



# **GREEN MANURE AS AN ALTERNATIVE FOR IMPROVEMENT OF SOIL FERTILITY**

## **СИДЕРАЦИЈАТА КАКО АЛТЕРНАТИВА ЗА ПОДОБРУВАЊЕ НА ПЛОДНОСТА НА ПОЧВИТЕ**

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# Agro ecological and environmental aspects of conventional agriculture

- ❖ Conventional agriculture is developed in order **maximizing production and profits**
- ❖ The industrialization of agriculture is supported by:
  1. Capital - intensive farming;
  2. Monocultures;
  3. Irrigation;
  4. Mineral fertilizers;
  5. Chemical plant protection;
  6. Genetic manipulation;

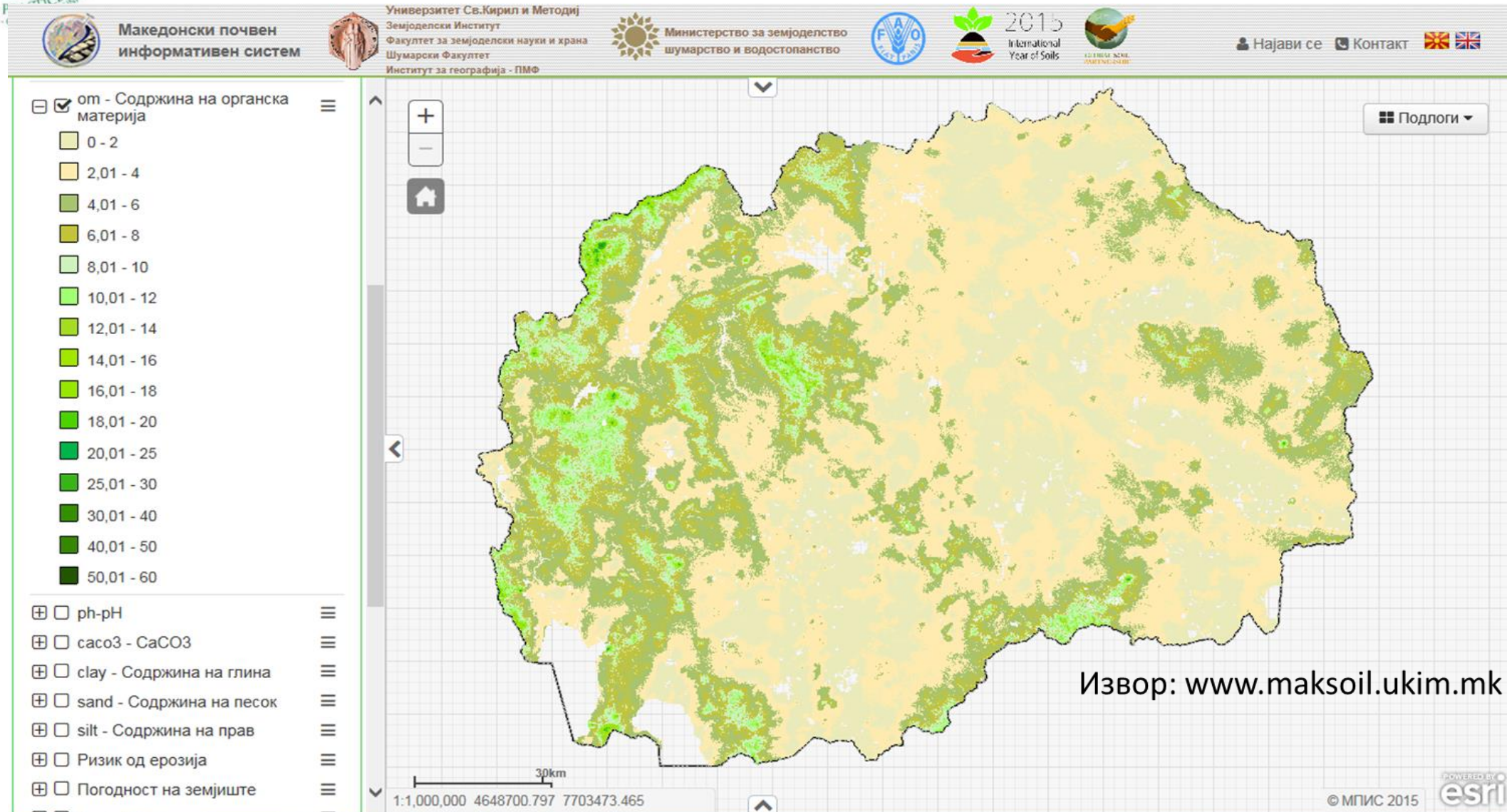
# Agro ecological and environmental aspects of conventional agriculture

