MINIMUM TILLAGE GUIDE

>> Summary

KUHN : A MINIMUM TILLAGE SPECIALIST

Changes in the economic and regulatory environment are forcing farmers to review their production systems by using minimum tillage techniques.

When fully implemented a minimum tillage system will enable producers to:

-reduce the cost of production e.g. machinery and labour

-rethink crop production systems e.g. retaining crop residues on the soil surface, improving biological activity

-make environmental improvements e.g. reduce erosion, and loss of nutrients

The area of land non-ploughed worldwide has increased fourfold in the last ten years. In Europe it is estimated that 25% of the cultivated area is no longer ploughed. There is a diverse range of options available from direct drilling into a cover crop to deep cultivations, which have the same versatility as ploughing. This would suggest that equipment adaptable for use in a variety of systems is required.

In this guide the **Kuhn group** outlines the various tillage systems available to farmers and makes suggestions on which Kuhn equipment is best adapted to which system. It must be emphasized that non-plough systems require changes in crop agronomy such as residue management, fertiliser policy and crop protection programmes.

To be successful, this approach needs to be viewed as a complete system.

Steve Townsend, Steve Townsend & Company, Economic Crop Systems Specialists, United Kingdom

Minimum tillage systems are now an established part of mainstream UK agriculture, accounting for an estimated 40% of all cultivations, but as across Western Europe as a whole, it is a concept still in its infancy when compared with activities in North America, Latin America, and Australia, for example.


> Steve Townsend

A false start in the 1970's and 80's, together with an agricultural support regime that encouraged complacency ahead of innovation, are jointly responsible for our own relatively slow uptake of minimum tillage, but we are now entering an era where better knowledge and superior drill technology are underpinning sustained growth.

With stronger financial imperatives now driving farmer decision making under the Single Farm Payment, and improved soil management at the heart of cross compliance requirements, there is every reason to expect an acceleration in the uptake of minimum tillage in the future.

Early adopters of minimum tillage systems in the 1970's and 80's were hampered by under-developed equipment often unsuitable for the UK's temperate climate. There was also little understanding of stale seedbeds at that time, and the cost of glyphosate was prohibitively high.

The ban on straw burning in 1992, which at the time seemed to signal the death knell for minimum tillage systems, has ironically triggered a revival that has led us to the position we are in now. Following the ban, a greater focus on straw incorporation accelerated our understanding of soil structure and the importance of increasing organic matter levels. These issues lie at the heart of the minimum tillage concept and are the reason that established systems succeed.

UK farmers exemplify the full spectrum of minimum tillage systems. Very few are exclusively using minimum tillage, and very few will now plough everything, and within this mix of usage is a range of activity from several-stage cultivation through to direct drilling. In each case, the primary incentive for the farmer is to reduce crop establishment costs, and in my experience a 40% saving should be achievable, and up to 60% is possible.

Beyond the reduction in establishment costs, an effective minimum tillage system will, through the improvements to soil structure and fertility, also lead to reduced variable costs and more consistent yields. Fertiliser inputs, for example, can typically be expected to fall by 20-30% once a system is fully established.

With soil management central to farmers' cross compliance obligations, the improved structure that increased organic matter levels bring provides an added incentive for minimum tillage. Soil erosion becomes less of a problem, and the risks of phosphate and nitrate leaching are reduced under effective minimum tillage systems. There are many different minimum tillage systems operating in the UK, and farmers will continue to range from the opportunists to the fully committed, but there is in my mind no doubt that uptake can only increase. We now have the technology and the knowledge, so with a continuing increase in the desire to make it work I see no reason why the proportion of UK cultivations in minimum tillage should not in time increase to 80% plus.

Prof. Dr. K. Köller < Universität Hohenheim, Germany

There is a strong need for a global transition from conventional to conservational farming methods due to :

- The dramatic global increase in soil destruction through soil erosion and the accumulation of salts.
- The increasing destruction of the humus layer due to intensive cultivation.
- The associated increase in carbon dioxide emissions as well as decreasing biodiversity due to the consistent removal of plant material from the ground.

> Prof. Dr K. Köller

The contribution of “Conservation Agriculture” to ensure sustainable world-wide nutrition, the fight against poverty and the conservation of sustainable resources is repeatedly emphasized, and has been widely outlined in extensive literary sources. The difficulties are generally recognised, but in this area there are essentially implementation problems.

The consequences of soil erosion do not only concern regions of the southern hemisphere. In Europe, conventional farming methods marked by the removal of vegetation following harvesting and intensive cultivation, result in negative effects on the quality of the soil, water and air, the global climate as well as biodiversity and the countryside.

Around 150 million hectares of farmland in Europe are affected by erosion. The average annual erosion rate amounts to 17 tons per hectare/year and lies far above the rate of soil formation at around 1 ton per annually. It is believed that through soil erosion, agricultural production costs in Europe will increase by 50 EUR per hectare per year. Taking the on- and off-site damage into account, the total costs of soil erosion are estimated at around 85 EUR per hectare of arable land in production.

As a result of conventional farming methods, regional water quality is declining along with biodiversity. Farm conservation methods enable the disadvantages outlined to be permanently avoided. Soil erosion, as well as the impairment of water quality from the application of manure, plant protection agents and CO_2 emissions, will be significantly reduced and the biological activity of the soil and biodiversity markedly improved.

Minimum tillage techniques viewed by two specialists

At the heart of conservation agriculture is permanent ground cover through vegetation and plant debris, and thus a preference towards non-plough soil preparation techniques and diversified crop rotations.

Conservation agriculture does not mean “Organic Farming”, as it can include the use of artificial fertilisers and plant protection agents; another goal of conservation agriculture is the sustainability of our food supply through increased yields.


> Prof. Dr K. Köller

In the long run conservation agriculture does not mean anything different from the implementation of minimum tillage or direct seeding, integrated into an area specific management system, where appropriate measures of crop rotation organisation and use of fertilisers and plant protection agents are considered.

These practices are more widely found in large areas of North and South America than in Europe because the soil erosion and economic pressures leave the farmers with no other choice. Whilst the environmental and economic advantages are evident and proven for European conditions, methods of conserving agriculture are unfortunately not employed nearly enough, but here also the economic and environmental constraints will significantly increase in the near future. It can only be hoped that through political and administration support, these technologies will experience increasing acceptance from farmers.

Conservation agriculture is more than a special means of land management that only serves farmers. It is applicable for the whole of society. Therefore politicians, international organisations, environmentalists, farmers, industries, science and research as well as training programmes and conferences, will use conservation agriculture as a basis to understand and develop a lasting life insurance for future generations.

The recommendation for European farmers can only be to move towards minimum tillage and direct seeding systems. For many this means a change in habits but there is no other serious alternative. Economic and environmental advantages are convincing. Agricultural entrepreneurs are sought after.

Inside the KUHN Minimum Tillage Guide you will find :

- Practical information on the transition to conservation cultivation and shredding.
- Detailed technical information.
- Answers to your field and plant structural questions.
- An insight into labour organisation and economic and environmental considerations.

During the modern era of farm support, the financial output of arable crops has been the sum of the commodity price plus area aid. CAP Reform, however, has brought a change in the payment regime and a reduction in the overall level of support. Farmers are now required to fulfil certain criteria in order to qualify for different forms of support payments.

"Aid to European farms and their method of distribution"

Aid to farmers is fundamental. It accounts for 69% of farm profit in the combinable crop sector and 53% in the mixed livestock sector. The survival of European agriculture is dependant upon a satisfactory level of aid.

To conform to the WTO, farm aid has had to be re-directed from production. Aid is now payable on an area basis independent of what is being produced on the land. The EU has set out the general framework and with national governments deciding how payments are made in their countries.

Certain criteria have been, or have to be adopted by each member state. For instance, a reference period (2000-2002) determines who is entitled to claim for aid. The exact crops and stock that can be claimed for during that period varies from country to country.

To be eligible to claim payments in future, it will be necessary in all countries for individual farmers to carry out cross-compliance. Again, this is interpreted differently in almost every state. Broadly speaking, producers must abide by certain animal welfare guidelines and in the case of arable cropping (with reference to this publication) the EU water framework directives. The main aim is to reduce soil erosion and in turn the offsite pollution that can occur.

In addition to cross-compliance, environmental schemes will enable farmers to claim extra payments by doing a little bit more in the way of "greening-up". This money will come from modulation of the main payment (starting at 3% in 2005 and going up to 5% by 2007 – with an exemption of those claiming less than €5000) by the EU.

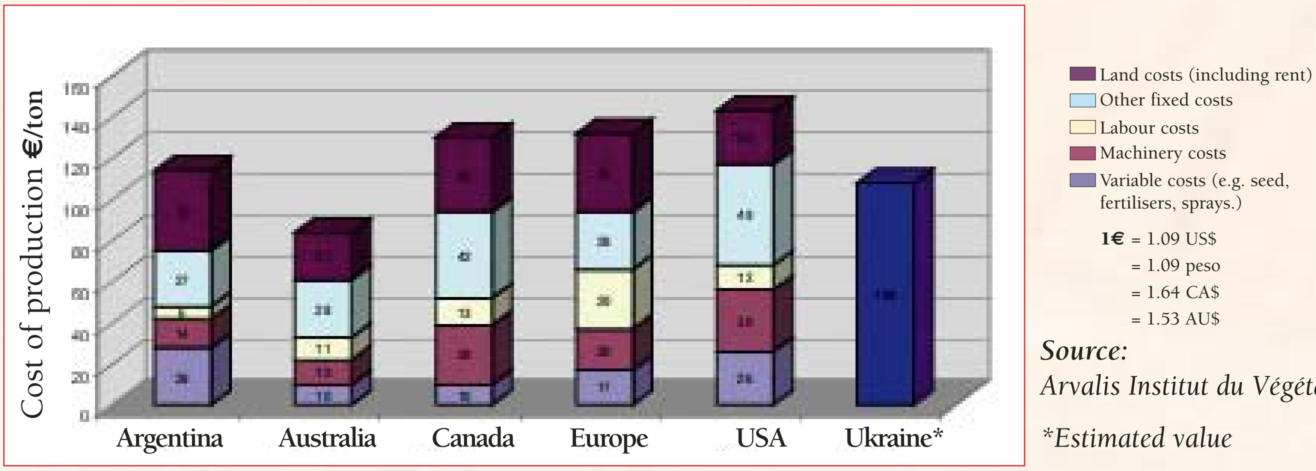
The individual member states will also be able to modulate the payments (by up to 30%) for rural development schemes. These schemes can vary from payments for agricultural infrastructure through to aid for young farmers. These payments are determined on a national basis and do not necessarily have to go into agriculture.

“ What is the future for European cereal production? ”

>> THE THREAT OF COMPETITION FROM OUTSIDE EUROPE

Wheat production costs in some countries can be more than double that of others (See graph 1). In the World market the position of European wheat is extremely fragile. Furthermore, when production in the Eastern European countries begins to take off, it will be difficult for European wheat to remain competitive. The cost of producing Ukrainian wheat is on average 20% less than that of Europe, due to lower input and labour costs. It is necessary to cut the cost of production in Western Europe if we are to remain competitive. However, consistency in terms of quantity and quality is still in our favour.

Graph 1 : *Production costs of the 5 main wheat exporting countries (2000)*



Source:
Arvalis Institut du Végétal

**Estimated value*

Exchange rates have a heavy influence on production costs in different countries, however countries such as Argentina, Australia and Ukraine are able to produce wheat at a lower cost than areas with higher costs such as Europe, USA and Canada.

>> WAYS TO IMPROVE

European wheat producers have cut their production costs through firm control of inputs, but also in the area of labour and machinery where perhaps most savings can be made.

