

penergetic
the natural biotechnology

With the impulse of nature

*...for intelligent
agriculture*

Penergetic International



Agriculture is one of the oldest economic sectors and most important occupations of mankind. Around 5.6 billion hectares or 11% of the Earth's surface are used for agricultural purposes. More than 40% of all employees worldwide work in this sector.

These may be enormous figures, but if we look at the global population of around 8 billion people, whose food comes from those 11% of surface area used for agricultural purposes, then we might get an idea of how important food production is. Unfortunately, this pressure to produce enough food, has an adverse effect on food production standards. The focus has been increasingly on quantity rather than quality. This has long-lasting effects on the soil, plants, animals and, consequently, on us humans. In addition, approximately 6 million hectares of agricultural land are lost to erosion, salinization, desertification or building development. Change is urgently needed and penergetic products can make an important contribution that will also yield commercial benefits.

Penergetic International AG is leading the change. Its vision is to think of future generations today and to drive the smart agricultural revolution. This is already being implemented in many countries! penergetic products were developed to promote a sustainable, high-

performing and efficient agriculture. In this way, the company wants to achieve its goal of saving resources and optimally utilizing existing potentials, and thus achieve the sustainable, ecologically sound, economically viable and independent agriculture of the future.

The penergetic product range comprises

- penergetic b – for soil
- penergetic p – for plants
- penergetic t – for animals
- penergetic g – for liquid manure
- penergetic k – for compost and livestock bedding
- AquaKat – for water vitalization

This product range tackles the root causes rather than just relieving the symptoms. At the same time, the individual products form one large system in which they support each other.

Cover Crops

	Spring – Summer cover crops
10 — 11	Pearl Millet (<i>Pennisetum glaucum</i>)
10 — 11	Crotalaria spectabilis (<i>Crotalaria spectabilis</i>)
12 — 13	Crotalaria ochroleuca (<i>Crotalaria ochroleuca</i>)
12 — 13	Crotalaria juncea (<i>Crotalaria juncea</i>)
14 — 15	Buckwheat (<i>Fagopyrum esculentum</i>)
14 — 15	Sunflower (<i>Helianthus annuus</i>)
16 — 17	Finger millet (<i>Eleusine coracana</i>)
16 — 17	Brachiaria ruziziensis (<i>Urochloa ruziziensis</i>)
18 — 19	Dwarf pigeonpea (<i>Cajanus cajan</i>)
	Autumn – Winter cover crops
18 — 19	Oilseed Radish (<i>Raphanus sativus</i>)
20 — 21	Common Vetch (<i>Vicia sativa</i>)
20 — 21	Hairy Vetch (<i>Vicia villosa</i>)
22 — 23	Rye (<i>Secale cereale</i>)
22 — 23	White Lupine (<i>Lupinus albus</i>)
24 — 25	Black Oat (<i>Avena strigosa</i>)
24 — 25	Field Pea (<i>Pisum sativum ssp. Arvense</i>)
	Consortium, cocktail and mix of cover crops
26 — 27	Amount of seeds (kg/ha)
26 — 27	Markings
26 — 27	General observations
28 — 33	Some additional cover crops in the U.S.A. and in Europe

Cover crop has been used in soil conservation since ancient times. During the collaboration with Dr. Ademir Calegari, Penegetic noted that cover crop and no-till methods have additional positive effects when penegetic products are used. For this reason, we want to introduce the different areas of applications for cover crops and contribute further to developing smart agricultural methods.

Dr. Ademir Calegari
Soil Scientist Researcher
Senior Agronomist IAPAR
Londrina, PR Brazil

A milestone in agriculture

All the information comprised can be applied to the plots in the rural areas, after an appropriate diagnosis of the local conditions for the implementation of cover crops species plants that best fit to the specifically cropping / farming systems according to the need of soil and commercial crops.

The introduction of these species, isolated or in cocktails (mix), are fundamental tools for the improvement of the crop rotation system and for the development of a no till system with quality. The adequate use of these species certainly

will contribute to the soil protection, improvement of physical, chemical and biological attributes, as well as promoting greater biodiversity in the production systems, contributing to a smarter and sustainable agriculture.

Project Living Soil

What is the Project Living Soil (PLS)?

A tool that works par excellence for the bioactivation of the productive systems (soil and plant) through the cover crops.

The “Living Soil Project” is an initiative of the WebBio Academy in Brazil, which makes it possible to identify select and at field level, alternatives, strategies and management practices of sustainable agricultural productions that promote a better balance between the soil-water-plant relationship. This should lead to greater productivity and profitability with a minimal environmental impact, providing a better and more intelligent use of the natural resources and greater rationality in the use of the necessary inputs to the means of agricultural production.



Importance of the project

Redeem of soil health

- To provide the soil with a high productive potential for crops through balance in their chemical, physical and biological attributes.

Integrating tools that contribute to a better management of the soil-plant-water system and harmonize the various components of the production system

- Massive adoption of different cover crops (isolated or cocktails) according to needs identified by the diagnosis of each area
- Integrated crop-livestock-forestry Systems (CLFS)
- Technologies in bioactivation
- Biological assets

Diversification, combination and rotation of crops

- Customized evaluation for each property
- Analysis of plant tissue for determination of nutrient contents

Return to the true no till system on straw with quality

- Soil protection and erosion risk reduction
- Elevation in infiltration rates and water retention in the soil profile
- Increase of organic matter
- Increased availability of nutrients
- Increase in macro-, meso-, microfauna and flora populations
- Less occurrence and propagation of weeds

“The project will last three years in the same area, covering the main Brazilian productive states.”

Action strategies

Diagnostic of the area

Before planting

- Standard georeferenced soil analyzes of 0–10cm, 0–20cm, 20–40cm and nematological analyzes for all treatments.

During the growth of coverage

- Biological evaluations (nematodes and microorganisms)
- Periodical measuring of the vegetative growth of plants
- Evaluation of root growth and soil profile effects (compaction), through the opening of trenches
- Evaluation of the dry matter of cover crops, which should be carried out in the full flowering of the plants, before the accomplishment of the management (mechanical and / or chemical)
- Evaluation of the suppression of invasive (weed) plant populations

After coverage management

- Evaluation of qualitative soil attributes (chemical, physical and biological)

As a strategic tool for better results, the penergetic b bio-activator for soil should be applied in total area before PLS implantation. Agronomic and economic evaluations will be carried out in all areas of the PLS.

Implantation of summer crops on the PLS

The crops should follow the recommendation of fertilization and soil correction by the technical team, and the use of the bio-activators penergetic b for soil in the implementation of the project and penergetic p for plants during the development of the crop is recommended.

Harvest

The cover crop areas will be compared to the management used by the farmer. Summer crops will be harvested (soybean, corn, cotton, beans, etc.) over the crops and compared to the farmer’s control areas. These evaluations should be conducted in the same locations (side by side).

Expected results

- Recuperation of soil health by promoting the rebalancing of biota through No Till System with quality (including cover crops, crop rotation) and the use of tools that promote the bioactivation.
- Adequate and rational use of inputs, reducing production costs and increasing the profitability of the agricultural activity.
- Contribution to the development of sustainable production systems, improving the quality of the lives of those who consume and of those who produce food.