- All together they create a system in which those pillars are interdependent from one another, and each of them also intensifies for the needs of others
- In many areas of the world, conventional farming has threatened the future fertility of the soil through:

- ❖ - Soil and water degradation;
- ❖ - Reducing diversity;
- ❖ - Changing ecological processes that are dependent on agriculture

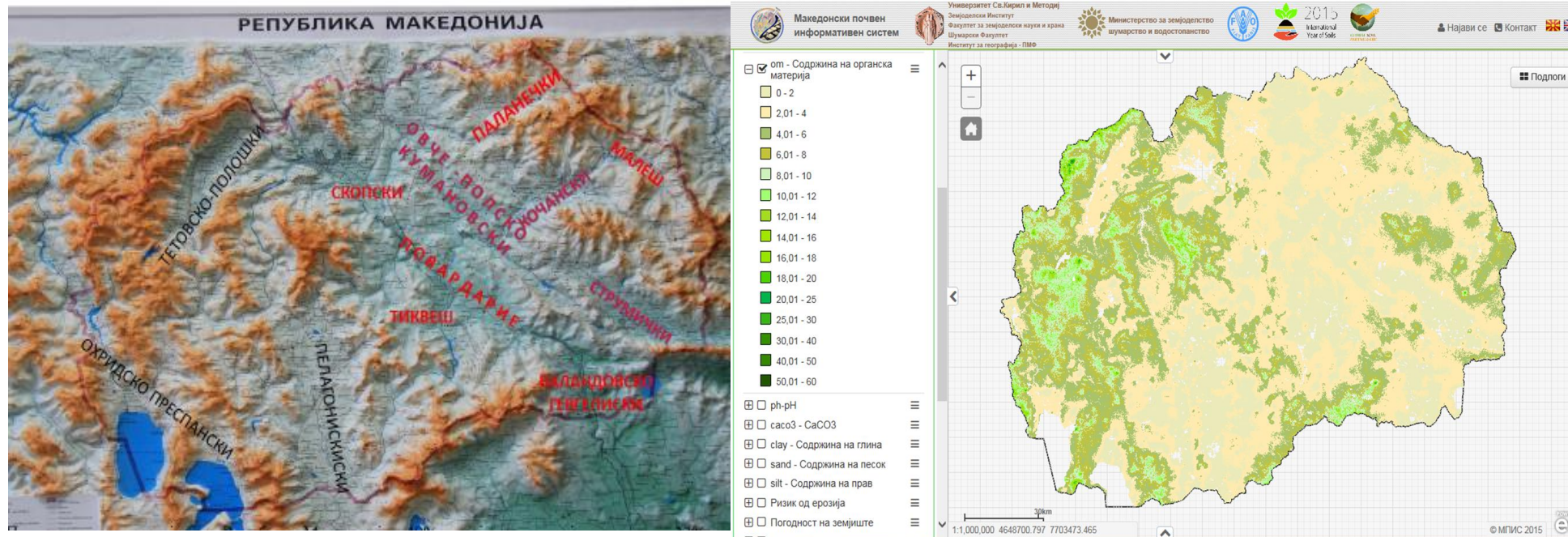


# Content of organic matter in the soils of the Republic of Macedonia





# Agricultural regions for crop production in the Republic of Macedonia





# EFFECTS OF GREEN MANURE - ЕФЕКТИ ОД СИДЕРАЦИЈАТА



- ❖ Nitrogen fixation
- ❖ Nitrogen conservation
- ❖ Making nitrogen available
- ❖ Effects on other soil nutrients
- ❖ Effects on soil structure and properties
- ❖ Effects on weeds
- ❖ Effects on pests
- ❖ Effects on diseases