Table 1: *Variation in the cost of winter cereal production in 5 countries.*

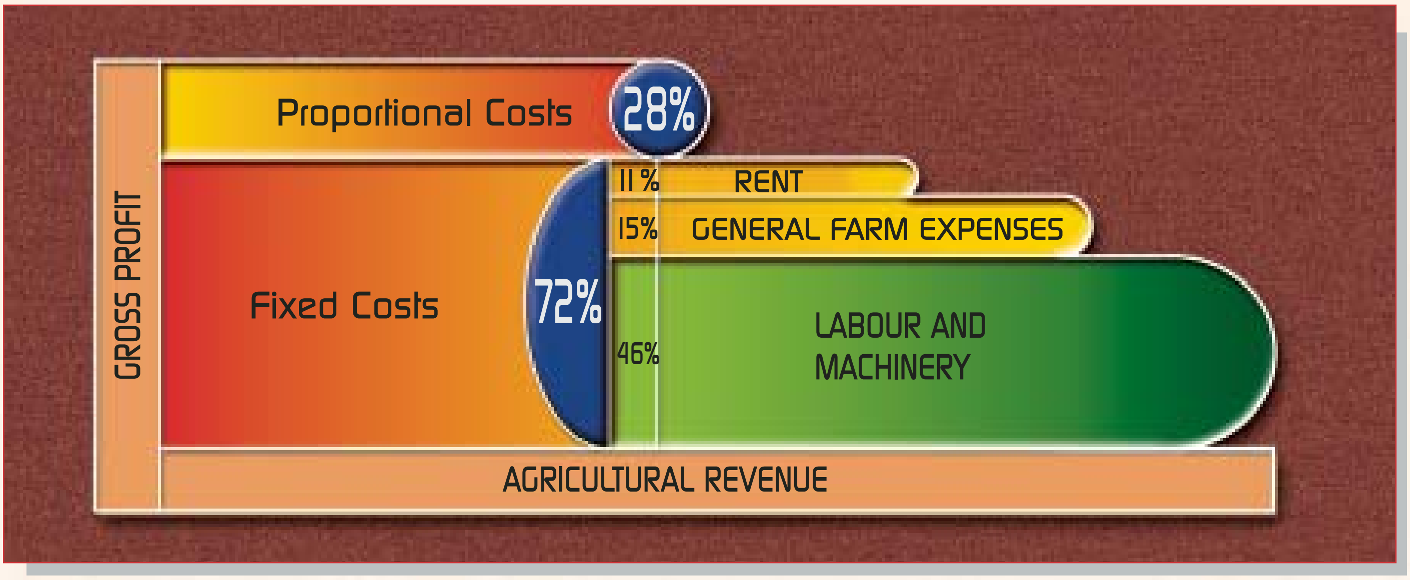
	€	€€	€€€	€€€€
Inputs	USA	Argentina, Australia, Canada		Europe
Equipment	Australia	Canada, USA	Europe	Argentina
Labour	Argentina	Australia, Canada		Europe, USA
External Services	Canada	Australia, Argentina		USA
Land	Europe	Argentina	Canada, Australia	USA

Source: Arvalis-Institut du Végétal, 2002.

With uncertain economic returns and market globalisation, European farmers are looking at ways to cut the cost of wheat production in order to remain competitive.

" Breakdown of production costs "

Figure 1 : Details of the cost structure of wheat production.



Source : Arvalis-institut du végétal-CNCER-UNIGRAINS, 2002

>> VARIABLE COSTS (e.g. seeds, sprays, fertilisers)

Management determines the unit cost of production. A spray programme based on insurance spray applications can cost as much as 30% more than a programme based on applying what is required for each field. However there comes a point where inputs can not be cut any further without reducing crop yields.

>> FIXED COSTS :
AN IMPORTANT AREA FOR COST REDUCTION

Labour and machinery costs account for 65% of fixed costs or 46% of the total cost of production. It is important to link labour and machinery as in general, when labour is reduced it is replaced by machinery. Obtaining the right balance will contribute to wheat production remaining competitive in Western Europe.

"Reducing labour and machinery costs"

Reducing capital investment and the time used to carry out field operations are the two areas where labour and machinery costs can be reduced.

>> LOWERING THE CAPITAL INVESTED PER HECTARE

2 possible solutions :

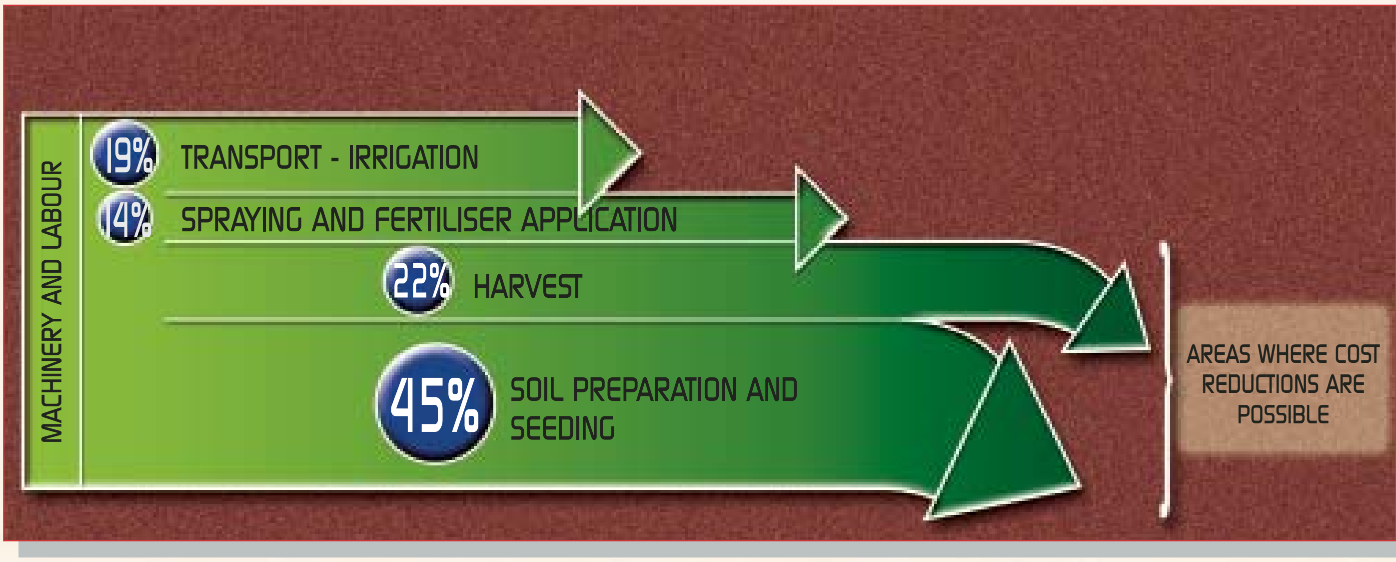
- **Reduce investment in equipment :** There is an element of risk involved in considering this route. The higher the investment in machinery, the higher the return on investment must be.
- **Spread investment over a larger area :** Increasing the area worked reduces the unit cost per hectare of machinery and labour.

>> REDUCING WORK TIME

As labour costs represent 20% of production costs, farmers need to cover the largest possible area with the minimum of labour. To do this requires suitable equipment and a satisfactory balance between the area farmed and available labour.

“ MANAGING THE INTER-CROP PERIOD, SOIL PREPARATION AND SEEDING ”

Figure 2 : Breakdown of labour and machinery costs involved in wheat production.



>> CULTIVATION COSTS REPRESENT 45% OF MACHINERY AND LABOUR COSTS !

Cultivation costs account for approximately 45% of the labour and machinery costs. The exact level will depend on the type of cropping used. Farms producing industrial crops (e.g. sugar beet, potatoes) and those with livestock will have higher costs than those producing solely combinable crops. Reviewing the overall system can have an important influence on cost reduction.

>> SHOULD PLOUGHING BE ELIMINATED ?

Systems in which the plough is used less can lead to reduced investment in equipment. Such systems are often less labour intensive, thus resulting in reduced labour and machinery costs. Agronomically speaking, it is now possible, it makes economic sense (reducing production costs) and concurs with the latest European directives (conditions required to receive EU payments).

Minimum tillage reduces the number of tractor hours required per hectare and in turn the amount of labour required. This results in cost savings for the business.

" Organisational implications "

>> TIME SAVING

The amount of time saved by adopting a non-plough system depends on how much cultivations can be reduced and the type of machinery used. By adapting existing machinery, savings in tractor hours rarely exceed 15-20%. However, by using specialist implements, savings of 40% can be achieved by simply moving less soil. The average plough based system takes 2.6 hours/ha to establish a crop whereas a minimum tillage based system would take about 1.3 hours /ha and direct drilling just half an hour.
It is important to understand how the tillage work schedule is broken down so that areas requiring re-structuring can be addressed. To illustrate this concept, the following example shows the estimated amount of time that would be spent cultivating an average 200ha clay-chalk farm growing combinable crops (rotation of oilseed rape, wheat, barley) using three different systems.

***Table 2** : Time needed for different cultivation practices*

Plough based system	Time /ha	Reduced tillage	Time /ha	Direct drilling	Time /ha
1 x 5 furrow plough, 6km/hr, 0.9ha/hr	1.1				
1 x 4m stubble tine cultivator , 5km/hr, 1.4ha/hr	0.35	2 x 4m stubble tine cultivator, 10km/hr, 2.5ha/hr	0.7		
1 drilling pass (4m power-harrow /drill combination), 5km/hr, 1.4ha/hr	0.7	1 drilling pass (3m specialist drill), 12km/hr, 2.5ha/hr	0.4	3m Direct drill, 12km/hr, 2.5ha/hr	0.4
Time spent in the field	2.15	Time spent in the field	1.1	Time spent in the field	0.4
Total time spent including travelling	2.6	Total time spent including travelling	1.3	Total time spent including travelling	0.5

>> MAKING BETTER USE OF WEATHER WINDOWS

Weather conditions often only allow a brief period in which to complete crop establishment. It is necessary to adopt a system which makes best use of these conditions and allows for timely sowing of all varieties (delaying drilling by 15 days can reduce wheat yields by 0.1 ton per ha). Where minimum tillage is adopted, although the weather windows may be shorter, output is greater, thus making better use of the available time. Picking the right time and acting quickly is important.

>> EASIER ORGANISATION

• **Time spent on other activities** ***(e.g. management, special cropping, livestock....)***

Time saved by changing to minimum tillage can be of value to other enterprises. A farmer, growing 120 ha of arable crops, would need to do 850 tractor hours per year (7hr/ha using a conventional system). If he changed to a direct drilling system, he would save 2 hours per hectare, giving an overall saving of 240 hours.

• **Labour flexibility**

Some businesses have potential labour shortages when they expand of if a partner pulls out of the business. In this situation minimum tillage makes the best use of existing labour resources.

" Economic Performance : Long term arguments "

>> SOME UNQUESTIONABLE BENEFITS

• **Fuel consumption as a key performance indicator**

Reducing the number of tractor hours/ha obviously reduces overall fuel consumption. This will be noticed by the farmer during the first year after changing his system.
Fuel consumption is estimated to be 100 litres/ha when a plough based system is operated. This can be reduced to approximately 75 litres/ha when ploughing ceases. When direct drilling, fuel consumption of 65 litres/ha could be expected, a 35% reduction from a plough based system. Furthermore, by working less hours, tractors need to be replaced less often. Fuel savings are also dependent on soil type, for example, higher saving will be made on clay soil than sand.