Pearl millet

Spring – Summer Soil Covers



Identification	Common name	Millet
	Scientific name	Pennisetum glaucum
	Family	Poaceae (Grasses)
Characteristics	Weight of 1,000 seeds (grams)	3,7 a 4
	Root system	Fasciculated
	Height (m)	1,5 a 2,5
	Growing habit	Erect thicket
	Flowering (days)	45 to 50
	Cycle (days)	130 to 140
	Green mass (mt/ha)	50 to 60
	Dry mass (mt/ha)	8,0 to 15
	Frost tolerance	Susceptible
	Seeding season	
Seeding	In line (kg/ha)	
	throwing sowing (kg/ha)	
	In mixtures with 2 to 3 coverages (kg/ha)	
	In mixtures with 4 to 6 coverages (kg/ha)	
Consortium with corn	In line (kg/ha)	—
	throwing sowing (kg/ha)	—
Nematodes ¹	Pratylenchus brachyurus	RF < 1
	Meloidogyne incognita	RF < 1
	Meloidogyne javanica	RF < 1
	Heterodera glycines	RF < 1
	Rotilenchulus reniformis	RF < 1
	Pratylenchus coeae	—
	Pratylenchus zea	—
Recycling of nutrients	Nitrogen (% in dry matter) ²	0,34 a 3,40
	Phosphorus P ₂ O ₅ (% in dry matter)	0,13 a 0,29
	Potassium K ₂ O (% in dry matter)	1,05 a 3,80
Indications	Benefits: Little picky in phosphorus. Reduces fusarium and rhizoctonia.	
	Attention points: Can increase population of caterpillars.	

RF = reproduction factor

Crotalaria spectabilis

Spring – Summer Soil Covers



Identification	Common name	Crotalaria spectabilis
	Scientific name	Crotalaria spectabilis
	Family	Fabaceae (Leguminous)
Characteristics	Weight of 1,000 seeds (grams)	16 to 19
	Root system	branched-penroot
	Height (m)	1,0 a 1,5
	Growing habit	shrubby erect
	Flowering (days)	110 to 140
	Cycle (days)	170 to 180
	Green mass (mt/ha)	20 to 30
	Dry mass (mt/ha)	4 to 6
	Frost tolerance	Tolerant
	Seeding season	
Seeding	In line (kg/ha)	12 to 15
	throwing sowing (kg/ha)	15
	In mixtures with 2 to 3 coverages (kg/ha)	10
	In mixtures with 4 to 6 coverages (kg/ha)	8
Consortium with corn	In line (kg/ha)	10
	Throwing sowing (kg/ha)	20
Nematodes ¹	Pratylenchus brachyurus	RF < 1
	Meloidogyne incognita	RF < 1
	Meloidogyne javanica	RF < 1
	Heterodera glycines	RF < 1
	Rotilenchulus reniformis	Susceptible
	Pratylenchus coeae	RF < 1
	Pratylenchus zea	RF < 1
Recycling of nutrients	Nitrogen (% in dry matter) ²	1,97 to 3,30
	Phosphorus P ₂ O ₅ (% in dry matter)	0,07 to 0,25
	Potassium K ₂ O (% in dry matter)	0,78 to 1,78
Indications	Benefits: Reduces nematode population.	
	Attention points: Difficult control of plants out of stage.	

RF = reproduction factor

Crotalaria ochroleuca
Spring – Summer Soil Covers



Identification	Common name	Crotalária ochroleuca
	Scientific name	Crotalaria ochroleuca
	Family	Fabaceae (Leguminous)
Characteristics	Weight of 1,000 seeds (grams)	6 to 8
	Root system	profound penroot
	Height (m)	1,5 to 2,0
	Growing habit	shrubby erect
	Flowering (days)	120 to 135
	Cycle (days)	125 to 135
	Green mass (mt/ha)	20 to 30
	Dry mass (mt/ha)	7 to 10
	Frost tolerance	Susceptible
Seeding season		Late spring – early summer
Seeding	In line (kg/ha)	10
	throwing sowing (kg/ha)	12
	In mixtures with 2 to 3 coverages (kg/ha)	10
	In mixtures with 4 to 6 coverages (kg/ha)	8
Consortium with corn	In line (kg/ha)	5 to 8
	throwing sowing (kg/ha)	20% more
Nematodes ¹	Pratylenchus brachyurus	RF < 1
	Meloidogyne incognita	Not hostess
	Meloidogyne javanica	Not hostess
	Heterodera glycines	RF < 1
	Rotilenchulus reniformis	RF < 1
	Pratylenchus coeae	—
	Pratylenchus zea	—
Recycling of nutrients	Nitrogen (% in dry matter) ²	0,80 to 1,25
	Phosphorus P ₂ O ₅ (% in dry matter)	0,06 to 0,08
	Potassium K ₂ O (% in dry matter)	0,50 to 0,87
Indications	Benefits: Fast growth, pivoting roots, soil reclaimer, high biomass	
	Attention points: Attention to the management of vegetation before full bloom (increase fibers), which can make it difficult to plant the later culture.	

RF = reproduction factor

Crotalaria juncea
Spring – Summer Soil Covers



Identification	Common name	Sunn Hemp
	Scientific name	Crotalaria juncea
	Family	Fabaceae (Leguminous)
Characteristics	Weight of 1,000 seeds (grams)	50
	Root system	deep taproot
	Height (m)	2,0 to 3,0
	Growing habit	shrubby erect
	Flowering (days)	70 to 130
	Cycle (days)	170 to 180
	Green mass (mt/ha)	35 to 60
	Dry mass (mt/ha)	10 to 15
	Frost tolerance	Susceptible
Seeding season		Late spring – early summer
Seeding	in lines	25 (kg/ha)
	broadcast sowing	30 (kg/ha)
	Spacing between rows (25 to 50 cm)	25 to 30 (seeds/linear m)
	In mixtures with 2 to 3 crops	10 to 12 (kg/ha)
	In mixtures with 4 to 6 crops	8 to 10 (kg/ha)
Intercropping with corn	in lines	16 (kg/ha)
	broadcast sowing	20% more
Nematodes ¹	Pratylenchus brachyurus	Susceptible
	Meloidogyne incognita	Susceptible / Resistent mod.
	Meloidogyne javanica	RF < 1
	Heterodera glycines	RF < 1
	Rotilenchulus reniformis	RF < 1
	Pratylenchus coffeae	—
	Pratylenchus zea	—
Recycling of nutrients	Nitrogen (% in dry matter) ²	1,13 to 4,40
	Phosphorus P ₂ O ₅ (% in dry matter)	0,09 to 0,37
	Potassium K ₂ O (% in dry matter)	0,57 to 3,37
Indications	Benefits: High nitrogen fixing capacity. Soil recovering and improvement. Allopathic effects on several invasive plants (weeds)	
	Attention points: Hostesses of <i>Pratylenchus brachyurus</i> , and some fungi. Biomass when incorporated, effects of tissue with glucosinolates are transformed into isothiocyanates and control nematodes (<i>Pratylenchus</i> , and others) and soilborne diseases trough "biofumigation". These molecules are volatile and toxic to soil microorganisms and nematodes.	

RF = reproduction factor

Buckwheat

Spring – Summer Soil Covers



Identification	Common name	Buckwheat
	Scientific name	Fagopyrum esculentum
	Family	Polygonaceae
Characteristics	Weight of 1,000 seeds (grams)	32 to 37
	Root system	Vigorous Taproot
	Height (m)	0,6 to 1,2
	Growing habit	Erect
	Flowering (days)	35 to 50 days
	Cycle (days)	75 to 85
	Green mass (mt/ha)	15 to 28
	Dry mass (mt/ha)	3 to 6
	Frost tolerance	Susceptible
	Seeding season	
Seeding	in lines	40 to 60 (kg/ha)
	broadcast sowing	20% more
	Spacing between rows (17 to 40cm)	25 a 30 (seeds/linear m)
	In mixtures with 2 to 3 crops	18 to 25 (kg/ha)
	In mixtures with 4 to 6 crops	15 to 18 (kg/ha)
Intercropping with corn	in lines	30 to 40 (kg/ha)
	broadcast sowing	20% more
Nematodes ¹	Pratylenchus brachyurus	Not hostess
	Meloidogyne incognita	Not hostess
	Meloidogyne javanica	Not hostess
	Heterodera glycines	Not hostess
	Rotilenchulus reniformis	—
	Pratylenchus coffeae	—
	Pratylenchus zea	—
Recycling of nutrients	Nitrogen (% in dry matter) ²	1,80 to 2,01
	Phosphorus P ₂ O ₅ (% in dry matter)	0,20 to 0,31
	Potassium K ₂ O (% in dry matter)	3,00 to 3,71
Indications	<p>Benefits: The deep roots with high amount of mycorrhiza fungi make support long drought period. The dense, fibrous roots produce mild acids that release nutrients from the soil. Quick soil cover, efficient weed control, nectar for pollinators and beneficial insects, topsoil loosening rejuvenator for low-fertility soils. Excellent in beekeeping (high amount of pollen and nectar). The flowers attract beneficial insects that parasitize aphids, mites and other pests. Including hover flies (<i>Syrphidae</i>), predatory wasps, minute pirate bugs, insidious flower bugs, tachinid flies and lady beetles.</p> <p>Attention points: Weeds can grow in low plant population.</p>	

