



Cover crops : some species observed, tested and mixed

by Frédéric Thomas and Matthieu Archambeaud from “ TCS magazine ”, France

Species	Seeding rate (kg/ha)	Comment
BASICS		During the period between cash crops, seeding any cover-crop is a big step forward in restoring water quality, maintaining and developing soil fertility and in the long term saving fertiliser inputs and reducing the need for tillage. There is no such thing as a bad species and neither are there any specifically good ones. Each plant has its own attributes that fit specific or diverse situations. So it is very important to have a good knowledge of each one of these important “agronomical tools” in order to use them properly and gain the maximum benefits.
Common (white) mustard	8 to 10 single, (3 to 4 into a mix)	The most widely used cover crop, easy to establish, quickly covers the soil surface but very sensitive to stress (lack of water, lack of nitrogen or very high temperature) and can run to seed very quickly. As it's biomass rapidly becomes fibrous, is slow to break down and during decomposition nitrogen losses can be high. The normal seed rate is about 10 kg/ha however due to its root structure: at this density there is a competition between plants and poor soil exploration: in a mixture a rate of 3 to 4 kg/ha would be used (to be divided by the number of species in the mix).
Phacelia	6 to 10	Requires better establishment, has small roots which are very beneficial in improving the surface soil structure, especially in clay soils. It is very popular with bees. Phacelia improves the density in mixtures and can easily be destroyed by a knife roller; its black coloured residues help to warm up the soil (just like the field bean residues). If nitrogen is available (manure or legumes), it produces a lot of biomass; it's also a good potash scavenger. Because it has an indeterminate flowering habit it produces a lot of seed.
Oat (spring or winter variety)	70 to 90	Not expensive and easy to establish, oats are better suited as autumn and winter cover-crops. When drilled too early they produce low levels of biomass and are susceptible to rust and aphids. Generally the crop is not killed by frosts and will re-grow in the spring
Fodder radish	6 to 8	A versatile plant suited to almost all soil types and conditions. A big biomass is produced and it leaves a good soil structure. It resists drought and is not attractive to slugs. Can produce some seeds. It's a good basis for a lot of mixes.
Rye	70 to 100	Very aggressive plant with a good soil restructuring root system. It will not develop a lot of biomass after autumn seeding but will become very productive at the following spring. Very sensitive to slugs when young, it is a very useful plant for farmers looking for thick mulch to direct drill legumes, maize or vegetable crops into. The C/N ratio of the residue is high, so there is a risk of early nitrogen deficiency, mixing with vetches or peas is advisable
Triticale	80 to 120	The same properties than the rye but a little bit less aggressive and is more susceptible to pests and diseases. Triticale should be sown as an over-wintered cover crop
Barley (spring or winter variety)		Useful and cheap cover-crop that can supply some biomass in autumn (spring varieties). Never the less barley is sensitive to stress and diseases. Not advisable in rotation with winter cereals.
Ray-grass	17 to 22	Early growth is slow but once established can become very aggressive. It is better suited to cover crops which will be over-wintered. It can supply a useful source of forage and is a nitrogen scavenger. It is one of the few species that can be grown under maize, but can be very difficult to manage either mechanically or chemically.