# Nitrogen fixation

- ❖ **Almost all legumes use Rhizobia bacteria to fix nitrogen from the atmosphere**
- ❖ **Sometimes the nitrogen fixation still does not occur, even if the roots form a symbiosis with the bacteria**
- ❖ **For effective fixation, a minimum soil temperature of about 7°C is needed and the plants need to have adequate nutrients available to them**
- ❖ **The amount of nitrogen fixed varies between different species (Graph 1). In broad terms it is related to total biomass production and so is affected by speed of establishment and growing conditions (for example water availability and weed competition).**

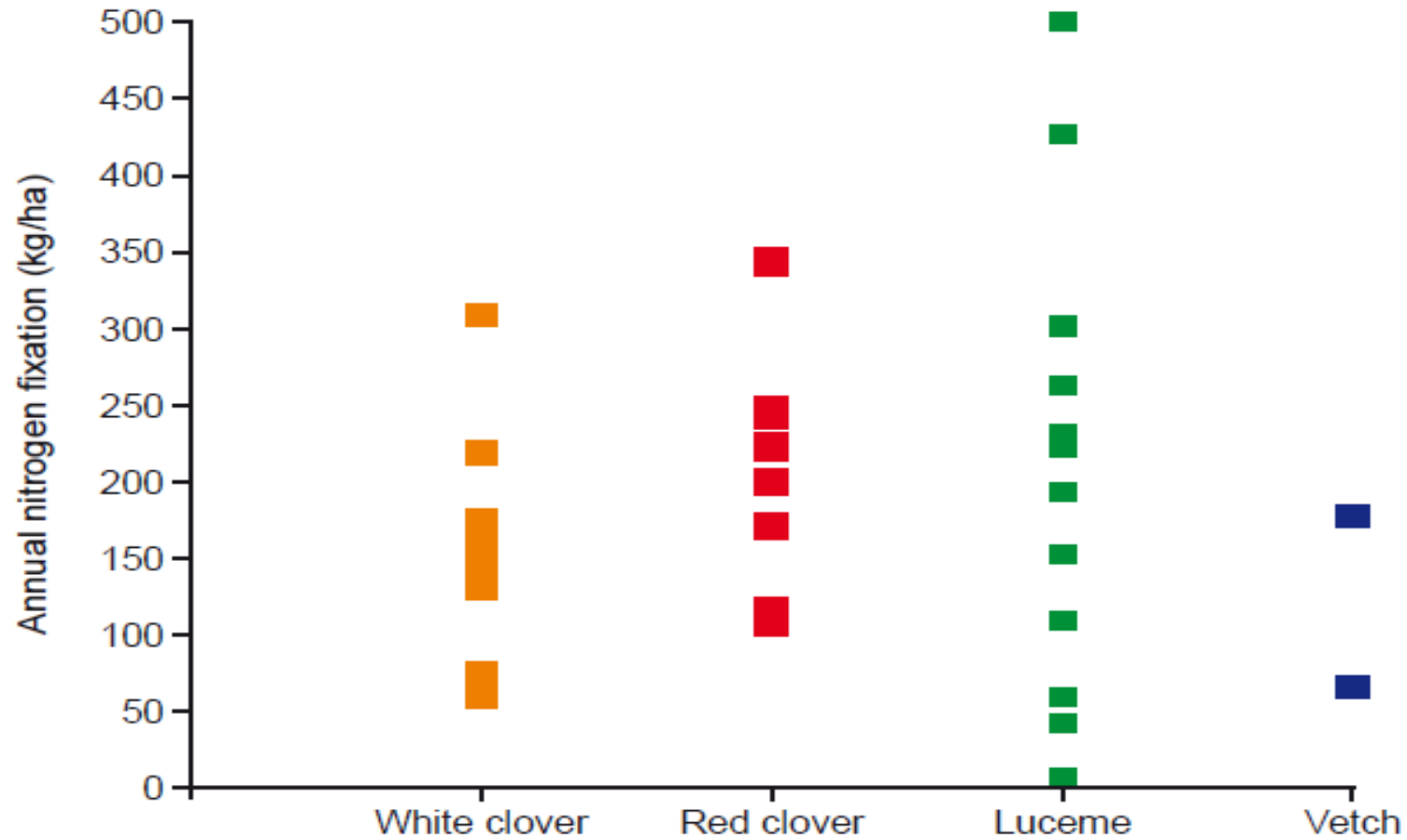
# Nitrogen fixation

| Rhizobium Spp.   | Cross<br>Inoculation<br>Grouping | Legume Types                       |
|------------------|----------------------------------|------------------------------------|
| R. leguminosarum | Pea group                        | Pisum, Vicia, Lens                 |
| R. phaseoli      | Bean group                       | Phaseolus                          |
| R. trifolii      | Clover group                     | Trifolium                          |
| R. meliloti      | Alfalfa group                    | Melilotus, Medicago,<br>Trigonella |
| R. lupini        | Lupini group                     | Lupinus, Orinthopus                |
| R. japonicum     | Soybean group                    | Glycine                            |
| Rhizobium sp.    | Cowpea group                     | Vigna, Arachis                     |

**Source:** *Abhinav Datta et al. Annals of Plant Sciences, 2015, 4 (01), 933-942*



# Nitrogen fixation



Graph 1 Nitrogen fixation by different leguminous green manures showing the range of measurements that have been made (data from Defra Project OF0316)



**Source :** Factsheet 24/10 Soil grown crops Projects FV 299 and 299a , 2010.

# Nitrogen fixation



Photos: Ljupco Mihajlov 2014



## ГЕНЕРАЛНИ ИНФОРМАЦИИ КОИ ТРЕБА ДА СЕ ПОЗНАВААТ ЗА РАСТИТЕЛНИТЕ ВИДОВИ ЗА ЗЕЛЕНО ЃУБРЕЊЕ

### Necessary to know:

- ❖ family to which belong
- ❖ growth habit
- ❖ cycle