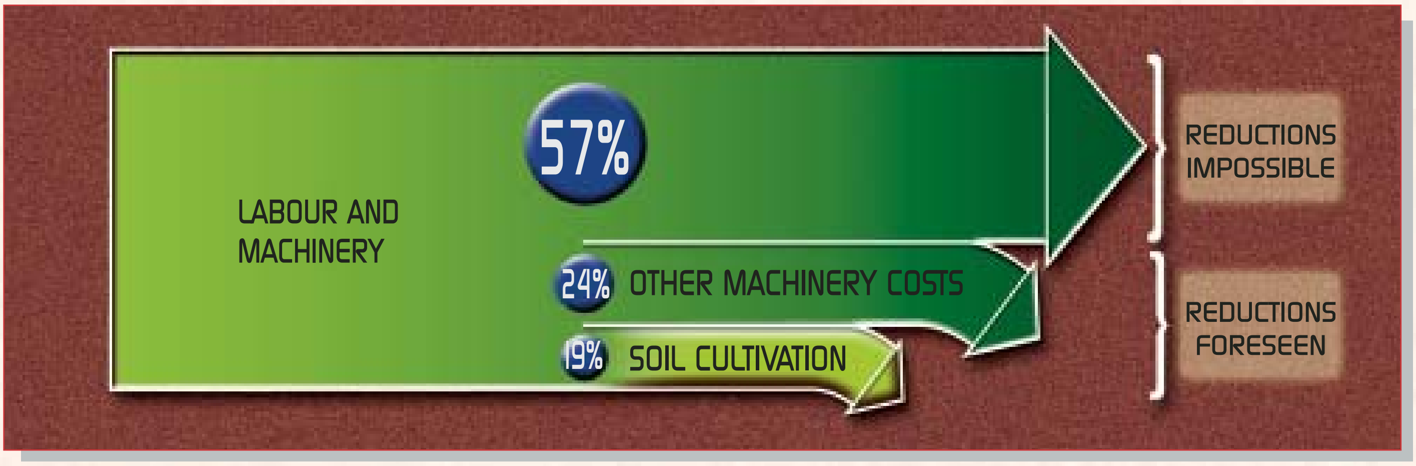
• **Long Term Benefits**

When converting to a minimum tillage system, there is a danger that machinery costs may rise in the short term. However, in the long term, wearing parts and maintenance costs will be much lower than where a plough based system was used. Furthermore, the equipment used will not depreciate so fast, thus improving its re-sale value.

>> BENEFITS OF SHARING LABOUR AND MACHINERY

Increasing the area worked reduces production costs. This reduction in unit costs can be achieved in a number of ways : by co-operating with neighbours, joining a machinery ring, or by contracting. When properly managed, such a 'co-operation' can reduce labour and machinery costs by as much as 40-45%. This would represent 20% of the total production costs. Minimum tillage accounts for a 19% share of these costs and labour in the order of 10%. The remaining 24% is accounted for in reduced capital investment and being able to re-deploy labour to jobs other than soil cultivation.

Figure 3 : Possibilities for reducing labour and machinery



These benefits depend very much on the type of minimum tillage system adopted, the soil type and the cropping system.

The impact of minimum tillage on plant development depends on the system used. (deep cultivation or direct drilling into a cover crop)

“ Germination and early establishment ”

The condition of the land (soil structure) has a strong influence on the final crop yield. This is especially true for crops requiring a good root structure (e.g. maize and sugar beet) and those with a short growing period (e.g. spring sown crops)

>> MOISTURE FOR GERMINATION

The absorption of water by the seed is dependent on the moisture surrounding the seed and the seed to soil contact. Non-inversion tillage retains a layer of mulch on the soil surface which retains soil moisture and thus reduces evaporation. Minimum tillage reduces clod formation especially in clay soils, and the continuous soil structure favours the re-distribution of water by capillary action. These conditions improve seed germination, notably for crops drilled under dry conditions such as oilseed rape.

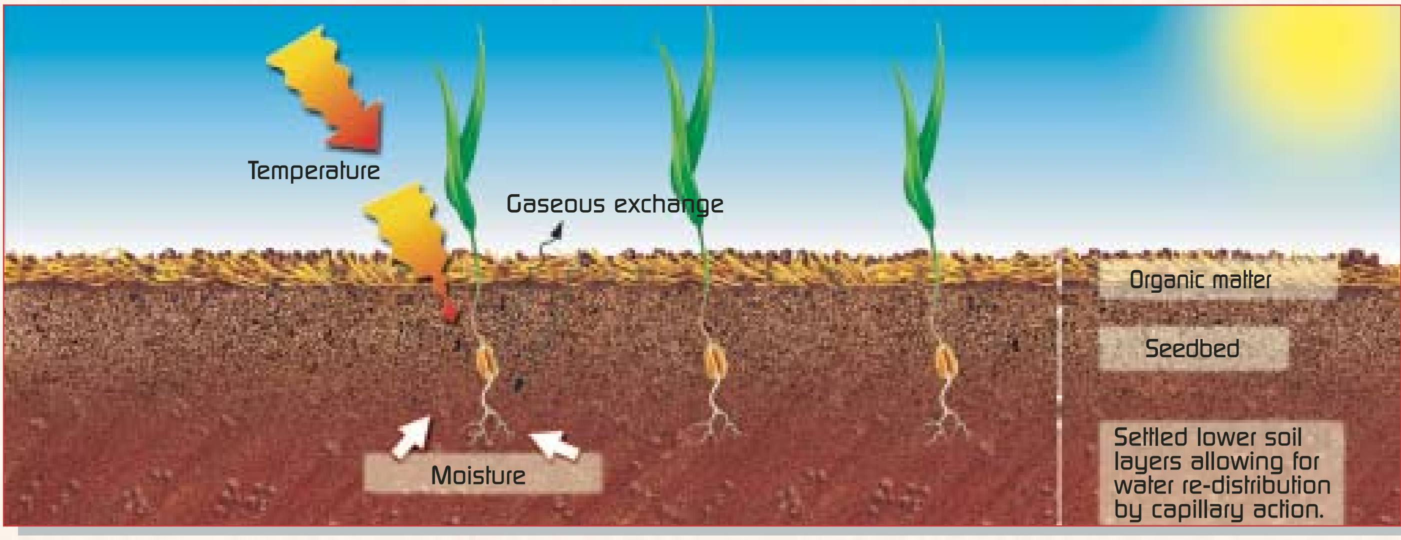
>> AERATION FOR SEEDLING RESPIRATION

Air is necessary for seed germination and establishment. The formation of surface crusting in silty soils and clods in clay soils reduces gaseous exchange. Where non-inversion tillage is used, the presence of organic material on the soils surface reduces capping. The lack of deep cultivation reduces the formation of clods and the possible mechanical limitation to early root growth is reduced.

>> TEMPERATURE

For initial germination, a certain level of accumulated temperature, directly relating to the porosity and moisture content of the soil, is required. A free draining soil warms up faster than a compact waterlogged soil. The presence of surface mulch slows down soil warming. This explains why spring crops germinate later. The mineralization of soil nutrients available to the plants are reduced in colder soils. For this reason, the fertiliser programme needs to be modified. However, later in the season the nutrients are released and this explains how min-till crops compensate for their slow early establishment.

***Figure 4** : The ideal seedbed.*



“ Growth and development ”

When the seed’s nutrient reserves are exhausted, the soil has to then supply nutrients via the roots. Plant development corresponds to root size and the availability of nutrients, oxygen and water in the soil. The development of the aerial parts of the plant are governed by photosynthesis.

>> ROOT DEVELOPMENT

The development of the root system depends upon mechanical resistance determined by differing layers in the soil structure. A consistent and porous soil structure, developed in a non-inversion tillage system, allows for good root exploration. With the absence of deep cultivation, soils tend to become firmer and form a new more natural structure. The structure is supported by cracking and galleries are formed by decaying roots and earthworm burrows. The new structure is more efficient than a man-made structure created by excessive cultivations.

>> PLANT NUTRITION

The reserve of soil nutrients depends on organic matter levels, the amount of fertilizer applied and the soil’s ability to retain fertility. By adopting non-inversion tillage, organic matter level in the upper layers of the soil profile increases and in time soil fertility is improved. These fundamental changes to the soil will have an effect on plant development. As the organic matter mineralises, the plant roots can easily absorb the nutrients released.

>> PLANT HEALTH

The presence of the residue on the soil surface from the previous crop creates the ideal environment for the development of pests and diseases for the emerging crop. However with good crop rotation, a judicious choice of varieties, effective stubble cultivation and an appropriate use of crop protection products, the risk of pests and diseases developing is reduced.

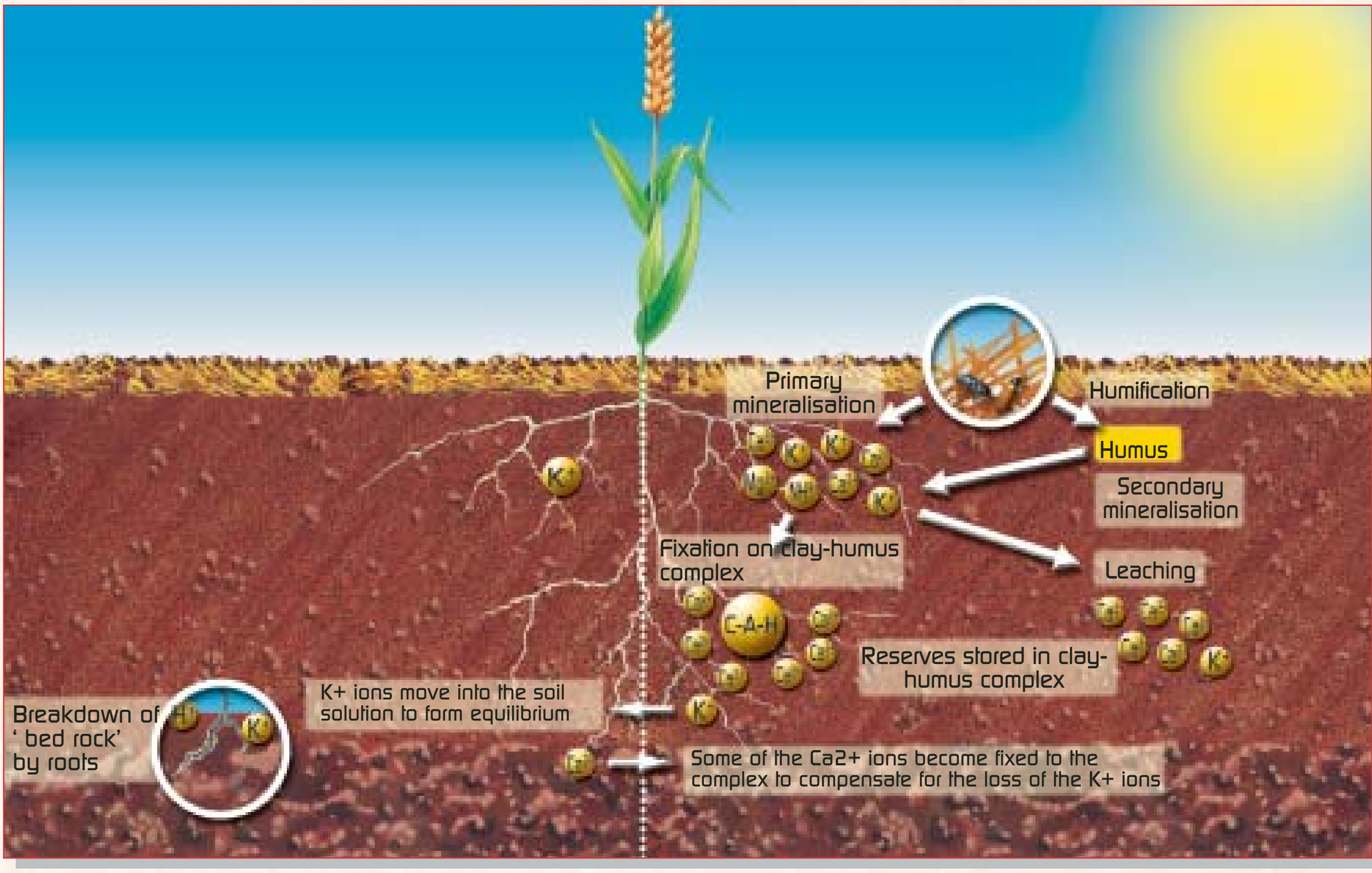


Figure 5 : Processes in plant nutrition.