RF = reproduction factor

Sunflower

Spring – Summer Soil Covers



Identification	Common name	Sunflower
	Scientific name	Helianthus annuus
	Family	Compositae
Characteristics	Weight of 1,000 seeds (grams)	50 to 95
	Root system	branched-tap root
	Height (m)	1,8 to 3,0
	Growing habit	erect
	Flowering (days)	60 to 80
	Cycle (days)	70 to 120
	Green mass (mt/ha)	40 to 70
	Dry mass (mt/ha)	7 to 15
	Frost tolerance	Moderately tolerant
	Seeding season	
Seeding	in lines	3 to 20 (kg/ha)
	broadcast sowing	20% more
	Spacing between rows (17 to 34cm)	12 a 15 (seeds/linear m)
	In mixtures with 2 to 3 crops	3 to 4 (kg/ha)
	In mixtures with 4 to 6 crops	2 (kg/ha)
Intercropping with corn	in lines	4 to 6 (kg/ha)
	broadcast sowing	5 to 7 (kg/ha)
Nematodes ¹	Pratylenchus brachyurus	Susceptible
	Meloidogyne incognita	Susceptible
	Meloidogyne javanica	Susceptible
	Heterodera glycines	RF < 1
	Rotilenchulus reniformis	RF < 1
	Pratylenchus coffeae	—
	Pratylenchus zea	—
Recycling of nutrients	Nitrogen (% in dry matter) ²	1,02 to 1,80
	Phosphorus P ₂ O ₅ (% in dry matter)	0,15 to 0,24
	Potassium K ₂ O (% in dry matter)	2,40 to 2,78
Indications	<p>Benefits: Develops well in sandy soils, clayey, acid (pH from 5.1), fast initial phase growing; Alternative for oil production, for biofuel with the use of the pie in animal feed.</p> <p>Attention points: Excessive rainfall and high temperatures, as well as crop residues can trigger attacks diseases of: Alternaria spot, rot of the stem (<i>Erwinia</i> sp.), Macrophomina, etc. Not recommended to rotate with beans (common diseases).</p>	

RF = reproduction factor

Finger millet
Spring – Summer Soil Covers



Identification	Common name	Finger millet
	Scientific name	Eleusine coracana
	Family	Poaceae (Gramineae)
Characteristics	Weight of 1,000 seeds (grams)	2,3 to 2,5
	Root system	Fasciculated Root
	Height (m)	0,8 to 1,2
	Growing habit	erect
	Flowering (days)	80 to 110 days
	Cycle (days)	130 to 170
	Green mass (mt/ha)	25 to 40
	Dry mass (mt/ha)	6 to 10
	Frost tolerance	Susceptible
	Seeding season	
Seeding	in lines	8 to 10 (kg/ha)
	broadcast sowing	20% more
	Spacing between rows (17 to 34cm)	45 a 60 (seeds/linear m)
	In mixtures with 2 to 3 crops	3 to 5 (kg/ha)
	In mixtures with 4 to 6 crops	2 to 4 (kg/ha)
Intercropping with corn	in lines	—
	broadcast sowing	—
Nematodes¹	Pratylenchus brachyurus	—
	Meloidogyne incognita	Susceptible
	Meloidogyne javanica	Susceptible
	Heterodera glycines	RF < 1
	Rotilenchulus reniformis	RF < 1
	Pratylenchus coffeae	—
	Pratylenchus zea	—
Recycling of nutrients	Nitrogen (% in dry matter) ²	1,03 to 1,53
	Phosphorus P ₂ O ₅ (% in dry matter)	0,06 to 0,17
	Potassium K ₂ O (% in dry matter)	1,24 to 1,89
Indications	Benefits: Fasciculate roots (can produce more than 6mt/ha of roots), indicated mainly in sandy soil where increase soil particle aggregates. Grows on poor soils and supports long drought season. High weed suppression.	
	Attention points: After biomass managed it's recommended to wait 15–25 days before sowing the next crop (slow decomposition of root system, which can lead to N temporary immobilization).	

RF = reproduction factor

Brachiaria ruziziensis
Spring – Summer Soil Covers



Identification	Common name	Brachiaria ruziziensis *
	Scientific name	Urochloa ruziziensis
	Family	Poaceae (Gramineae)
Characteristics	Weight of 1,000 seeds (grams)	12.5
	Root system	Fasciculated root
	Height (m)	0,8 to 1,2
	Growing habit	caespitosus
	Flowering (days)	40 to 50
	Cycle (days)	perennial
	Green mass (mt/ha)	20 to 55
	Dry mass (mt/ha)	12 to 16
	Frost tolerance	low
	Seeding season	
Seeding	in lines	7 to 10 (kg/ha)
	broadcast sowing	9 to 12 (kg/ha)
	Spacing between rows (17 to 34cm)	30 to 40 (seeds/linear m)
	In mixtures with 2 to 3 crops	4 to 5 (kg/ha)
	In mixtures with 4 to 6 crops	2 to 3 (kg/ha)
Consortium with corn	in lines	6 to 8 (kg/ha)
	broadcast sowing	20% more
Nematodes¹	Pratylenchus brachyurus	Susceptible
	Meloidogyne incognita	RF < 1
	Meloidogyne javanica	RF < 1
	Heterodera glycines	RF < 1
	Rotilenchulus reniformis	RF < 1
	Pratylenchus coffeae	—
	Pratylenchus zea	—
Recycling of nutrients	Nitrogen (% in dry matter) ²	0,75 to 2,01
	Phosphorus P ₂ O ₅ (% in dry matter)	0,04 to 0,15
	Potassium K ₂ O (% in dry matter)	0,60 to 1,49
Indications	Benefits: Grows in soils with medium chemical fertility. Precocity and high biomass production. Can be intercropped with corn and other crops, ease of handling, high nutrients recycling and high C/N ratio (around 40). Reduces Fusarium sp., Rhizoctonia sp. (white-mold).	
	Attention points: Attempt for continuous use and every 2 years to perform nematode analysis (Pratylenchus brachyurus), since it is host and can increase these populations and provoke damage to the next crops.	

RF = reproduction factor

Dwarf pigeonpea
Spring – Summer Soil Covers



Identification	Common name	Dwarf pigeonpea
	Scientific name	Cajanus cajan
	Family	Fabaceae (leguminosa)
Characteristics	Weight of 1,000 seeds (grams)	65 to 80
	Root system	vigorous / tap root
	Height (m)	1,0 to 1,8
	Growing habit	harpy / erect
	Flowering (days)	70 to 100
	Cycle (days)	130 to 160
	Green mass (mt/ha)	12 to 45
	Dry mass (mt/ha)	3 to 12 (mt/ha)
	Frost tolerance	Susceptible
	Seeding season	
Seeding	in lines	35 to 40 (kg/ha)
	broadcast sowing	20% more
	Spacing between rows (17 to 34cm)	18 to 25 (seeds/linear m)
	In mixtures with 2 to 3 crops	15 to 20 (kg/ha)
	In mixtures with 4 to 6 crops	12 to 18 (kg/ha)
Intercropping with corn	in lines	20 to 25 (kg/ha)
	broadcast sowing	20% more
Nematodes ¹	Pratylenchus brachyurus	RF < 1
	Meloidogyne incognita	RF < 1
	Meloidogyne javanica	RF < 1
	Heterodera glycines	RF < 1
	Rotilenchulus reniformis	RF < 1
	Pratylenchus coffeae	—
	Pratylenchus zea	—
Recycling of nutrients	Nitrogen (% in dry matter) ²	1,32 a 3,35
	Phosphorus P ₂ O ₅ (% in dry matter)	0,09 a 0,25
	Potassium K ₂ O (% in dry matter)	0,47 a 2,84
Indications	Benefits: Grows in soils with medium fertility, biological chisel plow (disrupting soil compacted layers); Allopathic effects on invasive plants (weeds). Reduces Fusarium sp. and Rhizoctonia sp.	
	Attention points: Avoid highly compacted soils, since the roots of this legume may not be so efficient. In this case use the giant pigeonpea, because their vigorous tap root system.	