Oil seed rape	8 to 12	Very inexpensive cover-crop, the plant is aggressive with good soil structuring attributes. To get the best from OSR as a cover crop there needs to be sufficient N available. It could be used in any rotation where OSR is not a part. OSR can and will encourage slugs so this should be taken into account when considering it.
Fodder rape	8 to 12	Very similar to OSR but with more foliage (better cover) and it can be grazed.
“ NEW SPECIES ”		These species have been introduced recently as potential cover-crops with some useful attributes. It is not a complete list; new species are screened every year by min-till and no-tillage organisations and also by seed suppliers. There are many other species which might be suited as cover-crops but it is a case of finding them and trialling them on a local basis.
Sunflower	20 to 25	This species is best suited to hot and dry conditions and can supply good levels of biomass if planted early in the summer. It is a very good option for summer cover-crops in the rotations where it is not planted as a cash crop; it is killed by frost. In Biomax type mixtures it forms a basis which absorbs nitrogen, phosphate and potash: It doesn't provide much soil cover but does absorb a lot of nutrients which can help suppress weeds
Rough oat or Brazilian oat (<i>avena strigosa</i>)	35 to 45	Will grow under all conditions. This type of oat, close to forage oat, is quite aggressive and produces a heavy biomass that can be converted into quality forage (could be fibrous). As a cover-crop, the straw remaining on soil can be difficult to break down and may require some extra nitrogen: therefore there is risk of nitrogen deficiency in the next crop (just like mustard) this can be reduced by including a legume.
Flax	20 to 30	A plant easy to establish even under dry conditions. Although it has a low surface biomass it produces a good level root development and competes well with weeds. The remaining surface residue can block tillage tools and seeders.
Buckwheat	45 to 55	This plant is quite easy to establish in stubble during the summer and competes well with broadleaved weeds (allatrophic effect). Initially it is a cash crop that is quite easy to use as “double” crop or catch crop. Never the less seeds remaining on the soil surface after harvest or in the cover-crops biomass will germinate next spring when the temperature reaches (12 °C). Buckwheat is so not recommended as cover-crop or in a mix before maize, sugar beet, sunflower.... It encourages bees and wild life. It's a good phosphorus scavenger.
Camelina	8 to 12	An oil seed plant that must be seeded very shallow (very small seed) but emerges and grows quickly competing well with weeds. As the growing cycle can be completed in 90 to 100 days there is a high risk of it producing viable seeds. However this species can be used as double crop, and as companion crop especially in association with legumes (Lentil, soyabean, lupin for example) still showing all its attributes as a cover-crop.
Asian radish	5 to 8	It is a species that is quite easy to establish and absorbs a lot of Nitrogen. Unlike the fodder radish this cover-crop doesn't grow a stem (if sown late summer and autumn) but develops rapidly and produces a long tap root. If there is sufficient soil fertility its root can become very big and weight several kgs. It is usually killed by winter frosts (-7 or -8 °C) or by rolling or shallow tillage. Although it is a crucifer, this crop returns the fertility stored in its root as it has a low C/N ratio.
Turnip	6 to 10	Another cruciferous species mopping up a lot of residual Nitrogen. Like OSR, this specie doesn't grow to stem in autumn and the foliage is good for grazing. It will not be killed during winter and will continue to absorb nitrogen during spring growth initially depleting the nitrogen available for the following crop. This nitrogen will be only available later to the cash-crop.

Moha millet	25 to 30	Summer grasses need high temperatures, water and nitrogen. It is an excellent source of forage and a useful catch crop when grown in conjunction with legume like Alexandra clover. Like all summer grasses, moha is sensitive to sunlight and must be seed early,(before mid-July) as the long day length stimulates its growth.
Sorghum	15 to 25	Very aggressive tropical grass producing a heavy biomass and roots, when planted early. This plant is supposed to be drought resistant when well established (it needs a good seeded). Never the less sorghum benefits from high temperatures, moisture and nitrogen. Several types are available (grain, <i>sugar</i> , <i>paper</i>) that can produce different volumes and qualities of vegetation. Sorghum is a good source of forage.
Black mustard	2 to 3	With a very low thousand grain weight and strong emergence (vegetal development a little bit like OSR but will produce a stem in the autumn), black mustard can be seeded at very low seed rate. Its growth cycle is longer than the white mustard so the chance of producing seed is lower, so it is less competitive with weeds. Some people say that it could be employed as a "bio-fumigant" on nematodes.
Nyger	8 to 12 kg	Nyger is closely related to sunflowers, and is best suited to hot moist conditions. If drilled early it can produce high levels of biomass and will smother volunteers and weeds. The first light frost will kill it and it is attractive to slugs. If planted early it is a versatile cover-crop. Planted alone or in a mixture it gives good results. Nyger should be considered as a companion crop with autumn sown oilseed rape because it attracts slugs and is killed off with the first frost so will not compete with the crop.
LEGUME COVERCROPS		
Common vetch (spring or winter cultivars)	40 to 50	Slow to establish, but as a climber will smother other species in the autumn (or spring if seeded late). It is a very good nitrogen fixer that combines quite well with cover-crops and forage mixes. Vetch is easily controlled with a knife roller or any other means of mechanical destruction. It has a tendency to re-grow and can block up tine based tillage machinery. Its shallow root system aids biologic activity.
Hairy vetch	35 to 45	Initially slower than the common vetch to establish once growing can become quite aggressive. It can dominate any species or mixture and will smother weeds on volunteers by its very high levels of vegetation. As a species it has a trait of having 3-5% of its seeds reaming dormant and these may well germinate in the following cash crop. The risk of contamination is limited by conservation tillage and direct drilling but could be a problem for organic growers.
Bengal vetch	40 to 50	The same traits than the common vetch but with faster growth: depending on conditions between 25% to 40% more biomass in 3 months of summer and autumn. It a quite good choice where sown between to winter cereal crops supplying nitrogen to the following crop.
Cerdagne vetch	30 to 40	Mountain vetch is well suited to dry and harsh conditions. Like the bitter vetch, the various species are not yet catalogued so cannot be differentiated between.

