inoculant solution. The total liquid applied is 10 ml/tonne. When full, the large capacity tank can treat 2,000 tonnes of chopped forage.

The tank easily can be removed at the end of the day for cleaning or to refrigerate unused product. The cab-mounted control panel allows the operator to turn the applicator on and off to precisely control the application rate. The panel estimates the number of tonnes of forage treated based on the tonnes/hour rate selected, giving the operator an indication of treatment left in the tank. The Appli-Pro SLV C2000 comes with manufacturer-approved, field-tested mounting brackets for most major forage choppers. Installation is quick and easy.

Advantages of the Appli-Pro SLV C2000 System:

- Treats up to 2,000 tonnes with 5.3 gallons of water.
- Operator time savings with fewer stops due to higher capacity versus original SLV.
- Unique back-flush system makes cleaning easy.
- System works without the use of solenoids for reduced maintenance.
- Basic product delivery system is identical to SLV, which provides excellent rate and distribution based on SLV experience.
- Leftover product can be poured into smaller containers for reuse, or the tank itself can be pulled off and refrigerated.
- Tank can be removed for easier cleaning.
- Dedicated compressor air intake filter for prolonged compressor life.
- Compatible with John Deere GreenStar system, which provides variable rate application based on chop rate.



Appli-Pro® Basic 12G Application System Appli-Pro® Basic 25G Application System Appli-Pro® Basic 55G Application System

The Appli-Pro® Basic tank mix application system is very versatile and can be used for many different applications. Whether applying dry hay inoculant with a baler or mower/ conditioner, silage inoculant on the chopper or at the silo/bunker, or high-moisture corn inoculant applied at the grinder/roller, this system offers simple, accurate and effective results. (Pictured to the right is the 25G System)



Advantages of the Appli-Pro Basic Application System:

- Appli-Pro® Basic 12G treats up to 96 tonnes with 12 gallons of water.
- Appli-Pro® Basic 25G treats up to 200 tonnes with 25 gallons of water.
- Appli-Pro® Basic 55G treats up to 440 tonnes with 55 gallons of water.
- Allows higher water inclusion rates to allow for variable harvest moistures.
- Simple design with reliable components:
 - The system has a strainer in the feed line, three individual strainers in each nozzle to reduce nozzle blockage and ensure uniform application, and all nozzles have stainless steel insert tips.
 - 12 Volt SHURflo Pump.
 - In-cab control unit with on/off switch, pressure gauge and volume control.
- Well-suited for small operations.



PIONEER

www.pioneer.com/inoculants



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