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Oilseed radish
Autumn – Early Winter Soil Covers



Identification	Common name	Oilseed radish
	Scientific name	Raphanus sativus
	Family	Brassicaceae (cruciferae)
Characteristics	Weight of 1,000 seeds (grams)	8 to 14
	Root system	deep / tuberous / tap root
	Height (m)	0,8 to 1,6
	Growing habit	Herbaceous determinated
	Flowering (days)	60 to 90
	Cycle (days)	140 to 160
	Green mass (mt/ha)	20 to 65
	Dry mass (mt/ha)	3 to 9
	Frost tolerance	Tolerant
	Seeding season	
Seeding	in lines	10 to 17
	broadcast sowing	20% more
	Spacing between rows (17 to 34cm)	25 a 35 (seeds/linear m)
	In mixtures with 2 to 3 crops	4 to 5 (kg/ha)
	In mixtures with 4 to 6 crops	2 to 3 (kg/ha)
Consortium with corn	in lines	5 to 8 (kg/ha)
	broadcast sowing	20% more
Nematodes ¹	Pratylenchus brachyurus	Not hostess
	Meloidogyne incognita	RF < 1
	Meloidogyne javanica	Susceptible
	Heterodera glycines	—
	Rotilenchulus reniformis	—
	Pratylenchus coffeae	—
	Pratylenchus zea	—
Recycling of nutrients	Nitrogen (% in dry matter) ²	0,92 to 2,96
	Phosphorus P ₂ O ₅ (% in dry matter)	0,18 to 0,33
	Potassium K ₂ O (% in dry matter)	2,02 to 3,90
Indications	Benefits: Fast growth – deep roots that can break down soil compacted layers, and high nutrient recycling (N, S, P). During growth period it can promote weed suppression.	
	Attention points: Do not sow in areas with Sclerotinia problems. Intercropped with other species such as rye, oat, millet, buckwheat, etc., may be use 2 to 3 kg/ha, will decrease white mold and undermine the later crops. Can be successfully mixed with grasses, legume and other cover crop species.	

RF = reproduction factor

Common vetch

Autumn – Winter Soil Covers



Identification	Common name	Common vetch
	Scientific name	Vicia sativa
	Family	Fabaceae (leguminous)
Characteristics	Weight of 1,000 seeds (grams)	36 to 60
	Root system	Tap root
	Height (m)	0,5 to 0,8
	Growing habit	decumbent
	Flowering (days)	120 to 150
	Cycle (days)	180 to 200
	Green mass (mt/ha)	20 to 30
	Dry mass (mt/ha)	4 to 6
	Frost tolerance	Tolerant
	Seeding season	
Seeding	in lines	50 to 80 (kg/ha)
	broadcast sowing	20% more
	Spacing between rows (17 to 34cm)	25 to 30 (seeds/linear m)
	In mixtures with 2 to 3 crops	18 to 25 (kg/ha)
	In mixtures with 4 to 6 crops	12 to 18 (kg/ha)
Intercropping with corn	in lines	—
	broadcast sowing	—
Nematodes ¹	Pratylenchus brachyurus	Susceptible and hostess
	Meloidogyne incognita	Susceptible and hostess
	Meloidogyne javanica	Susceptible and hostess
	Heterodera glycines	—
	Rotilenchulus reniformis	—
	Pratylenchus coffeae	—
	Pratylenchus zea	—
Recycling of nutrients	Nitrogen (% in dry matter) ²	0,20 to 3,47
	Phosphorus P ₂ O ₅ (% in dry matter)	0,13 to 0,38
	Potassium K ₂ O (% in dry matter)	2,10 to 2,56
Indications	Benefits: Efficient weed population control (mattress over the ground). High nitrogen supply by biological fixation and N recycling. Can be used as animal fodder (isolated or mixed with oat, rye, raygras, etc.).	
	Attention points: Better development in soils with high level of Ca and high soil pH.	

RF = reproduction factor

Hairy vetch

Autumn – Winter Soil Covers



Identification	Common name	Hairy vetch
	Scientific name	Vicia villosa
	Family	Fabaceae (leguminous)
Characteristics	Weight of 1,000 seeds (grams)	36 to 60
	Root system	Tap root
	Height (m)	0,5 to 0,8
	Growing habit	decumbent
	Flowering (days)	140 to 160
	Cycle (days)	200 to 230
	Green mass (mt/ha)	20 to 30
	Dry mass (mt/ha)	4 to 6
	Frost tolerance	Tolerant
	Seeding season	
Seeding	in lines	30 to 60 (kg/ha)
	broadcast sowing	20% more
	Spacing between rows (17 to 34cm)	25 to 30 (seeds/linear m)
	In mixtures with 2 to 3 crops	18 to 25 (kg/ha)
	In mixtures with 4 to 6 crops	12 to 18 (kg/ha)
Consortium with corn	in lines	—
	broadcast sowing	—
Nematodes ¹	Pratylenchus brachyurus	Susceptible and hostess
	Meloidogyne incognita	Susceptible and hostess
	Meloidogyne javanica	Susceptible and hostess
	Heterodera glycines	—
	Rotilenchulus reniformis	—
	Pratylenchus coffeae	—
	Pratylenchus zea	—
Recycling of nutrients	Nitrogen (% in dry matter) ²	1,88 to 4,36
	Phosphorus P ₂ O ₅ (% in dry matter)	0,10 to 0,41
	Potassium K ₂ O (% in dry matter)	2,30 to 4,26
Indications	Benefits: Rustic crop that fits well in soils with low content of pH, Al and P. Provide high N to the soil and next crops in temperate and subtropical regions. Trough mulching effects, soil structure, higher water retention, crop root development, soil biological activity leads to increase crop yields. Can be mixed with oat, rye, ryegrass, radish, buckwheat, phacelie, etc., produces quality fodder with high protein content.	
	Attention points: Mix hairy vetch with rye and other grasses reduce drastically N leaching and enhance cash crop yield. In France low cycle varieties.	

RF = reproduction factor

Rye

Autumn – Winter Soil Covers



Identification	Common name	Rye
	Scientific name	Secale cereale
	Family	Fabaceae (graminea)
Characteristics	Weight of 1,000 seeds (grams)	16 to 20
	Root system	fasciculated with tiller
	Height (m)	0,6 to 0,8
	Growing habit	Clump/Erect
	Flowering (days)	60 to 90
	Cycle (days)	140 to 150
	Green mass (mt/ha)	20 to 30
	Dry mass (mt/ha)	2 to 5
	Frost tolerance	Tolerant
	Seeding season	
Seeding	in lines	50 to 70
	broadcast sowing	20% more
	Spacing between rows (17 to 34cm)	60 to 70 (seeds/linear m)
	In mixtures with 2 to 3 crops	20 to 25 (kg/ha)
	In mixtures with 4 to 6 crops	10 to 15 (kg/ha)
Intercropping with corn	in lines	—
	broadcast sowing	—
Nematodes ¹	Pratylenchus brachyurus	Susceptible
	Meloidogyne incognita	Susceptible
	Meloidogyne javanica	Susceptible
	Heterodera glycines	—
	Rotilenchulus reniformis	—
	Pratylenchus coffeae	—
	Pratylenchus zea	—
Recycling of nutrients	Nitrogen (% in dry matter) ²	0,58 to 1,22
	Phosphorus P ₂ O ₅ (% in dry matter)	0,08 to 0,29
	Potassium K ₂ O (% in dry matter)	0,75 to 1,45
Indications	Benefits: Rye grows fast (even in cold fall) helps trap snow in winter, further boosting winter hardiness. Weed suppression, erosion control and soil root disease reduction. Due to lignin, hemicellulose and cellulose tissue content, remain higher soil covering. Deep roots promote better drainage, nutrient recycling of P, K and other nutrients. Quick maturity in spring can help maintain late-spring soil moisture. Can be mixed with oat, can avoid leaf rust attack; with vetch and other legume, more N during higher period for the next crop.	
	Attention points: Better soil effects when mixed with other cover crops such as hairy vetch, oat, lupine, field pea, radish, mustard, buckwheat, etc	