- ❖ rusticity
- ❖ weed competition
- ❖ effects on soil
- ❖ nutrient recycling
- ❖ nitrogen-fixing or not ?

### Потребно е да се знае:

- ботаничката припадност
- типот на раст и хабитус
- биолошкиот циклус
- автохтоноста (потеклото)
- конкурентноста со плевелите
- нивниот ефект врз почвата
- рециклирање на хранливи материи
- дали се азотофиксатори или не ?



# GENERAL REQUIREMENTS THAT SHOULD BE MET FOR PLANT SPECIES BY GREEN MANURE



## ГЕНЕРАЛНИ ИНФОРМАЦИИ КОИ ТРЕБА ДА СЕ ПОЗНАВААТ ЗА РАСТИТЕЛНИТЕ ВИДОВИ ЗА ЗЕЛЕНО ЃУБРЕЊЕ

### ❖ seed production

❖ performance when faced by pests and diseases, ways to manage, etc.

❖ aspects concerning the production systems in which they will be included (climate, soil type, conditions of soil fertility)

❖ crops with which they will be integrated in the system

### ❖ available machinery and/or implements

- семе производството

- чувствителноста на болести и штетници  
и начин на спречување на истите

- аспекти поврзани со производниот систем  
(агроеколошки и агротехнички барања)

- можност за нивно одгледување како  
здружени посеви

- расположлива механизација за нивно  
одгледување и/или прикулучна  
механизација



### ❖ How to grow green manures ?

1. When land is unused, or fallow between crops
2. While crops are still growing in the fields



### ❖ Како да се одгледуваат растенијата за зелено ѓубрење ?

1. На угари или како меѓу посеви
2. Во периодот на вегетацијата на одгледуваните растенијата





## РАСТИТЕЛНИ ВИДОВИ ЗА ЗЕЛЕНО ЃУБРЕЊЕ – ПРОЛЕТНА СЕИДБА И ЛЕТНА ИНКОРПОРАЦИЈА

- their quick growing will suppress weeds by light
- usually do not contain high proportions of carbon when incorporated into the soil
- shorter-term green manures can include non-legumes such as **mustard** and **phacelia**
- се карактеризираат со **брз пораст и конкурираат на плевелите со засенчување**
- вообичаено во моментот на нивна инкорпорација во почвата не содржат високи пропорции на јаглерод
- растенија за зелено ѓубрење со кратка вегетација, може да вклучуваат и не-легуминози култури како на пример **синапот** и **фацелијата**