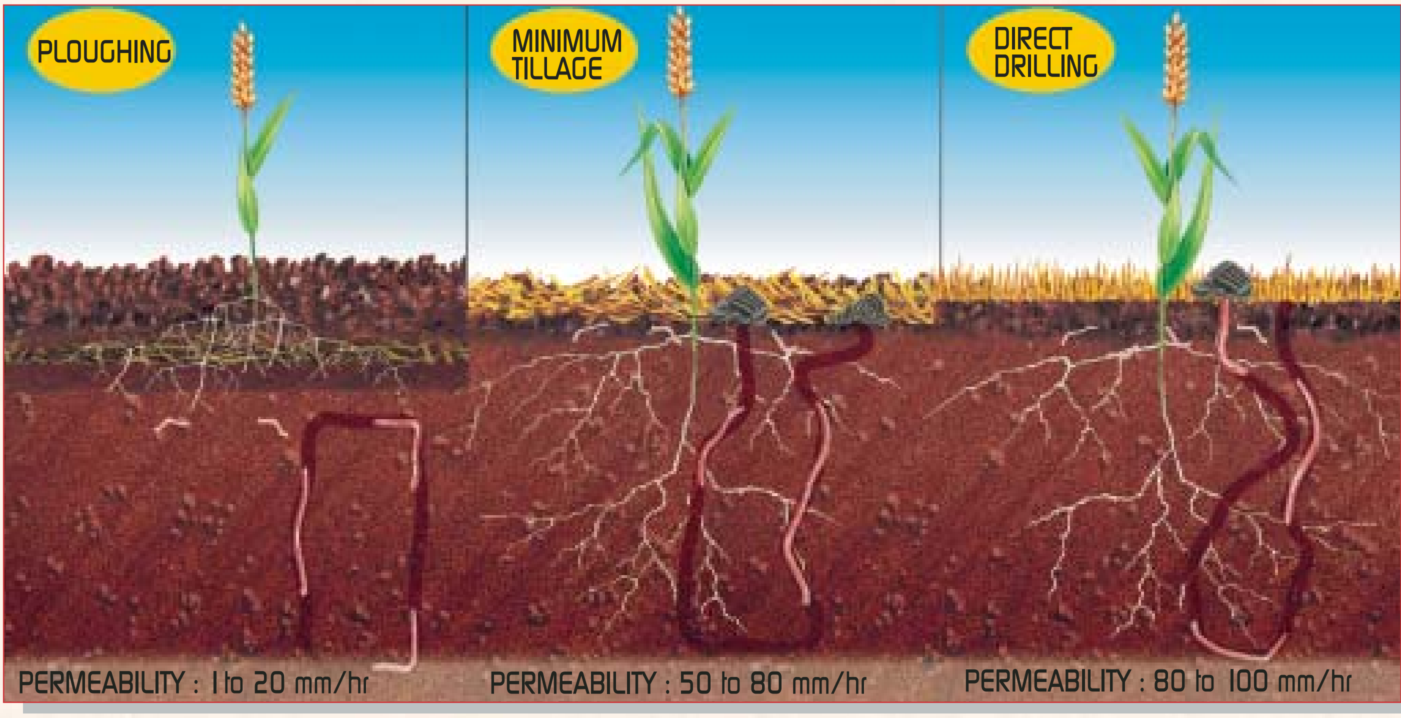
Changing from a plough based system will have an impact on organic matter distribution, the soil's processes and the agronomic situation.

" Soil biological activity "

>> WORM ACTIVITY CAN INCREASE TWO-FOLD

Minimum tillage is accompanied by changes to the soil's biological activity. Where the mineralization of soil nutrients is reduced, there is increased humus production. This in turn benefits the worm population and ultimately the soil structure. The increase in permanent worm galleries is due to less soil disturbance.

***Figure 6** : Worm activity and how it is affected by soil cultivation.*



***Source** : Bourguignon, 2000.*

>> INCREASE IN SURFACE MICRO FAUNA

The majority of micro-organisms are aerobic (i.e. need oxygen) and saprophytes (i.e. feed on organic material). They increase in the presence of surface organic matter. Where minimum tillage is used it is estimated that the number of micro-fauna are two times greater in the top few centimetres of soil than deeper down.

" PHYSICAL PROPERTIES OF SOIL "

>> INCREASE IN SURFACE STABILITY

The formation of surface mulch where minimum tillage is practised protects the soil from erosion and capping. This is particularly beneficial on sandy soils where surface capping can frequently impede crop establishment. The permeability of capped soils can be reduced to as little as 1mm/hr. Mulch helps to retain soil moisture through reduced evaporation.

>> IMPROVEMENT IN SOIL STRUCTURE

After a year without plough use, the porosity of a traditionally cultivated soil profile is reduced. It will then take between 2 and 5 years for the soil to reach a new equilibrium. This is largely dependent on soil texture, weather conditions, organic matter levels (i.e. structural element of the soil), biological activity (particularly earth worms) and the cultivation system used. A continuous structure, consisting of a network of galleries and cracks will eventually be obtained.

" SOIL FERTILITY "

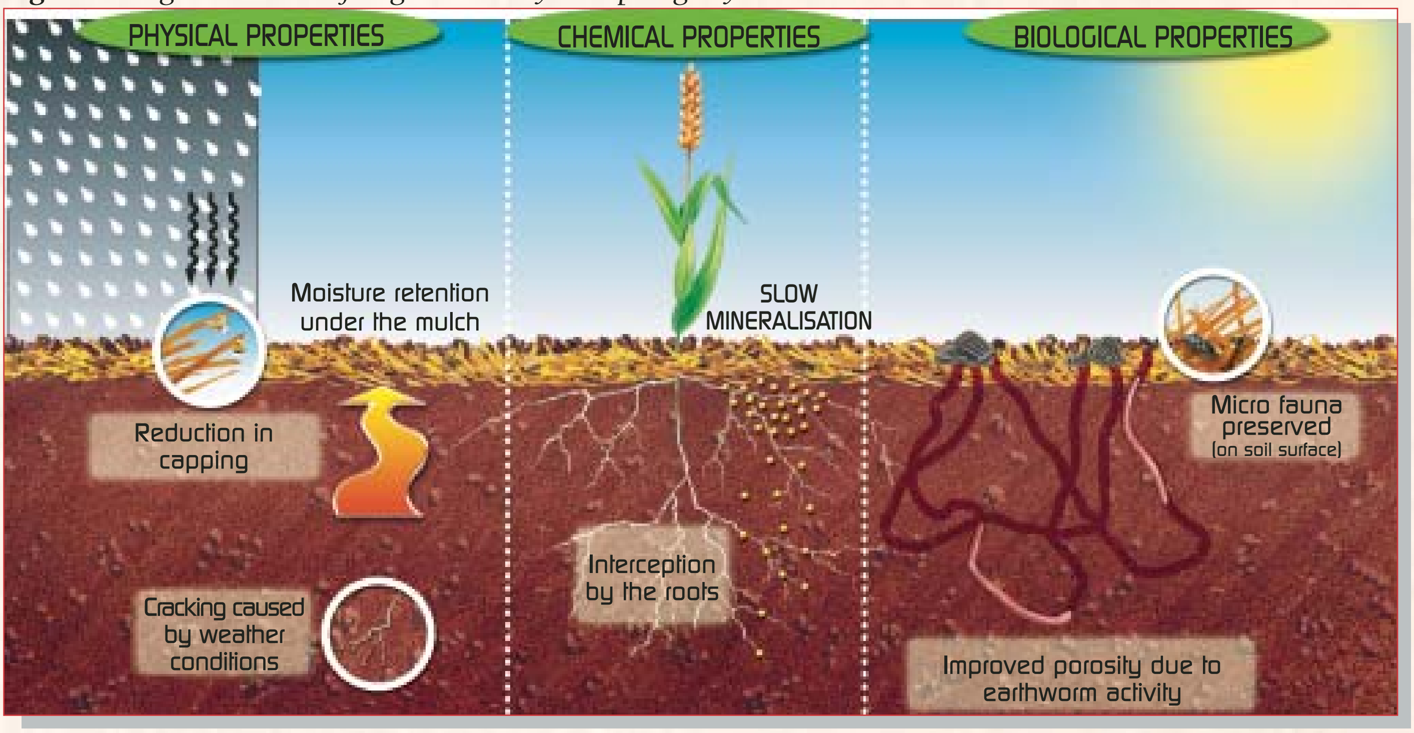
>> ROOT DEVELOPMENT

With the evolution of a soil higher in organic matter and with the absence of changes in the profile, root activity is increased. The root system has a tendency to develop deeper into the soil and colonise larger areas. This leads to greater exploration for nutrients and better use of soil moisture reserves.

>> NUTRITION

Organic matter levels are higher in the soil's upper layers in a non-plough system than in a conventional system. On the ARVALIS plots at Boigneville, France, after thirty years of non-inversion tillage, 33% of the soil's organic matter is now found in the top 5 cm of the soil profile where minimum tillage has been practised, and 85 % where direct drilling has been used. The increase in the amount of soil organic matter is less important than where the organic matter is positioned.

***Figure 7** : Agronomic benefits generated by non-plough systems.*



Environmental implications

Minimum tillage limits surface run off, the origin of soil erosion, and in turn has an effect on off-site flooding. Minimum tillage also reduces the amount of fertiliser and spray residues found in water courses. CO_2 emissions are reduced by non-inversion tillage which has a beneficial effect on the atmosphere.

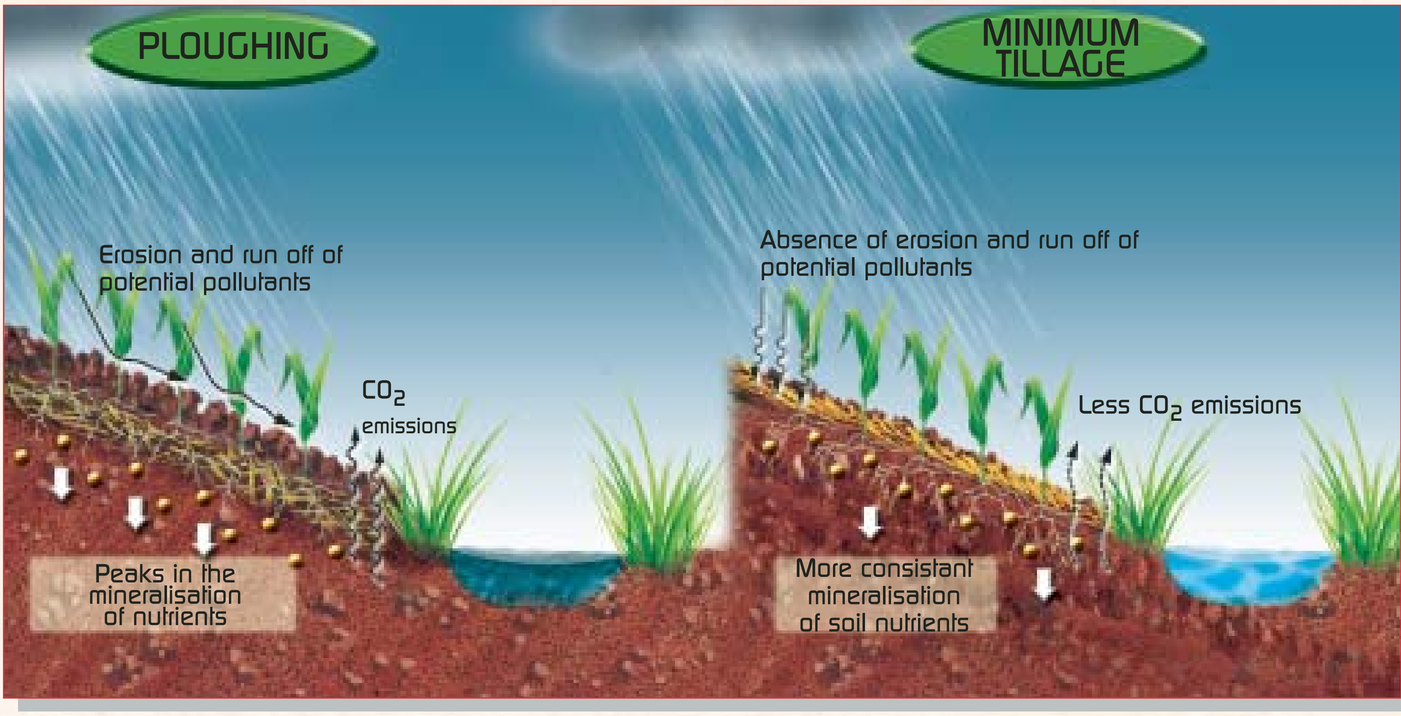
“ Reducing the impact of heavy rain ”

The presence of vegetation - dead or alive - protects the soil from heavy rainfall, limiting capping and runoff. Minimum tillage can reduce soil erosion amounting to 17 tons/ha annually (1.5 cm of top soil lost in 10 years). By reducing surface run off, losses of agrochemicals and soil nutrients into water courses are reduced. A 30% soil covering of residue protects against soil erosion and the other problems that can occur during a long season.