RF = reproduction factor

White lupine

Autumn – Winter Soil Covers



Identification	Common name	White lupine
	Scientific name	Lupinus albus
	Family	Fabaceae (Leguminous)
Characteristics	Weight of 1,000 seeds (grams)	300 to 500
	Root system	tap root
	Height (m)	0,8 to 1,2
	Growing habit	Bushy erect
	Flowering (days)	50 to 70
	Cycle (days)	180 days
	Green mass (mt/ha)	20 to 30
	Dry mass (mt/ha)	2 to 3
	Frost tolerance	Tolerant
	Seeding season	
Seeding	in lines	60 to 80
	broadcast sowing	20% more
	Spacing between rows (17 to 34cm)	15 to 20 (seeds/linear m)
	In mixtures with 2 to 3 crops	25 to 30
	In mixtures with 4 to 6 crops	15 to 20
Consortium with corn	in lines	—
	broadcast sowing	—
Nematodes ¹	Pratylenchus brachyurus	RF > 1
	Meloidogyne incognita	RF > 1
	Meloidogyne javanica	RF > 1
	Heterodera glycines	RF > 1
	Rotilenchulus reniformis	—
	Pratylenchus coffeae	—
	Pratylenchus zea	—
Recycling of nutrients	Nitrogen (% in dry matter) ²	1,22 to 1,97
	Phosphorus P ₂ O ₅ (% in dry matter)	0,09 to 0,29
	Potassium K ₂ O (% in dry matter)	1,00 to 2,66
Indications	Benefits: used as a cover crop, oil (seeds), forage (sweet varieties) and animal fodder. High fixing nitrogen and cycling phosphorus and other nutrients. Nitrogen fixing can vary from 100 to 200kg N ha ⁻¹ . P fixed by Fe, Al, and Ca phosphates can be released by root exudates (citric acid secretion) and citrate. The bitter seeds have higher protein content.	
	Attention points: As it is a host plant of several species of nematodes, it is recommended to mix with oat, rye, millet, triticale, among others to diminish these effect.	

RF = reproduction factor

Black oat

Autumn – Winter Soil Covers



Identification	Common name	Black Oat
	Scientific name	<i>Avena strigosa</i>
	Family	Poaceae (Gramínea)
Characteristics	Weight of 1,000 seeds (grams)	13 to 16
	Root system	Fasciculated/tillering
	Height (m)	0,8 to 1,2
	Growing habit	caespitose
	Flowering (days)	80 to 110
	Cycle (days)	120 to 180
	Green mass (mt/ha)	30 to 60
	Dry mass (mt/ha)	3 to 6
	Frost tolerance	little Tolerant
Seeding season		Late summer / early autumn – middle autumn
Seeding	in lines	55 to 70
	broadcast sowing	20% more
	Spacing between rows (17 to 34cm)	60 to 70 (seeds/linear m)
	In mixtures with 2 to 3 crops	30 to 40 (kg/ha)
	In mixtures with 4 to 6 crops	25 to 30 (kg/ha)
Intercropping with corn	in lines	—
	broadcast sowing	—
Nematodes ¹	<i>Pratylenchus brachyurus</i>	RF < 1
	<i>Meloidogyne incognita</i>	RF < 1
	<i>Meloidogyne javanica</i>	RF < 1
	<i>Heterodera glycines</i>	RF < 1
	<i>Rotilenchulus reniformis</i>	RF < 1
	<i>Pratylenchus coffeae</i>	—
	<i>Pratylenchus zea</i>	—
Recycling of nutrients	Nitrogen (% in dry matter) ²	0,70 to 1,68
	Phosphorus P ₂ O ₅ (% in dry matter)	0,10 to 0,42
	Potassium K ₂ O (% in dry matter)	1,08 to 3,08
Indications	Benefits: Very fast growth. High biomass production, efficient soil protection, efficient suppressing weed population and high versatility to fit in different cropping rotation systems, Soil attributes improvement. Can be used also as fodder (forage and grains) to animals. Good results can be achieved when mixed with other cover crop species (legume and other species). When mixed with rye, the rust occurrence can be highly decreased. Normally oats are more tolerant of wet soil than barley, but require more moisture.	
	Attention points: Oat can be used as soil covering (mulch or straw), forage or hay, and grain options.	

RF = reproduction factor

Field pea

Autumn – Early Spring Soil Covers



Identification	Common name	Austrian winter peas (black); Canadian field peas (spring peas)
	Scientific name	<i>Pisum sativum</i> ssp. <i>Arvense</i>
	Family	Fabaceae (leguminous)
Characteristics	Weight of 1,000 seeds (grams)	95 to 125
	Root system	Tap root
	Height (m)	0,6 to 0,8
	Growing habit	climbing
	Flowering (days)	40 to 50
	Cycle (days)	80 to 110
	Green mass (mt/ha)	20 to 30
	Dry mass (mt/ha)	4 to 6
	Frost tolerance	No tolerant
Seeding season		Autumn – early spring
Seeding	in lines	25 to 40 (kg/ha)
	broadcast sowing	45 to 50
	Spacing between rows (17 to 50cm)	15 to 20 (seeds/linear m)
	In mixtures with 2 to 3 crops	12 to 20 (kg/ha)
	In mixtures with 4 to 6 crops	10 to 14 (kg/ha)
Consortium with corn	in lines	very efficient, sow when maize are around 0,60 to 0,80 m.
	broadcast sowing	—
Nematodes ¹	<i>Pratylenchus brachyurus</i>	Susceptible
	<i>Meloidogyne incognita</i>	Susceptible
	<i>Meloidogyne javanica</i>	—
	<i>Heterodera glycines</i>	—
	<i>Rotilenchulus reniformis</i>	—
	<i>Pratylenchus coffeae</i>	—
	<i>Pratylenchus zea</i>	—
Recycling of nutrients	Nitrogen (% in dry matter) ²	0,20 to 3,47
	Phosphorus P ₂ O ₅ (% in dry matter)	0,13 to 0,38
	Potassium K ₂ O (% in dry matter)	2,10 to 2,56
Indications	Benefits: Fast growing, high biomass and soil covering. In spring can suppress weeds properly. Used as forage – normally 18-20% of protein or grain, isolated or mixed with oat, rye, raygras, etc , May be used as cash crop. Attract beneficial organisms. Nitrogen cycling.	
	Attention points: Moderately cold and drought tolerant. Can adapt in semi-arid climate, in soils with medium fertility. <i>Mycosphaerella</i> and <i>Ascochyta pisi</i> foot rot are the main diseases of economic importance in field pea. Also can be susceptible to <i>Sclerotinia</i> sp. in some regions.	