# PLANT SPECIES FOR GREEN MANURES - **SPRING SOWING AND SUMMER INCORPORATION**

## РАСТИТЕЛНИ ВИДОВИ ЗА ЗЕЛЕНО ЃУБРЕЊЕ – **ПРОЛЕТНА СЕИДБА И ЛЕТНА**

### **ИНКОРПОРАЦИЈА**



| Crop                                                                                               | Average sowing rate (kg/ha) | Treatment type                   | Sowing dates          | Incorporation period    | Root type/ depth    | Soil type                                     | Useful information and growing tips                                                                                                                                                                                                                                                                                                                                                                             |
|----------------------------------------------------------------------------------------------------|-----------------------------|----------------------------------|-----------------------|-------------------------|---------------------|-----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Short Term Crops      Spring/Autumn, Spring/Summer Sowing &amp; Summer/Autumn Incorporation</b> |                             |                                  |                       |                         |                     |                                               |                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>White Mustard</b><br><i>Sinapis alba</i>                                                        | 12 -20                      | Untreated, Cruiser OSR & Organic | Spring - Early Autumn | 8 weeks after sowing    | Fibrous root system | All types, best on light, sandy soils         | Fast growing and good weed supressor. Has biofumigation properties but not to same extent as brown mustard. Produces large equantities of biomass. Excellent scavenger of nitrogen. Requires fine seedbed. Susceptible to club root. Plough in before flowering to prevent self-seeding.                                                                                                                        |
| <b>Brown Mustard</b><br><i>Sinapis nigra</i>                                                       | 5 - 8                       | Untreated                        | Spring - Autumn       | Autumn - Spring         | Tap root            | All types, prefers moist ground.              | As white mustard, but contains high levels of glucosinolate which create biofumigation properties to reduce wireworm infestation. To maximise this benefit, crop must be finely chopped at flowering and thoroughly incorporated into moist soil. Brown mustard is winter hardy so is excellent for reducing soil erosion, water run-off and fertiliser leaching when grown after maize, potatoes & sugar beet. |
| <b>Phacelia</b><br><i>Phacelia sp.</i>                                                             | 8- 10                       | Untreated                        | Spring - Summer       | 10 - 12wks after sowing | Shallow, fibrous    | Most soil types, will tolerate dry conditions | Quick to establish and a good weed supressor. Flowers loved by bees and butterflies. The crop must be incorporated into the soil before setting seed or it may reappear in subsequent crops as a weed. Said to release many minerals into soil as it decomposes, especially P, Ca and Mg.                                                                                                                       |

## РАСТИТЕЛНИ ВИДОВИ ЗА ЗЕЛЕНО ЃУБРЕЊЕ – **ПРОЛЕТНА СЕИДБА И ЛЕТНА ИНКОРПОРАЦИЈА**

| Crop                                                                         | Average sowing rate (kg/ha) | Treatment type | Sowing dates    | Incorporation period | Root type/ depth                   | Soil type                                                                     | Useful information and growing tips                                                                                                                                                                                                      |
|------------------------------------------------------------------------------|-----------------------------|----------------|-----------------|----------------------|------------------------------------|-------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Short Term Crops Incorporation Spring/Summer , Spring Sowing & Summer/Autumn |                             |                |                 |                      |                                    |                                                                               |                                                                                                                                                                                                                                          |
| Buckwheat<br><i>Lens culinaris</i>                                           | 50 – 80                     | Untreated      | Spring - Summer | Summer - Autumn      | Shallow, but with good penetration | Tolerates poor, but not wet soils                                             | Fast growing and quick to mature, not winter hardy. Dislikes wet, heavy or compacted soil. Do not allow to set seed before incorporating into soil. Attractive to beneficial insects especially hoverflies. Good scavenger of phosphate. |
| Crimson Clover<br><i>Trifolium incarnatum</i> L.                             | 12 – 15                     | Untreated      | Spring          | Summer - Autumn      | Taproot with fibrous branch roots  | Prefers loam, will tolerate poor soils as long as alkaline and free draining. | Nitrogen fixing. Very attractive to insects. Excellent weed supressor. Biomass degrades quickly into soil.. Shade tolerant.                                                                                                              |
| Aslike Clover<br><i>Trifolium hybridum</i>                                   | 70                          | Untreated      | Spring          | Autumn               | Branched tap root Deep rooting     | Most types                                                                    | Nitrogen fixing. Less biomass than red and white clover but better adapted to wet, acid soils and cooler conditions. Requires shallow sowing and firm seedbed.                                                                           |