Alexandra clover (Bersim clover)	8 to 12	Annual or biannual clover which develops rapidly during the summer and autumn if conditions are favourable. Never the less it prefers deeper soils with a good natural fertility and sufficient moisture. It is significantly less competitive under dry conditions. Under good conditions it can produce high levels of biomass (3 to 4 t of DM/ha are possible after a barley or wheat crop) as well as fixing significant amounts of nitrogen. It is a very good source of forage alone or in mixes but also a very good cover-crop between two straw crops. It does not necessarily need to be destroyed before planting the next straw crop as it can be dealt by herbicides during the autumn and winter.
Persian clover	8 to 12	Like the Alexandra clover it provides biomass during the summer but will grow better in poorer soils and harder conditions: it's more resistant to frost and harder to destroy.
Crimson clover	12 to 15	Biannual clover, quite slow to establish in autumn but as opposed to the Bersim clover it performs better under more difficult climatic conditions and lighter soils. It is quite winter hardy and will regrow again in spring very fast (the main production period). It is a good source of forage and a useful plant to complement a cover-crop mix for early spring biomass production. Despite its qualities, it is not a big nitrogen fixer: In field trials it is often bottom of the list. It's a good cover crop to use on wet soils before maize so long as it is killed off before uses up all the soil moisture.
Field bean	150 to 200	Despite the large seed size, and heavy seed rates, field beans are a very useful and versatile plant as cover-crops (volunteers are a good indication). They can produce a descent amount of biomass and the taproot is good for soil re-structuring. Field beans are also one of the legumes able to quickly fix the high amounts of nitrogen (from 80 to 200 kg of N/ha in 3 to 4 months). It is not an ideal forage crop but can be made in silage or haylage. It can be included in many summer, autumn or winter mixes. Usually it is killed by winter frost but if sown late (after corn harvest), it will go through the winter easily and start to grow again in spring. Good companion crop (OSR, sunflower, corn, cereals) it is not a very competitive against weeds. The spring variety "Diana" with a lot smaller grain size (300 to 400 g/1000 Grains) that has been tested by conservation agriculture networks seems to bring equal results at half the seed rate.
Forage pea	60 to 80	Very versatile legume well suited to cover-cropping. A lot more hardy, producing a bigger biomass and is more disease resistant than the varieties used for grain production, it is a good supplement of any cover mix. As its name indicates, it also produces good quality forage useful in forage and grain mixes.
Latyrus	35 to 45	This legume is better suited to calcareous soil where it can produce good levels of biomass. In these conditions it is also a good nitrogen fixer. Because it grain is toxic it can't be use as forage but is useful as a companion plant especially for OSR (short growing cycle and easily killed by frost).
Lentil	25 to 35	This legume generally prefers calcareous and non-acidic soils. Although it does not produce high levels of biomass it is still quite competitive with weeds (when drilled at high seed rates). It is rarely used as a cover-crop and especially not in mixtures. However lentils are very useful as companion crop for OSR, the GFL mix (Gesse (Latyrus)/ fenugreeek/lentil). Its bigger sister, the black fodder lentil, produces more biomass and is more aggressive but seed is in short supply.