RF = reproduction factor

Consortium, cocktail and mix of cover crops

Consortium spring / summer

- Millet ADR-300 (5–8 kg/ha) + buckwheat (15–20 kg/ha) + crotalarias (spectabilis, breviflora and ochroleuca) (6–8 kg/ha each)
* may be mixed or each species individually.
- Millet ADR-300 (5–8 kg/ha) + buckwheat (15–20 kg/ha) + crotalaria (spectabilis, breviflora and ochroleuca) (6–8 kg/ha each) + dwarf pigeon pea or mucuna (10–15 kg/ha)

Consortium autumn / winter – Indicated for areas with altitude

- Forage turnip (3–4 kg/ha) + black oats (20–25 kg/ha) + common vetch (15–20 kg/ha)
- Black oats (20–25 kg/ha) + white lupine (30–35 kg/ha) + rye (15–20 kg/ha)

Markings

¹ RF = reproduction factor

RF < 1 initial population of nematodes is reduced

RF = 1 initial nematode population is maintained (does not increase or decrease)

RF > 1 initial population of nematodes is increased

² The values expressed in Nitrogen (N) are relative to biological fixation and recycled for legumes and recycled for other families.

General observations

The recommendation of seed density may vary from crop to crop, according to the weight, germination, vigor and purity of the seeds. The information in this leaflet has been summarized from the available literature for the practice of green fertilization, and not used for forage or seed and grain production. For any species, planting season and region it is important to comply with the soil moisture conditions for seed germination and development. The information and values may vary with plant age, plant type, soil, fertility, climate, season and sowing density.

Seed quantity (kg/ha)

Covers	Single	Cocktail with 2 or 3 covers	Cocktail with 5 to 6 covers	Intercropping with corn
Pearl millet	20	6–8	5–6	–
Crotalaria spectabilis	15	8–10	6–8	10
Crotalaria ochroleuca	12 – 15	8–10	6–8	10
Crotalaria juncea	20	8–10	6–8	–
Buckwheat	60	20	15	–
Sunflower	30	5	2	–
Finger millet	10	5	3	–
Brachiaria ruziziensis	10	6	3	3
Dwarf pigeon pea	35	20	15	20–25
Oilseed radish	20	4–5	2–3	–
Common vetch	50	30	15	–
Rye	60	30	20	–
White lupine	100	50	20	–
Black oat	65	40	29	–

References

CALEGARI, A.; COSTA, M.B.; MONDARDO, A.; WILDNER, L. do P.; ALCÂNTARA, P.B.; MIYASAKA, S.; AMADO, T.; Adubação Verde no Sul do Brasil. 2.ed. Rio de Janeiro: AS-PTA, 1993. 346p. 2ª. Edição

CALEGARI, A.; DONIZETI CARLOS, J.A. _ Recomendações de plantio e informações gerais sobre o uso de espécies para adubação verde no Brasil. In: LIMA FILHO, O. F. de; AMBROSANO, E. J.; ROSSI, F.; CARLOS, J. A. D. (Ed.). Adubação verde e plantas de cobertura no Brasil: fundamentos e prática. Brasília, DF: Embrapa, 2014. v. 2, Cap. 27, p. 453-478.

CALEGARI, A. Plantas de cobertura. Manual Técnico. Fev. 2016. Penergetic. Uberaba, MG 24p. (3a. edição).

CARLOS, J. A. D.; Tabelas de recomendações – Pirai Sementes, 2016.

DERPSCH, R.; CALEGARI, A.; Adubação verde de inverno. Londrina, IAPAR, 2ª edição, 1992. p. 80. (IAPAR, Boletim, 73).

Managing cover crops profitability? Project manager and Editor 3rd ed. Agriculture Network handbook series, bk 9. ISBN 978-888626-124 (pbk). Sustainable Agriculture Network. 10300 Baltimore ave. Bldg. 046, Beltsville, MD 20705 HYPERLINK "http://www.sare.org" www.sare.org, 2007. 244p.

Serrantonio, Marianne . Metodologies for screening soil improving legumes. 1956. ISBN – 0-87857-8=989-3 Rodale Institute Research Center, Rodale Institute. 611 Siegfriedale Road. Kutztown, Pa. 19530, USA. 1991, 312 p.

WUTKE, E. B.; CALEGARI, A.; WILDNER, L. DO P. Espécies de adubos verdes e plantas de cobertura e recomendações para uso. In: LIMA FILHO, O. F. de; AMBROSANO, E. J.; ROSSI, F.; CARLOS, J. A. D. (Ed.). Adubação verde e plantas de cobertura no Brasil: fundamentos e prática. Brasília, DF: Embrapa, 2014. v. 1, p. 59–168.

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Some additional cover crops in the U.S.A. and in Europe

In 2003, Ademir Calegari visited France and shared experiences and ideas and encouraged Frédéric Thomas, researcher and farmer from France, to start with different trials, testing and validating some different mix cover crops.

So, these different mix cover crops can be tested and used in different countries in Europe, U.S.A and also some other countries.

Phacelia tanacetifolia, *Vigna unguiculata* (cowpea), *Faba bean*, *Lotus corniculatus* (bird's trefoil), *Melilotus officinalis*, *Lolium multiflorum* (Ryegrass), *X-Triticosecale* (Triticale), (*Hordeum vulgare*) Barley, *Sorghum bicolor* (Sorghum), *Sudan grass*, *Brassica sp.* (Oil seed rape), *Asian radish*, *Fodder radish*, *Moha*, (*Sinapis sp.*) white and Black mustard, *Alexandrian clover* (Bersim clover), *Subterranean clover*, *Persian clover*, *Crimson clover*, *White clover*, *Red clover*, *Lathyrus sp.*, *Faba bean*, *Faenun graecum*, *Camelina sp.*, *Linum usitatissimum* (Flax), etc.

Species / basics

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 fertilizer inputs and reducing the need for tillage. Each plant has its own attributes that fit specific or diverse situations. Therefore, 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	Seeding rate: 8–10kg/ha single (3–4kg/ha into a mix) Most widely used cover crop, easy to establish, quickly covers soil surface but very sensitive to stress (lack of water, lack of nitrogen or very high temperatures) and can run to seed very quickly. Biomass rapidly becomes fibrous, breaks down slowly and during decomposition, N losses can be high.
Phacelia	Seeding rate: 6–10kg/ha Requires better establishment, small roots, very beneficial in improving surface soil structure, especially in clay soils. Popular with bees. Improves density in mixtures and can easily be destroyed by knife roller; its black coloured residues help to warm up the soil (just like field bean residues). If N is available (manure or legumes), it produces a lot of biomass; also a good K scavenger (indeterminate flowering habit and produces a lot of seeds).
Oat (spring or winter variety)	Seeding rate: 70–90kg/ha 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, crop is not killed by frosts and will re-grow in spring.

Fodder radish	Seeding rate: 6–8kg/ha Versatile plant suited to almost all soil types and conditions. Develops huge biomass and leaves a good soil structure. Resists to drought and is not attractive to slugs. Good basis for a lot of mixes.
Rye	Seeding rate: 70–100kg/ha Very aggressive plant with good soil restructuring root system. Does not develop a lot of biomass after autumn seeding but becomes very productive in the following spring. Very sensitive to slugs when young. Useful for thick mulch to direct drill legumes, maize or vegetable crops. High residue in C/N ratio, risk of early N deficiency. Mixing with vetches or peas is advisable.
Triticale	Seeding rate: 80–120kg/ha Same properties as rye but little bit less aggressive and more susceptible to pests and diseases. Should be sown as hibernate cover crop.
Barley (spring or winter variety)	Useful and cheap cover crop, can supply some biomass in autumn (spring varieties). Barley is sensitive to stress and diseases. Not advisable in rotation with winter cereals.
Rye grass	Seeding rate: 17–22kg/ha Slow early growth, once established becomes very aggressive. Better suited to cover crops which will be hibernate. Can supply a useful source of forage and is a N scavenger. One of the few species that can grow under maize, but can be very difficult to manage either mechanically or chemically.
Oil seed rape	Seeding rate: 8–12kg/ha Very inexpensive cover crop, aggressive with good soil structuring attributes. To get best from OSR as cover crop needs to be sufficient N available. Used in any rotation where OSR is not a part. OSR will encourage slugs, this should be taken into account when considering.
Fodder rape	Seeding rate: 8–12kg/ha Very similar to OSR but with more foliage (better cover) and can be grazed.