# PLANT SPECIES FOR GREEN MANURES – AUTUMN SOWING AND SPRING INCORPORATION

## РАСТИТЕЛНИ ВИДОВИ ЗА ЗЕЛЕНО ЃУБРЕЊЕ – ЕСЕНСКА СЕИДБА И ПРОЛЕТНА ИНКОРПОРАЦИЈА



| Crop                                                                        | Average sowing rate kg/ha | Treatment type      | Sowing dates    | Incorporation period | Root type/ depth                             | Soil type                                             | Useful information and growing tips                                                                                                                                                                                                                                                                             |
|-----------------------------------------------------------------------------|---------------------------|---------------------|-----------------|----------------------|----------------------------------------------|-------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Short Term Crops Incorporation Autumn, Spring/Autumn Sowing & Spring/Autumn |                           |                     |                 |                      |                                              |                                                       |                                                                                                                                                                                                                                                                                                                 |
| Forage Winter Rye<br><i>Secale cereale</i>                                  | 150 – 200                 | Untreated           | Autumn          | Spring               | Extensive, fibrous root system               | Grows well on light, sandy, free-draining soils       | Produces large amounts of green material. Excellent nitrogen scavenger and for the prevention of nitrate leaching during winter months. Do not allow to run to seed as this will 'lock-up' available nitrogen. Very hardy. Do not follow too soon with brassica crop or germination will be adversely affected. |
| Italian Ryegrass<br><i>Lolium perenne</i> ssp. <i>multiflorum</i>           | 35-40                     | Untreated & Organic | Autumn          | Spring               | Extensive, fibrous root system               | Diploids better in wet areas and tetraploids in drier | As with forage rye, produces high yields of biomass. Good root system for improving soil structure. If seed heads are produced, crop must be cut before seed is shed to prevent infestation of following crop. Good 'mopper-up' of excess soil nitrogen.                                                        |
| Cocksfoot<br><i>Dactylis glomerata</i>                                      | 8 – 10                    | Untreated & Organic | Spring / Autumn | Autumn - Spring      | Thick and fibrous with large energy reserves | Dry, free-draining                                    | When undersown at a low seed rate into winter wheat, cocksfoot is an excellent soil improver for droughtprone soils.                                                                                                                                                                                            |

# PLANT SPECIES FOR GREEN MANURES – AUTUMN SOWING, SPRING INCORPORATION

## РАСТИТЕЛНИ ВИДОВИ ЗА ЗЕЛЕНО ЃУБРЕЊЕ – ЕСЕНСКА СЕИДБА, ПРОЛЕТНА ИНКОРПОРАЦИЈА

- ❖ Autumn sown crops which go through the winter will scavenge nitrogen from soils thus preventing “leaching” and can be incorporated in the following spring, or can provide a source of forage, prior to incorporation. Help to control erosion.
- ❖ Есенските култури во текот на зимата го врзуваат азотот од почвата и го спречуваат неговото промивање во подлабоките слоеви, можат да се инкорпорираат во почвата следната пролет, или да обезбедат значителен извор на сточна храна пред да се инкорпорираат. Помагаат во контрола на ерозијата.