Fenugreek	10 to 15	<p>Its name means the “Hay of the Greeks” (<i>faenum graecum</i>), this legume is easy to recognize with its typical smell of curry (plant and seeds). It is a plant suited to clay and calcareous soil and quite hardy conditions. As with lentils, fenugreek is not an aggressive plant. The potential biomass is not great but its forage is of high quality (not for dairy cows because of the curry taste it gives to the milk). It does not perform well in cover crop mixtures; it is a good companion crop for OSR. Its strong smell can deter insects but attract hares and deer.</p>
<p>CLASSICAL BLENDS</p>		<p>Not an exhaustive list but contains the main species used at present. Other plants can also be used as cover-crops alone or in mixtures. Researchers, seed dealers and conservation agriculture networks continue to investigate other species and select some specific varieties that can perform new functions. Below are listed only few examples to give some ideas, associations and mixtures. Please note that more species put in a mix, the better it will perform in terms of soil structure, fertility, biomass, weed control, stability, etc.: the more complex the blend, more simple it becomes!</p>
Mustard/phacelia	4/5	<p>Conventional and very classic mix for fields with good levels of nitrogen or where some kind of manure or slurry will be applied. Usually the production of biomass is high. Depending on fertility and weather conditions, the mustard can become dominant (in this case it is best to reduce the seed rate of mustard or dilute it with a third species). The seedbed must be sufficiently good for the phacelia to establish well.</p>
Winter oat /mustard	20/4	<p>An easy mix to use with a good potential of biomass production if there is sufficient nitrogen available. This mix is good for weed control but its residues are high in carbon and may use more nitrogen from the soil during decomposition than return any for the next crop. This is even more evident if the cover crop is incorporated or ploughed down, if the following crop is direct drilled, the residue remains on the soil surface so decomposition is slower tying up less soil nitrogen.</p>
Spring oat/vetch	50/25	<p>The mix is better suited for seeding later on in the season, with the possibility of it over-wintering and completing its work the following spring. For earlier sowing oats may not be competitive enough and could leave space for weeds to develop. For a winter cover-crop the addition of some field beans having reduced the seed rate of the oats and vetch will be a better option (40 O./20 V./40 B.) and will fix more nitrogen.</p>
Winter oat/phacelia	20/5	<p>A good potential biomass producer with a better-balanced C/N ratio. Care must be taken as the oats can become dominant so it is wise to dilute with them with a third species such as a legume like the vetch.</p>
Winter oat/phacélie/vetch	15/3/15	<p>Very well balanced mix with species that have got different and complementary vegetative behaviours. Adding vetch will improve the biomass production, the soil coverage and increase the nitrogen pool while lowering the average C/N ratio of the residues. This mix can give good results after winter cereals crops (long intercrop period) as well after maize where it will over-winter well. In this situation it is recommended to increase the seed rates by 10 to 20% in order to get better cover more quickly.</p>

