Blending & Spreading Fertilizer- Physical Properties.

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Fertilizer Blending was original developed in the USA, but for many years has been adapted and further refined for use in Ireland. Blending can be described as a type of dry mixing of granule or prills or chips, without chemical reaction, to produce a multi-nutrient fertilizer of a required nutrient analysis.

Following the demise of Irish Fertilizer Industries in 2002, there is no primary manufacturer of fertilizer in Ireland. However, there is a wealth of experience, knowledge and know-how built up over the past 50 years from the remaining established fertilizer manufacturers.

Terminology.

To avoid confusion in further discussion, the technical terms used in this paper are based on the European Standard definitions as follows:

Straight Fertilizers: These are products where a nitrogen, phosphate or potassium fertilizer has a declared content of only one of the primary plant nutrients, N, P or K. In Ireland, mixtures of the two straight sources of nitrogen: calcium ammonium nitrate (CAN) and ammonium sulphate nitrate (ASN) would also be termed straight N. In this case the CAN is being used to dilute the sulphur proportion of ASN. Examples of straight N. Urea, Calcium Ammonium Nitrate, Triple Super, Muriate of Potash.

Compound Fertilizer:
Fertilizer is having a declared content of at least two of the nutrients, nitrogen, phosphorus and potassium, obtained chemically or by blending, or both.

Complex Fertilizer:
Fertilizer having a declared content of at least two of the nutrients nitrogen, phosphorus and potassium, obtained by chemical reaction.

Using the above definitions we should note that the products like (di-ammonium Phosphate) sometimes referred to as straights are now termed complex fertilizers.

In this paper the key physical properties necessary to optimise fertilizer performance in the marketplace, both from a manufacturing and from a spreading perspective will be reviewed. The aim is to supply and apply fertilizer products at the correct rate and uniformly to increase productivity and crop quality at minimum loss or risk to the environment.

There are a number of components required to achieve this objective:

- Design of spreading machine.
- Machine setting, calibration and maintenance
- Weather and ground conditions at time of application
- Ability of Individual
- Chemical Properties of fertilizer
- Physical properties of fertilizer

Fertilizer Supply
Fertilizer types are available from many sources around the world. Some, like Nitrogen will originate in countries were there is a source of natural energy. These will normally be Natural Gas or oil based. Others like Phosphorus or Potash are naturally occurring elements but generally need to be refined or converted to a suitable form that can be easily transported and used in agriculture.

Products & Sources.

Calcium Ammonium Nitrate (27%N)	Germany, Holland, Spain, Poland.
Urea (46%N)	European, Nigeria, FSU, Egypt.
Di-ammonium Phosphate	North Africa, FSU.
Muriate of Potash (50%K)	Germany, UK, Israel, Canada.
Ammonium Sulphate Nitrogen	Germany, Poland.
Calcium Nitrate	Norway.

Statutory Controls.

Up until recently, each country had its individual regulation governing parameters such as, methods of sampling and analysis. These statutory regulation are generally concerned with, adherence to guaranteed analysis within specific tolerances; declaration of the form and quantity of each nutrient; methods of sampling, analysis and guaranteed weights. These will help reduce fraudulent practice and provide information on the nutrient content for the consumer. The chemical properties are well recognised and are covered within the new EU Regulations 2003/2003. These now apply to all EC fertilizer labelled and marketed within the community.

Physical Properties.

In an Irish context, blended fertilizer accounts for 70% of the market; the remainder is made up of straight fertilizer products. The Irish market differs from much of the rest of Europe, as it is 90% grassland. A further issue for Ireland is the high percentage of product reaching the market as bagged product (50 Kg and 500Kg bags). The introduction of new larger bulk fertilizer spreaders will bring added issues in relation to fertilizer quality and physical characteristics. How will a blended product that is uniform and consistent when packed within the confines of a 50Kg or 500Kg bag react as bulk blended fertilizer having travelled 30 kilometres from its loading point?