Species / "new species"

"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	Seeding rate: 20–25kg/ha Best suited to hot and dry conditions, supplies good levels of biomass if planted early in the summer. Good option for summer cover crops in rotations where it is not planted as a cash crop; killed by frost. In biomass type mixtures form a basis, which absorbs N, P and K: Doesn't provide much soil cover but does absorb a lot of nutrients and helps suppress weeds.
Rough oat or Brazilian oat (avena strigosa)	Seeding rate: 35–45kg/ha Will grow under all conditions. Is close to forage oat, quite aggressive and produces a heavy biomass that can be converted into quality forage (could be fibrous). As a cover crop, remaining straw on soil can be difficult to break down and may require some extra N: therefore risk of N deficiency in next crop. Can be reduced by including a legume.
Flax	Seeding rate: 20–30kg/ha Easy to establish even under dry conditions. Low surface biomass, produces a good level of roots and competes well with weeds. Remaining residue can block tillage tools and seeders.
Buckwheat	Seeding rate: 45–55kg/ha Quite easy to establish in stubble during summer, competes well with broadleaved weeds (allotropic effect). Quite easy to use as "double" crop or catch crop. Remaining seeds after harvest or in cover crops biomass will germinate next spring when temperature reaches 12°C. Not recommended as cover crop or mix before maize, sugar beet, and sunflower. Encourages bees and wildlife. Good P scavenger.

Camelina	Seeding rate: 8–12kg/ha Oil seed plant, seeded very shallow, emerges and grows quickly and competes well with weeds. With a growing cycle (90–100 days), a high risk of producing viable seeds. Can be used as double crop and companion crop especially in association with legumes (e.g. lentil, soybean, lupine).
Asian radish	Seeding rate: 5–8kg/ha Quite easy to establish, absorbs a lot of N. Unlike the fodder radish, stem doesn't grow (if sown late summer and autumn) but develops rapidly and produces long tap roots. In sufficient soil fertility, root can become very big and weigh several kg. Usually killed by winter frosts (-7 or -8°C) or by rolling or shallow tillage. Crucifer. Crop returns fertility stored in its root as a low C/N ratio.
Turnip	Seeding rate: 6–10kg/ha Cruciferous species mopping up a lot of residual N. Like OSR, no growth of stem in autumn and foliage is good for grazing. Will not be killed during winter and continue to absorb N. During spring growth initially depletes N available for the following crop. This N will be only available later to the cash crop.
Moha millet	Seeding rate: 25–30kg/ha Summer grass, need high temperatures, water and N. Excellent source of forage and useful cash crop, when in conjunction with legume (e.g. Alexandrian clover). Sensitive to sunlight, must be seeded early (before mid-July), long day length stimulates growth.
Sorghum	Seeding rate: 15–25kg/ha Very aggressive tropical grass producing heavy biomass and roots, when planted early. Drought resistant when well established (needs to be well seeded). Benefits from high temperatures, moisture and N. Several types (grain, sugar, paper) can produce different volumes and qualities of vegetation. Good source of forage.
Black mustard	Seeding rate: 2–3kg/ha Very low thousand grain weight and strong emergence (vegetal development a little bit like OSR, produce a stem in autumn), can be seeded at very low seed rate. Growth cycle is longer than white mustard, chance of producing seed lower, therefore less competitive with weeds. Could be employed as a “bio-fumigant” on nematodes.
Nyger	Seeding rate: 8–12kg/ha Closely related to sunflowers and best suited to hot moist conditions. If drilled early, it can produce high levels of biomass and will smother volunteers and weeds. First light frost will kill it. Attractive to slugs. If planted early is a versatile cover crop. Planted alone or in mixture, gives good results. Should be a companion crop with autumn sown OSR (attracts slugs) and killed with first frost, will not compete with crop.

Species / legume cover crops

Legume cover crops	In Europe, few are included in our crop rotations, so they should be included in cover crops mixes. This is probably at odds with the concept of the N holding cover crops aimed at reducing nitrate level in drainage water. They bring more diversity, promote a higher biomass production and, none the less, fix some N, which can reduce the dependence on artificial fertilizer. Finally, legumes have a low C/N ratio so do not tie up soil N. As an essential natural plant species, they should be included wherever possible.
Common vetch (spring or winter cultivars)	Seeding rate: 40–50kg/ha Slow to establish, but as a climber will smother other species in autumn (or spring if seeded late). Very good N fixer, that combines quite well with cover crops and forage mixes. Easily controlled with knife roller or any other mechanical destruction. Tendency to re-grow and can block up tine based tillage machinery. Its shallow root system aids biologic activity.
Hairy vetch	Seeding rate: 35–45kg/ha Initially slower to establish than common vetch, once growing can become quite aggressive. Can dominate any species or mixture and will smother weeds on volunteers by its very high levels of vegetation. Has trait of having 3–5% seeds remaining dormant and may well germinate in the following cash crop. Risk of contamination is limited by conservation tillage and direct drilling, but could be a problem for organic growers.

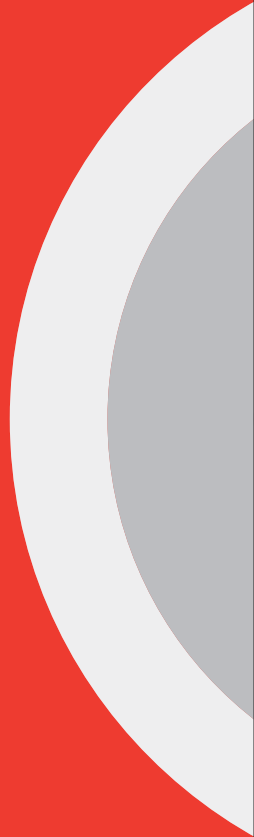
Bengal vetch	Seeding rate: 40–50kg/ha Same traits as common vetch but with faster growth: depending on conditions, of 25% to 40% more biomass in 3 months in summer and autumn. Quite good choice where sown between winter cereal crops supplying N to the following crop.
Cerdagne vetch (Mountain vetch)	Seeding rate: 30–40kg/ha Well suited to dry and harsh conditions. Like bitter vetch, various species are not yet catalogued so cannot be differentiated in between.
Alexandrian clover (Berseem clover)	Seeding rate: 8–12kg/ha Annual or biennial clover, develops rapidly during summer and autumn if conditions are favourable. Prefers deeper soils with a good natural fertility and sufficient moisture. Significantly less competitive under dry conditions. Under good conditions it can produce high levels of biomass (3–4mt of DM/ha are possible after barley or wheat crop), fixing significant amounts of N. Very good source of forage alone or in mixes but also very good cover crop between two straw crops. No need to destroy before planting next straw crop (can be dealt by herbicides during the autumn and winter).
Persian clover	Seeding rate: 8–12kg/ha Like Alexandrian clover it provides biomass during summer. Grows better in poorer soils and harder conditions: more resistant to frost and harder to destroy.
Crimson clover	Seeding rate: 12–15kg/ha Biennial clover, quite slow to establish in autumn but opposed to Berseem clover performs better under more difficult climatic conditions and lighter soils. Quite winter hard, will regrow again in spring very fast (the main production period). Good source of forage and a useful complement for cover crop mix with early spring biomass production. Despite its qualities, is not a big N fixer: In field trials, often at bottom of the list. Good cover crop to use on wet soils before maize, as long as it is killed off before using up all soil moisture.
Field bean	Seeding rate: 150–200kg/ha Despite large seed size and heavy seed rates, very useful and versatile plant as cover crops (volunteers are a good indication). Produces a considerable amount of biomass and tap root is good for soil re-structuring. Able to quickly fix the high amounts of N (80–200kg N/ha in 3–4 months). Not ideal forage crop but can be used in silage or haylage. Can be included in many summer, autumn or winter mixes. Usually killed by winter frost but if sown late (after corn harvest), will go through winter easily and start to grow again in spring. Good companion crop (OSR, sunflower, corn, cereals), not very competitive against weeds. Spring variety “Diana” with a lot smaller grain size (300–400gr/1000 grains) tested by conservation agriculture networks, seems to bring equal results at half seed rate.
Forage pea	Seeding rate: 60–80kg/ha Very versatile legume well suited cover crop. A lot hardier, producing a bigger biomass and more disease resistant than varieties used for grain production. Good supplement of any cover mix. Produces good quality forage useful in forage and grain mixes.
Latyrus	Seeding rate: 35–45kg/ha Better suited to calcareous soil where it can produce good levels of biomass. In these conditions good N fixer. Grain is toxic, can't be used as forage, but useful as companion plant especially for OSR (short growing cycle and easily killed by frost).
Lentil	Seeding rate: 25–35kg/ha Generally prefers calcareous and non-acidic soils. Does not produce high levels of biomass, still quite competitive with weeds (when drilled at high seed rates). Rarely used as cover crop and especially not in mixtures. Very useful as companion crop for OSR, if used GFL mix (Gesse/ fenugreek/lentil). Black fodder lentil, produces more biomass and is more aggressive, but seed is in short supply.
Fenugreek	Seeding rate: 10–15kg/ha Typical smell of curry (plant and seeds). Suited to clay and calcareous soil and quite hardy conditions. With lentils, fenugreek is not an aggressive plant. Potential biomass is not great but for forage has high quality (not for dairy cows – curry taste goes into the milk). Does not perform well in cover crop mixtures: good companion crop for OSR. Its strong smell can deter insects but attract hares and deer.