“ Reduced atmospheric pollution ”

Humus stores quantities of carbon. Reducing cultivation contributes to the soil's carbon stock, lowering mineralisation and favouring humus production. This in turn reduces the amount of carbon emitted into the atmosphere.

Figure 8 : Environmental implications of non-plough techniques.



The type of minimum tillage adopted by a farm depends on the type of soil and cropping system. To maintain crop yields there are certain key criteria which farmers must implement to be successful.

" Soil types "

>> CONSERVING SOIL STRUCTURE

There is a high risk of damage to soil structure after late harvested crops such as grain, maize and sugar beet. This is due to reduced carrying capacity under wetter conditions. Such damage is a problem where minimum tillage is adopted. In this case, a deep loosening method is needed to create a reasonable seedbed and ensure plant development is not impeded. Where autumn crops are established soil can be re-structured over the winter period. However, on silty soils, all cultivation should be carried out in good conditions using appropriate tyres and implements that will remove soil compaction. This is particularly important where spring sown crops, sensitive to soil compaction, such as oilseed rape, maize and sugar beet are planted.

>> PAY ATTENTION TO SOILS WITH A HIGH CLAY CONTENT

The clay percentage of a soil effects its ability to re-structure. This is dependent on weather conditions such as raining and drying, freezing and thawing. Although chalky soils rarely suffer from structural problems, clay soils are perhaps the most easy to manage as they are self-structuring. It can be difficult to create seedbeds on soils with very high clay content. Under dry conditions and also wet conditions these soils can be very difficult to manage. However, with increased humus levels the soil becomes easier to work.

>> BEWARE OF WATERLOGGED SOILS

Waterlogged soils during winter result in reduced plant growth. The reduction in soil porosity, a feature in the early years of conversion to minimum tillage, can have the effect of increasing waterlogging. This is why minimum tillage can be difficult on these soils. Increased worm activity along with artificial drainage will help to increase water infiltration.

>> COMPACTION REQUIRES MECHANICAL INTERVENTION

Where compacted layers are discovered in the soil (found with the aid of a spade) mechanical intervention (sub-soiling) will usually be required to re-create soil porosity. This stage is fundamental to the conversion to minimum tillage to ensure a lasting improvement in soil structure.

"Cropping systems"

>> DIFFERENCES IN PLANT DEVELOPMENT

Winter sown crops have a longer period in which to develop and can compensate for low plant numbers through tillering in cereals and branching in the case of oilseed rape. Certain spring sown crops such as maize and sugar beet do not have this ability to compensate. For this reason, they need to be planted under good conditions to ensure yields are not reduced.

>> WEED MANAGEMENT

Cropping and rotations on a farm are often governed by weed species and population levels. By adopting non-inversion tillage, the weed seeds are confined to the upper soil layers, which favours certain species that adapt to the new conditions (e.g. brome…). In short rotations, based on autumn sown crops, certain weed species will always dominate. The introduction of a spring crop in the rotation breaks their growth cycle and they are easier to control with a total herbicide than with a selective product. Mastering chemical weed control and creating an efficient stale seed bed (as soon as possible after harvest to benefit from residual soil moisture) between crops is the secret to managing weed control. Particular attention should be paid to keeping fields clear of weeds in the first few years of non-inversion tillage.

>> MANAGEMENT OF CROP RESIDUES

Crop residues create a favourable environment for the development of crop pests and diseases. They can also make producing an acceptable seedbed difficult.

• Straw removal

Removing crop residue after harvesting, especially that of cereals, creates an unfavourable environment for pest development such as slugs and ensures that seed placement is not effected by excess straw in the seedbed.

• Straw incorporation

When straw is left on the land (up to 10 tons/ha on fertile land), it should be broken down as quickly as possible to reduce its effect on the establishment of the next crop. Trash should be finely chopped and evenly spread. The combine harvester should be fitted with a chaff spreader. Residues should then be incorporated into the upper layers of the soil. When the next crop is going to be direct drilled, it is better to leave longer stubble, thus reducing the incidences of straw blocking the slot and affecting the seed to soil contact. Care should be taken when planting oilseed rape into straw mulch as it can often lead to extended shoots which can increase the incidences of disease and slug damage.

• Spreading waste

Spreading farmyard manure and slurry can compact the soil if it is done in wet conditions. Farmyard manure containing large amounts of straw can obviously cause problems with seedbed production. In a non-plough system any material spread should be composted and well-rotted.

• **Presence of cover crops or catch crops**

The destruction of cover or catch crops is usually done by using chemicals such as glyphosate or by mechanical methods such as shredding or a combination of the two methods. The choice of method depends primarily on the cover crop planted. A light surface cultivation allows the soil to warm up and improve the establishment of the next crop. This operation can be omitted and the next crop can be established into the cover crop residue if the farmer has a suitable direct drill.

"Specifications in terms of crop quality"

Retaining crop residues on the soil surface creates a favorable environment for the development of certain diseases such as fusarium, which can have an effect on final grain quality due to the presence of mycotoxins. To minimise the risk to the crop, particular attention should be paid to crop rotation, planting resistant varieties and applying the appropriate fungicides.

Table 3 : Minimum tillage analysed as a function of soil type and crop to be grown.

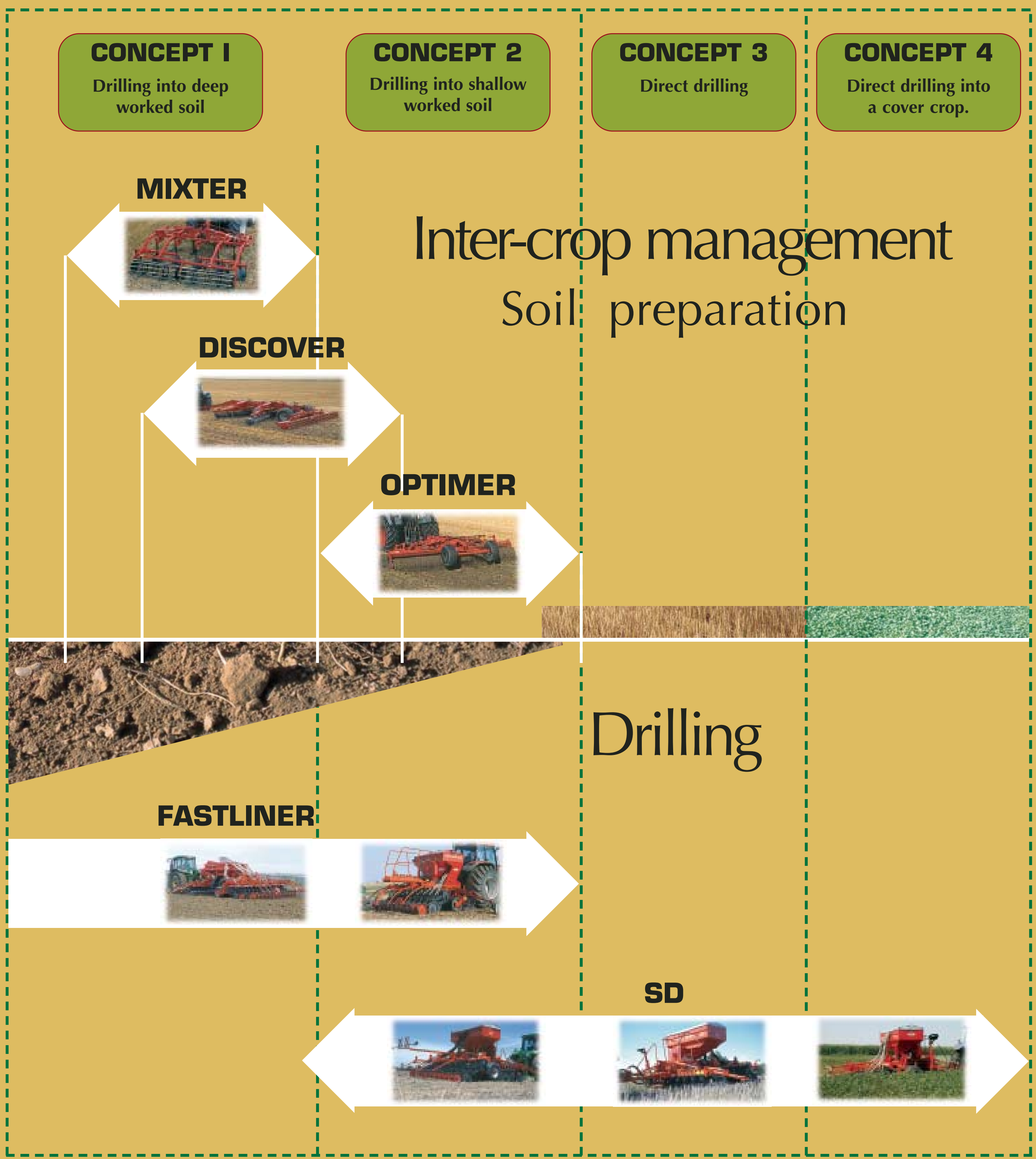
<table>
<tr><th>Type of Crop</th><th colspan="2">Cereals, OSR, Pulse crops, Sunflower, Soya</th><th colspan="2">Maize grain, Maize silage</th><th colspan="2">Sugar Beet, Grass silage, Potatoes</th></tr>
<tr><td>Risk of compaction</td><td colspan="2">Low</td><td colspan="2">Medium</td><td colspan="2">High</td></tr>
<tr><td>Speed of drainage</td><td>Good</td><td>Average</td><td>Good</td><td>Average</td><td>Good</td><td>Average</td></tr>
<tr><td>Clays
Clay-loams
Chalky-clays
Chalk soils</td><td colspan="2">Possible</td><td>Possible</td><td>Risky</td><td colspan="2">Risky</td></tr>
<tr><td>Silty-clays</td><td colspan="2">Possible</td><td>Possible</td><td>Risky</td><td colspan="2">Not Recommended</td></tr>
<tr><td>Silts
Sandy-silts</td><td colspan="2">Possible</td><td colspan="2">Risky</td><td colspan="2">Not Recommended</td></tr>
</table>

Source : Arvalis-institut du végétal

In the situations highlighted as risky or not recommended, precautions should be taken to avoid soil structure damage such as :

• Harvesting in good conditions.
• Using suitable tyres.
• Using a subsoiler / soil loosener if necessary.