Quality Blends.
Again, let me clarify some terminology generally used in particle measurement discussions.

Particle Size. -Dimension that corresponds to the smallest sieve aperture size through which a particle will pass if presented in the most favourable attitude.

Mean Particle Size. - This will generally be in a range 2.2-3.7 mm. When used for blending purposes, then Mean Particle Size should be within a 10% margin.

Particle Size Distribution. - This refers to the various percent, within each specified size range, for the full range of material.

Size Grade Number (SGN). -This is the calculated mean diameter expressed in millimetres and multiplied by 100.

The aim for a good blend will be for the careful matching of particle sizes, with similar particle size distribution, so that within each fraction, the average analysis will be the same. In addition the particles should have a similar density and shape.

Manufacturing Issues.

Problems that need to be avoided include; segregation of particles, excessive dust levels, excessive moisture, tendency to cake, poor attrition characteristics and high salt index.

Particle Size Distribution/Mean Particle Size.
It is well established that these qualities need to be foremost when reviewing segregating properties of blends. Segregation of non-uniform particles can occur in a number of different aspects of manufacturing, distribution, transport and final spreading. Fertilizer flowing characteristics may vary and led to segregation within heaps in store depending on if tipped or use of elevators. Vibration may lead to segregation in transport from ship to site, or from site to farm. Historically the likelihood of this was reduced as the majority of fertilizer was distributed within the confines of a bag. The type of spreader mechanism can also influence settings for different component blends. It should be noted that raw materials of specified similar size ranges would not always produce non-segregating blends. Distribution particle size is all so critical.

Granule Hardness.

The product needs to fit for the purpose for which it is intended. A number of quantifiable quality tests can be used to demonstrate varying attributes of hardness. Granule crushing strength is a measurement of the pressure the particle can withstand before fracturing. Resistance to abrasion can be viewed both from a point of within the blended mix or from the external materials it interacts with. Resistance to impact is also of importance.

The density of fertilizer particles will influence the spreading characteristics of a product. A heavier particle will generally travel further far a given size range. In creasing particle size increases the distance that particles will travel for a given release speed.

Material Flow.
Material Flow rate is an important characteristic directly influencing the calibration of spreaders and, if variable, can reduce the uniformity of an application. Results from various trials demonstrate that the flow of a prilled or granulated material is related to the bulk density, mean particle size. It is also known that surface and shape characteristics of the product will vary and result in different flowing characteristics.

Particle Shape.

The importance of particle shape cannot be over emphasised. We have product that are labelled, large and small prill, large and small granule, spherical granule, compound granule, compacted granule or chips. These terminologies's are in common use, but can be extremely difficult to quantify when required for comparative purposes.

Moisture Content.
This is generally a function of manufacturing conditions. This is extremely important in relation to all products but even more so in relation to dry mixing of blend ingredients. Apart from degrading the granule itself, there is increased likelihood of continuing internal chemical reactions both within the granule but also across mixed granules. This can result in bonding and hard lumps or aggregates occurring within the fertilizer blend.

Critical Relative Humidity.

This is a function of the fertilizer ability to absorb moisture from the atmosphere. A relatively high CRH is preferable in situations where there is free moisture in the air. Also, blends of separate components in a blend may have a lower CRH as a blend, than when stored separately.

In Ireland upwards of 55% of fertilizer is applied to land in an 8 week period in March and April. However it would be physically impossible to ship, transport and make available the wide range of analysis required at farm level, in various pack sizes or bulk, without such strict quality controls and know-how operated by established fertilizer manufactures.

The following is an example of a Suppliers Standard Specification.

Supplier Name.