Species / classical blends

Classical blends	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 the more species put in a mix, the better they will perform in terms of soil structure, fertility, biomass, weed control, stability, etc.: the more complex the blend, the more simple it becomes!
Mustard phacelia	Seeding rate: 4kg/ha 5kg/ha Conventional and very classic mix for fields with good levels of N or where some kind of manure or slurry will be applied. Usually high biomass production. Depending on fertility and weather conditions, mustard can become dominant (in this case reduce the seed rate of mustard or dilute it with a third species). Seedbed must be sufficiently good for phacelia to establish well.
Winter oat mustard	Seeding rate: 20kg/ha 4kg/ha Easy mix to use with a good potential of biomass production if sufficient N available. Mix is good for weed control but residues are high in C and may use more N from the soil during decomposition than return any for the next crop. Is even more evident if cover crop is incorporated or ploughed down, if following crop is directly drilled. Residue remains on the soil surface, decomposition is slower tying up less soil N.
Spring oat vetch	Seeding rate: 50kg/ha 25kg/ha Mix is better suited for seeding later in the season, possibility to hibernate and completing its work the following spring. Earlier sowed oats may not be competitive enough and could leave space for weeds to develop. Winter cover crop and addition of some field beans with reduced seed rate of oats and vetch will be a better option (40kg/ha oat, 20kg/ha vetch and 40kg/ha Berseem) and will fix more N.
Winter oat phacelia	Seeding rate: 20kg/ha 5kg/ha Good potential biomass producer with a better balanced C/N ratio. Care must be taken as oats can become dominant. Better to mix with a third species (a legume like vetch).
Winter oat phacelia vetch	Seeding rate: 15kg/ha 3kg/ha 15kg/ha Very well balanced mix with species that have got different and complementary vegetative behaviours. Adding vetch will improve biomass production, soil coverage and increase N pool. While lowering average C/N ratio of residues. Mix can give good results after winter cereals crops (long intercrop period) as well as after maize (where it will hibernate). In this situation it is recommended to increase the seed rates by 10 to 20% in order to get more quickly better cover.
Alexandrian clover phacelia	Seeding rate: 5kg/ha 5kg/ha Two less competitive species that can cooperate well together to produce a good cover and a well-balanced biomass. Easy to manage. Mix needs to be established well and prefers deep silty soils with good natural fertility. 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	Seeding rate: 5kg/ha 25kg/ha More impressive and bushy, able to produce a large biomass (4–6mt of DM/ha) if sown early. Good couple for short intercrop periods before winter cereals if OSR is not one of the main crops in the rotation. Performance will be improved by incorporating other species in the mixture like sunflower, phacelia, flax, vetch.
Pea vetch field bean	Seeding rate: 25kg/ha 20kg/ha 50kg/ha Quite well balanced mixture with the objective of fixing max. N to boost soil's natural fertility. For summer-autumn or winter-spring intercropping it is recommended to add some oats, phacelia or radish or maybe all three to boost biomass production and level of cover without reducing ability to fix N. Pure legume mix, fits well in no-till and organic farming systems. Care should be taken when the crop is destroyed, possible for N leaching, breaching environmental legislation.

Species / "Biomax" type blends

"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 bio-diversity 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	Seeding rate: 2kg/ha 2kg/ha 20kg/ha 12kg/ha Mixture is quite well balanced with some good conventional cover crops associated with a couple of very good legumes. Well suited for sowing from middle to the end of august for autumn and winter intercropping. If sown too early, risk that mustard will run to seed even if the seed rates are reduced.
Sunflower radish phacelia pea vetch	Seeding rate: 6kg/ha 2kg/ha 2kg/ha 15kg/ha 10kg/ha Mixture produces more impressive vegetation and a bigger biomass capable of fixing good levels of N. Possible to drill early, right after harvesting winter cereals. Can be used for longer intercrop periods or between two winter cereals. Usually controlled by the winter weather and does not need to be destroyed chemically or mechanically.
Radish flax phacelia pea vetch	Seeding rate: 3kg/ha 7kg/ha 2kg/ha 15kg/ha 10kg/ha If sunflower is grown on the farm as a cash-crop, it is possible to increase amount of radish and add some flax. Mix probably less productive in term of biomass but with soil structuring effect in combination with radish and flax makes a useful cover crop.
Asian radish phacelia field bean Alexandrian or Crimson clover vetch or pea	Seeding rate: 2kg/ha 2kg/ha 30kg/ha 3kg/ha 10kg/ha Cover consists five "levels" with the tillage radish dealing with "deep underground level". Biomax will be a bit shorter with slightly less biomass but its vegetation will be very dense. Good N fixer with fast return to next crop. Ideal cover crop between winter cereal crops.
Oat field bean Pea vetch phacelia	Seeding rate: 25kg/ha 50kg/ha 20kg/ha 15kg/ha 2kg/ha Mixture for winter-spring intercropping, slightly higher seed rate. Drilled in October or November, majority of plants will go through the winter and come up in spring. As most are legumes, their growth will not only absorb soil moisture but also increase level of N fixed and of C returned to the soil during the intercrop period. Oat can be easily replaced by summer oat, rye or any other winter cereals by adjusting seed rate.
Sorghum radish moha rough oat pea vetch Alexandrian or Crimson clover	Seeding rate: 3kg/ha 2kg/ha 5kg/ha 10kg/ha 10kg/ha 5kg/ha Summer biomax for forage production. Should be sown early after winter barley or OSR. Potential of biomass production is very high and such a diversity of plants will easily adapt to and compensate adverse climatic conditions.
Field bean vetch pea Alexandrian clover lentil	Seeding rate: 30kg/ha 10kg/ha 15kg/ha 3kg/ha 5kg/ha Pure legume biomax for max. N fixation. During 3–4 months summer intercrop period, possible that mixture can produce 4–5mt/ha of DM with 100–180kg of N/ha (kept in total biomass: surface vegetation and roots) a large percentage (40–50%) will be available for the next crop.
Sunflower phacelia radish OSR rough oat flax nyger pea vetch Alexandrian clover field bean	Seeding rate: 3kg/ha 2kg/ha 1kg/ha 3kg/ha 4kg/ha 3kg/ha 1kg/ha 6kg/ha 5kg/ha 2kg/ha 15kg/ha Ten species are a very complex biomax mixture. If weather conditions are favourable, (when sown after a winter cereal), possible for this type of mixture to produce 10mt/ha of DM with 150–250kg of N/ha recycled and fixed in the surface vegetation. Mixture is a real soil fertility booster.



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