PRECISION APPLICATIONS
using strip-tillage

Using the strip-till technique, fertiliser can be placed at the bottom of the cultivated band made by the tine.

Strip-till users often incorporate nitrogen fertiliser into the soil. ARVALIS has established some trials designed to test this technique and acquire precise reference data. The first results are now available.

Strip tillage consists of localised soil cultivation in the row, while the soil between the rows remains uncultivated. It also gives the option of placing fertiliser in the soil while cultivating. It is one of the *raisons d'être* of this technique in the United States, its country of origin. The theory is that incorporating the fertiliser into the root zone can help limit losses when using nitrogen fertilisers that are likely to volatilise. Furthermore, the proximity to the roots is also beneficial for the uptake of nutrients with low mobility, such as phosphorus and potassium.

However, strip-tillage presents some disadvantages, including the gap between the fertiliser input (strip-tillage date) and the time when maize plants really need nitrogen, i.e. from 6-8 leaf stage. In the interim, some of the mineral nitrogen input is lost as it is turned into organic matter by the microbial biomass, or through nitrate leaching in very permeable soils and/or during wet springs.

A separate survey of 41 strip-till users carried out in the spring of 2011 revealed a strong interest in developing the technique further, in particular as regards to the precision positioning of mineral fertiliser. As France has very different soil and weather conditions to the USA, American practices are not always readily applicable.

Three years of trials on two experimental sites

To try and shed some new light on those different issues, ARVALIS established specific trials running from 2013 to 2015, at Boigneville (near Paris) and La Jaillière (western France). On the first trial site, which has an intermediate clayey, silty soil, grain maize was planted each year after a cereal followed by a green cover during the intercropping season. At the La Jaillière site, the experiments involved forage maize grown as the main crop after a cereal, also followed by a green cover during the intercropping season. The soil on this second site consists of silt on shallow shale (around 40 cm). In each case, the soil was strip-tilled with concomitant fertiliser application, a few days before the crop was planted.

Two maize nitrogen fertilisation strategies, combined with the same strip-till cultivation method, were analytically compared. Given maize's needs and the PK level in the parcels in question, nitrogen is the only nutrient studied in those trials. With the first strategy, "broadcasting", the nitrogen input is applied entirely to the soil surface (at sowing time and then at the 6-7 leaf stage in Boigneville and 3-4 leaf stage in La Jaillière), except for the band application of the starter fertiliser at sowing time, which, in the case of the Boigneville trial, represents 110 to 120 kg DAP/ha.

The other strategy, "band application", consists in incorporating part of the nitrogen into the soil when strip-tilling, at the depth to which the tine is cultivating, i.e. 15 to 18 cm. Several possible splits

were tested with this strategy between input at the strip-tilling stage and 6-7 leaf stage at Boigneville/3-4 leaf stage at La Jaillière. From 2014, various types of nitrogen were also tested. All surface applications were carried out using the broadcasting method with ammonium nitrate.

Different results from one site to the other

The yield difference between the band application strategy, with various splits, and the surface application strategy was measured for each site. This comparison was carried out with suboptimum total nitrogen rates (X - 40 or X - 50 kg/ha depending on the year and/or site).

At La Jaillière, results for forage maize vary from one year to the next, but yields never differ significantly. On the Boigneville site, grain maize results also vary from one year to the next. More precisely, the yield differences noted in 2013 are extremely variable and are not meaningful. 2014 showed significant differences, in favour of the "band application" strategies, regardless of the type of fertiliser being tested. For instance, the higher the proportion of nitrogen input while strip-tilling, the higher the yield increase. As the proportion of band-applied nitrogen at the strip-tilling stage decreases, ureic nitrogen, with or without urease inhibitors, seems more robust than other types tested. The 2015 results confirm those obtained in 2014, but from a statistical point of view, with the lower level of precision only two scenarios with urea were significant.

As for fertiliser input optimisation through rainfall, the La Jaillière site never lacked precipitations during the three-year trials. The observations made at Boigneville were on the whole similar, except in 2015 for input carried out when the plants were in leaf, which only received 4 mm over the fortnight following the application. However the first round of irrigation occurred three days after that period. There was therefore no major lack of availability with the broadcasting method, neither for this trial, nor the other five case scenarios.

Observations showed that the maize plants' root systems reached the localised fertiliser deposited while strip-tilling (15 to 20 cm deep) around the 6 leaf stage.

Assessing benefits in light of local conditions

The effectiveness of localising nitrogen through the strip-till technique varies depending on the soil and weather characteristics: the outcome was neutral at La Jaillière and neutral to positive at the Boigneville site. However, those conclusions hide, for instance, leaching activity, in particular for the 2014 trial at La Jaillière where 110 mm of rain fell between planting and the 3-4 leaf stage. During that period, maize's root system is not sufficiently developed to explore the area where the fertiliser has been deposited. The soils of those experimental sites are "intermediate to light" and not very permeable. Current knowledge and results from an experiment carried out in spring 2015 by a partner on permeable soil (gravel in the Rhône valley) would indicate that the risk of leaching is likely to be very high in this type of soil, and that results should tend towards the opposite of those obtained in Boigneville.

Other considerations must also be taken into account when drawing up the nitrogen fertilisation strategy with the strip-till method. Depending on local conditions for the implementation of the 5th Nitrate Directive, nitrogen applications in parcels situated in a vulnerable zone may be limited to 50 or 60 kg of N/ha before a certain cut-off date. In addition, if the soil is clayey, deep cultivation must take place at the end of summer, or if need be at the beginning of autumn in friable conditions. If this is the case, nitrogen can be applied during the light tilling of the strip of soil again in the spring, by incorporating it into the top few centimetres of soil, but definitely not during the autumn strip-tilling work.

Further experimental work will be carried out, focusing on characteristic highly permeable soils (trials in 2016 in partnership with the Chambre d'Agriculture du Rhône), as well as on topics such as the incorporation of slurry and localised application between rows, when the plants are in leaf, with minimal disturbance. A model of the interaction between soil, plant and air (CHN model) will also help understand and characterise nitrogen flows in the soil in specific situations, with various meteorological case scenarios.

Results obtained thanks to contributions from final year students on placement: Arnaud GOBILLOT, Marie ROUGIER and François PIOT.

Damien Brun - d.brun@arvalisinstitutduvegetal.fr
Baptiste Soenen - b.soenen@arvalisinstitutduvegetal.fr
Romain Légère
ARVALIS - Institut du vegetal

April 2016