The KUHN Concept : Non–PTO driven implements



Definition of the concepts

Soil type and cropping system determine the specific system to be adopted. At Kuhn, we suggest four systems and the appropriate machinery to go with them. You should choose the system which best suits your production objectives and the constraints of your own farm such as soil type, weather, regulations…

“Concept 1 : Drilling into deeply worked soil”

The first Kuhn concept is for producers working with poorly structured soils or soils prone to waterlogging. Working the soil deeply pre-empts compaction problems as well as soil asphyxiation that can occur after heavy rainfall. Sub-soiling may be carried out if conditions are dry, but does not have to be systematically done. Certain silty soils are more prone to compaction if they are worked when wet…

“Concept 2 : Drilling into shallow worked soil”

The aim of this type of cultivation is to manage crop residues, weeds, volunteers and pests rather than restructure the soil. Stubble should be cut short and the residue, well chopped by the combine harvester, should then be evenly spread and incorporated into the top few centimetres to ensure a rapid breakdown. By working the soil in this fashion, pests such as slugs are controlled, as are volunteers and weeds especially when several stale seedbeds are created.

“Concept 3 : Direct drilling into stubble”

Where direct drilling is used, no soil cultivation is done during the inter-crop period, and no soil is moved into the seeding area other than along the line where the seed is to be placed. This system is useful where there is only a short turnaround between crops (e.g. oilseed rape, wheat after maize or sunflower). For the system to work, it is essential to have a good soil structure and a soil surface suitable for crops to establish properly.

“Concept 4 : Direct drilling into a cover crop”

Certain farmers who wish to improve the natural fertility of their soils drill into cover crops. This must be established as soon as possible after harvest to capitalise on any residual soil moisture. It should limit soil erosion, mop up any excess soil nutrients as well as smother any emerging weeds and volunteers. The following crop is direct drilled into the cover crop after it has been chemically destroyed (glyphosate) and/ or cut and shred.

>> OBJECTIVE

The Kuhn group offers a versatile range of equipment suitable for these concepts, which correspond to the varying requirements of your farm.

The cost of the different concepts

•*The figures given in the tables below are given as an indic*

" Concept 1 "

Tine stubble cultivator (12 cm)

Glyphosate (1.5 litres/ha)

Mounted drill **Trailed drill**

>> DRILLING WITH A MOUNTED DRILL

Farm Size	100 ha	200 ha	400 ha	600 ha
Tine implement	3m, 18€/ha	4 m, 19€/ha	5 m, 16€/ha	6 m, 14€/ha
Glyphosate	1.5 l/ha / 11.5€/ha			
Mounted drill	3 m, 33€/ha	3 m, 22€/ha	4 m, 21€/ha	4 m, 18€/ha
Total	**63€/ha**	**52€/ha**	**48€/ha**	**44€/ha**
*Cost of 2nd stubble cultivation	16€/ha	14€/ha	13€/ha	14€/ha

>> DRILLING WITH A TRAILED DRILL

Farm size	100 ha	200 ha	400 ha	600 ha
Tine implement	3 m, 18€/ha	4 m, 19€/ha	5 m, 16€/ha	6 m, 14€/ha
Glyphosate	1.5 l/ha / 11.5€/ha			
Trailed drill	3 m, 60€/ha	3 m, 38€/ha	4 m, 29€/ha	6 m, 26€/ha
Total Cost	**90€/ha**	**68€/ha**	**57€/ha**	**52€/ha**

" Concept 2 "

Shallow stubble cultivation (4cm)

Glyphosate (1.5litres/ha)

Mounted drill **Trailed drill**

>> DRILLING WITH A MOUNTED DRILL

Farm size	100 ha	200 ha	400 ha	600 ha
Shallow Stubble cultivation	3 m, 21€/ha	3 m, 15€/ha	4 m, 14€/ha	6 m, 13€/ha
Glyphosate	1.5 l/ha / 11.5€/ha			
Mounted drill	3 m, 33€/ha	3 m, 22€/ha	4 m, 21€/ha	4 m, 18€/ha
Total	**66€/ha**	**49€/ha**	**45€/ha**	**42€/ha**
*Cost of 2nd stubble cultivation	15€/ha	13€/ha	12€/ha	13€/ha

>> DRILLING WITH A TRAILED DRILL

Farm size	100 ha	200 ha	400 ha	600 ha
Shallow Stubble cultivation	3 m, 21€/ha	3 m, 15€/ha	4 m, 14€/ha	6 m, 13€/ha
Glyphosate	1.5 l/ha / 11.5€/ha			
Trailed drill	3 m, 60€/ha	3 m, 38€/ha	4 m, 29€/ha	6 m, 26€/ha
Total	**93€/ha**	**64€/ha**	**54€/ha**	**50€/ha**

cation only. The amounts are estimated for an average usage.

"Concept 3"

Glyphosate (1.5 litres/ha)

▼

Direct drill

>> DIRECT DRILLING

Farm size	100 ha	200 ha	400 ha	600 ha
Glyphosate	1.5 l/ha / 11.5€/ha			
Direct drilling	3 m, 44€/ha	3 m, 23€/ha	4 m, 26€/ha	6 m, 22€/ha
Total	**55€/ha**	**34€/ha**	**37€/ha**	**34€/ha**

"Concept 4"

Direct drill (cover crop)

▼

Glyphosate (2 litres/ha)

▼

Direct drill (crop)

>> DIRECT DRILLING

Farm size	100 ha	200 ha	400 ha	600 ha
Direct drilling Cover crop	3 m, 44€/ha	3 m, 23€/ha	4 m, 26€/ha	6 m, 22€/ha
Direct drilling Cash-crop	11€/ha	11€/ha	11€/ha	9€/ha
Cover crop Seed cost	15€/ha			
Glyphosate	1.5 l/ha / 11.5€/ha			
Total	**81€/ha**	**61€/ha**	**63€/ha**	**58€/ha**

"Extra information"

All costs included in the tables take into account :

- Machinery depreciation over 10 years.
- Interest on finance (5%).
- Housing.
- Repairs.
- Tractor costs include: depreciation over 8 years, interest on finance (5%), housing, insurance, fuel, lubricants, repairs and tyre wear.

Working the soil during the inter-crop period allows for the management of weeds and volunteers, starts the breakdown of crop residues, reduces the population of pests and prepares the soil for the next crop. Today most of these agronomic reasons remain, but there are added regulatory and economic constraints which are forcing farmers to re-think this stage (e.g. drilling a cover crop).

"Drilling cover crops"

>> THE REASONS

Regulations such as nitrate and water directives have forced a number of growers to plant a cover crop during the inter-crop period. Other than simply enabling compliance with regulations, introducing cover crops into the crop rotation has other benefits. Cover crops can have an effect on soil structure due to the development of root systems, they mop up any surplus soil nutrients and they aid the management of weeds and volunteers.

>> PRACTICAL GUIDELINES

When establishing a cover crop during the inter-crop period, action needs to be taken immediately after harvest to take advantage of any residual soil moisture. The cover crop should be destroyed chemically or mechanically before it sets seed. The cash crop (e.g. wheat, barley…) can then be direct drilled or sown after some shallow cultivation. This will help warm up the soil and aid the mineralisation of the nutrients retained in the cover crop.

>> WHICH COVER CROP TO PLANT ? CHOICE OF COVER CROPS RELATIVE TO THE FOLLOWING CROP.

	Mustard	Radish	Oilseed (Rape)	Rye	Oats	Cereal (Re-growth)	Phaecelia	Legumes (Clover, Vetches)
Wheat in rotation				P	P	?		
Wheat after wheat	PE?	PE?	PE?	P	P	P		
Spring Barley								
Maize		?	A					
Peas, Beans, Soya								P
Oilseed (Rape in rotation)	D	D						S
Sunflower	S							S
Sugar beet	N-	N-	N+		?			
Potatoes								
Vining peas and beans	S,D	S,D	S,D					P

	Positive effect		Cover not recommended
	Little effect		Not tried
	Cover crop with specific characteristics	?	No information

Source : Arvalis-institut du végétal, 2002.

P : Risk linked to parasites
D : Risk of weed (and remaining cover crop) control problems in following crop
S : Risk of Sclerotinia
A : Yield reduction possible

N- : Aids control of nematodes in sugar beet (N+ encourages nematodes)
PE : Reduction in take-all observed after mustard in a trial (little reduction in second trial)

KUHN

"Without planting a cover crop"

>> WEED MANAGEMENT

• Chemical control

The growth in minimum tillage has been driven by the availability of cheaper herbicides, notably glyphosate. Some root acting herbicides are less efficient in a minimum tillage system, due to the increase in surface mulch and increased biological activity in the soil. Where appropriate foliar acting products should be chosen. Surface mulch can fix some herbicides (e.g. 2.4D, sulfonylureas) and this can have an impact on the following crop. To reduce the problem, care should be taken with the choice of product and its application (timing and rates).

• Mechanical control

Many annual weeds (e.g. ryegrass, brome…) can be controlled in a stale seedbed. To be effective, the stale seedbed should be established as soon after harvest as possible in order to make best use of the soil's residual moisture. It should be quite shallow, but should be re-consolidated immediately to ensure maximum germination of weeds (and volunteers). Deeper cultivations are required to up-root weeds, to ensure they dry out and die on the soil surface. Repeated cultivations can in time reduce the weed seed bank. When adopting minimum tillage, rotation (including both spring and autumn sown crops) needs to be planned in order to prevent the build up of specific weeds (e.g. blackgrass…). Furthermore, by rotating cereals and broadleaved crops, it is possible to target specific weeds chemically in the different crops.

>> SLUG MANAGEMENT

• different types of slug

Slugs are gastropods which flourish in areas where there is shelter, moisture and a plentiful supply of food. Grey slugs are usually found on the surface and black slugs are found underground and therefore are harder to control. Slugs are generally inactive during frost and dry weather.

• Thresholds for chemical control

Thresholds for control before and after drilling defined by Arvalis are as follows :

• **1 - 20 slugs/m² :** Wait until crop damage is seen before treating.

• **20 slugs/m² :**
Grey slugs : treat 15 days before drilling and probably again before emergence;
Black slugs : incorporate slug pellets when drilling with the seed, not forgetting to apply surface pellets to control those individuals remaining on the surface.

• **50 slugs/m² :**
Apply pellets 15 days before drilling when the slugs are active and then again at drilling. With such high infestations every effort should be made to mechanically destroy as many slugs as possible by repeated cultivations.

• Agronomic control

Working the soil and producing a fine tilth destroys the slug's shelter and exposes them to high temperatures and the risk of drying out. Post-harvest, it is advisable to chop any remaining trash and to chemically destroy any weeds and volunteers. You may also like to consider planting a cover crop that is unattractive for slugs to feed on. At seeding, it is advisable to have a well prepared firm seed bed and to drill deeper than normal (avoid leaving grain on the surface), increase seed-rates if poor emergence is anticipated and roll after drilling to avoid fluffy seed beds.

"OPTIMER"

>> AGRONOMIC BENEFITS

• Shallow working and re-consolidating the soil to encourage weeds to germinate in a stale seedbed.
• Accelerate decomposition of harvest residue by thorough mixing into the soil.
• Preserve the flora and fauna (e.g. earthworms) through shallow working and by not re-adjusting the soil structure.
• Reduce water loss through evaporation (due to less soil being moved).
• Limit slug development by crumbling and re-firming the soil.