Product Analysis

Nitrogen.	Ammoniacal Nitrogen		-----%
	Nitric Nitrogen		-----%
	Total Nitrogen		-----%
Phosphorus	Soluble in Neutral Ammonium Citrate		-----%
	Soluble in water		-----%
	Total		-----%
Potash	Total Soluble in water		-----%
Sulphur			-----%
Calcium			-----%
Magnesium			-----%
Moisture (Method of Determination)			-----%
Bulk Density	(? tapped/Loose)	kg/m3	------
Granule Hardness		Kg	------
Screen Analysis	>5.00mm		-----%
	1.0-5.0mm		-----%
	1.6-4.0mm		-----%
	>1.6mm		-----%
	>1.0mm		-----%
Mean Diameter	SNG		-----
General	Colour, Shape, CRH, etc.		-----

Other Aspects.

Dust and conditioner adherence are issues that are of importance in the storage, packing and maintaining the free flowing characteristics required at farm level.

Bulk Spreading

In recent years there have been big changes in the handling and spreading of fertilizers on many farms. Wider tramlines and bulk spreading have become quite common. The need for higher work rates has necessitated wider spreading machines, and bout widths up to 24 metres are now widely used. Scarcity of labour and a sensible dislike of handling 50-kg bags have increased the demand for bulk spreading. The availability of a contract spreading service at a reasonable cost is a boon to farmers, but only if the quality of the spreading is satisfactory. The quality of the distribution will depend on: (1) the spreader; (2) the fertilizer; and (3) the operator.

Spreader

Most modern twin disc spreaders, whether tractor-mounted or trailed machines are capable of producing an even distribution over a wide range of bout widths. In the past, there have been problems with trailed spreaders when used for fertilizer. Using lime-spreading mechanisms as fertilizer spreaders would not meet the demands of modern cereal or grassland farmers. Operating machines with wide bouts in grassland without marker or a guidance system is a recipe for uneven spreading. The incorporation of GPS into the spreader set-up has simplified the spreading operation and enables accurate driving at any selected bout width, even at night.

Trailed bulk spreaders can have the advantage that the feed belts are ground speed related so that changes in forward speed should not affect the rate per acre. One popular make of bulk spreader has a very simple calibration device that is used to measure the bulk density of the fertilizer. Based on the bulk density readings, the application rate can be set quite easily from a chart. Recent independent tests in Denmark have shown that some bulk spreaders are capable of giving an acceptably accurate spread, even at wide bout widths.

A word of caution regarding bulk spreaders – some of these carry loads of up to 10 tonnes when full and weigh up to 3 tonnes unloaded, so the weight on the single axle will be high. From a soil compaction viewpoint a single axle load of 6 tonnes is regarded as the upper limit; it would seem that with some of these spreaders the axle load could be a high as 10 tonnes.

Even with large tyres fitted, there is a danger that soil compaction extending into the subsoil could result where such loads are carried on a single axle on moist soils. The fact that there are tracks only every 12-24 metres will limit the damage caused compared with, for example, forage harvesting outfits, but the danger of soil damage and forage yield reduction is still there.

Fertilizer

Fertilizer is an important input in crop and animal production systems. Evenness of application is critical. In arable and grass-based systems it ensures optimum production from the quantity of fertilizer applied. There are risks attached to the inclusion of spreading in the purchase price of the product. The spreading service can have a huge impact on crop returns - yet it may only be considered as a bonus in the fertilizer purchase deal, with little regard to the quality of the service. In cereal crops uneven spreading can lead to yield loss and quality penalties if the crop lodges.

Spread patterns with coefficient of variation (CV) values less than 10 per cent are considered good with little or no yield loss. A slight loss will occur when the CV value is in the range 10-15% but at CV values of 20 per cent or greater the effects begin to bite. When striping starts to become visible, yield losses are probably costing around €15 per hectare. Losses increase rapidly as CV values increase especially when quality effects such as screenings or nitrogen content come into play. In this context, a saving of €20/tonne on fertilizer purchase is minuscule compared to the potential loss from uneven spreading. A lodged crop of wheat could easily result in a reduced revenue of €250/ha because of poor spreading.