| Crop                                 | Av sowing rate kg/ha | Treatment type                   | Sowing dates    | Incorporation period                               | Root type/ depth             | Soil type                                                                 | Useful information and growing tips                                                                                                                                                                                                                                                         |
|--------------------------------------|----------------------|----------------------------------|-----------------|----------------------------------------------------|------------------------------|---------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Short Term Crops                     |                      |                                  |                 | Spring/Autumn Sowing & Autumn/Spring Incorporation |                              |                                                                           |                                                                                                                                                                                                                                                                                             |
| Forage Rap<br><i>Brassica napuse</i> | 6 – 10               | Untreated, Cruiser OSR & Organic | Spring / Autumn | Autumn - Spring                                    | Deeply penetrating tap root. | Most types, able to tolerate poor soil & exposed sites                    | Fast growing. Good alternative to mustard if using high glucosinolate varieties, as decomposition can release chemicals which produce a biofumigation effect if incorporated within 24 hours of cutting. Where club root is a problem, make sure a resistant variety is used.               |
| Vetches<br><i>Vicia spp.</i>         | 65 - 85              | Untreated & Organic              | Spring / Autumn | Autumn - Spring                                    | Tap root                     | Prefers loams and clay. Will not thrive in wet or waterlogged conditions. | Nitrogen fixing. Good weed supressor. Ensure winter hardy variety is used. Due to its large seed size, will establish later than most other legumes. Requires fine, firm seed-bed. As with forage rye, do not follow too soon with brassica crop or germination will be adversely affected. |



# PLANT SPECIES FOR GREEN MANURES – LONGER TERM CROPS

## РАСТИТЕЛНИ ВИДОВИ ЗА ЗЕЛЕНО ЃУБРЕЊЕ – ПОВЕЌЕГОДИШНИ КУЛТУРИ



| Crop                                                  | Av sowing rate kg/ha | Treatment type      | Sowing dates             | Incorporation period | Root type/ depth                  | Soil type                                                         | Useful information and growing tips                                                                                                                                                                                        |
|-------------------------------------------------------|----------------------|---------------------|--------------------------|----------------------|-----------------------------------|-------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Longer Term Crops                                     |                      |                     |                          |                      |                                   |                                                                   |                                                                                                                                                                                                                            |
| Lucerne<br><i>Medicago sativa</i>                     | 20 – 25              | Untreated & Organic | Spring - Early<br>Autumn | Autumn - Spring      | Very deep tap root                | Light/chalky/ free-draining                                       | Nitrogen fixing. Seed must be inoculated with rhizobium bacteria. Prefers dry growing conditions. Uncompetitive particularly in early stage of development so grow as pure stand or with non-aggressive companion grasses. |
| White Clover<br><i>Trifolium repens</i>               | 8 – 10               | Untreated & Organic | Spring - Early<br>Autumn | Autumn - Spring      | Creeping stolons. Shallow rooting | Wide range. Tolerates dry conditions.                             | Nitrogen fixing. Continued defoliation stimulates root growth and nitrogen fixation. Smaller leaved varieties are more persistent than larger leaved. Good weed suppressor. Shallow sow into fine, firm seed bed.          |
| Red Clover<br><i>Trifolium pretense</i>               | 15 – 20              | Untreated & Organic | Spring - Early<br>Autumn | Autumn - Spring      | Large, strong tap root            | Wide range, avoid poorly drained, acid soils                      | Aggressive, nitrogen fixing plant, does not release N until crop is ploughed in. Shorter term than white clover. Good for improving and aerating soil structure & useful weed suppressor. Ensure fine, firm seed bed.      |
| Yellow Blossom Clover<br><i>Melilotus officinalis</i> | 15 - 20              | Untreated           | Spring                   | Summer - Autumn      | Long tap root.                    | Prefers poor soil and dry conditions. Dislikes wet, heavy ground. | Biennial. Nitrogen fixing, quick to establish and grows vigorously. Improves soil structure. Plough in before flowering and before stems becomes woody. Attractive to bees and other insects if allowed to flower.         |





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# Recommendations - Препораки

## Зошто да не ?

|           |                                 |
|-----------|---------------------------------|
| Наут      | - <i>Cicer arietinum</i> L.     |
| Еспарзета | - <i>Onobrychis</i> sp.         |
| Уров      | - <i>Vicia sativa</i> L.        |
| Сусам     | - <i>Sesamum indicum</i> L.     |
| Лен       | - <i>Linum usitatissimum</i> L. |

International Journal of Agronomy  
Volume 2017 (2017), Article ID 4767509, 6 pages  
<https://doi.org/10.1155/2017/4767509>  
Research Article

Effect of Organic Mulching on Soil Moisture, Yield, and Yield Contributing Components of **Sesame (*Sesamum indicum* L.)**  
[Goitom Teame](#)<sup>1</sup>, [Alemtsehay Tesfay](#)<sup>2</sup> and [Berhanu Abeta](#)<sup>2</sup>