>> SPECIFICATIONS

Optimer	Optimer 301 (mounted)	Optimer 401 (mounted)	Optimer 4001 (trailed)	Optimer 6001 (trailed)
Working width (m)	3	4	4	6
Working depth (cm)	3 - 10			
Working speed (km/h)	7 - 15			
Output per hour (ha)	2.5 - 3.0	3.1 - 4.0	3.1 - 4.0	5.0 - 6.0
Potential * output/day (ha)	25 - 30	31 - 40	31 - 40	50 - 60

" DISCOVER "

>> AGRONOMIC BENEFITS

• Destruction of vegetative residues by cutting and chopping.
• Working in high levels of residue.
• Very good soil levelling effect.
• The packer roller ensures good straw to soil contact with any harvest residues, encourages the germination of weeds, maintains soil moisture and prevents the formation of puffy soils.
• Alternating smooth and notched discs enables the machine to work in a variety of soil types and residues.
• It is possible to fit the Discover with a SH small seed broadcaster to enable cover crops to be established at the same time as stubble cultivating. It is also possible to use the machine, with the aid of the packer roller, as a shallow cultivation implement.

>> SPECIFICATIONS

Discover	**XS**	**XM**	**XL**
Working Width (m)	2.95 - 3.85	3.40 - 5.65	5.65 - 7.00
Working depth (cm)	5 - 12		
Working speed (km/h)	5 - 10		
Output per hour (ha)	1.9 - 2.5	2.4 - 3.0	3 - 4.0
Potential * output/day (ha)	19 - 25	24 - 30	30 - 40

* A working day = 10 hours

Choice of Non-PTO driven implements

" Mixter "

>> AGRONOMIC BENEFITS

- Destruction of plant rhizomes (e.g. couch, thistles…).
- Re-structuring the upper soil horizons (layers).
- Soil levelling with a combination of tines and discs.
- The pressing effect of the roller encourages the breakdown of harvest residue and germination of weeds, maintains soil moisture and prevents puffy soil.

>> SPECIFICATIONS

Mixter	Mixter 107	Mixter 109 folding	Mixter 111 folding	Mixter 113 folding
Working width (m)	3	4	5	6
Working depth (cm)	6 - 15			
Working speed (km/h)	8 - 10			
Output per hour (ha)	2.1 - 2.5	2.8 - 3.5	3.5 - 4.2	4.0 - 5.0
Potential *output/day (ha)	21 - 25	28 - 35	35 - 42	40 - 60

* Working day = 10 hours

"DC Cultisoil"

Before adopting minimum tillage the deeper soil structure should be inspected to identify compacted layers and plough pans. If there is a problem a soil loosener should be used to alleviate the situation. After harvesting under poor conditions as with roots crops, the DC Cultisoil can be used to re-structure the soil after it has dried out. Certain soils such as silts and sands naturally re-compact, so again it is an application for the DC Cultisoil.

>> AGRONOMIC BENEFITS

The DC Cultisoil can be used under dry conditions in solo or in combination with a HR power harrow or EL power tiller :

- The DC Cultisoil cracks and breaks up the compacted layer when the soil is lifted in a wave effect.
- Neither the soil's vertical capillary action nor the surface micro-fauna are destroyed.
- The different soil horizons are not mixed and the surface is left level.
- Good clearance for trash flow.
- Leaves the residue on the soil's surface.

>> SPECIFICATIONS

DC Cultisoil	**DC 301**	**DC 401**
Working width (m)	3	4
Working depth (cm)	10 - 35	10 - 35
Working speed (km/h)	4 to 7	4 to 7

“WORKING COSTS FOR STUBBLE CULTIVATORS” (AIM : 20€/ha)

>> BASIS FOR CALCULATING COSTS

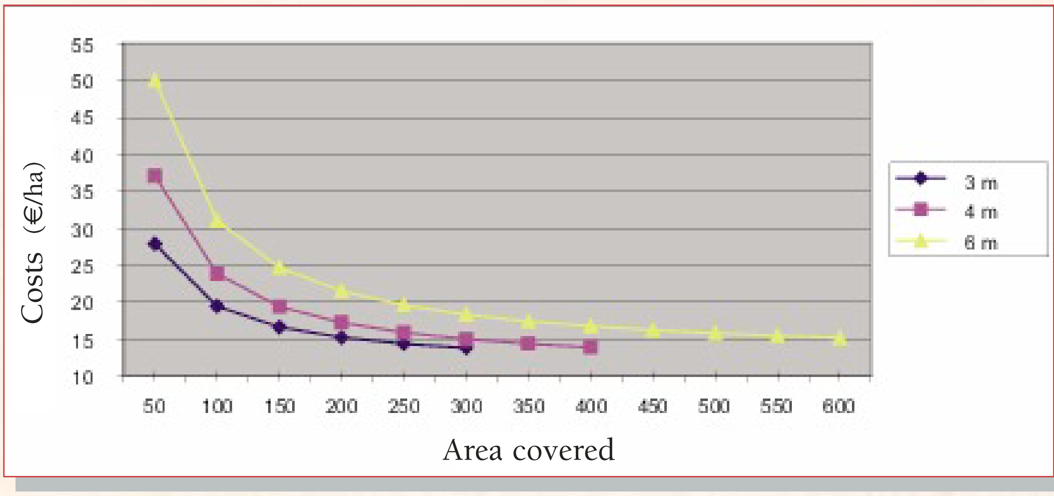
• **TRACTOR USAGE**

	Number of hours per year	Depreciation period (years)	Interest on finance
Tractor >140 hp	400 hr	8	5.5%
Tractor< 140 hp	600 hr	8	5.5%

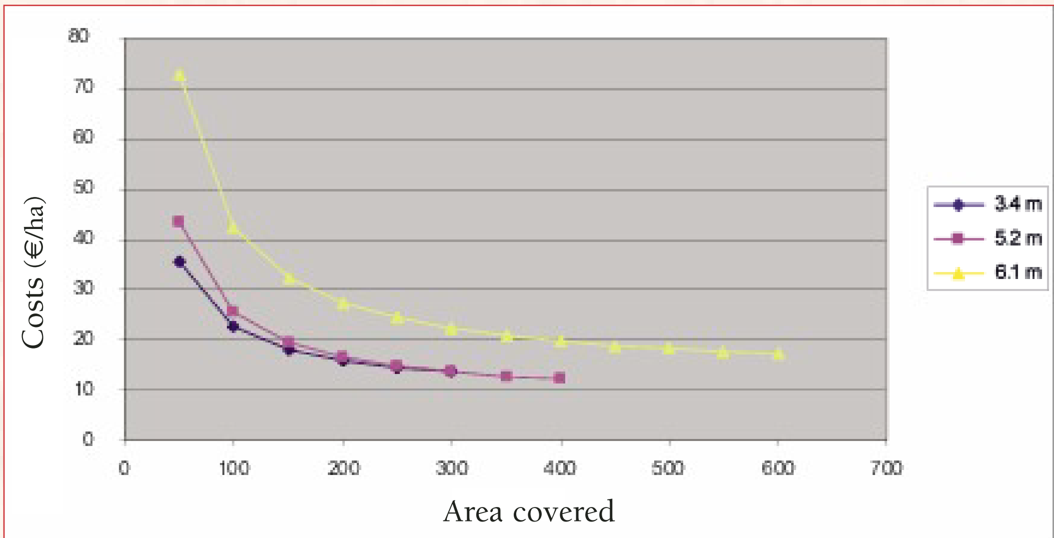
• **STUBBLE CULTIVATION IMPLEMENTS**

- Write-off period for equipment (10 years).
- Interest on finance (5.5%).
- Cost of housing.
- Cost of repairs and wearing parts (0.8€/ha for disc implements and 3€/ha for those with tines).

>> TINE IMPLEMENTS



>> DISC IMPLEMENTS



Soil structure and the even distribution of residues have an effect on the quality of the seedbed. Every opportunity should be taken to ensure that the soil is not damaged and that the trash is evenly re-distributed when harvesting the previous crop.

28/10

22/12

"PRACTICAL ADVICE"

In a conventional plough based system, ploughing will remove any soil structure problems and bury the crop residues so seed placement is unaffected. In a non-plough system, the opportunities for rectifying these problems are less. The farmer should therefore ensure that the system is managed as efficiently as possible.

>> SUITABLE SOIL STRUCTURE

Planting into a good soil structure is necessary for the seed to germinate successfully and develop a good root system. On silty soils, where there is the danger of producing an over worked seedbed, there is then the risk of capping, which can affect establishment. On the other hand cloddy seedbeds can create a physical barrier to the shoot's development. In puffy soils, following dry conditions, germination can be poor due to the lack of available water for the seed.

>> DISTRIBUTION OF HARVEST RESIDUE

With large quantities of harvest residue in the seedbed it is more difficult to achieve an accurate seeding depth. An even spread of chopped straw is essential when direct drilling. Where shallow surface cultivations are used, crop residue should be finely chopped and evenly spread, then incorporated into the top 5 cm of soil to encourage decomposition. Work should be done as soon after harvest as possible. If large volumes of residue need to be incorporated, working the soil deeper should be considered in order to dilute the straw into a larger volume of soil.

“ USE OF SPECIALIST DRILLS ”

When direct drilling only the soil along the line where the seed is going to be placed is worked. The furrow is opened and the soil pulverised to create an ideal environment around the seed, warming the soil and encouraging the mineralization of nutrients in the seed row. The depth control wheel also lightly presses the soil over the seed, thus improving the seed to soil contact, and re-establishing capillary action without starving it of oxygen.

Where minimum tillage is used, all the soil is moved to achieve a level seedbed and remove any weeds and volunteers that may have grown. Pressing the soil before the drilling elements is important, particularly on puffy soils.

There are two categories of drill:

- Specialist machines which are very versatile and adapted for use in a variety of soil and residue conditions.
- Conventional drills which have been converted for minimum tillage use.

" MOUNTED FASTLINER 100 SERIES "

>> AGRONOMIC BENEFITS

— DOUBLE ROW OF WAVY DISCS OR LEVELLING BAR AND VIBRATING TINES :

- Levelling ploughed land or after stubble cultivations.
- Creating fine soil for a good seedbed.

— PRESS ROLLER :

- Firms the soil to avoid puffy seedbeds.
- Creates a uniform seedbed for good seeding depth.

— DRILLING DISCS :

- Good drilling depth controlled by depth wheel and its parallelogram mounting system, which allows good ground following.
- The depth wheel firms the soil around the grain for good seed to soil contact.
- Good clearance to allow large quantities of residue to pass.

— FOLLOWING HARROW :

- Covers the seed and protects the soil from capping by spreading clods and residue on the surface.
- Little chance of blockages as the harrow is fully adjustable for pressure and angle of attack.

>> SPECIFICATIONS

Fastliner	**Fastliner 300**	**Fastliner 400**
Working width (m)	3	4
Hopper capacity (l)	1000	1000
Output per hopper load (ha)	6.5	
Working speed (km/h)	7 - 15	
Output per hour (ha)	2.5 - 3.0	3.1 - 4.0
Power requirement (hp)	120	150
Potential daily output (ha)	25 - 30	31 - 40

" TRAILED FASTLINER 1000 SERIES "

>> AGRONOMIC BENEFITS

— LEVELLING BOARD :

- Levelling ploughed land or after stubble cultivations.

— DOUBLE ROW OF STRONGLY WAVED NOTCHED DISCS (WORKING ACROSS THE SOIL SURFACE) :

- Creating a fine seedbed for good seed to soil contact.
- Breaking-up harvest residue.
- Destroying weeds and volunteers.
- Destruction of an environment favourable to pests such as slugs.
- Reduces the need for cultivation passes prior to drilling.

Module 2

— *ONE ROW OF DISCS IN LINE WITH DRILLING DISCS :*
- Versatility : enables direct drilling into stubbles or cover crops.