Alexandrian clover/ phacelia	5/5	Two less competitive species than can cooperate well together to produce a good cover and a well balance biomass which are easy to manage. This type of mix needs to be established well and prefers deep silty soils with good natural fertility. This mixture is useful between two winter cereals or for longer inter crop periods where if planted too early it will be held back by winter frosts.
Radish/forage pea	5/25	More impressive and bushy cover-crop mixture able to produce a large biomass (4 to 6 t of DM/ha) if sown early. It is a good pair for short intercrop periods before winter cereals if OSR is not one of the main crops in the rotation. The performance of the cover-crop will be improved by incorporating other species in the mixture like sunflower, phacelia, flax, vetch...
Pea/vetch/field bean	25/20/50	Quite well balanced mixture with the object of fixing the maximum of nitrogen to boost the soil's natural fertility. For a summer-autumn or winter-spring intercropping it is recommended to add some oats, phacelia or radish or maybe all three to boost the biomass production and the level of cover without reducing the ability to fix nitrogen. Being a pure legume mix, it fits well in no-till and organic farming systems. Care should be taken as to when the crop is destroyed as it is possible for nitrogen to be leached, breaching environmental legislation.
« Biomax » type blends		The word "Biomax" explains the objective of the multiple species cover-crops: to produce the maximum level of biomass encouraging a maximum amount of biodiversity in the soil and the surface. Once again this list of examples is obviously not complete. Never the less it should supply ideas and guidelines to help growers understand how to blend plants types in order to be able to make their own Biomax mixes according to their conditions, objectives and available seed.
Mustard/phacelia/ pea/vetch	2/2/20/12	This mixture is quite well balance with some good conventional cover-crops associated with a couple of very good legumes. It is well suited for sowing from the middle to the end of august for autumn and winter intercropping. If it is sown to early there is a risk that the mustard will run to seed even if the seed rated are reduced.
Sunflower/radish/ phacelia/pea/vetch	6/2/2/15/10	This mixture produces more impressive vegetation and a bigger biomass capable of fixing good levels of nitrogen. It is possible to drill it early right after harvesting winter cereals. It can be used for longer intercrop periods or between two winter cereals. It is usually controlled by the winter weather and does not need to be destroyed chemically or mechanically.
Radish/flax/phacelia/ pea/vetch	3/7/2/15/10	If sunflower is already being grown on the farm as a cash-crop, it's possible to increase the amount of radish and to add some flax. This mix with probably be less productive in term of biomass but its soil structuring effect with the combination of the radish and the flax make it a useful cover-crop.
Asian radish /phacelia/field bean/Alexandrian or Crimson clover/ vetch or pea	2/2/30/3/10	This cover consists of 5 "Levels" with the tillage radish dealing with "Deep underground level". The Biomax will a bit shorter with slightly less biomass but its vegetation will be very dense. It is a good nitrogen fixer with a fast return to the next crop. It is an ideal cover-crop in between to winter cereal crops.
Oat/field bean/pea/ vetch/phacelia	25/50/20/15/2	This mixture for winter-spring intercropping has slightly higher seed rate. Drilled in October or November, the majority of the plants will go through the winter and come up in spring. As most are legumes, their growth will not only absorb soil moisture but increase the level of nitrogen fixed and of carbon returned to the soil during the inter-crop period. In this biomax-mixture oats can be easy replaced by summer oat, rye or any other winter cereals by adjusting the seed rate.

<p>Sorghum/radish/Moha/ Rough oat /pea/vetch/ Alexandrian clover</p>	<p>3/2/5/10/10/5</p>	<p>Summer biomax for forage production that should be sown early after a winter barley or OSR. The potential of biomass production is very high and as it contains such a diversity of plants it will easy adapt and compensate for adverse climatic conditions.</p>
<p>Field bean/vetch/pea/ Alexandrian clover/ lentil</p>	<p>30/10/15/3/5</p>	<p>Pure legume biomax for maximum of nitrogen fixation. During the 3 to 4 months of a summer intercrop period it is possible that this mixture can produce 4 to 5 t/ha of DM with 100 to 180 kg of N/ha (held in the total biomass: surface vegetation and roots) a large percentage (40 to 50%) will be available for the next crop.</p>
<p>Sunflower/phacelia/ radish /OSR/ Rough oat /flax/nyger/pea/ vetch/Crimson clover /field bean</p>	<p>3/2/1/3/4/3/1/6/5/ 2/15</p>	<p>With ten species this is a very complex biomax mixture. If the weather conditions are favourable, when sown after a winter cereal it is possible for this type of mixture to produce 10 t/ha of DM with 150 to 250 kg de N/ha recycled and fixed in the surface vegetation. These mixtures are real soil fertility boosters.</p>
<p>Your own Biomax</p>	<p>Let your imagination blend some species...</p>	<p>Don't hesitate to send pictures of your cover-crops with some measurement or analyses. Your success, your observations and your comments are of great interest.</p>