Changes in the fertilizer market, with more suppliers importing smaller quantities in bulk from a variety of sources, and quite a lot of this being sold ‘forward’ without the buyer seeing the actual material increases the possibility for poor spreading. Farmers should be very selective when purchasing fertilizer, as granule quality has as big an effect on evenness as the spreader. Most modern spreaders have no difficulty spreading fertilizer evenly at bout widths up to 12 metres, provided the fertilizer is of reasonable quality and the particles are not too small. As bout widths increase from 15 metres upwards - and particularly at tramline or bout widths greater than 18 metres - the quality of the fertilizer becomes critical.

All the most commonly used spreaders have one thing in common - spread pattern shapes change with different types of fertilizer and all the spreaders tend to behave similarly with any particular fertilizer to a greater or lesser extent. In other words, fertilizer physical characteristics can have a bigger effect on the shape of the spread pattern than make of spreader.

Three main factors come into play:
1. Granule size;
2. Granule shape;
3. Granule or prill density.

As spread widths get larger, small or light granules are not thrown far enough and overlapping may be incomplete. Small particles are very harmful to quality spreading; dust is especially detrimental; particles less than 1mm in diameter also have a bad effect on the spread pattern.

With most wide-spreading machines, increasing spread width using round granule, normal density fertilizer (e.g. CAN) does not change the basic spread pattern shape which remains triangular and so relatively easy to overlap successfully (Figure 1). However, fertilizer with angular material (some blends) tend to produce spread patterns with 'shoulders' which are not as easy to overlap correctly (Figure 2).

Lighter, less dense fertilizers, such as urea, unless they have large grains can be difficult to project the required distance. In order to get the full bout width when overlapped the spread pattern changes to a flat-topped type with a sharp cut-off at the edges (Figure 3). While it is possible to get a very even spread with this type of material, the margin for error in overlapping is very small so the machine has to be set precisely or the large errors in the spread will be obvious as striping in the crop. Fertilizer quality becomes increasingly important as tramline width increases. The physical characteristics of the fertilizers used in these tests are given in Table 1.

Table 1: Fertilizer physical characteristics

Fertilizer	**Particle size range (mm)**					**Density (kg/l)**
	<1	**12**	**2-2.8**	**2.8-4**	**>4**	
	(% in each size range)					
CAN (Fig 1)	0.0	0.5	9.0	68.9	21.6	1.03
0-10-15 Blend (Fig 2)	0.3	8.2	35.9	40.5	15.1	1.31
Urea (Fig 3)	0.1	59.3	39.3	1.0	0.1	0.72

Blended fertilizers are cheaper to produce than compound or CCF formulations and have the advantage that they can be easily made up to 'prescription' for specific requirements. The traditional problem with blends has been segregation or separation of the individual constituents while being handled, transported or spread. It is well known that the individual constituents of a blend must be well matched, i.e. each constituent should have the same range of particular sizes, to prevent segregation.

If segregation occurs while spreading, different parts of the spread will get different rates of N, P or K. Even if the nitrogen is spread evenly, uneven spreading of the P and K may not be noticeable in a particular year.

Operator

While the improvements in spreaders have made it easier for operators to achieve good results, they have to understand the basics of the spreading operation and machine setting. Spreader maintenance is very important, especially the feed outlets and spreading discs or spout. If worn or damaged, these can cause serious deterioration in the spread pattern. The operator should be aware of the effect of fertilizer physical characteristics on the spread pattern.

References

Miller.P.C.H. " *The Measurement and Classification of the flow and spreading characteristics of individual Fertilizers*" Proc.Fert Soc.,No.390 Dec 1996.
Leonard, J.E. "*Technology of Fertilizer Blending*"- Proc.Fert Soc., No.388 Dec 1996.
Young. T.M. "*Blending in Ireland*" Proc.Fert Soc., No.255 Apr 1987.