— *PRESS ROLLER TO LEVEL UNEVEN SOILS :*
- Avoids puffy seedbeds.
- Creates a level seedbed for accurate seeding depth.

— *DRILLING DISC ASSEMBLY MOUNTED ON PARALLELOGRAM FRAME (DOWN-PRESSURE OF 50-80 kg) :*
- Regular drilling depth thanks to depth wheel and mounting on parallelogram linkage.
- The wheel also firms the soil around the grain to ensure good seed to soil contact.
- Good clearance to allow for the easy passage of large quantities of residue.

— *FOLLOWING HARROW :*
- Covers the seed and protects the soil from capping by spreading clods and residue on the surface.
- Being fully adjustable for pressure and angle of attack there is very little chance of blockages.

>> SPECIFICATIONS

Fastliner	Fastliner 3000	Fastliner 4000	Fastliner 6000
Working width (m)	3	4	6
Hopper capacity (l)	2000	2000 (2600)*	2600 (3200)*
Output per hopper load (ha)	13	13	17
Working speed (km/h)	7 - 15		
Output per hour (ha)	2.5 - 3.0	3.1 - 4.0	5.0 - 6.0
Potential output per day (ha)	25 - 30	31 - 40	50 - 60

*Optional

" SD AND FASTLINER 6000 SD DIRECT DRILLS "

>> AGRONOMIC BENEFITS (TRIPLE DISC SYSTEM)

— *OPENER DISCS :*

> Serrated discs with a diameter of 430 mm work a narrow strip of soil (8 mm) and are particularly suited to hard and/or stony soils where large quantities of trash are present.

> Wavy discs with a diameter of 460 mm cut a wider slot (20 mm) and move more soil :
- Soil conditions are good around the seed.
- Soil warming and mineralization of soil nutrients are encouraged in the slot.
- Working depth can be adjusted to suit soil type.

— *DRILLING DISC :*
- Uniform drilling depth thanks to depth control wheel and parallelogram mounting.
- The press wheel firms the soil around the seed ensuring a good seed to soil contact.
- Good clearance to allow for the easy passage of large quantities of residue.

>> SPECIFICATIONS

SD	SD 3000 P	SD 4000	SD 4500	Fastliner 6000 SD
Working width (m)	3.00	4.00	4.50	6.00
Hopper capacity (l)	2000			2600
Output per hopper load (ha)	13			17
Working speed (km/h)	7 - 15			
Output per hour	2.5 - 3.0	3.1 - 4.0	3.4 - 4.5	5.0 - 6.0
Potential output per day (ha)	25 - 30	31 - 40	34 - 45	50 - 60

"Cost of using specialist drills"

(aim : 35€/ha)

>> CRITERIA FOR CALCULATING THE COST OF USE

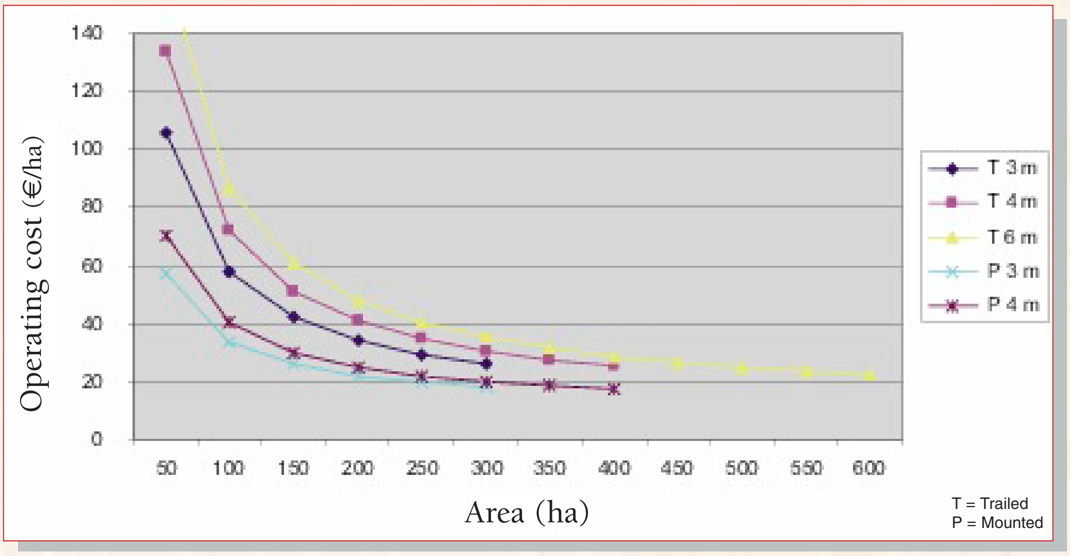
- **Tractor cost**

	Number of hours per year	Depreciation period (years)	Interest on finance
Tractor > 140 hp	400 hr	8	5.5%
Tractor < 140 hp	600 hr	8	5.5%

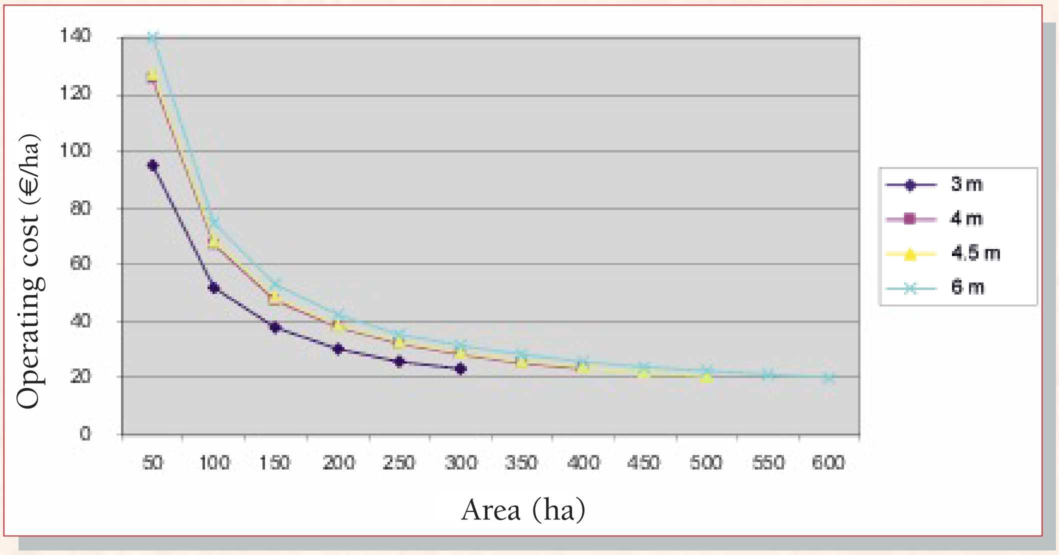
- **Drill costs**

- Depreciation over a 10 year period.
- 5.5% interest on finance.
- Shelter.
- Repairs and spares (2.30€/ha for the SD and 3€/ha for the Fastliner).

>> MINIMUM TILLAGE DRILLS



>> DIRECT DRILLS



" Precision drills : Maxima " Maize, Sunflower, Sugar beet...

>> AGRONOMIC BENEFITS

- Residue is cleared from seeding row to ensure a good seed to soil contact. This also increases the soil temperature thus improving germination.
- Accurate seeding depth is achieved by cutting and residue in the seeding line; this ensures a better contact between seed and soil.
- Residue is maintained between the seed rows to reduce evaporation and soil erosion.
- Effective slot closing.
- Heavy drill able to follow ground contours, ensuring regular sowing depth even where only minimal soil preparation has been carried out.

>> SPECIFICATIONS

	Maxima			
Type	Single bar mounted	Telescopic		Folding
		Simple	Double	
Working width (m)	2.50, 3.00, 3.45 4.40, 6.00, 9.00	4.40	4.40	6.00
No. of units	2 - 12	6-7-8		8 - 12
Average weight of each unit	From 120 to 150 kg			
No. of wheels	2, 4 or 6	2		4
No. of gearboxes	1 or 2	1		2
Hopper capacity	52 litres			
Minimum row width	40 - 70 cm depending on version			
Attachment	Semi-automatic as standard			
	Automatic optional			
Markers	SA hydraulic			DA
Fertiliser	2 x 190 l hoppers			Front Hopper TF 702
	2 x 280 l hoppers			
	1 x 1350 l hopper			
Micro-granule application	Insecticides / slug pellets 3, 6, 9 of 60 to 100 l			
	Herbicides 3, 6, 9 of 110 to 180 l			

EQUIPMENT FOR MINIMUM TILLAGE :

1 - Trash moving wheels
2 - Pre-cutting disc
3 - Furrow closing disc

" ALTERNATIVE PTO DRIVEN SOLUTIONS FOR MINIMUM TILLAGE "

These alternatives offer the flexibility which farms may need:
- by allowing for a progressive adoption of minimum tillage without high investment in specialist machinery;
- or providing for the situation where the plough is still necessary in certain conditions.

>> WITH A POWER TILLER

The EL power tiller can work directly into stubble, after stubble cultivation or after soil loosening. The EL power tiller can be used in combination with or without a seed drill and /or a soil loosener.

Agronomic benefits :
- Even mix and incorporation of crop residues.
- A good levelling effect.
- The soil is crumbled and firmed for good plant development.
- Works well where grassland is being re-seeded.

>> SPECIFICATIONS

EL	EL 102	EL 142	EL 201
Working width (m)	3	3	3 or 4
Working depth (cm)	8 - 23	8 - 25	8 - 26
Working speed (km/h)	3 - 8	3 - 8	3 - 8

>> WITH A POWER HARROW

A power harrow is suitable in a minimum tillage system for preparing seedbeds after stubble cultivations or soil loosening. This can be carried out in conjunction with a seed drill and/or a soil loosener.

- **AGRONOMIC BENEFITS :**
  - Good mix and shallow incorporation of crop residues.
  - Good levelling effect.
  - The soil is crumbled and firmed for good plant development.

>> SPECIFICATIONS

HR	HR 303 - HR 3003	HR 403 - HR 4003
Working width (m)	3	4
Working depth (cm)	3 - 25	3 - 25
Working seed (km/h)	3 - 8	3 - 8

“ ESSENTIAL FOR RESIDUE MANAGEMENT ”

>> SHREDDERS

- Improves the breakdown of harvest residue where there are large amounts by chopping and even re-distributing.
- Reduces the transmission of vegetative diseases from residue and destroys pests (e.g. pyralid moth, corn borer, clearwing moth) by mechanically shredding and exposing the larvae to cold weather.
- Reduction in the nitrogen tie-up associated with residue breakdown.

>> SPECIFICATIONS

Flail Shredders	**RM 320**	**RM 400**	**NK 3201**	**NK 4001**	**NK 4801**
Working width (m)	3.20	4.00	3.20	4.00	4.95
Cutting height (mm)	300 - 135		300 - 135		
Forward speed (km/hr)	5 - 8				
Output per hour (ha)	2.0	2.6	2.0	2.6	3.2

“ YOUR NOTES ”

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	CONCEPT 1 Drilling into deep worked soil	CONCEPT 2 Drilling into shallow worked soil	CONCEPT 3 Direct drilling	CONCEPT 4 Direct drilling into a cover crop
SOIL PREPARATION				
> NON-PTO DRIVEN:				
• Optimer		X		
• Discover	X	X (Use a roller)		
• Mixter	X	X (Adjust position of tines)		
• CultiSoil (DC)	X			
> PTO DRIVEN:				
• Power Harrow with Optimix	X	X		
• Powertiller	X	X		
DRILLING				
• Fastliner 100	X	X		
• Fastliner 1000	X	X	(X) (On easy to prepare soil)	
• Fastliner 1000 SD		X (On pressed soil)	X	X
• SD		X (On pressed soil)	X	X
• Maxima	X	X	(X) (On easy to prepare soil)	

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