Australian Journal of  
Crop Science

AJCS 4(9): 769-775 (2010)

AJCS

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Response of organic linseed (*Linum usitatissimum* L.) to the combination of tillage systems, (minimum, conventional and no-tillage) and fertilization practices: Seed and oil yield production

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**Wild sunflower as a green manure for rice in the mid country wet zone [in Sri Lanka, 1982]**

**Див сончоглед како зелено ѓубриво во централен дел на земјата со влажна клима [Шри Ланка, 1982]**

**Nagarajah, S. Nizar, B.M. (Central Agricultural Research Inst., Peradeniya (Sri Lanka)**

<http://agris.fao.org/agris-search/search.do?recordID=LK8700017>



## INTERESTING EXAMPLES FROM FOREIGN STUDIES - ИНТЕРЕСНИ ПРИМЕРИ ОД СТРАНСКИ ИСТРАЖУВАЊА

New green manuring *Lathyrus sativus* variety AC Greenfix available in USA  
David Krause and Ila Krause Dakota Frontier Seeds, 6520 45th Avenue Flasher, North Dakota 58535, USA  
Email: dakotafrontierseeds@westriv.com

AC Greenfix was officially registered under the Canada Seeds Act and became commercially available in May 1996 from Johnson Seeds, of Arborg, Manitoba, Canada. Its benefits were shown in four years of on-farm studies with **only 125-150 mm of rainfall**. The studies showed an average production rate of **90-100 kg N/ha**, with more than 200 kg produced in one research test plot. Nitrogen fixing begins in the top 30 cm of soil **about two weeks after emergence and reaches maximum activity between early and full bloom**.

AC Greenfix официјално бил регистриран под Canada Seeds Act и станал комерцијално достапен во мај 1996 од Johnson Seeds, од Арборг, Манитоба, Канада. Неговите придобивки биле прикажани во четиригодишен експеримент на фарма со **само 125-150 mm врнежи**. Испитувањата покажале просечна стапка на продуктивност од **90-100 kg N/ha**, со повеќе од 200 kg произведени во една експериментална парцела. Фиксацијата на азот почнува во горните 30 cm почва **околу две недели после поникнувањето и достигнува максимум активност помеѓу почетно и масовно цветање**.



Fig. 1. *Lathyrus sativus* cv AC Greenfix. From left to right: Seeds, 2-3 weeks growth, flowers and pods.

[http://www.web.uwa.edu.au/\\_\\_data/assets/pdf\\_file/0004/919786/ACGreenfix.pdf](http://www.web.uwa.edu.au/__data/assets/pdf_file/0004/919786/ACGreenfix.pdf)



## SUMMARY – CONCLUSIONS

- ❖ Higher **institutional support** of this agricultural practice.
- ❖ Inclusion of this subject in the **teaching programmes** at all levels.
- ❖ **Research ..... Missing... ???**
- ❖ There are **no recipes and patterns** in agriculture !!! cultivation site, climate, variety, soil, conditions of production year??? That's why there is need **for testing of several plant species and grass mixtures on smaller fields in order the most appropriate for specific location to be found.**
- ❖ Green manure **has less disadvantages and more advantages,** thus its application shall be extended on large-scale !!!

## РЕЗИМЕ – ЗАКЛУЧОЦИ

- ❖ Поголема **институционална поддршка** за оваа агромерка.
- ❖ Поголемо вклучување на тематски единици од оваа област во **наставните програми** на сите нивоа.
- ❖ **Истражувања ..... Недостасуваат... ???**
- ❖ Во земјоделството **нема конкретни рецепти и шаблони !!!** местоположба, клима, сорта, почва, услови на годината ??? Затоа потребно е да **се испитаат неколку растителни видови или тревни смески на помали површини, со цел да се најдат најсоодветните за одреден локалитет.**
- ❖ Зеленото ѓубрење има **помал број на слаби страни а поголем број на позитивности,** па затоа треба да се омасовува !!!



**THANK YOU FOR YOUR ATTENTION!**

**БЛАГОДАРАМ ЗА ВНИМАНИЕТО!**